RMP
REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY
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RMP Selenium Workgroup Teleconference

May 14, 2020

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DRAFT AGENDA

1.	**Logistics, Introductions, Meeting Goals, Agenda Review** Goals for the meeting: 1. Update on RMP planning 2. Updates on North Bay monitoring studies 3. Update on USGS activities 4. Recommend studies for 2021, update multi-year plan, and identify potential SEP studies Materials: 2019 SeWG Meeting Summary - pages 4-12	9:00 Jay Davis
2.	**Information: RMP Planning Overview** An overview of the RMP planning process will be provided. An update on the Multi-Year Plan (which includes the Selenium multi-year plan) and budget status will be given. An update on recent regulatory developments will be provided. Materials: Selenium Pages from the RMP Multi-Year Plan – pages 13-14 **Desired Outcome:** Group understanding of the RMP planning process, existing plans for selenium studies, and regulatory status.	9:10 Jay Davis

3.	**Information and Discussion: Update on North Bay Monitoring – Clams and Water** The North Bay clam and water RMP special study began in 2019. An update on progress and results will be provided. Some kinks that have arisen in the transition to the new labs for processing and analysis will be described, as well as steps taken to work through them. Challenges related to vessel availability will also be discussed. Materials: Powerpoint presented at the meeting **Desired Outcomes:** o Informed Workgroup o Feedback on progress, methods, and plans	9:30 Nina Buzby
	Break	10:30
4.	**Information: Update on North Bay Monitoring – Sturgeon Plugs** Biennial sturgeon muscle plug sampling as a RMP special study began in 2019. An update on progress and results will be provided. Pro bono plug collection was unsuccessful in 2019, so staff are recommending shifting this effort to 2020. Materials: Powerpoint presented at the meeting **Desired Outcomes:** o Informed Workgroup o Decision on shifting the effort from 2019 to 2020	10:45 Nina Buzby
5.	**Information: USGS Updates** Updates on USGS activities related to selenium: • Update on South Bay results from 2017 • Clam data visualization • Publications and next steps on splittail Materials: None **Desired Outcomes:** o Informed workgroup	11:05 Robin Stewart
	Break	11:25

6.	**Decision: Selenium Workgroup Proposals for 2021 and Updated Multi-Year Plan** 1) North Bay Clam and Water Monitoring 2021 ($100,400) 2) North Bay Sturgeon Muscle Plugs 2021 ($21,825) SFEI staff will present a description of each proposal, followed by group discussion. Multi-Year Plan Items • Long-term plan for North Bay sampling • Future of the Selenium Workgroup SEP Study Ideas • South Bay Clams and Water (USGS) Materials: Proposals – pages 15-29 **Desired Outcomes:** o Workgroup consensus on a recommendation to the TRC regarding the funding of these proposals o Updated multi-year plan for selenium o List of SEP study ideas	11:40 Jay Davis Nina Buzby Bridgette DeShields Group
9.	**Wrap-up and Adjourn**	12:40 Jay Davis

REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY
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RMP Selenium Workgroup Meeting

April 26, 2019
San Francisco Estuary Institute
4911 Central Avenue, Richmond, CA

Meeting Summary

Attendees

Science Advisor	Affiliation	Present
Harry Ohlendorf	CH2M Hill	Yes

Others Present

Sam Engelage (City of Palo Alto)
Diego Martinez Garcia (City of Palo Alto)
Luisa Valiela (EPA)
Bridgette DeShields (WSPA, Integral Consulting)
Mary Lou Esparza (CCCSF)
Sujoy Roy (Tetra Tech Inc.)
Tom Grieb (Tetra Tech Inc.)
Barbara Baginska (Water Board)
Eric Dunlavey (City of San Jose)
Ryan Mayfield (City of San Jose)
Ian Wren (Baykeeper)
Ann Vorderbrueggen (Shell)
Sam Luoma (USGS)
Jay Davis (SFEI)
Don Yee (SFEI)
Nina Buzby (SFEI)

Remote
Robin Stewart (USGS)
Vince Palace (International Institute for Sustainable Development - Experimental Lakes Area)
Tom Hall (EOA)
Melissa Foley (SFEI)

The last page of this document has information about the RMP and the purpose of this document.

1. Information: Introductions, Meeting Goals, Agenda Review

Jay Davis began the meeting by identifying the lighter agenda load as an opportunity to think about the Workgroup's long-term plan. Time was given for introductions and housekeeping reminders. Jay then outlined the goals for the meeting, which included updates on RMP planning developments and monitoring, information from SFEI partner work, and discussion of 2020 proposals and potential Supplemental Environmental Project (SEP) options.

2. Information: RMP Planning Overview

Jay Davis presented a brief overview of the RMP planning process and budget, as well as the existing plans for selenium. Jay showed the meeting participants the current iteration of the RMP's Multi-Year Plan, and outlined the management questions and policies, such as the North Bay TMDL, that tend to guide projects. Barbara Baginska provided an update to the Workgroup on the Water Board's interest in the South Bay. She noted that South Bay-related efforts aren't a high priority, given the recent release of the USEPA freshwater criteria and the lack of POTW exceedances of the 5 mg/L threshold. Additionally, there are no plans for the next two years to develop a TMDL for South Bay.

Jay's overview of the Multi-Year Plan included a more in-depth explanation of the budget table and available funding breakdown. Jay noted the previous year's decision to alternate data management tasks to every other year (in multi-year studies); Bridgette DeShields identified that the WG is in excellent shape related to study prioritization, given the time spent in past years on focusing the group's efforts. Related to multi-year studies, Jay commented that an important discussion point for later in the meeting would be considering how long to continue these long-term studies. Jay also underscored the importance of thinking about potential SEP ideas, explaining that funding has often come from refinery permit violations and selenium studies are often relevant to those actions.

3. Decision: Clam and Water Sampling Design Details

Nina Buzby provided an update to the Workgroup on the 2019 efforts for monitoring selenium in water and clams in North Bay. The presentation included details on the sample collection plan, specifically the time at which the coordinated clam and water sample collections would occur. The proposed timing would be two, 3-month sampling periods from June-August and November-January. It takes approximately 2-3 months for selenium concentrations in clams to be reflected in sturgeon tissue. Water and clam collections are timed to predate sturgeon tissue sampling by DFW in September and October, and sturgeon spawning in March and April. Sujoy Roy pointed out that optimizing the timing of the water sampling should also be considered, and it would be ideal to capture low flow and high flow periods. The group agreed on the proposed 3-month sampling periods, with the refinement that sampling late in the months of these periods would be better for characterizing low-flow and high-flow periods. Nina also reminded the meeting participants of the modular budget for this work; there is a separate data management component that occurs in alternating years. Additionally, selenium monitoring will coincide with RMP Status and Trends (S&T) biennial full-Bay water monitoring efforts. The collection protocol will likely be duplicated on the S&T cruise to maintain consistency across efforts. The sampling also coincides with RMP S&T sport fish monitoring in 2019.

Nina also informed the meeting participants of the ongoing planning efforts related to sturgeon muscle plug monitoring, noting the planned partner for this work, CA Department of Fish and Wildlife, has not yet definitively confirmed if they will be conducting sturgeon tagging this year.

Jay told the group that the data management task for 2020 clam and water monitoring ($40k) has been submitted to the Water Board as a SEP project. While the funds are not confirmed, the probability is high that they will be received.

Decisions:

- The group agreed on the timing of the two 3-month sampling periods: Jun-Aug and Nov-Jan, with sampling occurring toward the end of these months.

4. Discussion: Intercomparison Study Update

Nina Buzby presented the current status of the in-progress laboratory intercomparison study to the meeting attendees. Given the lapse in funding to the USGS lab that has been performing selenium analyses in the North Bay (led by Robin Stewart), the study goal is to find a new lab to analyze clam, sturgeon, and water samples collected by the RMP. Nina noted that the five participating labs should be submitting results by the end of April, and outlined the rest of the timeline leading up to the final lab selection. The reporting and selection dates are consistent with the plan to begin clam and water monitoring in late June.

Don Yee explained possible criteria for lab selection and proposed a potential weighting scenario to the workgroup and how statistics would be translated into “scoring” metrics. Criteria categories included CEDEN reporting ability, cost, communication, precision (comparison amongst IC results), and recovery (comparison to target/historic results). Meeting participants noted that it would be critical to evaluate labs by each individual matrix, and then possibly come up with a plan on how to aggregate evaluations after the fact. Additionally, Robin Stewart and Sam Luoma - USGS investigators conducting long-term clam monitoring in the Bay - noted that special attention should be paid when calculating the mean result amongst labs because one result can alter the value significantly with such a low number of labs, and the propensity for outliers to occur when dealing with selenium analysis. All outliers should be flagged in the data.

Robin Stewart also suggested that RMP staff ask the participating labs for a history of lab performance with certified reference materials (CRMs), duplicates, and blanks to assess the labs historical capabilities. There was further discussion on reference materials, specifically synthetic versus natural materials. This topic led to the decision to allot additional points to labs that can report where they receive CRMS and their makeup. SFEI will develop a list of QA samples needed from the labs, with input from Robin Stewart. Labs will be asked to submit the information quickly so the timeline for the effort is not affected.

Action Items:

- Ask the participating labs for a history of lab performance with certified reference materials (CRMs), duplicates, and blanks. (Nina Buzby, 4/30/19)
- Allot additional points to labs that can report where they receive CRMs and their makeup. (Don Yee, 4/30/19)

- Send laboratory selection memo to workgroup with scoring criteria included. (Nina Buzby, 5/22/19)

5. Information: Sturgeon Fin Ray Study

Vince Palace presented results from his sturgeon fin ray and otolith analysis of temporal selenium exposure patterns. Given that soft tissues are metabolically active, analysis of muscle tissue only provides a snapshot of selenium exposure. However, bony structures like otoliths (small inner-ear bones) and fin rays are metabolically stable and grow in a similar fashion to tree rings, allowing trace elements to be quantified over the life of the fish. Results from the three years of collections show generally similar trends, indicating an increase in selenium content over time, particularly for females.

Otoliths, which are non-vascularized and assumed to produce better age estimation than fin rays, were only collected in later years (2016 & 2017) because the literature suggested some possible instability in fin-rays. Using the growth rings of bony structures, age of sturgeon was estimated and overlaid with concentrations of various trace elements (i.e., selenium, mercury, zinc, strontium). Comparison between fin ray and otolith age estimates were variable, with most fin ray estimates being greater than otolith estimates, despite the reported trend that fin rays consistently underestimate age. In addition, there was not a consistent relationship between selenium concentration in otoliths and fin rays, suggesting fin rays may not be a suitable non-lethal method for estimating long-term selenium exposure.

The later collection years also involved endolymph collection, the fluid that otoliths are suspended in and therefore the pathway through which the bony structures have access to trace metals. There was no significant relationship between otoliths and endolymph selenium concentration; the relationship between endolymph and fin ray concentrations was stronger, but still not significant.

Vince and his colleagues are in the process of writing a manuscript that outlines these results; they are also generating a model that could explain the other aspects influencing selenium deposition. In addition to the work on endolymph, Vince informed the committee of looking at the concentrations of other trace elements, like mercury (which is known to influence the uptake of selenium), zinc, and strontium. Other possible influential factors noted by Vince include: selenium concentrations in soft tissues (e.g., liver, muscle, ovaries), exposure pathway (water vs. diet), and physiological factors (e.g., size, sex, reproductive stage).

The following discussion focused primarily on the data for trace metals other than selenium that Vince presented, which all meeting attendees noted were quite interesting. For example, Robin Stewart noted the dramatic increase in mercury shown in Vince's results that doesn't seem consistent with other data from fish tissue in the North Bay. Vince acknowledged this point and also added that instead of the suspected negative interaction between selenium and mercury concentrations, the results indicated a positive interaction between the two elements. Sujoy Roy

also brought up the topic of looking at the literature for ideas on the relationship between bony structure and tissue concentrations, though Vince noted there aren't as much data available as one would expect, motivating this study and ongoing efforts to develop a model that will allow the input of other factors.

6. Information: USGS Synthesis of Information on Selenium in the South Bay

Sam Luoma presented to the group on the 2018 USGS synthesis that pulled together all available data on selenium concentrations in South Bay. The purpose of the study was to assess if selenium levels in South Bay are elevated, and if so how to proceed. Sam noted the primary interest in the region is in the smaller area of Lower South Bay (LSB) given the number of wastewater treatment facilities. The synthesis looked at data from multiple sources and matrices including water, sediment, benthos, fish, and bird eggs. USGS long-term monitoring of clams on the Palo Alto mudflat have continued, and will continue until Dan Cain retires. There were three main takeaways from the study. First, the most influential sources of selenium came from LSB, particularly Alviso Slough and the Guadalupe River. However, peak selenium concentrations in the Guadalupe River have declined since the 1990s. Second, there was a gradient in selenium concentrations, declining from south to north within the region. Finally, declining concentrations noted in water were less evident in sediment and clams and did not appear in fish. Sam hypothesized that the declines in water selenium might be related to wetland restoration in the South Bay or mercury remediation in the Guadalupe River watershed.

Discussion after Sam's presentation led to anecdotal reports of increasing presence of *Potamocorbula amurensis* and white sturgeon in the South Bay in recent years. Sam Luoma and Ryan Mayfield noted that filter feeders like *P. amurensis* tend to respond to wet years in the way that is being observed - given that CA was in a period of intense drought until the high flows of January 2017. Additionally, meeting participants brought up an interest in conducting selenium speciation analysis to get further insight into whether or not there are differences between North Bay and South Bay inputs and pathways. Robin Stewart did some analyses of clams and water after the high flows of 2017.

These points led to a broader discussion of what the Workgroup would like to do in relation to South Bay. For instance, should the RMP monitor clams in the South Bay in 2019 to take advantage of *P. amurensis* presence? Many participants noted that speciation data (i.e., dissolved selenate, selenite, and organo-selenium) would be very valuable and could be an easy add-on to the RMP S&T water cruise that will already be collecting selenium samples throughout the Bay. Barbara Baginska noted that speciation should be prioritized over clam collection because speciation is the only data that isn't available in the South Bay and clam data would only provide a snapshot of information. Robin Stewart added to this point, noting that clam monitoring involves a lot of effort and is expensive. Additionally, it would be helpful to establish the relationship between particulate selenium concentrations in water and selenium in biota tissues, so it would be most helpful to collect *P. amurensis* 2-3 months following water sample collection.

This discussion landed on the decision to add selenium speciation analysis to the 2019 S&T Water Cruise samples and to scope out a proposal for clam and water (with speciation) monitoring for review by the Selenium Workgroup that could potentially be presented to the RMP Steering Committee for funding in 2019. Such a proposal could then be filed for use in later years and be helpful in a multi-year planning context. When another wet year occurs, the option could be implemented. In order to leverage USGS and Santa Clara existing monitoring efforts, Robin Stewart offered to help scope this proposal.

Action Items

- Add selenium speciation (i.e., dissolved selenate, selenite, and organo-selenium and particulate selenium through filtration) to the S&T water monitoring for comparison to North Bay speciation data (Jay Davis, 8/1/19)
- Scope a proposal for South Bay clam and water (with speciation) monitoring for review by the Selenium Workgroup that could potentially be presented to the RMP Steering Committee for funding in 2019 or consideration in future wet years (Robin Stewart, 8/31/19)

7. Decision: Selenium Workgroup Proposals for 2020 and Updated Multi-Year Plan

Jay Davis first asked the group for approval on the two proposals (strategy coordination and clam and water sampling in North Bay) to pass along to the RMP Technical Review Committee. With the multi-year monitoring in mind, Jay also asked the group for input on whether to continue the annual and biennial monitoring indefinitely or to establish a year for re-evaluation. The meeting participants responded that the decision to continue should be based on data trends and also consider the power calculations done for clams and sturgeon for the North Bay Selenium Monitoring Design finished in 2018. The Steering Committee and TRC should understand that the designs are for long-term monitoring. For multi-year planning purposes, the group advised to set a “check-in” on the monitoring efforts in 2021 but have the year be subject to change based on data.

Jay then presented the list of possible SEP ideas to the group which from the day’s previous discussions could include sturgeon plug data management, as well as clam sampling in the South Bay further down the road. Tom Grieb and Barbara Baginska commented on the North Bay water transect idea, saying that it would be an expensive exercise that was helpful when establishing the TMDL, but may not be as much of a priority. There was support for the idea of a spatial survey of clams in the North Bay that had been discussed in prior years by Robin Stewart.

Jay asked the workgroup members for other possible SEP ideas, and to send any his way if anything came to mind after the meeting. This prompted a quick discussion from Ryan Mayfield on interest in doing a stomach content analysis on sturgeon. Given the labor intensive manner

of this work, Jay suggested that it should be easy enough to save the gut contents from the 2019 S&T sturgeon collections for possible dissection later.

Decisions

- The group approved the two proposals (strategy coordination and clam and water sampling in North Bay) to pass along to the RMP Technical Review Committee
- Continue the North Bay clam and water sampling through 2021, but then have a check-in on continuing the monitoring

Adjourn

About the RMP

RMP ORIGIN AND PURPOSE

In 1992 the San Francisco Bay Regional Water Board passed Resolution No. 92-043 directing the Executive Officer to send a letter to regulated dischargers requiring them to implement a regional multi-media pollutant monitoring program for water quality (RMP) in San Francisco Bay. The Water Board's regulatory authority to require such a program comes from California Water Code Sections 13267, 13383, 13268 and 13385. The Water Board offered to suspend some effluent and local receiving water monitoring requirements for individual discharges to provide cost savings to implement baseline portions of the RMP, although they recognized that additional resources would be necessary. The Resolution also included a provision that the requirement for a RMP be included in discharger permits. The RMP began in 1993, and over ensuing years has been a successful and effective partnership of regulatory agencies and the regulated community.

The goal of the RMP is to collect data and communicate information about water quality in San Francisco Bay in support of management decisions.

This goal is achieved through a cooperative effort of a wide range of regulators, dischargers, scientists, and environmental advocates. This collaboration has fostered the development of a multifaceted, sophisticated, and efficient program that has demonstrated the capacity for considerable adaptation in response to changing management priorities and advances in scientific understanding.

RMP PLANNING

This collaboration and adaptation is achieved through the participation of stakeholders and scientists in frequent committee and workgroup meetings (see Organizational Chart, next page).

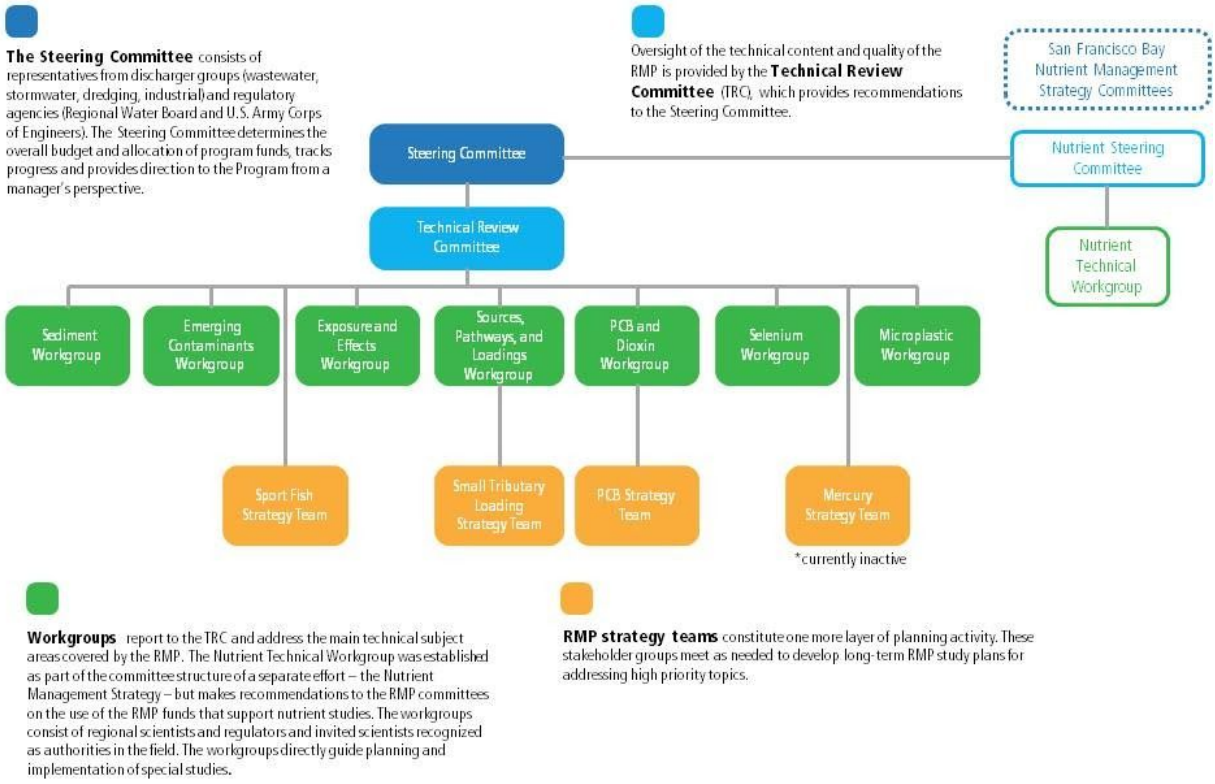
The annual planning cycle begins with a workshop in October in which the Steering Committee articulates general priorities among the information needs on water quality topics of concern. In the second quarter of the following year the workgroups and strategy teams forward recommendations for study plans to the Technical Review Committee (TRC). At their June meeting, the TRC combines all of this input into a study plan for the following year that is submitted to the Steering Committee. The Steering Committee then considers this recommendation and makes the final decision on the annual workplan.

In order to fulfill the overarching goal of the RMP, the Program has to be forward-thinking and anticipate what decisions are on the horizon, so that when their time comes, the scientific knowledge needed to inform the decisions is at hand. Consequently, each of the workgroups and teams develops five-year plans for studies to address the highest priority management questions for their subject area. Collectively, the efforts of all these groups represent a substantial body of deliberation and planning.

PURPOSE OF THIS DOCUMENT

The purpose of this document is to summarize the key discussion points and outcomes of a workgroup meeting.

Governance Structure for the Regional Monitoring Program for Water Quality in San Francisco Bay



SELENIUM

Relevant Management Policies and Decisions

- North Bay Selenium TMDL
- USEPA Selenium Criteria for the Bay-Delta
- South Bay Selenium TMDL (under consideration)

Recent Noteworthy Findings

White sturgeon, a benthic species, is recognized as a key indicator of selenium impairment in the North Bay due to its susceptibility to selenium bioaccumulation. In general, white sturgeon muscle selenium concentrations measured over the past 30 years have exceeded the North Bay TMDL target in some individual sturgeon, but annual average concentrations have remained below the target and no long-term trend has been apparent since 1987. The highest tissue selenium concentrations were measured in Suisun Bay; the lowest were in Central Bay. Sturgeon muscle plug sampling provides a non-lethal means of obtaining a larger sample size of concentrations in the North Bay. Selenium concentrations measured in sturgeon muscle plugs and muscle fillets are well-correlated. Concentrations in muscle plugs were relatively high in 2015 and 2016, with medians near the TMDL target. Concentrations were much lower, however, in 2017, apparently in response to high flows in the winter of water year 2017.

The Lower South Bay has much higher average selenium concentrations in water than the other Bay segments, but white sturgeon collected in South Bay have had lower concentrations than North Bay sturgeon. This difference from the North Bay may be due to the low abundance of *Potamocorbula* (overbite clam) in South Bay.

The RMP Selenium Workgroup has developed a monitoring plan for sturgeon, water, and clams to track trends, with a special emphasis on early detection of change. It is an integrated, long-term design for all three indicators based on a solid statistical framework that is explicitly linked to management decision-making.

Priority Questions for the Next Five Years: General

1. What are appropriate thresholds?
2. Are the beneficial uses of San Francisco Bay impaired by selenium?
3. What is the spatial pattern of selenium impairment?
4. How do selenium concentrations and loadings change over time?
5. What is the relative importance of each pathway of selenium loading in the Bay?

Priority Questions for the Next Five Years: North Bay

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

Selenium Multi-Year Plan

Selenium studies and monitoring in the RMP from 2014 to 2024. Numbers indicate budget allocations in $1000s. Budgets in parentheses represent funding or in-kind services from external sources. Items included in planning budget are shaded in yellow. Bold boxes indicate multi-year studies.

Element	Funder	Questions addressed	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Selenium Strategy Coordination	RMP SEP	1,2,3,4,5, 6,7,8	10	10	10	25 (10)	10	10	10	Covered by core workgroup funding			
Selenium Information Synthesis	RMP SEP	1,2,3,4,5, 6,7,8		10		(50)							
Selenium Sturgeon Plugs	RMP SEP	1,2,3,4, 6,7,8	23	35		(57)		22		22	24	22	
Selenium Sturgeon Derby	RMP	1,2,3,4,6		29	37	42							
Selenium Monitoring in North Bay Clams and Water	RMP	1,2,3,4,5, 6,7,8				39		75	88	95	115	95	115
Data Management for North Bay Selenium Monitoring	SEP	1,2,3,4,5, 6,7,8						(40)					
Selenium in North Bay Water: Synthesis	SEP	1,2,3,4,5, 6,7,8				(50)							
Selenium South Bay Water (Speciated) and Clam Sampling (Wet Year)	RMP	1,2,3								100			
Selenium South Bay Model	RMP	5										100	
Spatial Survey of North Bay Clams	RMP	3									100		
RMP-funded Special Studies Subtotal - Se			**33**	**84**	**47**	**106**	**10**	**107**	**98**	**217**	**249**	**217**	**115**
High Priority Special Studies for RMP Funding										**117**	**149**	**117**	**115**
RMP-funded Special Studies Subtotal – Other Workgroups			**0**	**0**	**0**	**0**	**0**	**0**	**0**				
RMP Supplemental Environmental Projects Subtotal			**0**	**0**	**0**	**167**	**0**	**40**					
Pro-Bono & Externally Funded Studies Subtotal			**0**	**0**	**0**	**0**	**0**	**0**					
OVERALL TOTAL			**33**	**84**	**47**	**273**	**10**	**147**	**98**	**217**	**145**	**217**	**115**

Selenium Workgroup 2021 Special Study Proposal: Selenium in North Bay Clams and Water

Summary: The proposed monitoring would extend and leverage a long-term time series for selenium in clam tissue and associated water sampling. The RMP approved funding in 2017 that enabled monitoring to extend a USGS time series through September 2017, and then re-initiated clam and water monitoring in 2019. This proposal would support a third year of monitoring following a monitoring design optimized for cost-effective early detection of changes in selenium trends in clams and water. Clam and water samples would be collected monthly at two locations in two three-month blocks (Jun-Aug and Dec-Feb).

Estimated Cost: $100,400

Oversight Group: RMP Selenium Workgroup

Proposed by: Nina Buzby and Jay Davis

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	**Due Date**
Task 1. Collect water and clam samples	June 2021 - February 2022
Task 2. Analyze water and clam samples	May 2022
Task 3. Data Management	July 2022
Task 4. Draft Report	October 2022
Task 5. Final Report	December 2022

Background

In 2016, the USEPA approved a selenium TMDL for North San Francisco Bay. The TMDL established a target concentration of 11.3 µg/g dw in white sturgeon muscle tissue as the basis for evaluating impairment (SFBRWQCB 2015). In June 2016 the USEPA published proposed aquatic life and aquatic-dependent wildlife criteria for selenium in the Bay and Delta. The proposal includes criteria for fish tissue (muscle and whole body), clam tissue, and water (dissolved and particulate).

After establishing the North Bay TMDL, the San Francisco Water Board asked the Selenium Workgroup to develop a robust monitoring design for the North Bay. The goal is to track leading indicators of change to allow prompt management response to signs of increasing impairment. The Workgroup convened a technical workshop on this topic on July 27, 2016. At this workshop, participants reached a consensus that monitoring of sturgeon, clams, and water are all needed to answer management questions. Recommendations for long- term monitoring of these three matrices were presented in a North Bay Monitoring Design document (Grieb et al. 2018).

USGS conducted monthly clam monitoring at multiple locations in the North Bay for over 20 years, but USGS funding for this work ended in 2016. In 2016, the RMP approved the use of Undesignated Funds to support the continuation of the USGS monitoring, which covered monitoring through September 2017. Monitoring was not conducted between October 2017 and June 2019, creating the first gap in this long-term time series. In 2019, the RMP resumed clam and water monitoring following a modified monitoring design optimized for early detection of changes in selenium trends in clams. Following the recommendations in the North Bay Monitoring Design document (Grieb et al. 2018), this monitoring is continuing on an annual basis through 2020.

This work addresses an important gap in systematic selenium monitoring in the North Bay. Previously, studies of selenium speciation across the estuarine salinity gradient were conducted only periodically from 1999-2000, and in 2010 as well as 2012. Currently, only dissolved selenium is collected at randomly selected sites in the North Bay once every two years through the RMP Status and Trends program. The RMP also recently retired its biennial Status and Trends Bivalve monitoring, which previously measured selenium in mussel tissue. Recommendations in Grieb et al. (2018) for future water monitoring included monthly water sampling at the two clam stations in the North Bay for three years. The clam and water studies funded by the RMP in 2019 and 2020 included water sampling concurrent with clam sampling at the two primary USGS long-term monitoring stations (4.1 and 8.1) in two three-month blocks (Jun-Aug and Nov-Jan).

Study Objectives and Applicable RMP Management Questions

The goal of this project is to continue long-term monitoring of *Potamocorbula amurensis* and water in the North Bay, to track long-term interannual trends and provide an indication of changes in sources or environmental processes influencing food web selenium exposures in North Bay. This study addresses key questions identified by the Selenium Strategy and the RMP (Table 1).

Table 1. *Study objectives and questions relevant to RMP management questions.*

RMP Management Question	Priority Management Question for Selenium	Priority Management Question for Selenium in North Bay	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely?	2. Are the beneficial uses of north San Francisco Bay impaired by selenium?	1. Are the beneficial uses of north San Francisco Bay impaired by selenium?	Compare measured concentrations to the North Bay TMDL target for water and USEPA selenium criteria for water and clams.	Do the data indicate a need for management actions? What factors are influencing the observed selenium concentrations?
2) What are the concentrations and masses of contaminants in the Estuary and its segments?	3. What is the spatial pattern of selenium impairment?		Compare measured concentrations across two sites in North Bay.	Are there distinct differences in selenium concentrations and patterns across sites? What do these differences indicate about selenium sources and bioaccumulation in different regions of North Bay?
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased?	2. Are changes occurring in selenium concentrations that warrant changes in management actions?	2. Are changes occurring in selenium concentrations that warrant changes in management actions?	Compare measured concentrations to clam and water concentrations measured during past studies. Evaluate trends using change point and normal range analyses.	Are selenium concentrations increasing or decreasing? What factors may be influencing these trends?

Approach

Field Sample Collection

Potamocorbula amurensis and water samples will be collected from two long-term USGS monitoring locations in northern San Francisco Bay: (1) station 4.1 near the confluence of the Sacramento and San Joaquin Rivers, and (2) station 8.1 at the mouth of the Carquinez Strait in Suisun Bay. Samples will be collected and processed by SFEI field staff and Applied Marine

Sciences. Sampling activities will either occur aboard the *RV Sentinel* (CA DWR) or a vessel from Dixon Marine Services, depending on vessel availability and capacity. Similar to the sampling design from 2019 and 2020 monitoring, clam sampling will take place six months each year in two key three-month periods of monthly sampling preceding fall muscle plug monitoring (June-August) and the spring pre-spawning period (December-February).

Each month, approximately 100 clams will be collected from each site using a clam dredge and depurated for 48 hours prior to being measured and divided into 5 composite size classes representing the range in collected clam lengths. Groups of composite clam samples will be shipped to Brooks Applied Labs (BAL) for further sample processing and analysis.

Water sampling will take place at the same time as the clam sampling. Both selenium and ancillary parameters (Chl-A, SSC, TOC) will be collected from the same two sites (USGS 4.1 and 8.1) using a peristaltic pump. Selenium samples will be collected for both the dissolved and particulate phase. Dissolved phase samples will be collected through a 0.45-µm Voss capsule in-line filter cartridge. Particulate phase samples will be created by filtering approximately 300 mL of water, depending on sample turbidity, through 0.45 µm polycarbonate filters with an onboard vacuum filtering apparatus.

Laboratory Analyses

Clams will be dissected and homogenized into 5 composite samples by BAL. A wet weight will be recorded before the samples are freeze dried, after which a dry weight will be recorded and samples will be analyzed for Se concentrations. Samples will also be prepared for analysis of carbon and nitrogen stable isotopes by the UC Davis Stable Isotope Facility.

Clams will be analyzed by BAL monthly, after each sampling event. QA/QC samples will be analyzed at a rate of one laboratory blank, one laboratory duplicate, one matrix spike, one matrix spike duplicate, and one certified reference material for every 20 samples. BAL will also analyze dissolved and particulate water samples, by EPA Method 1640 (Modified with Column Separation and Analysis with ICP-QQQ-MS) and EPA Method 1638 (Modified with EPA 3050B digestion), respectively. Method and reporting details are outlined in Table 2.

Ancillary parameters, including total suspended material, total organic carbon, and chlorophyll-a, will also be collected at each selenium water sampling location and analyzed by Caltest Analytical Laboratory. Method and reporting details are outlined in Table 2.

Table 2. *Analytical Methods and Detection Limits*

Matrix	**Surface Water**	
Analyte Name	**Average MDL**	**Lab - Method**
Selenium	0.04 ug/g ww	BR-EPA 1640
Chl-A	1 mg/3	SM 10200 H
SSC	0.5 mg/mL	ASTM D3977-B
TOC	0.3 mg/mL	SM 5310B
Matrix	**Bivalves**	
Analyte Name	**Average MDL**	**Lab - Method**
Selenium	0.0422 ug/g dw	EPA 1638M

Budget

As noted in the Multi-Year Plan, data management and reporting is planned for the following year of monitoring beginning in 2022.

Table 3 . *Proposed Budget*

Expense	Estimated Hours	Estimated Cost
Labor		
Project Staff	140	$12,200
Senior Mgmt Review	16	$3,000
Project/Contract Mgmt *		$0
Data Technical Services	45	$5,000
		$20,200
Subcontracts		
Applied Marine Sciences **	250	$36,300
Brooks Applied Labs **		$19,000
CalTest Laboratories		$5,300
UC Davis Stable Isotope Lab		$2,200
		$62,800
Direct Costs		
Vessel		$16,800
Equipment		*included in BAL costs*
Shipping		$600
		$17,400
Grand Total		***$100,400***

** Not needed because core RMP funding provides this service.*
*** Also includes equipment/travel costs*

Budget Justification

Field and Direct Costs

This special study proposal has an overall budget of *$100,400*, which includes *$20,200* devoted to labor. These funds would cover field efforts for six cruises, coordination with subcontractors (analytical labs, vessels, and field partner AMS), and preliminary data review. Efforts will be made to minimize direct costs through leveraging vessel partnerships and utilizing sampling equipment from monitoring efforts in previous years.

Laboratory Costs

After an intercomparison study completed in 2018, BAL was chosen as the analytical partner to conduct selenium analyses. The selection was based on comparison to past USGS monitoring results as well as lab accuracy and precision metrics (e.g. CRM performance, replicate agreement). BAL provides analyses for Total Se in the dissolved and particulate phase as $110 and $90/sample, respectively. Clam analysis costs are $185/sample with homogenization and subsampling at $25/sample. 14 water and 60 clam samples will be analyzed, including water field duplicates and blanks. Other BAL costs include sampling equipment (e.g., filter cartridges) and MS/MSDs.

Ancillary water parameter analyses (chlorophyll-a, suspended sediment concentration, and total organic carbon) will be conducted by CalTest laboratories at $158, $86, and $77/sample, respectively. Additional costs for CEDEN formatting and sample pickup are also included in CalTest analytical costs. Stable isotope analysis will be completed by the UC Davis Stable Isotope Laboratory at $27/sample with additional $5/sample solid weight analysis.

Data Management Costs

Data services will include generating EDD templates and analytical laboratory communications. To reduce study costs, previous years conducted data management biennially. Since the 2020 monitoring budget included data services costs, the full set of data management tasks (QA/QC review, CEDEN upload, data report) for 2021 would similarly be deferred until 2022.

Data Management and Reporting

Preliminary data review will be conducted by RMP staff during the collection year, including preparation of data tables that can be available for internal RMP and Workgroup review. Complete RMP data management and reporting will be conducted as part of 2022 monitoring efforts.

References

Grieb, T.; Roy, S.; Rath, J.; Stewart, R.; Sun, J.; Davis, J. A. 2018. North Bay Selenium Monitoring Design. SFEI Contribution No. 921. San Francisco Estuary Institute: Richmond, CA. https://www.sfei.org/documents/north-bay-selenium-monitoring-design-0

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 2015. Total Maximum Daily Load Selenium in North San Francisco Bay: Staff Report for Proposed Basin Plan Amendment. Report prepared for the California Regional Water Resources Control Board, San Francisco Bay Region, November 2015. San Francisco Bay Regional Water Quality Control Board, Oakland, CA. http://www.waterboards.ca.gov/sanfranciscobay/board_info/agendas/2015/November/6_appendix_c.pdf

Selenium Workgroup 2021 Special Study Proposal: Selenium in White Sturgeon Muscle Plugs

Summary: In March 2016, the USEPA approved a Selenium TMDL for North San Francisco Bay, which established a white sturgeon muscle tissue target of 11.3 ug/g dry weight as a basis for evaluating impairment. From 2014-2017, the RMP conducted annual monitoring of selenium in sturgeon muscle plug tissue, through a collaboration with the California Department of Fish and Wildlife (CDFW) and other partners. Preliminary power analyses suggest that long-term monitoring of 60 samples per year at a minimum biennial frequency is needed to detect potential long-term trends driven by changes in environmental selenium sources. This study proposes to continue the biennial sampling started in 2019 as part of the long-term North Bay monitoring work, that aims to track North Bay condition relative to the TMDL target and evaluate long-term trends.

Estimated Cost: $21,825

Oversight Group: RMP Selenium Workgroup

Proposed by: Nina Buzby and Jay Davis

PROPOSED DELIVERABLES AND TIMELINE

Deliverable	Due Date
Task 1. Collect 2021 muscle plugs (field sampling)	August-October 2021
Task 2. Analyze 2021 muscle plugs	January 2022
Task 3. Data Management	March 2022
Task 4. Prepare draft data report	October 2022
Task 5. Prepare final data report	December 2022

Background

In 2016, the USEPA approved a selenium TMDL for North San Francisco Bay. The TMDL established a target concentration of 11.3 ug/g dw in white sturgeon muscle tissue as the basis for evaluating impairment (SFBRWQCB 2015). In order to support implementation of the TMDL, the Selenium Workgroup has developed a monitoring method that will allow for the routine collection of large numbers of white sturgeon muscle tissue samples.

Muscle plug sampling provides a non-lethal method for monitoring contaminants that has been successfully used to monitor mercury and selenium concentrations in fish, including threatened fish species. During 2009 and 2014 RMP Status and Trends sport fish sampling, and the 2016 and 2017 RMP Sturgeon Derby special study, paired muscle plug and fillet samples were analyzed for selenium as part of an effort to establish a non-lethal and efficient method of collecting sturgeon muscle tissue using plugs. Results from these studies show that muscle plug and muscle fillet selenium are strongly correlated, indicating that muscle plugs can be used as proxies for muscle fillets to monitor selenium in sturgeon muscle tissue (Sun et al. 2018).

Muscle plug sampling from live sturgeon in the field was also successfully piloted in the 2014-2017 RMP Sturgeon Muscle Plug studies (Sun et al. 2018). This monitoring is made possible through a valuable collaboration with the California Department of Fish and Wildlife (CDFW), which has collected samples for the RMP *pro-bono* during its annual sturgeon population tagging study (DuBois and Danos 2017). Over the past four years, samples have been collected in Suisun and San Pablo Bays between August and October of each year. 30, 38, and 58 muscle plug samples were successfully collected and analyzed for selenium in 2015, 2016, and 2017, with an additional 28 samples collected and archived in 2015. Sufficient sample mass was collected for most samples to also enable analysis of C, N, and S isotopes, to provide information about dietary selenium sources (foraging location and trophic position). Overall, this work has established fall muscle plug monitoring as a valuable tool to continue tracking long-term trends.

A preliminary power analysis conducted using all historically available data on selenium in sturgeon muscle tissue indicated that a sample collection frequency of once every two years should allow for detection of long-term trends of 2-3% per year over a 20 year period (power > 0.75; Grieb et. al., 2018). This supported a decision by the RMP to initiate a biennial sampling design beginning in 2019.

Sampling was attempted in 2019, but the sample masses obtained for most of the samples were too small to support reliable selenium analysis. The 2019 effort was postponed to 2020 because of this, with measures taken to ensure this problem does not occur again. Sample collection is primarily performed pro bono by CDFW, so the budgetary impact of this problem was small.

This proposal outlines a scope and budget for sturgeon muscle plug monitoring in 2021, with analysis of the plugs for selenium and C, N, and S stable isotopes.

Study Objectives and Applicable RMP Management Questions

The ultimate objective of this monitoring element is to obtain a relatively large number of sturgeon muscle samples to assess attainment of the North Bay selenium TMDL target and other regulatory thresholds. These data will also allow continued tracking of long-term interannual trends. This study addresses key questions identified by the Selenium Strategy and the RMP (Table 1).

Table 1. *Study objectives and questions relevant to RMP management questions.*

RMP Management Question	Priority Management Question for Selenium	Study Objective	Example Information Application
1) Are chemical concentrations in the Estuary at levels of potential concern and are associated impacts likely? 1B. What potential for impacts on humans and aquatic life exists due to contaminants in the Estuary ecosystem?	1. Are the beneficial uses of north San Francisco Bay impaired by selenium?	Compare measured concentrations to regulatory thresholds (North Bay Selenium TMDL).	Do the data indicate a need for management actions? What factors are influencing the observed selenium concentrations? How should the TMDL muscle tissue target be assessed?
4) Have the concentrations, masses, and associated impacts of contaminants in the Estuary increased or decreased? 4.B. What are the effects of management actions on the potential for adverse impacts on humans and aquatic life due to Bay contamination?	2. Are changes occurring in selenium concentrations that warrant changes in management actions?	Compare measured concentrations to plug and fillet concentrations measured during past studies, including past iterations of this study. Evaluate trends using linear regression and change point method analyses	Are selenium concentrations increasing or decreasing? What factors may be influencing these trends?

Approach

Muscle plugs from approximately sixty white sturgeon will be collected by California Department of Fish and Wildlife (CDFW) staff between August and October 2021, during the CDFW sturgeon tagging effort in North Bay. SFEI staff will plan and coordinate the study and CDFW staff will collect the samples. SFEI staff will instruct and train CDFW field staff on

muscle plug collection techniques at the beginning of the collection season to ensure that the plugs contain sufficient tissue for analysis (Buzby et. al., 2020). SFEI staff will retrieve samples from CDFW staff periodically throughout the duration of the field season in order to keep samples chilled at a colder and more stable temperature until sample analysis. Masses of the collected plugs will be checked frequently to ensure that they are sufficient.

At the conclusion of the field season, SFEI staff will conduct initial processing of muscle plug samples for shipment to Brooks Applied Laboratories (BAL). BAL will complete processing of the plug samples and perform selenium analyses, and subsequently prepare and ship samples to UC Davis to perform C, N, and S stable isotope analyses.

Table 2. *Analytical Methods and Detection Limits*

Matrix	**Sport Fish (ug/g ww)**	
Analyte Name	**Average MDL**	**Lab - Method**
Selenium	0.15	MPSL-DFG 200.8

Two laboratory method blanks and one standard reference material will be analyzed with the lab batch; duplicates, matrix spikes, and matrix spike duplicates will be analyzed at a frequency of 1 per 20 samples. Costs for these QA/QC samples will be included in the sample cost; no additional QA/QC samples will be requested.

Budget

As noted in the Multi-Year Plan, data management and reporting is planned for the following year of monitoring beginning in 2022.

Table 3. *Proposed Budget*

Task	Estimated Cost
Labor	
Project Planning & Coordination	$4,000
Field Work	$3,000
Data Management	$3,000
Subtotal	***$10,000***
Subcontracts	
BAL – 60 selenium & total solids analyses @ $100/sample**	$6,900
BAL – 60 samples processed & subsampled @ $25/sample	$1,500
UCD – 60 C, N, S analyses @ $32/sample	$2,175
Subtotal	***$10,575***
Direct Costs	
Equipment - biopsy plugs, sample containers, dry ice, etc.	$1,000
Shipping	$250
Subtotal	***$1,250***
Grand Total	***$21,825***

***Includes cost of QA samples*

Budget Justification

Field and Direct Costs

This special study proposal has an overall budget of $21,825, which includes $10,000 devoted to labor. These funds would cover initial field training, coordination with CDWF and analytical subcontractors, and preliminary data review. Direct costs are minimal due to the *pro bono* collection of samples by CDFW as well as the ability to utilize sampling equipment from monitoring efforts in previous years.

Laboratory Costs

After an intercomparison study completed in 2018, BAL was chosen as the analytical partner to conduct selenium analyses. The selection was based on comparison to past RMP

monitoring results as well as lab accuracy and precision metrics (e.g. CRM performance, replicate agreement). BAL provides analyses for Total Se in sport fish tissue at $100/sample, with subsampling for isotope analysis at $25/sample. Approximately 60 muscle plug samples will be analyzed, including lab duplicates and blanks. Other BAL costs include MS/MSDs.

Stable isotope analysis will be completed by the UC Davis Stable Isotope Laboratory at $8.50/sample for ^{13}C and ^{15}N analyses and $18.75/sample for ^{34}S analysis. An additional $4.50/sample will go towards solid weight analysis.

Data Management Costs

Due to the staggered data management approach of this study, the full set of data management tasks (QA/QC review, CEDEN upload, data report) will not occur until 2022 data are available. The proposed data management costs in 2021 refer to efforts in generating EDD templates, transcribing field data sheets, and general laboratory communications.

Data Management and Reporting

Data management and reporting will be performed in 2022. Initial data review will be conducted by RMP staff and presented to the Selenium Workgroup at the 2023 meeting.

References

Buzby, N.; Yee, D.; Salop, P.; Foley, M. 2020. 2019 RMP North Bay Selenium Monitoring Sampling and Analysis Plan. SFEI Contribution No. 969. San Francisco Estuary Institute: Richmond, CA.

DuBois, J and Danos, A. 2017. 2017 Field Season Summary for the Sturgeon Population Study. California Department of Fish and Wildlife – Bay Delta Region, Stockton, CA.

Grieb, T.; Roy, S.; Rath, J.; Stewart, R.; Sun, J.; Davis, J. A. 2018. North Bay Selenium Monitoring Design. SFEI Contribution No. 921. San Francisco Estuary Institute : Richmond, CA.

San Francisco Bay Regional Water Quality Control Board (SFBRWQCB). 2015. Total Maximum Daily Load Selenium in North San Francisco Bay: Staff Report for Proposed Basin Plan Amendment. Report prepared for the California Regional Water Resources Control Board, San Francisco Bay Region, November 2015. San Francisco Bay Regional Water Quality Control Board, Oakland, CA.

Sun, J., J.A. Davis , S.N. Bezalel, J.R.M. Ross, A. Wong, R. Fairey, A. Bonnema, D.B. Crane, R. Grace, R. Mayfield, and J. Hobbs. 2017. Contaminant Concentrations in Sport Fish from San Francisco Bay, 2014. San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA.

Sun, J.; David, J.; Stewart, R.; Palace, V. 2018. Selenium in White Sturgeon from North San Francisco Bay: The 2015-2017 Sturgeon Derby Study. SFEI Contribution No. 897. San Francisco Estuary Institute : Richmond, CA.