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The San Francisco Estuary Institute Collection at the NIST Biorepository

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Abstract

The National Institute of Standards and Technology (NIST) has been collaborating with the San Francisco Estuary Institute (SFEI) since 2009, providing biobanking services at the NIST Biorepository in Charleston, South Carolina, in support of their ongoing water quality monitoring program, the Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP). Specimens (bivalve tissue, bird egg contents, fish tissue and sediment) are collected and processed by SFEI-partnering institutions according to their established protocols and shipped to the NIST Biorepository for archiving. This report outlines NIST's role in the project, describes collection and processing protocols developed by SFEI and their collaborators, details shipping and archival procedures employed by biorepository staff and provides an inventory of the collection maintained by NIST from 2009 to 2020.

Key words

Biobanking, specimens, SFEI, protocols.

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1. THE SAN FRANCISCO ESTUARY INSTITUTE PROJECT

1.1 Background and Responsibilities

The San Francisco Estuary Institute (SFEI) is a non-profit research institute in Richmond, California that administers the Regional Monitoring Program for Water Quality in the San Francisco Bay (RMP). The RMP was created in 1993 through San Francisco Bay Regional Water Quality Control Board Resolution No. 92-043 that directed the Executive Officer to implement a Regional Monitoring Plan in collaboration with permitted dischargers pursuant to California Water Code, Sections 13267, 13383, 13268 and 13385. The goal was to replace individual receiving water monitoring requirements for dischargers with a comprehensive Regional Monitoring Program. As such, the RMP has been collecting and archiving tissue and sediment samples for retrospective chemical analyses to assess water quality in San Francisco Bay and surrounding areas.

Prior to 2010, these samples had been stored at -20 °C at SFEI and collaborator facilities. However, reports from other research groups indicated that a storage temperature of -20 °C may not be suitable for the long-term (> 10 years) stability of chemical contaminants in these samples. Storage at -80 °C or lower is recommended, with storage at cryogenic temperatures (≤ -150 °C) believed to allow sample preservation without any major structural or biochemical changes over several decades [1],[2]. Since 2010, the National Institute of Standards and Technology (NIST) has been providing banking services to SFEI for long-term archiving of biological and environmental specimens at the NIST Biorepository located in the Hollings Marine Laboratory, Charleston, South Carolina. These services include:

1. **Providing clean storage containers** for sample collection, which include both 22 mL perfluoroalkoxy (PFA) jars and 5 mL or 10 mL polypropylene cryovials
2. **Providing pre-printed barcode labels** according to information obtained from SFEI or SFEI-affiliated field collectors for sample tracking in the NIST Biorepository database
3. **Providing long-term archival of samples** in liquid nitrogen vapor-phase freezers and maintaining samples according to NIST Biorepository standard operating procedures
4. **Shipping samples** banked from SFEI-administered programs to testing laboratories upon request
5. **Maintaining an electronic database** of SFEI samples, including sample identification information and sample location tracking information

A 25-year plan was developed for service from 2009-2034 (Table 1). Though the collaboration began in 2010, the previous year's collection (2009) was incorporated into the NIST Biorepository as well. Every five years, the agreement is revisited by both NIST and SFEI and the terms agreed upon. If changes are made during the span of the five-year agreement, amendments are drafted and included to incorporate changes in collection, funding or other necessary details.

1.2 Projected Collections

The RMP is responsible for the collection of bivalve, bird egg, sediment and sport fish specimens. SFEI also collects sport fish specimens for the California Surface Water Ambient Monitoring Program (SWAMP), which are included in the archive. Collections are conducted by SFEI or their associated contractors according to protocols developed within their institution. Details regarding each archived collection are outlined below, including projected plans for SFEI collections. Deviations from these plans can occur for various reasons and are addressed on a case-by-case basis. Current sampling schemes are described by component below.

- Bivalves, including mussels (*Mytilus californianus*) are collected from a reference site and deployed for about 100 days at seven fixed locations. Native clams (*Corbicula fluminea*) are collected from two sites synoptically with mussel deployments. Bivalve collection frequencies have varied over time.
- Double-crested cormorant (*Phalacrocorax auritus*) eggs are collected from three fixed sites and Forster's tern (*Sterna forsteri*) eggs from a variable number of sites every three years.
- Sediment was historically collected every four years from 27 subtidal locations (seven fixed sites, 20 random sites). The frequency of subtidal collections decreased to every ten years starting in 2018. Sediment samples from the Bay margins were collected in 2015 and 2017 from 40 locations each year. Bay margins collections will continue to be collected every four years.
- Five to 15 sport fish species are collected from seven popular fishing locations every five years.
- Other SFEI programs, such as SWAMP, have also been included in the collection.

The key contacts and collaborators for each collection are outlined in Figure 1.

2. PREPARING FOR A COLLECTION

Prior to each collection event, SFEI contacts the NIST Biorepository to notify them of upcoming events and requests clean supplies and labels for shipment to the appropriate collaborator.

2.1 Supplies

NIST is responsible for receiving storage containers purchased by SFEI, cleaning these containers and shipping them to field collectors prior to each collection event. Because the main objective of the SFEI collections is to monitor a range of environmental pollutants that have different chemical properties, two different storage container types were chosen at the inception of the collaboration with NIST in order to prevent sample contamination and accommodate various downstream analyses. Samples are stored in either 22 mL PFA jars or polypropylene cryovials (either 5 mL or 10 mL volumes). Polypropylene cryovials are purchased sterile directly from the manufacturer. PFA jars and their accompanying recessed lids are cleaned at the NIST Biorepository using a standard solvent wash protocol (Table 2).

Prior to each collection, sample information is provided to the NIST Biorepository to facilitate labeling of specimens in the field and ensure proper identification. This information includes, but is not limited to, a field ID, the species and common name (in the case of sport fish and egg content collections) and other identification information. This data is entered into the Biorepository's electronic sample tracking database and adhesive barcode labels are printed and shipped to the appropriate field collectors along with the clean storage containers. During sample processing the field collector adheres the aliquot label onto the appropriate sample container. Barcode labels are applied to the cryovials so that the clear portion of the label wraps around the printed portion (Figure 2). This helps ensure the label remains adhered to the vial once stored cryogenically. To effectively label PFA jars, small cardboard tabs are provided. The label is adhered to the tab ensuring the barcode is fully visible, with the clear portion of the label wrapped around the tab (Figure 3). The tab is then inserted into the recessed portion of the lid to fit tightly (Figure 4).

2.2 Permits

All required permits are submitted and maintained by SFEI and/or their collection partners. United States Fish and Wildlife Service (USFWS) permits are required for the take, transport and possession of bird egg specimens and various state permits are required for the capture and sacrifice of sport fish and the collection of bivalves for research.

3. FIELD COLLECTION AND SAMPLE PROCESSING

Each sample type that is part of SFEI efforts is collected according to a specific protocol developed and modified as necessary by SFEI and their collaborators. Field collection and processing procedures specific to each sample type are outlined below.

3.1 Bivalves

Mussels

Applied Marine Science (AMS) is responsible for harvesting approximately 2000 coastal mussels (*Mytilus californianus)* biennially from a low-contaminant site near Bodega Head State Marine Reserve and deploying them at seven sites in San Francisco Bay to measure uptake of organic and inorganic contaminants as an indicator of food web bioaccumulation (Table 2).

Adult mussels (55 to 65 mm in size) are targeted for collection in May or June of a sampling year and removed from the beds using an oyster knife. After harvesting, mussels are placed in buckets and transferred to free-flowing tanks containing filtered seawater at the Bodega Marine Lab for a one to two- week period of depuration, which includes removing encrusting organisms attached to the mussels. Mussels are then transported to AMS in preparation for an approximately 100-day deployment. One additional set of mussel samples are processed and stored as a control, representing the pre-deployment (T-0) condition from the Bodega Head harvesting location.

From the onset of the program until 2016, deployment and retrieval activities were conducted

by SCUBA divers who affixed bivalve cages to United States Coast Guard Aids to Navigation or privately-owned piles. In 2018, due to known failure of the piles, the RMP moved to deployment and retrieval using weighted containment cages deployed from vessels and retrieved using acoustic releases. The seven sites targeted for deployment are shown in Table 3.

Subcontractor laboratories, hired through the RMP, process and prepare bivalves into sample homogenates by removing the shell and blending tissue from multiple individuals using a stainless-steel wand blender. The mass from the homogenate is apportioned into containers for the different analyses and archives. Archived samples are specifically collected as a split from the organics homogenate. Once storage containers have been filled and labeled, the jars and vials are stored at -80 °C until shipment on dry ice.

Clams

AMS is also responsible for collecting approximately 600 resident freshwater clams (*Corbicula fluminea*) in October of the sampling year from the lower Sacramento and San Joaquin Rivers for bioaccumulation studies (Table 3). Clams are collected using a benthic dredge deployed from a vessel and dragged as slowly as possible along the river bottom. When the dredge is brought to the surface, all collected material is dumped into a pre-cleaned cooler where the viable clams are separated, placed in clean plastic bags and immediately frozen on dry ice. Subcontractor laboratories process, prepare, bottle, label and ship homogenates as previously described for the mussels.

3.2 Sediment

Subtidal sediments, collected by AMS, and margins sediments, collected by the Marine Pollution Studies Lab at Moss Landing Marine Labs (MPSL-MLML), are sampled from various sites in the San Francisco Bay using a 0.1 m^2 modified Van Veen sediment grab sampler deployed from a vessel. The grab is constructed entirely of stainless-steel and the jaws and doors are coated with Kynar to improve chemical inertness. Using the Van Veen, a minimum of two acceptable sediment grabs are composited. The scoop and bucket used to remove and composite sediments are constructed of Kynar-coated stainless-steel, polyethylene, or polycarbonate depending on the contaminants being analyzed. For analysis of chemical constituents, samples of bulk surficial sediments (top 5 cm) are collected in a manner such that surface layers are not disrupted when removed for processing.

Depending on the intended analysis, the samples are collected either directly from the grab using appropriate, non-contaminating equipment, or after the compositing process. Once a sufficient volume of subtidal sediment is collected, the Kynar-coated compositing bucket and scoops are transferred into the vessel cabin and the doors closed for processing to minimize potential vessel exhaust contamination. For the margins sediment, samples are composited in polycarbonate tubs on the open deck of the boat.

Sediment sample material in the compositing containers is mixed using Kynar-coated stainless-steel scoops until achieving a consistent appearance. While conducting mixing, sampling personnel avoid scraping the coated bucket in the interest of maintaining the

coating's integrity. Portions of the composited sample are then aliquoted into storage containers provided by each laboratory and labeled as previously described. The exteriors of the sample containers are wiped clean of excess sediment and samples are transferred to cold storage for shipment to the biorepository on dry ice.

3.3 Seabird Eggs

The United States Geological Survey Western Ecological Research Center (USGS-WERC) is responsible for collecting bird eggs for downstream analysis of mercury, selenium, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and per- and polyfluoroalkyl substances (PFAS) in egg content tissue every three years. Approximately 63 cormorant eggs are collected from up to three locations and approximately 84 tern eggs are collected from up to four locations for analysis (Table 4), though total numbers may vary. A small number of these eggs may be analyzed individually for environmental contaminants, however the majority are combined together to generate composite samples.

Eggs are collected according to established protocols [3], tagged with a unique ID and transported on wet ice to the USGS-WERC. Tern eggs are processed at USGS-WERC, while cormorant eggs are shipped at room temperature to SGS AXYS Analytical Services Ltd. for processing according to established protocols. (Of note and beginning in 2021, all seabird eggs will be processed at USGS-WERC.) Briefly, egg morphometrics are documented, including egg weight, length and width. Egg contents are homogenized individually and, if requested, a portion of the homogenate is bottled for analysis. The remaining homogenate is collected in a clean stainless-steel bowl. Each egg is homogenized the same way in turn, and the homogenate from each is added to the stainless-steel bowl. This composite sample is then thoroughly mixed and aliquoted into 22 mL PFA jars or polypropylene cryovials and labeled appropriately. All specimens are frozen immediately and shipped on dry ice to either the appropriate analytical laboratory or to the NIST Biorepository for archival.

3.4 Sport Fish

Historically, the RMP, in collaboration with the MPSL-MLML and the California Department of Fish and Wildlife (CDFW), has been responsible for the collection of various species of sport fish (Table 5). Collections occur every five years for long-term biomonitoring of historically relevant organic and inorganic contaminants (e.g., pesticides, mercury) and identification of previously unknown contaminants. Species are chosen for their ability to serve as indicator species for water quality guidelines and the need for data to support the Office of Environmental Health Hazard Assessment (OEHHA) Bay fish consumption advisory.

Collection methods vary based on the species being targeted, but include otter trawls (> 50 %), hook and line fishing (≈ 20 %), gill nets (≈ 15 %), beach seines/cast nets (≈ 10 %) and spearfishing (< 5 %). Details regarding each method of collection are outlined below.

- Otter trawl collections: Trawling is the predominant method used to collect target fish species. Target species that meet size requirements are kept for chemical analyses and remaining fish are immediately released. The target fish are struck with a plastic or

wooden mallet to euthanize them prior to placing them on dry ice.

- Hook and line collections: Various types of tackle and gear are used for hook and line fishing, depending on the targeted species and where fish are being collected (e.g., boat, pier, shoreline).
- Gill nets: Gill nets are used as a last resort, as they allow for the greatest amount of potential bycatch. Mesh size is chosen specifically to target the desired species and the nets are pulled behind the boat for a limited amount of time (a few hours) to limit the amount of bycatch.
- Beach seines: This method is used for fish that inhabit nearshore shallow areas. One sampler stands on the shoreline while another pulls the seine in a horseshoe-shaped path in the water and back to shore. Target species are picked out and others are immediately released.
- Cast nets: Also used for targeting fish in shallow areas, cast nets are tossed with the complete net opening (the weighted edges) striking the surface of the water. The weighted end sinks, entrapping the fish inside the net. As the net is pulled to the surface, the weighted edges come together, allowing the net to fully encircle the fish. Once the entire net is brought up, the targeted fish are quickly collected and others are immediately released.
- Spearfishing: This technique may be required for bottom dwelling species and is highly selective. After a fish is speared, if it is still alive, a blunt tool is used to euthanize it under water.

Approximately 150 g of tissue is required depending on the analytical application targeted. In order to minimize the risk of sample contamination, fish are handled only with non-contaminating gloves and wrapped in trace cleaned fluorinated ethylene propylene (FEP) sheets or aluminum foil, avoiding all contact with other field gear. Muscle is dissected from the fish in an ISO Class II laboratory clean room so that the exposure of the tissues to contaminants is minimized. MPSL-DFW dissects and homogenizes composite fish tissue samples according to established protocols. Briefly, fish within the same size class are used to create a composite sample and equal masses from each individual fish are included. The length of the smallest fish in the composite should be no less than 75% of the length of the largest fish. The majority of samples are processed as muscle fillets with the skin off. Species that are too small to be filleted are processed whole but with head, tail, and viscera removed. Composite samples are then mechanically homogenized, aliquoted into PFA jars and polypropylene cryovials and labeled appropriately before shipment to the NIST Biorepository on dry ice.

4. SHIPMENT AND ARCHIVAL

4.1 Sample Shipment

Following each collection event and before shipment, field collectors should ensure that the outside of all sample collection containers are wiped clean of extraneous debris. Collaborators are then responsible for packing all samples in coolers on blue or dry ice and shipping them to the following address:

NIST Biorepository
Hollings Marine Laboratory
331 Fort Johnson Road
Charleston, SC 29412

Shipments should be coordinated with NIST Biorepository staff, ensuring they can be received in a timely manner to prevent thawing of the samples. An inventory or chain of custody and any unused barcode labels should also be included in the shipment.

4.2 Sample Archiving

Upon receipt, the frozen samples are archived in liquid nitrogen vapor phase freezers (≤ -150 °C). Barcode labels are scanned into the biorepository's electronic sample-tracking database and each sample is assigned a storage position. This position, the date of receipt and recipient name is also recorded. Any inventory or chain of custody sent with the shipment is cross-checked with the samples received, initialed, dated and retained in the biorepository's records. This inventory can also be used to update additional data fields in the sample-tracking database, including date and time of collection, site identification or location information, and field collector. In the case of discrepancies or shipping-associated issues, NIST Biorepository staff communicates directly with the field collector and/or SFEI personnel to ensure a resolution is reached and the integrity of the sample and data remains intact.

5. COLLECTION INVENTORY

The current SFEI collection inventory can be obtained through the following link (password required), while a summary of the collection is provided in Table 6. The summary table includes data from all samples received at the NIST Biorepository from 2009 through 2020. Collection inventories with specfic inclusion/exclusion criteria can be provided to partners upon request via email to the NIST Biorepository staff.

Table 1: Actual (2009-2020) and Estimate (2021-2033) of SFEI Collections

Estimates are highlighted in yellow																									
22 ml teflon vials	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Sport Fish - RMP	129					177					49					177					177				
Sport Fish - SWAMP (BOG)[b]		24	46																						
Bivlaves-RMP		28		36		21				26		0													
Bird Eggs-RMP		27		27				18		21			27			27			27			27			27
Sediment-RMP[e]		21	21	21		21				21										21					
Sediment-RMP Margin							118	17	120			120		30	30			30	30			30	30		
Sportfish-ARTSLGH							12				3														
Total teflon vials in LN2 storage	129	229	296	380	380	599	729	764	884	952	1004	1124	1151	1181	1211	1415	1415	1445	1502	1523	1700	1757	1787	1787	1814
Total 3" boxes in LN2 storage	12	21	27	35	35	54	66	69	80	87	91	102	105	107	110	129	129	131	137	138	155	160	162	162	165
Total racks in LN2 storage (assuming	1.7	3.0	3.8	4.9	4.9	7.8	9.5	9.9	11.5	12.4	13.0	14.6	14.9	15.3	15.7	18.4	18.4	18.8	19.5	19.8	22.1	22.8	23.2	23.2	23.6

10 ml cryo vials	2009[a]	2010[a]	2011	2012[c]	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Sport Fish - RMP	31					24					13					36					36				
Sport Fish - SWAMP			63																						
Bivlaves-RMP		44		27		14				16		0													
Bird Eggs-RMP		45		45				27		21			27			27			27			27			27
Sediment-RMP[e]		34	14	11		14				21										21					
Sedimen-RMP Margin							80	10	80			80		30	30			30	30			30	30		
Sportfish-ARTSLGH							3																		
Total cryovials in LN2 storage	31	154	231	314	314	366	449	486	566	624	637	717	744	774	804	867	867	897	954	975	1011	1068	1098	1098	1125
Total 3" boxes in LN2 storage	0.4	1.9	6.4	8.7	8.7	10.2	12.5	13.5	15.7	17.3	17.7	19.9	20.7	21.5	22.3	24.1	24.1	24.9	26.5	27.1	28.1	29.7	30.5	30.5	31.3
Total racks in LN2 storage (assuming 7 boxes/rack)	0.1	0.3	0.9	1.2	1.2	1.5	1.8	1.9	2.2	2.5	2.5	2.8	3.0	3.1	3.2	3.4	3.4	3.6	3.8	3.9	4.0	4.2	4.4	4.4	4.5

[a]5 ml cryovials were used in 2009 & 2010

[b]BOG sportfish will not be archived in the forseable future per JD 8/3/12af

[c]10 ml cryovials were used in 2012 for bird eggs but they were only filled to 3 g tissue each so there were 5 per composite. The number of cryovials that will fit in a box decreased from 81 to 36 when we changed size from 5 ml to 10 ml in 2011. The forecast beginning in 2014 forward

[d]In 2014, two 10 ml cryovials were archived per composite. Beginning in 2015, the archive forecast will reflect three 10 ml cryovials archives per composite per (Jay Davis)

[e]Beginning in 2014, sediment samples will be collected every 4 years

[f]Beginning in 2014, number changed from 168 to 177 reflect number of archives in "Archive Sample Bank Protocol (Appendix E)"

[g]In 2014 the decision was made to change the number of bivalve sites from 11 to 9. Including the Bodega reference site, this changes from 12 to 10. 2016 was the first year the new site number was used.

[h]The bird-egg sampling that was scheduled for 2015 was postponed to 2016 due to a permitting issue.

[i]Number of archived bivalve and bird-egg samples in 2016 should have been 30 and 27, respectively, as per the change explained by footnote "d." Instead, the 20 and 18 numbers still reflected only 2/site instead of 3/site.

Table 2. Solvent Wash Protocol

Reagent Information	Soak Time
Chloroform (≥ 99.8% ACS grade)	1 hour
Ethanol (99.5% ACS grade)	1 hour
18.2 MΩ-cm water	rinse
Hydrochloric Acid (36.5-38% ACS grade):18.2 MΩ-cm water (1:2)	4 hours
18.2 MΩ-cm water	rinse
Nitric Acid (68-70% ACS grade):18.2 MΩ-cm water (1:2)	4 hours
18.2 MΩ-cm water	rinse
Ethanol (99.5% ACS grade)	rinse
18.2 MΩ-cm water	rinse
18.2 MΩ-cm water	rinse

Table 3. Sampling Sites for RMP Bivalve Monitoring

Site ID	Species Collected	Latitude	Longitude	Location Details
T-0	*Mytilus californianus*	38.30482	-123.06534	Bodega Head Marine Reserve, reference site
BA10	*Mytilus californianus*	37.46983	-122.06383	Coyote Creek, near channel marker 18
BA30	*Mytilus californianus*	37.51333	-122.13467	Dumbarton Bridge (backup site), near channel marker 14
BA40	*Mytilus californianus*	37.54700	-122.19500	Redwood Creek, near channel marker 4
BB71	*Mytilus californianus*	37.69550	-122.33967	Alameda (backup site), near channel marker 1
BC10	*Mytilus californianus*	37.81392	-122.35873	Yerba Buena Island, east of USCG station
BD30	*Mytilus californianus*	38.01667	-122.36750	Pinole Point, near channel marker P
BD20	*Mytilus californianus*	38.05900	-122.42367	San Pablo Bay (backup site), near channel marker 4
BG20	*Corbicula fluminea*	38.05967	-121.79167	Sacramento River
BG30	*Corbicula fluminea*	38.02117	-121.80533	San Joaquin River

Table 4. Sampling Sites for RMP Seabird Egg Monitoring

Site ID	Site Type	Latitude	Longitude	Location Details
2EEPSWI	Cormorant/Historical	38.08490	-121.93750	Wheeler Island
2EEPSRB	Cormorant/Historical	37.93520	-122.43730	Richmond Bridge
2EEPSDEP9/10C	Cormorant/Target	37.45110	-122.01170	Pond A9/10 in Don Edwards NWR
2EPPSDEP16	Tern/Historical	37.45120	-121.96940	Pond A16 in Don Edwards NWR
A2W	Tern/Historical	37.44290	-122.06900	Pond A2W in Don Edwards NWR
AB2	Tern/Historical	37.43170	-122.04950	Pond AB2 in Don Edwards NWR
EL	Tern/Historical	37.58110	-122.11000	Eden Landing Ecological Reserve
2EEPSHRS	Tern/Historical	37.63110	-122.14590	Hayward Shoreline Regional Park
2EEPSNM	Tern/Historical	38.14850	-122.31550	Napa-Sonoma Marsh Wildlife Area
2EEPSNCM	Tern/Possible Target	37.43800	-121.96800	New Chicago Marsh
2EEPSPA1	Tern/Possible Target	37.43760	-122.09600	Pond A1 in Don Edwards NWR
2EEPSPA7	Tern/Possible Target	37.44350	-122.00890	Pond A7 in Don Edwards NWR
HAY3B	Tern/Possible Target	37.63020	-122.14680	Hayward Pond 3B
2EEPSDEP_AB1	Tern/Possible Target	37.44430	-122.06370	Pond AB1 in Don Edwards NWR

Table 5. Sampling Information for Sport Fish Monitoring

Common Name	Genus/Species	Gender	Age/Weight	Number/ Year	Number/ Project	Pain Category*
Barred sand bass	*Paralabrax nebulifer*	M/F	2-7/.2-2 kg	220	440	2
Barred surfperch	*Amphistichus argenteus*	M/F	2-5/.1-1 kg	515	1030	2
Bat ray	*Myliobatis californica*	M/F	2-5/.5-4 kg	110	210	2
Black & yellow rockfish	*Sebastes chrysomelas*	M/F	2-10/.3-3 kg	300	600	2
Black croaker	*Cheilotrma saturnum*	M/F	2-5/.1-1 kg	435	600	2
Black rockfish	*Sebastes melanops*	M/F	2-10/.3-3 kg	400	800	2
Black surfperch	*Embiotoca jacksoni*	M/F	2-5/.2-1 kg	450	900	2
Blacksmith	*Chromis punctipinnis*	M/F	2-10/.3-3 kg	300	600	2
Blue rockfish	*Sebastes mystinus*	M/F	2-10/.3-3 kg	400	800	2
Bocaccio	*Sebastes paucispinis*	M/F	2-10/.3-3 kg	300	600	2
Bonefish	*Albula vulpes*	M/F	2-5/.2-1 kg	450	900	2
Brown rockfish	*Sebastes auriculatus*	M/F	2-10/.3-3 kg	300	600	2
Brown smoothhound	*Mustelus henlei*	M/F	4-8/2-10 kg	110	210	3
Butter sole	*Isopsetta isolepis*	M/F	2-5/.2-1 kg	1000	1100	2
Cabezon	*Scorpaenichthys marmoratus*	M/F	2-10/.5-5 kg	100	300	2
Calico surfperch	*Amphistichus koelzi*	M/F	2-5/.1-1 kg	515	1030	2
California corbina	*Menticirrhus undulatus*	M/F	2-10/.3-3 kg	300	600	2
California flounder	*Paralichthys californicus*	M/F	2-10/.5-5 kg	500	800	2
California grunion	*Leuresthes tenus*	M/F	2-10/.5-5 kg	500	800	2
California halibut	*Paralichthys californicus*	M/F	4-8/4-30 kg	170	340	2
California killifish	*Fundulus parvipinnis*	M/F	2-10/.3-3 kg	300	500	2
California lizardfish	*Synodus lucioceps*	M/F	2-10/.3-3 kg	100	300	2
California scorpionfish	*Scorpaena gutta*	M/F	2-10/.3-3 kg	400	800	2
California sheephead	*Pimelometopon pulchrum*	M/F	2-10/.5-5 kg	400	800	2
California tonguefish	*Symphurus atricaudus*	M/F	2-10/.3-3 kg	1000	1100	2
Canary rockfish	*Sebastes pinniger*	M/F	2-10/.3-3 kg	300	600	2
Chilipepper rockfish	*Sebastes goodei*	M/F	2-10/.3-3 kg	300	600	2
China rockfish	*Sebastes nebulosus*	M/F	2-10/.3-3 kg	300	600	2
Chinook salmon	*Oncorhynchus tshawytscha*	M/F	4-8/4-30 kg	170	340	2
Copper rockfish	*Sebastes caurinus*	M/F	2-10/.3-3 kg	300	600	2
Diamond turbot	*Hypsopsetta guttulata*	M/F	2-10/.3-3 kg	300	600	2
Dwarf surfperch	*Micrometrus minimus*	M/F	2-5/.1-1 kg	515	1030	2
English Sole	*Pleuronectes vetulus*	M/F	2-10/.3-3 kg	1000	1200	2
Fantail sole	*Xystreurys liolepis*	M/F	2-10/.3-3 kg	300	600	2
Gopher rockfish	*Sebastes carnatus*	M/F	2-10/.3-3 kg	300	600	2
Grass rockfish	*Sebastes rastrelliger*	M/F	2-10/.3-3 kg	300	600	2
Greenspotted rockfish	*Sebastes chlorostictus*	M/F	2-10/.3-3 kg	300	600	2
Grey smoothhound shark	*Mustelus californicus*	M/F	4-8/2-10 kg	110	210	3
Halfmoon	*Medialuna californiensis*	M/F	2-10/.3-3 kg	300	600	2
Jack mackerel	*Trachurus symmetricus*	M/F	2-10/.3-3 kg	300	600	2
Jacksmelt	*Atherinopsis californiensis*	M/F	2-5/.1-1 kg	515	1030	2
Kelp bass	*Paralabrax clathratus*	M/F	2-10/.3-3 kg	400	800	2
Kelp greenling	*Hexagrammos decagrammus*	M/F	2-10/.3-3 kg	300	600	2
Kelp rockfish	*Sebastes artovirens*	M/F	2-10/.3-3 kg	300	600	2
Kelp surfperch	*Brachyistius frenatus*	M/F	2-5/.1-1 kg	515	1030	2
Leopard shark	*Triakis semifasciata*	M/F	4-8/2-10 kg	110	210	3
Lingcod	*Ophiodon elongatus*	M/F	4-8/2-10 kg	110	210	2
Longfin sanddab	*Citharichthys xanthostigma*	M/F	2-5/.1-1 kg	435	435	2
Northern anchovy	*Engraulis mordax*	M/F	2-10/.3-3 kg	300	500	2
Ocean whitefish	*Caulolatilus princeps*	M/F	2-10/.3-3 kg	300	300	2
Olive rockfish	*Sebastes serranoides*	M/F	2-10/.3-3 kg	300	600	2
Opaleye	*Girella nigricans*	M/F	2-10/.3-3 kg	300	600	2
Pacific angel shark	*Squatina californica*	M/F	4-8/2-10 kg	110	210	3

Table 5. Sampling Information for Sport Fish Monitoring (Cont.)

Common Name	Genus/Species	Gender	Age/Weight	Number/ Year	Number/ Project	Pain Category*
Pacific halibut	*Hippoglossus stenolepis*	M/F	4-8/4-30 kg	170	400	2
Pacific mackerel	*Scomber japonicus*	M/F	2-10/.3-3 kg	300	600	2
Pacific sand sole	*Psettichthys melanostictus*	M/F	2-10/.3-3 kg	1000	1200	2
Pacific sanddab	*Citharichthys sordidus*	M/F	2-5/.1-1 kg	515	1030	2
Pacific sardine	*Sardinops sagax caeruleus*	M/F	2-10/.3-3 kg	300	600	2
Pacific staghorn sculpin	*Leptocottus armatus*	M/F	2-10/.3-3 kg	1000	1100	2
Pacific whiting	*Merluccius productus*	M/F	2-10/.3-3 kg	300	500	2
Pile surfperch	*Damalichthys vacca*	M/F	2-5/.1-1 kg	515	1030	2
Queenfish	*Seriphus politus*	M/F	2-10/.3-3 kg	300	600	2
Quillback rockfish	*Sebastes maliger*	M/F	2-10/.3-3 kg	300	600	2
Rainbow surfperch	*Hypsurus caryi*	M/F	2-5/.1-1 kg	2000	4000	2
Redtail surfperch	*Amphistichus rhodoterus*	M/F	2-5/.1-1 kg	515	1030	2
Reef surfperch	*Micrmetru aurora*	M/F	2-5/.1-1 kg	2000	4000	2
Rosethorn rockfish	*Sebastes helvomaculatus*	M/F	2-10/.3-3 kg	300	600	2
Round stingray	*Urolophus halleri*	M/F	2-7/.2-2 kg	220	400	2
Rubberlip surfperch	*Rhacochilus toxotes*	M/F	2-5/.1-1 kg	515	1030	2
Sablefish	*Anoplopoma fimbria*	M/F	2-10/.3-3 kg	100	300	2
Saddleback sculpin	*Oligocottus rimensis*	M/F	2-10/.3-3 kg	1000	1100	2
Sargo	*Anisotrmus davidsonii*	M/F	2-10/.3-3 kg	300	500	2
Shiner surfperch	*Cymatogaster aggregata*	M/F	2-5/.1-1 kg	1000	4000	2
Shovelnose guitarfish	*Rhinobatos productus*	M/F	4-8/2-10 kg	110	210	2
Silver surfperch	*Hyperprosopon ellipticum*	M/F	2-5/.1-1 kg	515	1030	2
Speckled sanddab	*Citharichthys stigmaeus*	M/F	2-5/.1-1 kg	2000	4000	2
Spiny dogfish	*Squalus acanthias*	M/F	4-8/2-10 kg	110	210	2
Splitnose rockfish	*Sebastes diploproa*	M/F	2-10/.3-3 kg	300	600	2
Spotfin croaker	*Roncador stearnsii*	M/F	2-5/.1-1 kg	515	1030	3
Spotfin surfperch	*Hyperprosopon anale*	M/F	2-5/.1-1 kg	515	1030	2
Spotted sand bass	*Paralabrax maculatofasciatus*	M/F	2-7/.2-2 kg	500	800	2
Spotted scorpionfish	*Scorpaena guttata*	M/F	2-10/.3-3 kg	300	600	2
Spotted turbot	*Pleuronichthys ritteri*	M/F	2-10/.3-3 kg	300	600	2
Starry flounder	*Platichthys stellatus*	M/F	4-8/1-5 kg	500	600	2
Striped bass	*Roccus saxatilis*	M/F	4-8/4-30 kg	170	340	2
Striped mullet	*Mugil cephalus*	M/F	4-8/4-30 kg	170	340	3
Striped sea perch	*Embiotoca lateralis*	M/F	2-10/.3-3 kg	1000	1100	2
Striped surfperch	*Embiotoca lateralis*	M/F	2-5/.1-1 kg	515	1030	2
Three-spined stickleback	*Gasterosteus aculeatus*	M/F	2-10/.3-3 kg	1000	1100	2
Thresher shark	*Alopias vulpinus*	M/F	4-8/4-30 kg	30	60	3
Topsmelt	*Atherinops affinis*	M/F	2-5/.1-1 kg	515	1500	2
Vermillion rockfish	*Sebastes miniatus*	M/F	2-10/.3-3 kg	300	600	2
Walleye surfperch	*Hyperprosopon argenteum*	M/F	2-5/.1-1 kg	515	1030	2
White croaker	*Genyonemus lineatus*	M/F	2-5/.1-1 kg	515	1030	2
White surfperch	*Phanerodon furcatus*	M/F	2-5/.1-1 kg	515	1030	2
Widow rockfish	*Sebastes entomelas*	M/F	4-8/4-30 kg	100	340	2
Yellowfin croaker	*Umbrina roncador*	M/F	2-5/.1-1 kg	515	1030	2
Yellowtail rockfish	*Sebastes flavidus*	M/F	2-10/.3-3 kg	300	600	2

* Pain category 2 indicates no procedure is expected to cause more than momentary or slight pain and distress. Pain category 3 indicates more distress may be caused, and includes those species potentially caught by gill net.

Table 6. Summary of SFEI specimens archived at the NIST Biorepository (2009-2020)

Collection Types	Number of Aliquots
Artesian Slough - Sportfish	**18**
2015	15
2019	3
RMP - Bivalves	**239**
2010	72
2012	63
2014	35
2016	27
2018	42
RMP - Eggs	**231**
2009	72
2012	72
2016	45
2018	42
RMP - Sediment	**199**
2010	55
2011	35
2012	32
2014	35
2018	42
RMP - Sportfish	**423**
2009	160
2014	201
2019	62
RMP Margins - Sediment	**598**
2015	198
2017	200
2020	200
SWAMP - Sportfish	**133**
2010	24
2011	109
Grand Total	**1841**

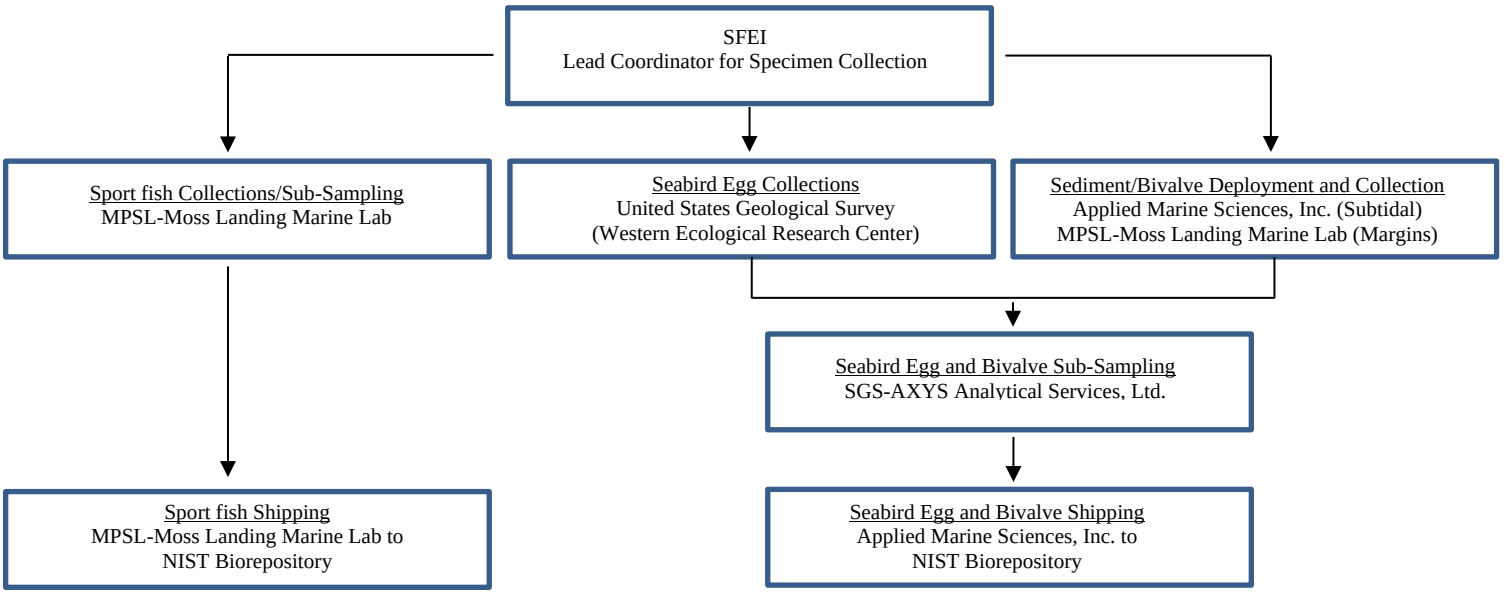

Figure 1. Principle SFEI Collaborators and Responsibilities

Figure 2. Cryovial with barcode label appropriately applied

Figure 3. PFA jar lid tab with barcode label appropriately applied

Figure 4. PFA jar with barcoded tab appropriately inserted into the lid

Acknowledgments

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References

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