SAN FRANCISCO ESTUARY INSTITUTE
4911 Central Avenue, Richmond, CA 94804 • p 510-746-7334 • f 510-746-7300 www.sfei.org

RMP Selenium Workgroup Meeting
June 5, 2017
San Francisco Estuary Institute

Meeting Summary

Science Advisors
Harry Ohlendorf

Stakeholders
Eric Dunlavey (City of San Jose)
Bridgette DeShields (Integral Consulting)
Peter Carroll (Tesoro Golden Eagle Refinery)
Naomi Ferger (SFBRWQCB)
Ian Wren (San Francisco Baykeeper)
Mary Lou Esparza (CCCSD)
Marisol Mendez (Tesoro Golden Eagle Refinery)
Eugenia McNaughton (US EPA)
Tom Hall (EOA)
Sarah Hughes (Shell Oil Corporation)

Other Attendees
Tom Grieb (Tetra Tech)
Sujoy Roy (Tetra Tech)
Robin Stewart (USGS)
Jay Davis (SFEI)
Jennifer Sun (SFEI)
Don Yee (SFEI)
Sam Lopez (SFEI)

1.Introductions, Meeting Goals, Agenda Review

No questions or changes to the agenda were presented.

2. RMP Planning Overview

The Selenium Multi-Year Plan includes a budget of $106k for special studies, but a reduced target of 70k has been established due to budget cuts. The Multi-Year Plan includes a list of priority management questions, and a second set of questions were developed at the last workgroup meeting in February to focus more on the North Bay and and the long-term monitoring plan (see Item 3 below). Since the last workgroup meeting, the Multi-Year Plan has been updated to reflect $34k in additional funding approved by the SC to support the selenium strategy and clam monitoring.

3. Update on Selenium Design Planning and Overview of Proposed Integrated Selenium Monitoring Design

Priority management questions related to long-term monitoring in North Bay were developed in February 2017:

1. Are the beneficial uses of north San Francisco Bay impaired by selenium?
2. Are changes occurring in selenium concentrations that warrant changes in management actions?
3. Will proposed changes in water flows and/or selenium loads in the Bay or upstream cause impairment in the North Bay?

$90k in SEP funding was approved in 2016 to support the development of a long-term selenium monitoring strategy, including $30k to support analysis of water data, $30k to develop the long-term monitoring plan, and $30k to support currently undefined monitoring activities. Jay presented a broad outline of the long-term monitoring strategy being proposed, as well as several funding options to consider based on monitoring priorities and current funding and logistical limitations.

Clams, the leading indicator of selenium in the system, would be sampled on a monthly or bimonthly basis. Water samples would also be collected bimonthly alongside clam samples for five years, until enough data has been collected to better evaluate the need for ongoing sampling. Water and clam monitoring with primarily address priority management question #2.

Sturgeon monitoring will occur separately, primarily to address priority management question #1. Monitoring of this lagging indicator is logistically limited to the fall season, and was proposed to be conducted annually from 2015-2017 to establish a consistent baseline of data from a period including both drought (2015-2016) and wet year (2017) conditions. Following this baseline period, biennial monitoring is proposed beginning in 2019. Samples from 2015 and 2016 have already been collected, and samples from 2015 have already been analyzed.

<u>Funding Options</u>

The Steering Committee is considering providing additional funding for 2017 monitoring connected to understanding the effects of the recent wet year. The $30k needed to fund 2017 muscle plug monitoring could potentially come from additional Steering Committee funds or the unallocated SEP funds.

Four funding proposals were initially proposed. Under Scenario A, a USGS contract would cover clam and water monitoring, as well as sturgeon tissue analyses. However, recent circumstances have made it such that the USGS is unable to commit to a new contract. Current funding supports USGS clam monitoring through September 2017.

Scenario B includes continued collaboration with USGS, but with a hiatus year in 2018 for clam and water samples. This scenario assumed using funds initially proposed for 2018 to fund 2017 sturgeon muscle plug monitoring. $50k allocated for the South Bay selenium synthesis could also be moved forward from 2019 to 2018, but the group decided against this option.

Scenario C includes $100k in funding for clam monitoring beginning in 2018, assuming the use of a separate contractor. Scenario D was identical to Scenario B, except it assumed non-USGS contractors beginning in 2018.

The group also agreed on the need for a separate study specifically focused on synthesizing existing data across years and matrices. Sujoy noted that selenium loads from the Delta have indeed changed since the TMDL, and would warrant further monitoring.

Fin ray and otolith monitoring was discussed and determined to be a low priority. Initial results do not show a good correlation between concentrations measured in the fin rays versus other tissues, suggesting fin rays may not be a good monitoring indicator. Further evaluation of the data is need to determine whether further studies in this direction are warranted.

4. Discussion: Clam Monitoring Design

Robin Stewart presented results from USGS's long-term monitoring of selenium in clams. According to her data, clam selenium concentrations in recent years have reached some of the highest levels ever recorded. Primary factors that influence clam selenium concentrations are well understood. For example, factors like size influence clam selenium concentrations (small clams generally filter more), and we can constrain sampling to account for these sources of variability. Efforts to identify similar sampling constraints for sturgeon are ongoing.

Clam Data

Flow and Water Year

Robin presented an analysis showing that freshwater inflow is correlated with bivalve selenium concentrations, as well as a significant interaction with water year type. This analysis was done using Sacramento River water year data, with a 60 day lag period between bivalve concentrations and preceding monthly water flows to account for for selenium uptake and trophic transfer. Because of the water year interaction, bivalve data cannot be normalized to flow.

At site 4.1 (Delta), there is a negative relationship between flow and clam Se data, while at site 8.1 (Carquinez Strait), the type of correlation observed depends on the water year. During dry/critical years, there is increasing clam selenium with increasing freshwater flows, while at wet and above normal years, there is a negative relationship between clam selenium and freshwater inflow. In normal years, the relationship is flat.

Robin is starting to be able to look at residence times with the CASCADE model as a potential explanation for this phenomenon. Sujoy raised the point that it is hard to explain why such trends are occurring at Carquinez but not upstream in the delta, which raises the question of whether there are in fact inputs downstream of the delta. More examination of total loads to the Bay with modeling may be necessary to explain this trend.

There was not much difference in filtered selenium concentrations over the past year, but concentrations peaked in January with a large influx of freshwater due to a wet period. Concentrations this past winter may not be that unusual relative to historical values during wet periods. The highest concentrations are at Pacheco Creek.

Spatial Patterns

In general, bivalve Se concentrations exhibited the following trends between sites:

Site 8.1 (Carquinez Strait) > Pacheco Creek > Site 12.5 (San Pablo Bay) > Site 4.1 (Delta)

Selenium concentrations have been variable but in general have decreased since January 2016. However, there was an increase in bivalve Se concentration at the San Pablo Bay site beginning in March

2016 and increasing more sharply beginning in September 2016 and past January 2017. This is a pattern that had not been observed before, and that begun prior to the wet period and thus are not likely to be connected to freshwater flow alone. At all other sites, Se bivalve concentrations clearly decreased during and after the wet period. Robin has looked at factors like total particulates, TSS, chlorophyll a, selenium / chorophyll a, and selenium / TSS, but has not yet been able to explain this pattern.

Trophic Relationships

Mean Se concentrations in sturgeon liver and ovaries in a 3 year period from 2015-2017 (Sturgeon Derby data) were highest in 2015 and lowest in 2016, with concentrations in 2017 only slightly higher than 2016. However, these trends were not observed in sturgeon muscle samples, which showed a decline over the entire three year period.

Mean Se concentrations in bivalves collected at sites 4.1 and 8.1 decreased over the past three years. The only group that showed the same pattern as sturgeon liver and ovary was Station 8.1, three months ahead of the sturgeon data. This raises the question of whether this site is more representative than others of where sturgeon are obtaining selenium. However, Bridgette suggested that the observed trends in sturgeon could just be a reflection of the small sample sizes and natural variability within a small dataset. Robin also believes that there is a shorter lag time between clams and sturgeon. However ,she found that the best index for the linkage between clam and sturgeon uses a combination of all clam stations with a 3 month lag.

Monitoring Design

Robin presented her proposed framework for evaluating early indicators of change in clam selenium, based on the 2015 Arciszewski and Munkittrick Adaptive Monitoring Framework paper and a 2017 Arciszewski paper discussing the use of critical effect sizes. Based on this framework, “normal” ranges of clam selenium concentrations are calculated based on historical baseline data, and exceedances of these ranges at different levels can serve as triggers. Ranges can be calculated using all available historical data,

Barbara suggested that if we use all the historical clam data, it should incorporate variability from all different kinds of water year and that we should also have a saftey measure of needing a certain number of exceedances to trigger something. Naomi said that this trigger will be for more intense sampling to start.

Peter asked if the ranges and management triggers need to be adjusted for different water years. Robin believes from a toxicity standpoint that the most important thing is the value above which we have a toxicity problem.

Robin recommended that certain criteria be used to define “normal” for San Francisco Bay Se concentrations. Factors that should be taken into account include site specific changes (changes in source exposures, i.e. pre- or post-wastewater treatment plant upgrades; changes at multiple sites signal a greater ecosystem shift), time scales (monthly at 4.1 and 8.1; annual at 12.5), and the type of water year (either all, wet, or dry). Bridgette suggested a quarterly time scale, and Robin said this would be feasible if we define the correct quarters. Splitting the “normal” values into months or quarters is meant to

serve as a proxy for flow, to which the clam data cannot be normalized. Harry suggested a running 3 month average as well.

Model Framework

Robin then presented an example application of the Arciszewski and Munkittrick adaptive monitoring framework model. Based on this model, a minimum of 8 values is needed to define a normal range. If we want to establish monthly ranges separately for wet and dry years, the number of historical values available to establish these normal ranges becomes low. Baseline ranges established without the minimum of 8 values were calculated but can be considered "interim" baselines established without enough data. Annual data from site 12.5 was used throughout the entire year due to the lack of available monthly data.

Robin calculated normal ranges using the entire historical period as well as using data from either wet or dry years only. The normal range for dry years generally falls within the normal range for all years, though the lower bound of the dry year range tends to be towards the middle or upper ranges of the total normal value range. Similar but opposite trends are observed with wet years (upper bound tends to be towards the lower ranges of the total normal value range).

Robin pointed out that this framework would serve to detect changes following some type of impact, within about 3 months after the time period of impact (i.e. how long it takes to process and analyze samples). This approach does not *forecast* changes, although it provides a framework within which to consider the effects of potential changes.

Robin also emphasized that selenium concentrations already appear relatively high, and further emphasized the need to define triggers and trigger thresholds. Based on this analysis, selenium concentrations exceeded the 75th percentile of "normal" during 9 months in 2014 and 11 months in 2015. These values already exceed the proposed EPA criterion of 15 ug/g, while sturgeon concentrations are also already approximately at regulatory threshold levels, although some of these higher concentrations occurred during a drought period. Depending on the management question of concern, do current selenium concentrations already warrant action (i.e. are we seeing "freak out" values?

Three options for time periods for monitoring are monthly, pre-sturgeon monitoring (July-September), and pre-spawning (December-March). Robin suggested that some forecasting could be done based on current trends in weather, climate, and hydrology. The impact of events like drought, changes in San Joaquin River brine management, and hydrodynamic changes due to climate change and wetland restoration efforts should be able to be evaluated at least somewhat in advance.

<u>Discussion</u>

Robin is aiming to publish a clam data synthesis report by September. Robin suggested that if SFEI were to switch labs, there should be some overlap between labs. She offered to provide any future RMP lab with information about the analysis methods and stressed the importance of precisely following SOPs for clam collection in the field. She also warned that sturgeon plugs may be harder for other labs to analyze with precision due to small sample mass (requires a hydride generation method).

Barbara brought up the point that literature suggests that dissolved Se contributes to maybe only <2% of Se in bivalves, and as such you may not expect see a linear relationship between water and clams.

However, Robin maintained that it is still valuable to look at water to see what is happening with the entire system.

Concerns were voiced about the depth at which water samples have been collected, but Robin and Sujoy indicated that simulations in CASCADE indicate strong vertical mixing. Surface water samples therefore seem to be a good indication of aqueous Se concentrations at all depths, including the bottom where clams reside. Additionally, isotopic clam data indicates good mixing.

Naomi asked if there were changes in diet with changes in freshwater flow that may be affecting sturgeon selenium concentrations, and if the abundances of Potamocorbula were changing based on flow conditions. Robin said that we were still seeing Potamocorbula far up into the North Bay/Delta. She speculated that the abundances may be changing a bit, but that the sturgeon may also be just moving to where the food is.

Peter expressed concern that the bright line numbers (i.e. regulatory thresholds) do not make sense for sturgeon or clams because of the variability of the data. SFEI and other groups need to figure out how to present the data to be useful to the Water Board. The bright line numbers may be useful, but there is a need to be able to put these numbers into a framework and need more information to understand them. We need to decide what to do when Se concentrations fall outside the “normal” values that we will establish with an internal framework for adaptive monitoring and management. This again resulted in discussion of the need for a synthesis across matrices.

Robin recommend bringing in Kelly Munkittridge in to help with monitoring design. Naomi suggested that triggers and trigger values should be established before the group brings in external advisors. First, additional synthesis among the three matrices is needed to understand how to use them together to develop a trigger.

Trigger Values

Discussion shifted to the significance of the “freak out” values in the adaptive monitoring framework. Many exceedances of the 75 percentile but not the 95th percentile (i.e. 2015 drought) might be a flag that things might be changing, but may not necessarily be a “freak out” indicator. If concentrations decrease during subsequent wet years, then the system may be fine.

The group discussed whether or not it would be appropriate to have different trigger values for wet and dry years. Some agreed that the TMDL should be set to be protective of the most sensitive conditions as that would relate most to ecological relevance (i.e. the trigger should be established with regard to concentrations that begin to pose an ecological threat, so only a single trigger value is needed). However, having two different trigger values could be useful to make sure management actions are not triggered only because of weather conditions. The group came to the consensus that while it is important to examine trends in the context of different conditions that affect Se levels, there should be a single underlying criteria that is consistent overall when it comes to setting trigger values.

Ian Wren pointed out that while the group was discussing when the “freak out” about increasing concentrations, the system is already impaired. Ian and Robin advocated for identifying triggers that related to ecological risk in addition to triggers that identify changes in the system. Bridgette proposed that any observed changes could be clearly associated with weather patterns vs. other factors, which

could then warrant different levels of management actions. Bridgette and Naomi both suggested that the first level of triggers based on clam data could simply trigger more intensive fish monitoring.

More work is needed to evaluate potential alternative statistical frameworks. Tom Grieb suggested looking at noncentral distributions suggested by Kilgour et al. to compare data to wet and dry year ranges rather than only comparing to overall historical ranges. Robin agreed, and said that she is still trying to look at this in her synthesis paper. Robin also mentioned that she wanted to look at the bootstrap method for establishing normal ranges.

Lastly, Robin provided an update on other selenium activities being conducted by her group. USFWS collected sturgeon eggs in both the San Joaquin and Sacramento rivers for Robin to analyze, beginning in February and likely to continue through June. Robin indicated that she believes that the eggs are more responsive to changes in the maternal diet during the period immediately prior to spawning compared to previous years -- that is, that egg concentrations should be linked to recent clam selenium concentrations. These data will help to more rigorously evaluate this hypothesis.

Decisions

- Stop bivalve monitoring for October 2017 - September 2018. Consider the use of emergency funds (i.e. RMP undesignated funds) for sampling if needed

Action Items

- Develop management triggers & more clearly outline what kinds of changes we are trying to detect
- Identify secondary clam laboratory

5. Discussion: Water Monitoring Design

Potential future changes that affect water column Se

- Concentrations in riverine inflows
- Relative proportion of San Joaquin and Sacramento Rivers
- Droughts and low overall freshwater flow
- Nutrients and algal growth
- Point source loads -- constant outside of any dilution

There was discussion of a partnership with USGS Sacramento lab if the USGS Menlo Park lab goes offline for a period of time due to federal budget uncertainty. It is important to maintain riverine sampling at the Freeport and Vernalis sites. The upper management priority will be river sampling, so these sites may easier to continue monitoring.

<u>Dissolved Se</u>

Looking at historical data for the last 1-2 decades, the Se/Cl ratio was more variable at Freeport (Sacramento River) but showed no appreciable trend over time. The ratio has been decreasing over time at Vernalis (San Joaquin River) from 2008-2017 which is likely tied to management actions. These ratios were still higher than those observed in the Sacramento River, but were only 2-3 times higher rather than

~10x higher (historically). In the Western Delta (RMP sampling), we might be seeing a decline but there are no statistically significant trends. .

The San Joaquin River during high flow conditions delivers more Se to the SFB during wet months. For example, March 2017 had some of the highest freshwater flows in decades but still had high Se concentrations. Robin brought up the point that there could be differences in the forms of Se that are coming into the bay at different times. We have generally come to assume that it's all ~selenate, but there could be differences that we are not taking into account.

Recommendations:

- 3 locations (Suisun, San Pablo, Carquinez)
- Dissolved & particulate with no additional speciation -- recommendation that cost & field effort of speciation is not worth it or needed at this time for ongoing monitoring, but maybe for special studies
- Co-located clam and water sampling locations as much as possible
- Propose at least a 5 year monitoring program, reassess at the end
- 6 samples per year per site seems adequate to detect a 20% change in a reasonable time frame (~2-3 years)
    - Sujoy raised the concern that such a study would have limited value if not done over an extended period of time since you would not know if you're getting an anomalous year.

Robin brought up that it might be possible for USGS to get water samples without clams since collection and processing of water samples is much easier.

One of the identified needs from Terry Young and the TMDL was to identify where there are needs to monitor in the delta. Therefore, we should establish that and propose something even if it's outside the basic scope of the RMP and give that information to the State Board.

Harry made the point that water might be a predictor of other media if SFEI wanted to invest in water sampling. However, it may not be worth it to start the 5 year water sampling now if we are taking a hiatus on clams, since water data is not as useful without the corresponding clam data (discussed later in the meeting).

6. Discussion: Sturgeon Monitoring Design

Jennifer Sun presented preliminary results from the RMP special studies and a preliminary long-term monitoring design for sturgeon.

7. Discussion: Options for Optimal Use of Available Funds

The South Bay synthesis was discussed and was decided to remain a lower priority due to lower Se concentrations across matrices and the lack of a strong regulatory driver. Long term Se levels in the South Bay have not changed much, and bivalve Se concentrations have been relatively constant. The synthesis would not just be an impairment assessment and would occur separately from evaluating a

potential delisting, but instead would be looking at sources of Se to the South Bay. This might include a summary of selenium data collected by the RMP stormwater group. The Water Board noted that fish tissue criteria should take precedence over other criteria, since fish are the endpoint of concern. The synthesis is planned for 2019 and was not proposed for funding sooner.

The group instead agreed on the need for a North Bay synthesis based on an agreed upon statistical framework and to further evaluate the proposed monitoring design. Barbara emphasized the need for one report to address all three matrices, with an explanation of how they work together. Sujoy suggested that the story of clams, water, and sturgeon could be put together in several papers that could be completed by late 2018. The synthesis would include two components: (1) understanding the data, and (2) evaluating the statistical design for monitoring.

The group discussed what would be missed if monitoring in 2017 focused on only one of the matrices instead of all three. It was established that sturgeon muscle plugs were a priority for sampling in 2017, given the importance of collecting data from the wet year and maintaining the continuity of this long-term trend indicator. Robin indicated that she could support analysis of muscle plug samples under a contract amendment at a level over $10k. Water sampling alone would not be particularly valuable at this time, as the linkage between water and the other matrices is not yet well established. Naomi suggested exploring other sources of funding for water monitoring.

The group also discussed the need to establish an alternative or backup lab for conducting selenium in tissue analysis. The USGS National Water Quality Laboratory and UC Davis were proposed as two potential labs. Funding would be needed to support researching options for a secondary lab and conducting a laboratory intercomparison study.

Peter Carroll again pointed to the Water Board's interest in updating the current understanding of Delta loads, which could require additional modeling.

8. Closed Session Discussion: Recommendations for 2018 Special Studies Funding

A proposed funding decision was agreed upon without a closed session. Funding will be proposed to support (1) strategy support, (2) a North Bay synthesis, and (3) 2017 sturgeon monitoring. The third task will also include laboratory analysis of 2016 sturgeon muscle plug samples that were collected *pro-bono* by CDFW. The South Bay synthesis was not prioritized. Other recommendations were tabled for further discussion.

9. Report Out on Recommendations

See attached table

10. Wrap-up and Adjourn

4:00 pm adjourn