REGIONAL MONITORING
PROGRAM FOR WATER QUALITY
IN SAN FRANCISCO BAY
sfei.org/rmp

2026/27 RMP Status & Trends: North Bay Selenium Monitoring Sampling and Analysis Plan

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1. Introduction

In 2016, the State Water Resources Control Board 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). Following discussions surrounding the North Bay TMDL, the San Francisco Bay Regional Water Quality Control Board asked the RMP Selenium Workgroup to develop a robust monitoring design for North Bay.

The goal of the monitoring is to identify leading indicators of change to allow prompt management response to signs of increasing impairment. At the 2016 technical workshop, participants reached a consensus that monitoring sturgeon, clams, and water are all needed to answer management questions. Recommendations for long-term monitoring of these three matrices are detailed in the North Bay Monitoring Design document (Grieb et al. 2018).

The USGS conducted monthly clam monitoring at multiple locations in North Bay for over 20 years, but USGS funding for this work ended in 2016. In 2019, the RMP resumed clam monitoring following a modified monitoring design optimized for early detection of changes in selenium trends in clams. The efforts will continue the long-term monitoring of *Potamocorbula amurensis.* Grieb et al. (2018) also recommended monitoring dissolved and particulate selenium in the water column. Long-term monitoring of water and sturgeon tissue in North Bay will be added to the clam sampling to track interannual trends and changes in sources or environmental processes influencing food web selenium exposures in North Bay.

Potamocorbula amurensis and water samples will be collected from two long-term USGS monitoring locations in northern San Francisco Bay. Samples will be collected and processed by SFEI and Applied Marine Sciences (AMS) aboard a Cal Poly Maritime vessel, the R/V *Questuary*. Sampling will take place over six months each year in two key three-month periods: June-August and December-February. White sturgeon (*Acipenser transmontanus*) samples will be collected by CDFW during their White Sturgeon Monitoring project. These efforts occur during both the spring (Apr-May) and late summer - fall (Aug - Sept) CDFW tagging cruises. Non-lethal muscle plug samples will be collected from the epaxial muscle of each fish, just in front of the dorsal fin (Figure 5). U.S. Geological Survey Earth System Processes Division Lab (USGS), Brooks Applied Labs (BAL), and CalTest Analytical Laboratory (CalTest) will be the analytical partners for this work. Any remaining clam tissue after selenium analysis will be archived by SFEI for potential future stable isotope analysis to identify spatial and temporal relationships within a food web, as well as potential sources of selenium. BAL will analyze total dissolved and particulate selenium in water; USGS will analyze total selenium in clams and sturgeon tissue samples; and CalTest will conduct ancillary analyses on water samples.

The purpose of this Sampling and Analysis Plan is to clearly document the sampling design, methods, and responsibilities; and to facilitate coordination among project partners.

2. Key Personnel

Table 1. Key Personnel

Contact	Role	Phone/Email
Jay Davis	RMP Lead Scientist	jay@sfei.org
Amy Kleckner	RMP Manager	amyk@sfei.org
Don Yee	RMP QA Officer	don@sfei.org
Adam Wong	RMP Data Services	ds@sfei.org
Paul Salop	Senior Scientist, Principal - Applied Marine Sciences (AMS)	salop@amarine.com 925-373-7142
Ellen Goldenberg	Water and clam collection, Senior Marine Biologist, AMS	goldenberg@amarine.com
Vanessa Lo John Kelly Ryan McKim	Fish collection, CA Department of Fish and Wildlife	Vaness.Lo@wildlife.ca.gov, John@Wildlife.ca.gov, Ryan@Wildlife.ca.gov
Amy Goodall	Brooks Applied Labs, project manager	amy@brooksapplied.com
Sonya Allahyari	Caltest Analytical Laboratory General Manager	sallahyari@caltestlabs.com 707-258-4000
Nic Shields	Captain R/V *Questuary*	nshields@csum.edu
Ben Linhoff	USGS, Research Hydrologist	blinhoff@usgs.gov

3. Sampling Equipment

Clams & Water

The following is a list of recommended sampling equipment needed for clam and water sampling efforts. Equipment and materials should be prepared 2-3 days prior to sampling cruises.

AMS

- Field datasheets & sampling binder
- Pens & pencils
- Mesh sieves
- Clam sample containers & labels
- Coolers & ice
- Carboys / collapsible containers for clam water collection
- Calipers
- Gloves
- Clam dredge with float & line
- CTD (calibrated)
    - Field laptop
    - Deionized water
    - Batteries
- Niskin bottle
- Sampling pole for dunking 4L amber glass bottles

AMS Lab

- CTD Calibration solution
- Mesh bags
- Aquarium aerator
- Depuration tank
- Water chiller

SFEI (field)

- 4 L amber glass bottles
- Coolers & ice
- Nitrile gloves
- Field collection sheets
- COC forms for CalTest
- Containers for Chl-a (from CalTest)
- Containers for SSC (from CalTest)
- Containers for TOC (from CalTest)

SFEI (lab)

- Peristaltic pump
    - Ring stand and clamps
- From BAL: Pre-cleaned tubing, 3' peristaltic tubing, Materflex® size 24 attached to 3' Teflon (1 per sampling event, per station)
- From BAL: Voss 0.45-um Capsule Filters (2 per sampling event)
- Vacuum pump and filtration glassware (Millipore columns, flasks, tubing)
    - Metal ring stand & clamps
    - Forceps
    - Graduated cylinder
    - Kim wipes
- GE Healthcare Whatman brand, 47mm Nuclepore Polycarbonate Track-Etched Membrane filters (0.4 µm pore size)
- Blank water provided by SFEI
- COC forms for BAL
- Containers for dissolved Se (from BAL)
- 50ml centrifuge tubes for holding particulate samples

Sturgeon

The following is a list of required sampling equipment that should be handed off to CDFW field staff at the beginning of tagging efforts.

- Binder with sample labels, field sheets, and printed sampling instructions
- 5mm biopsy punches (1 per fish, up to 30)
- 2 mL Nalgene cryovials (1 per fish, up to 30)
    - 25 pack
    - 500 pack
- DI water in a squeeze bottle
- Ziplock bags, containers, and cryovial box to hold samples

- Nitrile gloves
- Kim wipes
- Miscellaneous supplies (pencils, sharpies, bamboo skewers, baster tool - for egg sampling, sample prep container/tray)
- Small cooler(s)
- Dry ice (weekly deliveries of dry ice could be made on the Tuesday of each sampling week)

Sampling containers and transport/shipping storage for each matrix are specified in the following table. Per recommendations from USGS contributors to previous monitoring, storage containers should not be made of glass.

Table 2. Sampling Containers

	Collection Container	**Post-processing**	**Shipping**
Sturgeon muscle tissue	2mL Cryovial *(1 per fish, 2-3 plugs)*	N/A	Frozen, SFEI or CDFW to USGS
Clam tissue - Total Se	2.5L Plastic wide mouth bottle *(2 per sampling event, 1 per station)*	Ziploc freezer bag	Frozen, AMS-USGS
Water - Dissolved	Pre-cleaned 1 gallon (4L) amber glass bottles *(4 per sampling event, 2 per station, more if collecting QA/QC samples)*	250 mL HDPE plastic bottle *(2 per sampling event, 1 per station)*	SFEI-BAL
Water - Particulate		Polycarbonate filter in 50 mL centrifuge tube *(4 per sampling event, 2 per station)*	
Chl-a	3x1 L plastic amber bottles *(6 per sampling event, 3 per station, more if collecting lab duplicate)*	N/A	Caltest courier will pick up
SSC	1L clear plastic bottle during summer; 1L plus 250mL for winter *(2 per sampling event, 1 per station, more if collecting lab duplicate)*	N/A	Caltest courier will pick up
TOC	3x40 mL amber VOAs (triplicate) *(6 per sampling event, 3 per station, more if collecting lab duplicate, field duplicate, and or matrix spike)*	N/A	Caltest courier will pick up

4. Clam & Water Sampling Design

Concurrent clam and water sampling will be conducted at the two primary USGS long-term monitoring stations: 4.1 near the confluence of the Sacramento and San Joaquin Rivers, and station 8.1 at the mouth of the Carquinez Strait in Suisun Bay (Figure 1). These locations were chosen to allow for continuity of the pre-existing long-term dataset on clam selenium concentrations at such locations (Stewart et al. 2013). Samples will be collected and processed by staff with SFEI and Applied Marine Sciences (AMS) aboard the R/V *Questuary*.

Table 3. Field Staff for Clam and Water Sampling

Name	**Affiliation**	**Phone (cell)**
Amy Kleckner	RMP Manager, SFEI	(415) 531-3390
Ellen Goldenberg	Senior. Marine Biologist, AMS	goldenberg@amarine.com
Paul Salop	Senior Scientist, AMS	(925) 373-7142
Jennifer Dougherty	Environmental Scientist, SFEI	jenniferd@sfei.org
Sasha Mariniuk	Environmental Analyst, SFEI	sasham@sfei.org

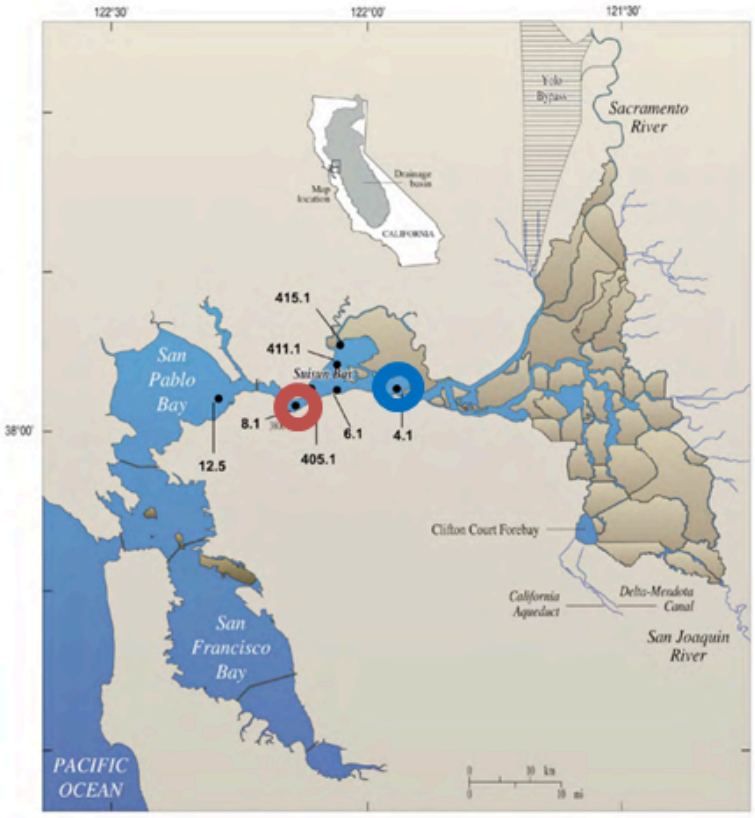

Figure 1. Clam and water USGS sampling locations. Station 4.1 (blue) -near the confluence of the Sacramento and San Joaquin Rivers 38° 03.427' N 121°56.691'W (11.6 m, depth). Station 8.1 (red) - at the mouth of the Carquinez Strait in Suisun Bay 38°01.900' N 122°08.416' W (14.3 m, depth).

Sampling will occur in two three-month blocks for a total of six sampling events each year. Based on the recommended sampling design (Grieb et al. 2018) and tissue lag-time literature (Beckon and William, 2016), the sampling periods will precede sturgeon muscle plug collection and spawning by 2-4 months. Sturgeon spawning occurs in the spring. (Table 3; Section 5). The planned sampling periods for water and clams are therefore June-August and December-February (Table 3).

After all field efforts are complete (February 2027), AMS will prepare a Field Report. The Field Report will contain a Cruise Description and Sample Collection Spreadsheet in CEDEN format (more details in Section 10). The Cruise Description will provide information on cruise participants, schedule, field conditions, coordinates of sample locations, and problems for each cruise.

5. Sturgeon Sampling Design

Sturgeon samples will be collected by the CA Department of Fish and Wildlife (CDFW) during their White Sturgeon Monitoring project. These efforts occur during both the spring (Apr-May) and late summer - fall (Aug - Sept) CDFW set line tagging cruises. Fish will be collected in Suisun and San Pablo Bays. The design accounts for total selenium analysis of muscle plugs from up to 60 adult sturgeon, ideally, equally distributed across each 10-cm size increments between 100 and 160 cm fork length. The size distribution will allow for the characterization of the relationship between selenium levels and length. Each fish will require 2-3 muscle plugs to provide sufficient mass for analysis.

SFEI will provide sample field-storage (e.g. cooler, dry ice, sample containers), sampling materials, and data sheets. At the end of sampling, SFEI will pick up the samples from CDFW and ship or deliver all muscle plug and egg/ovary samples to USGS for analysis.

Table 3. Water, clam and sturgeon sampling timeline

	2026										2027				
	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Water & clams				x	x	x				x	x	x			
Sturgeon tissues		x	x			x	x							x	x
	Spawning												*Spawning*		

6. Field Collection Methods

Water and clam sampling will be a concurrent effort. The vessel used for collections should have enough deck space to accommodate a CTD, clam dredge, and multiple coolers to store water and clam samples. The vessel should have hydraulics to deploy and retrieve the sampling dredge. A paper field sheet or digital field data form will be used to record field information:
Sheet: Selenium Field Sheet
Form:
https://docs.google.com/forms/d/e/1FAIpQLScG4coVxEhaR3Q3QfjpFDJHjdpEiaugVgTRmnGvXVDOBKH8Dw/viewform?usp=sharing&ouid=107905029462472499986

While at clam/water sampling stations, a CTD cast will be made along with Niskin bottle grabs to collect at-depth water for clam storage and depuration. Approximately 30 L of source water should be collected between the two stations and stored on wet ice. Two additional water samples will be taken for the analysis of chlorophyll-a (Chl-a), total organic carbon (TOC),

suspended sediment concentration (SSC); and dissolved and particulate selenium. Further details below.

At each sampling station the following must be completed (more details can be found in the following sections):

1. *Simultaneous steps:*
    a. *CTD cast*
    b. *Niskin bottle grabs (depth water collection for clams)*
    c. *Surface sample bottle grabs (4 L amber glass; two per site, more if collecting for QA/QC samples)*
2. *Clam Collections (repeat as needed)*
    a. *Begin clam sampling line, deploy dredge*
    b. *Record start lat/long and end lat/long*
    c. *Sort and collect clam individuals (~100 individuals > 8 mm)*

Clams

During each sampling event approximately 100 clams will be collected from each site using a clam dredge or benthic ponar grab (Figure 2). Dredge lines should begin approximately 50 meters upstream of the station location and continue 100 meters downstream, through the station point. Latitude and longitude of dredge start and end points will be recorded for each sampling line. Depending on location and time of year, collection efforts can vary between 15 minutes to 2 hours per station. Cruise coordinators should plan accordingly.

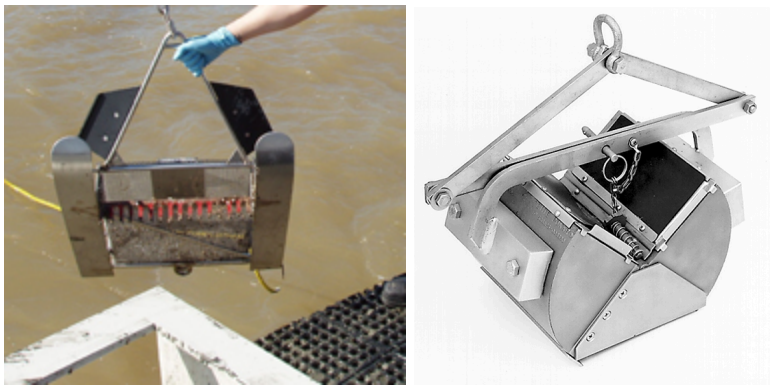

Figure 2. Clam sampling equipment (left - clam dredge, right - benthic ponar grab)

Contents of each dredge/grab will be poured into a plastic container (e.g., cooler) and rinsed to remove excess mud/debris. Field staff will sort through the contents for *P. amurensis* (Figure 3) larger than 8 mm, making sure to collect extra clams if the majority of the grab contains smaller individuals. This species is more triangular in shape and tends to have an “overbite”, meaning one shell is larger than the other (Figure 3). Clams will be placed into containers with water collected from the same depth and location. Sourcing this water can be done following the CTD cast with a Niskin bottle as described above. Clam storage containers should be non-glass jars with wide mouth openings. Clams should be kept at a constant temperature (10°C) to prevent

overheating (Brown & Luoma, 1995). Clam sample containers can be stored in a wet ice cooler with sufficient aeration until they can be transferred to the depuration tank.

Figure 3. *Potamocorbula amurensis* individuals (and shells)

Water

At each station, water will be collected into 4 L amber glass bottles that have been rinsed 3x with DI before sampling. When on station, the 4L bottles are attached to a sampling pole and are rinsed three times with site water and then filled to the top from approximately 3 feet below the surface of the water. The collected site water will then be used to fill lab containers The 4L bottle is shaken vigorously before subsampling, to ensure the water is well mixed before filling the lab containers for Chl-a, SSC, and TOC. Chlorophyll and SSC bottles should be rinsed three times with site water and then filled to the neck. VOAs should have minimal headspace (no more than one small air bubble). Use a sufficient, but limited amount of water for bottle rinsing. Samples will be collected in 3 x 1L amber plastic (chlorophyll), 1-1L plastic or 1- 250mL (winter) plastic (SSC), and amber 3 x 40 mL VOAs (TOC), respectively. All water samples should be stored in coolers with blue/wet ice until pickup by lab or transit to SFEI.

CalTest staff will pick up samples (chlorophyll, SSC, TOC) at the dock (Benicia Marina). All remaining water will be transported back to SFEI for immediate processing of dissolved and particulate selenium. If possible, samples should be shipped to BAL after processing, with next day delivery.

Sample bottles will be labeled with YYMMDD_ station_analyte code (Ex. 260626_USGS4.1_Chla) For blanks and field replicates in place of a station a three digit code will be used (800 series for blanks and 900 series for blind replicates)

Analyte codes:
Chlorophyll-a: Chla; Total Organic Carbon: TOC; Suspended Sediment Concentration: SSC; Dissolved Selenium: SeD; Particulate Selenium: SeP.

Field replicates and field blanks will be collected for selenium analyses during the first sampling event of each 3 month sampling block at station 4.1. For ancillary parameters, field replicates and additional volumes for lab duplicate and matrix spike (lab QA/QC) samples will be collected at station 4.1 in the second month of each sampling block See
Selenium Sampling Combined Site-Parameter List and Handling Instructions

Sturgeon

Prior to each tagging season, SFEI personnel will communicate with CDFW about expected sampling protocol.

A detailed version of the plug sampling protocol can be found here: https://docs.google.com/document/d/1j8Mmwy3sWC0cZtiGnHyZf3nFLRox9aPcAfU1Vq7Xyno/edit#

In addition, an SFEI staff member should participate in the first tagging cruise to demonstrate sampling procedures while in the field. It is also recommended that a designated CDFW staff member(s), and not cruise volunteers, conduct the sampling to ensure quality of sample plugs.

Two to three muscle plugs will be taken from each fish using a disposable 5 mm biopsy punch. Plugs should be taken from the epaxial muscle near or slightly in front of the dorsal fin, offset from the midline (Figure 4a). The sturgeon skin will be rinsed with DI water prior to sampling. The biopsy punch should be inserted into the muscle tissue using a twisting motion and removed with a scooping motion (Figure 4b). A piece of fishing line or bamboo skewer can be used to push the tissue plug out of the biopsy punch and into the 2 mL cryovial. The ideal length of a muscle plug is approximately 10 mm (Figure 4c). A new biopsy punch should be used for each fish. Other tools used should be rinsed with DI water and wiped with a kimwipe between use on samples from different fish.

All plugs taken from the same fish can be stored in the same cryovial. Cryovials pre-labeled with the Organism ID, and space to mark the sampling date will be provided by RMP staff. The RMP will also provide CDFW staff with field sheets to record other collection information including sampling date, time, tag number, fork length, total length, fish condition (live/weak/dead), and life stage (adult/juvenile) (see Appendix C). Cryovials will be frozen in a dry ice cooler in the field (-4ºC) and transferred to a commercial freezer (-20ºC) during the sampling season.

Figure 4a. Location of muscle plug collection

Figure 4b. Muscle plug sampling process and video demonstrations (1 and 2)

Figure 4c. Biopsy punch and example muscle plugs

7. Sample Processing

Clams

After collection the bivalves will be depurated for 48 hours, measured to the nearest millimeter and then grouped by size into n=2-5 replicate composites of n=1-124 individuals and frozen at -20 or -80 degrees Celsius. Later clam soft tissues will be removed from shells, freeze dried and homogenized using a ball mill.

Literature shows a residence time for gut material of approximately 24 hours in *Potamocorbula* (Decho & Luoma, 1991), therefore, clams should be allowed to depurate for approximately 48-72 hours. Applied Marine Sciences (AMS) will set up and maintain the depuration tank using a composite of filtered Bay water from the two clam collection locations, chilled via recirculation to maintain a stable 10°C temperature. AMS will then measure and sort all clams into individual mesh pouches by size, with an additional mesh separation between stations, and place them into the depuration tank. After the depuration period, AMS will sort the clams into five size classes or "bins". Starting with bins of 1 mm difference (e.g., 11, 12, 13, 14, 15, 16, 17 mm), clams can be combined with adjacent bins (e.g., 11-12, 13-14, 15, 16, 17 mm) to meet the limit of 5 classes. If necessary, clams *only* greater than 15 mm can be combined with bins 2 mm difference (e.g., 11-12, 13-14, 15, 16, 17-19). Each size class will make up one of the five composite samples per collection site. If five size classes cannot be created with all collected clams (e.g., 11, 12, 14, 15 mm), more abundant bins can be split and then combined to meet the five composite targets (e.g., 11-12, 12, 14, 15 mm). Clams will be frozen and shipped or delivered by AMS to USGS at the end of each 3 month sampling period (see section 8 for more details).

Once received from AMS, USGS will dissect and homogenize clams from each size class by removing the soft tissue from the shells and placing the tissue into a pre-weighed vial for freeze drying. Since shells can break easily during dissection, it is recommended to only shuck a small number of frozen clams at a time. A wet weight will be recorded before the samples are freeze dried. A dry weight will then be recorded and samples will be analyzed for Se concentrations.

Water

Selenium samples should be processed at the SFEI lab immediately upon return from sampling.

Particulate Selenium

For particulate selenium processing, staff must wear clean nitrile gloves continuously throughout the filtration process. The necessary equipment includes a portable vacuum pump, vacuum tubing, clean graduated cylinders, clean metal forceps, labeled centrifuge tubes, and dual glass Millipore filter setups consisting of receiving flasks, frit filter supports, funnel chimneys, and filtration clamps (see assembly in figures 5 and 6). Samples are filtered using 0.4 µm Nuclepore

Polycarbonate Track-Etched Membrane filters, ensuring the shiny side faces up (note that blue paper sheets are packaging separators and should be discarded).

The entire filter apparatus is shown in Figure 5 and consists of the pump and glass millipore filter columns. The order of glass column aspects, with and without a filter is shown in Figures 6a and 6b. Filters should be handled using clean(DI rinsed) metal forceps and placed in the middle of the glass column (Figure 6c).

Figure 5. Particulate water sample filtration setup

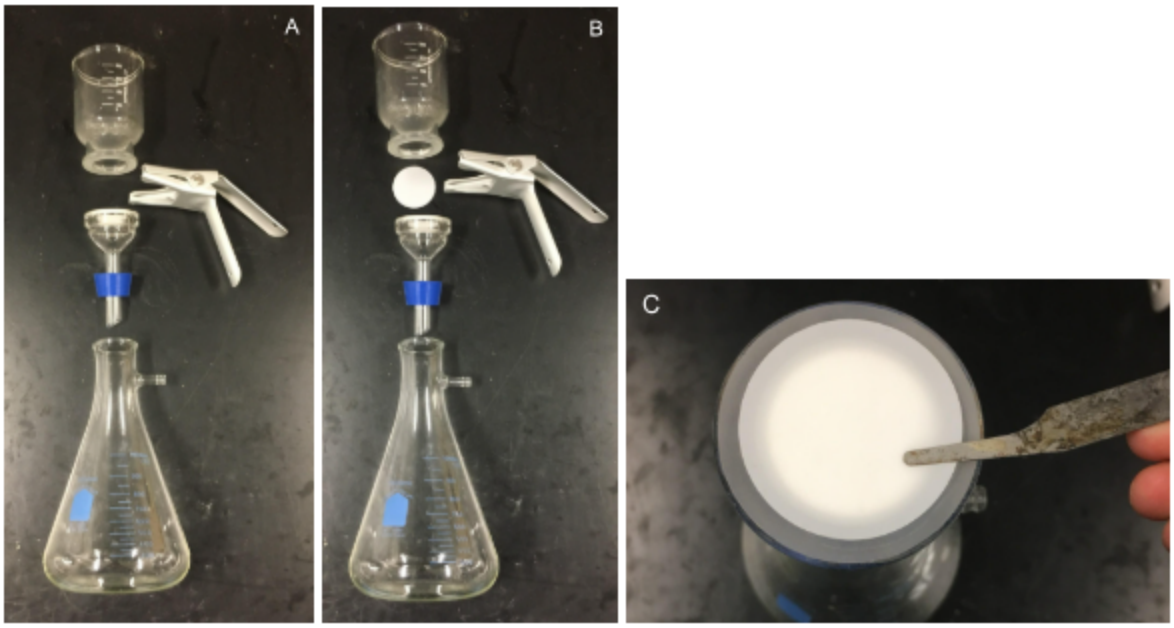

Figure 6. Column installation order with (a) and without filter (b), and (c) filter placement.

Prior to processing samples, clean all equipment by thoroughly rinsing forceps, filter supports, and funnel chimneys with deionized (DI) water. Assemble the glass columns without filters and run approximately 50 mL of DI water through the system. For field or equipment blanks, process designated aliquots of DI water through fresh 0.4 µm filters using the standard routine outlined below. The apparatus should be rinsed with DI between samples from different stations, and the

filter forceps should also be rinsed with DI water. Record the filtration start and end times, total volume filtered per filter and 4 L sample bottle number, and any notes on the laboratory sheet for the sampling event.

Each sample site requires two filter replicates processed simultaneously using side-by-side glass filter assemblies. Connect the vacuum tubing securely to both receiving flasks and the portable pump, then place clean filter supports on top of each flask. Using clean metal forceps, place a 0.4 µm membrane filter shiny-side up onto each support base, checking to ensure there are no wrinkles, creases, or trapped air bubbles. Place the funnel chimneys over the filter supports and secure the assemblies with filtration clamps.

Before measuring an aliquot, shake the 4 L sample jug to ensure complete mixing. With the vacuum pump turned off, measure a 100 mL aliquot using a clean graduated cylinder and pour 100 mL into each funnel chimney. Turn on the vacuum pump to begin filtration. Do not allow the filter to go dry. Add a second aliquot of 100mL and then 20-50ml aliquots up to a total filtered volume of 500mL (minimum of 200mL) or until the filter clogs (drip rate of around 1 drop per second). At the end of filtering, the vacuum should run until no liquid remains on the filter. Do not overdry the filter or it may get stuck to the glass column.

When filtration is complete, turn off the pump, release the vacuum pressure, remove the clamps, and lift off the funnel chimneys. Using clean metal forceps, fold each filter in half with the sample side facing inward, then transfer it into its dedicated pre-labeled centrifuge tube. Using a waterproof marker, write the total volume filtered directly on the side of the centrifuge tube. Immediately store sample tubes on ice in a field cooler, then transfer them to a freezer immediately after finishing for the day.

Dissolved Selenium

For dissolved selenium sample processing, the required equipment includes a MasterFlex yellow peristaltic pump, a ringstand with bench clamp, a waste filtrate bin, pre-cleaned sample bottles directly from BAL, and supplier-provided equipment (BAL) consisting of pre-cleaned 3 ft Teflon tubing attached to 3 ft silicon tubing (Masterflex® size 24), and 0.45 µm Voss capsule filter cartridges.

Plug in the peristaltic pump and test it to confirm proper operation. Position the standing bench clamp nearby with the waste filtrate bin placed directly underneath it. Remove a Voss capsule filter cartridge from its packaging and secure it upright in the bench clamp, ensuring it is oriented so that the fluid path aligns with the flow arrow on the cartridge. Unpack the tubing assembly, feed the flexible Masterflex section into the peristaltic pump head, and attach the flexible discharge end (without hard tubing) directly to the top inlet of the capsule filter.

Before initiating filtration, vigorously shake the 4 L sample jug to ensure the volume is well mixed. Place the intake end with the rigid Teflon tubing into the 4 L jug and flip the switch to pump forward on the peristaltic pump. Allow the pump to run and discharge filtered water into the waste bin for approximately one minute without collecting samples to thoroughly flush the

lines and condition the capsule filter. Following this one-minute flush, prepare the sample bottle. Using the filtered site water, rinse the sample bottle three times before filling. Once rinsed, fill the sample bottle completely with filtered water, taking care to ensure there is zero headspace remaining. Store filtered samples on ice in the field cooler in the lab until transfer to the fridge at the end of the day, and remain there until shipped.

Sturgeon

Muscle plug samples will be stored in cryovials and stored at -4°C in a dry ice cooler in the field. Each cryovial should contain all muscle plugs taken from each individual fish (2-3 plugs). Samples will be transported back to CDFW, where they will be stored until the end of the sampling period. Muscle plug samples should be stored at -80°C whenever possible, and should not be stored at -20 C for longer than 3 months.

Sturgeon plugs will be processed and analyzed by the USGS following previous USGS processing methods. The objective of plug processing is to remove the skin and lipid layer from the muscle plugs, leaving only fish muscle tissue remaining. The tissue, skin, and lipid can usually be differentiated by color and texture; dark grey skin, more opaque/pink lipid layer (Figure 7). Skin removal should be conducted while the plugs are still frozen, on a clean dissection tray, and under sufficient lighting to aid in differentiating between the layers of tissue. Dissection tools can be a sharp scalpel or dissection scissors; all tools should be cleaned with ethanol between samples. When no obvious lipid layer is apparent, the skin and muscle tissue should be separated approximately 1-2 mm below the skin. When the lipid layer appears mixed with muscle tissue, it should not be removed to preserve muscle tissue for analysis.

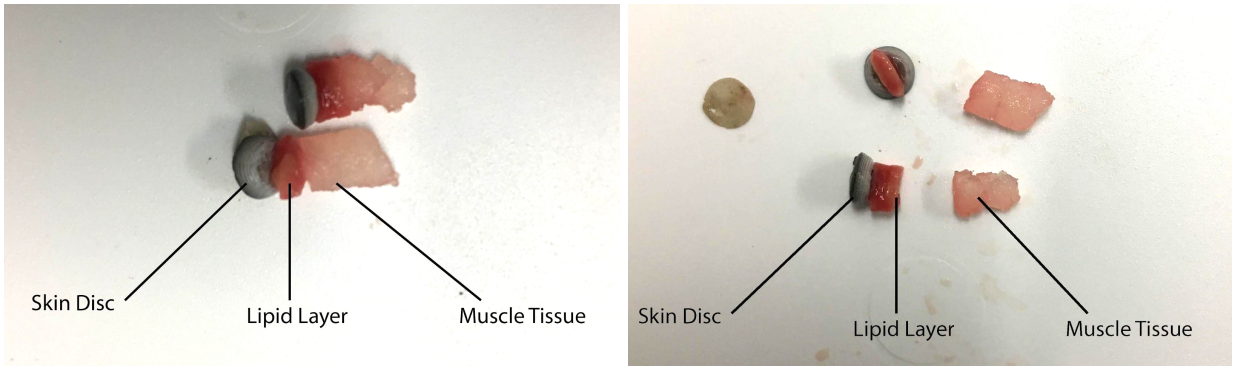

Figure 7. Muscle plugs before (left) and after (right) skin and lipid layers removal

After skin and lipid layer removal, muscle tissue samples are placed into a pre-weighed vial for freeze drying. A wet weight will be recorded before the samples are freeze dried. A dry weight will then be recorded and samples will be analyzed for total Se concentrations.

8. Shipping

SFEI shipping COC template is located here:
https://docs.google.com/spreadsheets/d/1YJQoTA01nBDBOkS4uqHJh8lBvgcOkzBqYJY6b-nm2mA/edit?usp=drive_link

CalTest COC template is located here:
https://docs.google.com/spreadsheets/d/1sG2UVatA1gI-5I9SFjnqvM5DMqSbMwZl/edit?usp=sharing&ouid=107905029462472499986&rtpof=true&sd=true

Copies of completed COCs should be saved here. For CalTest pickups, scan CalTest COC form and save to the folder as PDF.
https://drive.google.com/drive/folders/1TMERuM3gKZEda5VsvvqeO9V7LCs6U8I7?usp=sharing

All shipped samples will be accompanied by a chain of custody form (COC) provided by SFEI, USGS, or AMS. The COC form will include the Organism ID, site name, collection date, sample type, analysis required, and any other significant notes.

Table 4. Shipping Contact Information

	Contact	Address	Shipment Speed
BAL	*Amy Goodall*	*18804 North Creek Pkwy #100, Bothell, WA 98011*	*FedEx Standard Overnight or Same-Day*
USGS	*Veronika Kocen*	*US Geological Survey Selenium Research Lab 350 N. Akron Rd. Moffett Field, CA 94035*	*FedEx Standard Overnight or Same-Day*
SFEI	*Amy Kleckner*	*4911 Central Avenue, Richmond, CA 94804*	*N/A*
AMS	*Paul Salop*	*4749 Bennett Dr # L, Livermore, CA 94551*	*N/A*
CalTest	*Sonya Allahyari*	*1885 N Kelly Rd, Napa, CA 94558*	*N/A*

Clams

Samples will be shipped or delivered by AMS to USGS. The clams will be frozen (ideally at -80°C; Kleckner et al., 2010), separated into baggies of size class and station, and packed on dry ice. AMS staff will label clam composites with site, date, and size range information (e.g. STN41_2026-0627_13-14). Frozen clams will be shipped or delivered by AMS to USGS at the end of each 3 month sampling period.

Water

Dissolved selenium water samples will be shipped by SFEI to BAL. Samples will be shipped in coolers on ice via same-day or next-day shipping (same day should be reserved for Thursday cruises, to avoid weekend delays). Particulate selenium sample filters will be held frozen at SFEI until the end of all sampling and shipped together to be analyzed in a single batch.

Ancillary parameter samples (Chl-a, TOC, SSC) will be picked up from the dock by CalTest staff. Until pickup, samples should be refrigerated or kept on ice.

Sturgeon

Muscle plugs and egg/ovary tissue samples will be picked up by SFEI staff and shipped or delivered to USGS at the end of CDFW's sturgeon tagging efforts. Samples will be shipped on dry ice via FedEx overnight service or delivered on dry ice to the USGS.

9. Analytical Methods

The analytes of interest for each matrix, the corresponding lab, and analytical method associated with these analyses are outlined in Table 5.

Table 5. Analytical Methods and Reporting Information

	Analyte(s)	Method	MDL (µg/L)	Lab
Sturgeon tissue	Total Selenium	Kleckner et al 2017		USGS Earth Systems Processes Division Lab
Clam tissue	Total Selenium	Kleckner et al 2017		USGS Earth Systems Processes Division Lab
Water	Dissolved Se	EPA Method 1640, Mod. with Column Separation and Analysis with ICP-QQQ-MS	4.00E-02	Brooks Applied Laboratories
	Particulate Se	Tot rec. Se Analysis by ICP-QQQ-MS EPA 6020, Mod. with EPA 3050B digestion		
	SSC (ancillary)	ASTM D3977-B	1 mg/L	CalTest Analytical Laboratory
	TOC (ancillary)	SM 5310B	1 mg/L	
	Chl-a (ancillary)	SM 10200 H-2ab	0.5 ug/L	

10. Quality Assurance Measures

General RMP QA/QC protocols can be found in the Quality Assurance Project Plan for Tracking Bay Heath: Water Quality Science to Inform Management (Appendix B). QA/QC samples will be analyzed at a rate of a minimum of one laboratory blank and laboratory control sample per batch (or per 20 samples for larger batches), and one laboratory duplicate, one matrix spike, one matrix spike duplicate, and one certified reference material (CRM) for every 20 samples (with at least one per reporting year). This frequency indicates, for example, a lab batch of 10 samples would still require at least one lab blank, while a set of 35 field samples requires 2 or more CRMs even if these samples were all reported as a single dataset. Chl- and SSC do not require field duplicate or matrix spike samples.

11. Reporting & Data Management

All data collected for 2026/27 North Bay Selenium Monitoring will be checked for completeness, reviewed for quality assurance and quality control, formatted for display on CD3 and CEDEN, and uploaded to the Regional Data Center database for long term storage and public accessibility. Field reports will be posted to the SFEI website RMP Status & Trends page. A report summarizing all RMP North Bay Selenium monitoring will be completed by the end of calendar year 2027.

12. References

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Brown, C. L.; and Luoma S. N. 1995. Use of the euryhaline bivalve *Potamocorbula amurensis* as a biosentinel species to assess trace metal contamination in San Francisco Bay. Mar Ecol Prog Ser. 124:129-142.

Decho A. L. V.; Luoma S. N. 1991. Time-courses in the retention of food material in the bivalves *Potamocorbula amurensis* and *Macorna balthica*: significance to the absorption of carbon and chromium. Mar Ecol Prog Ser. 8:303-314.

Kleckner, A. E.; Stewart, R. A.; Kent, E.; Luoma, S. N. 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. USGS Open File report 2010-1252.

Kleckner, Amy E., Evangelos Kakouros, and A. Robin Stewart. "A practical method for the determination of total selenium in environmental samples using isotope dilution-hydride generation-inductively coupled plasma-mass spectrometry." Limnology and Oceanography: Methods 15.4 (2017): 363-371.

Sun, J.; Davis, J. A.; Stewart, R.; Palace, V. 2019. 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.

Appendix B.

Quality Control Documents

Quality Assurance Project Plan for Tracking Bay Health: Water Quality Science to Inform Management
https://drive.google.com/file/d/1bCt1MkOxCo2ilQOQFHf80JGiB1Nh1jML/view?usp=sharing

Appendix C.

Sample collection field data forms/sheets

Clam & Water:
https://forms.gle/NQoExpmP8eNWdeGP9

Sturgeon Muscle Plugs and Egg/Ovary tissue:
https://docs.google.com/spreadsheets/d/1LEtFVz3z_aeIedMPI12WXHXUG5TUkfOW/edit?usp=sharing&ouid=107905029462472499986&rtpof=true&sd=true

Link to CEDEN Chemistry and Tissue Data Templates:
https://ceden.waterboards.ca.gov/data-templates.html#chemistry

Appendix D.

Selenium Sampling Combined Site-Parameter List and Handling Instructions

https://docs.google.com/spreadsheets/d/1FS20k7lFabzJ1P2q00dlMnlGl3n9C2ghgWsj1E-i-FY/edit?gid=0#gid=0

Other field resources

Detailed Sturgeon Muscle Plug Sampling Protocol:
https://docs.google.com/document/d/1j8Mmwy3sWC0cZtiGnHyZf3nFLRox9aPcAfU1Vq7Xyno/edit#

Early Morning Dry Ice Retailers List:
https://docs.google.com/spreadsheets/d/1OmnYqals6tdX1YwRucJT6XtclaTVp3bUeryYdSrG-t0/edit?usp=sharing

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