The Carquinez Strait Fish and Preservation Project: Contaminant Concentrations in Fish

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Executive Summary

This report presents the results of a community-led effort to assess contaminant concentrations in fish collected from the Carquinez Strait in 2023-2024. All Positives Possible developed this project with support from the San Francisco Estuary Institute (SFEI) to assess contaminant exposure from subsistence fishing. The project was conducted to fill critical data gaps for contaminants of concern, including mercury, polychlorinated biphenyls (PCBs), and per- and polyfluoroalkyl substances (PFAS), in species commonly caught and consumed by local anglers, especially those living near and overburdened by historic and ongoing pollutant sources. The study responds directly to community concerns about potential health risks associated with eating locally caught fish, particularly for subsistence and cultural fishers in historically neglected San Francisco Bay shoreline areas. The project complements the dataset generated by the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) to document spatial patterns in contaminant exposure and to evaluate progress toward long-term cleanup goals.

Fish were collected through a collaborative process involving community fishers, All Positives Possible (APP), ICF, and the San Francisco Estuary Institute (SFEI). Five species - striped bass, jacksmelt, staghorn sculpin, leopard shark, and starry flounder - were analyzed for a suite of contaminants. These included the full PCB congener list (209 congeners), a list of 40 PFAS, mercury, percent lipid, and moisture content. Samples were processed and analyzed by Moss Landing Marine Laboratories and SGS AXYS following established RMP protocols. All analytical methods and data quality procedures adhered to stringent criteria outlined in the project Quality Assurance Project Plan (QAPP) for the Carquinez Strait Fish and Preservation Project, ensuring comparability with previous RMP Bay-wide fish contaminant studies.

Across the three contaminant classes, results indicate that concentrations remain elevated in several species relative to thresholds of concern for human health.

Mercury

Mercury concentrations in striped bass were high, with an average concentration in Carquinez Strait fish (0.35 parts per million, or ppm) below the Office of Environmental Health Hazard Assessment (OEHHA) no-consumption advisory tissue level (ATL) of 0.44 ppm for women ages 18 to 49 and children ages 1 to 17 (referred to as the “sensitive population”). Five out of the 32 individuals tested were still above this threshold. For comparison, the 2019 RMP dataset for all of San Francisco Bay showed a higher mean of 0.44 ppm, with 10 of 29 samples exceeding the no-consumption ATL. Striped bass caught for this effort had a similar average concentration to a sample

caught near Mare Island in 1994 (0.31 ppm). This was also the case for leopard sharks caught for this study. The average mercury concentration in leopard sharks (0.31 ppm), similar to the striped bass average, exceeded the water quality objective of 0.2 ppm, but was below the no-consumption ATL.

Lower concentrations were measured in other fish species. The average jacksmelt concentration (0.082 ppm) was lower than the water quality objective of 0.2 ppm but higher than the two servings per week ATL of 0.07 ppm for the sensitive population. The average mercury concentrations of staghorn sculpin (0.063 ppm) and starry flounder (0.053 ppm) were lower than the two servings per week ATL.

PCBs

PCB concentrations also exceeded thresholds. Staghorn sculpin composite samples caught at three Napa River stations had an average PCB concentration of 43 ppb, exceeding both the Water Board numeric target (10 ppb) and the OEHHA two servings per week ATL (21 ppb). Striped bass samples averaged 13 ppb—below the 21 ppb ATL threshold but above the numeric target. The average jacksmelt concentration (7.8 ppb) was just under the 10 ppb numeric target, but some individual samples were higher than this threshold. Starry flounder and leopard shark both had average concentrations and ranges well under the numeric target (average = 7 ppb, n = 1, and average 2.7 ppb, n = 4, respectively). The average PCB concentration in Carquinez Strait staghorn sculpin (43 ppb) was lower than the RMP average for other Bay locations (82 ppb).

PFAS

PFAS were detected in all species evaluated, and PFOS was the dominant compound. PFOS concentrations were highest in starry flounder (average 4.2 ppb), while staghorn sculpin averaged 2.7 ppb and striped bass averaged 2.1 ppb. These species exceeded fish consumption advisory thresholds established by other US states, suggesting that PFAS contamination is an emerging concern for people who eat fish from the Carquinez Strait. In contrast, jacksmelt (0.65 ppb) and leopard shark (0.37 ppb) exhibited the lowest PFOS concentrations. The RMP Bay-wide average concentration in striped bass (7.5 ppb) was higher than the average for the APP samples (2.1 ppb).

Conclusions

The engagement of community members in the collection of fish in this study was novel for the Bay Area, and was successfully implemented. The fish collected by community members yielded results that were similar to the results for the fish collected by the ICF environmental consultants. This study provided a thorough spatial assessment of contaminants in the Vallejo area, with four stations along a four-mile stretch of shoreline. Concentrations of mercury, PCBs, and PFAS were at levels of concern in Carquinez Strait fish. However, concentrations of contaminants in this area were

generally lower than those observed in the most recent Bay-wide sampling by the RMP. Fish in the Carquinez Strait area are not clean, but they appear to be less contaminated than fish from other parts of the Bay. A broader range of species and larger numbers of fish are needed for a more definitive assessment of contaminants in fish in this area. Analysis of prey fish would be a good way of confirming the relatively low levels observed to date.

Introduction

Consumption of locally-caught fish is an important cultural and subsistence practice for communities living along the Carquinez Strait and lower Napa River. However, several contaminants - including mercury, polychlorinated biphenyls (PCBs), and per- and poly-fluoroalkyl substances (PFAS) - remain present in the San Francisco Bay food web at levels that may pose risks to human health. The Carquinez Strait, located at the confluence of the Sacramento–San Joaquin Delta and San Pablo Bay, is a region with a long history of industrial activity, petroleum refining, and maritime commerce. Several neighborhoods adjacent to the Strait, particularly in Vallejo and Rodeo, have been identified as environmental justice communities disproportionately exposed to environmental hazards. These communities include Black American populations who could face elevated exposure burdens.

In response to community concerns about potential health risk from consuming locally caught fish, the Carquinez Strait and Preservation Project was developed by All Positives Possible who contacted SFEI to partner in developing data that was not available for 30 years. The sampling plan was designed to test and represent the species and sizes of fish that residents regularly catch and consume.

In 2023, APP, a nonprofit organization with 501(c)3 status, received a grant from the US Environmental Protection Agency (USEPA) to provide shoreline education, fish testing, garbage abatement, and preservation process and engage members and train leaders of disadvantaged communities living on the shoreline of the Carquinez Strait and Napa River located in Vallejo, CA. APP discovered in 2019 there were no data available for fish contaminant testing along the Vallejo or Rodeo shorelines of the Carquinez Strait since 1994. Therefore, APP contacted SFEI to assist with implementation of a subsistence fish testing and monitoring project to obtain needed data. SFEI contracted the Sacramento office of ICF to collect individuals of seven fish species in four priority sampling locations within the area for later testing.

Fish from San Francisco Bay contain concentrations of mercury, PCBs, and other chemical contaminants that are above thresholds of concern for human health. This problem was first thoroughly documented in 1994 when the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) performed a pilot study to measure contaminant concentrations in Bay fish (Fairey et al. 1997). As a result of this pilot study, the California Office of Environmental Health Hazard Assessment (OEHHA) issued an interim health advisory for consumption of fish from San Francisco Bay (OEHHA 1994). In 1997 the Regional Monitoring Program for Water Quality in San Francisco Bay (RMP) initiated a long-term monitoring program to follow up on the 1994 pilot study. In 2011, OEHHA published an updated health

advisory, based in large part on RMP data collected over the previous decade (OEHHA 2011). However, after the 1994 pilot study the RMP collected very few fish in the Carquinez Strait, with only four fish coming from the area near Vallejo, and no data specific to the Vallejo area were generated.

All segments of San Francisco Bay appear on the 303(d) List due to impairment of the beneficial use of the Bay for fishing. The Clean Water Act also requires that Total Maximum Daily Loads (TMDLs), or cleanup plans based on evaluation and reduction of contaminant loads, be developed in response to inclusion of a water body on the 303(d) List. TMDLs have been completed for mercury and PCBs in the Bay, and amendments to the San Francisco Bay Basin Water Quality Control Plan (Basin Plan) have been adopted (SFBRWQCB 2006; SFBRWQCB 2008; SFBRWQCB 2015). The implementation of these TMDLs focuses on indicators that are directly linked with impairment - particularly mercury and PCB concentrations in fish consumed by humans and wildlife. Concentrations of mercury, PCBs, and other contaminants in fish are, therefore, fundamentally important indices of Bay water quality.

The goal of this study was to investigate contaminant concentrations in fish in the Carquinez Strait near Vallejo, where neighborhoods adjacent to the Strait that have been identified as environmental justice communities have effectively not been studied since the first RMP Bay-wide fish study in 1994. Community fishers from APP who have been fishing this area for generations noticed this gap and obtained funding from the US Environmental Protection Agency’s San Francisco Bay Water Quality Improvement Fund to characterize fish contamination in the species they fish and consume. This was a novel study that analyzed fish caught directly by community fishers in addition to fish caught by the contractor ICF International.

Methods

Sampling Design

Fish were collected at four sampling locations in Carquinez Strait between September 2023 and February 2024 (Figure 1). APP identified these four areas as key fishing locations for community members. APP members fished these areas along the shoreline using hook and line, catching 22 fish total. ICF used a combination of fish gear types to catch target fish species, including otter trawl, mamou trawl, hook and line, and gillnets. On 20 field days between 9/5/23 and 10/12/23, ICF collected a total of 231 fish from four species. Further details on sampling locations and collections can be found in the 2024 Carquinez Strait Fish and Preservation Project Quality Assurance Project Plan (Trinh et al. 2024) as well as the ICF 2023 Fish Cruise Report (Appendix 1).

Fish species were selected based on a number of criteria, including species that (1) are popular for consumption by community members (striped bass, jacksmelt, starry flounder, and California halibut), (2) are sensitive indicators of problems (accumulating relatively high concentrations of contaminants), (3) are widely distributed, (4) represent different exposure pathways (benthic vs. pelagic), and (5) have been monitored in the past.

For this effort, striped bass, shiner surfperch, staghorn sculpin, white surfperch, jacksmelt, starry flounder, and California halibut were targeted. The contaminants that were measured in fish tissues were mercury, PCBs, and PFAS.

Additional sampling details, including station coordinates, sampling dates, field methods, and deviations from the original sampling design can be found in the 2023 Carquinez Strait Fish Cruise Report (Appendix 1).

In general, some target species were successfully collected; others that were not are noted here. Both APP fishers and ICF were unable to catch white surfperch or California halibut at all. Jacksmelt and staghorn sculpin were caught but did not reach the numeric goals of the study. Most importantly, shiner surfperch, a good indicator of PCBs due to their fatty tissue and site fidelity, were not caught by either fishing effort. Whether these species are scarce in the area either seasonally or more generally is not known.

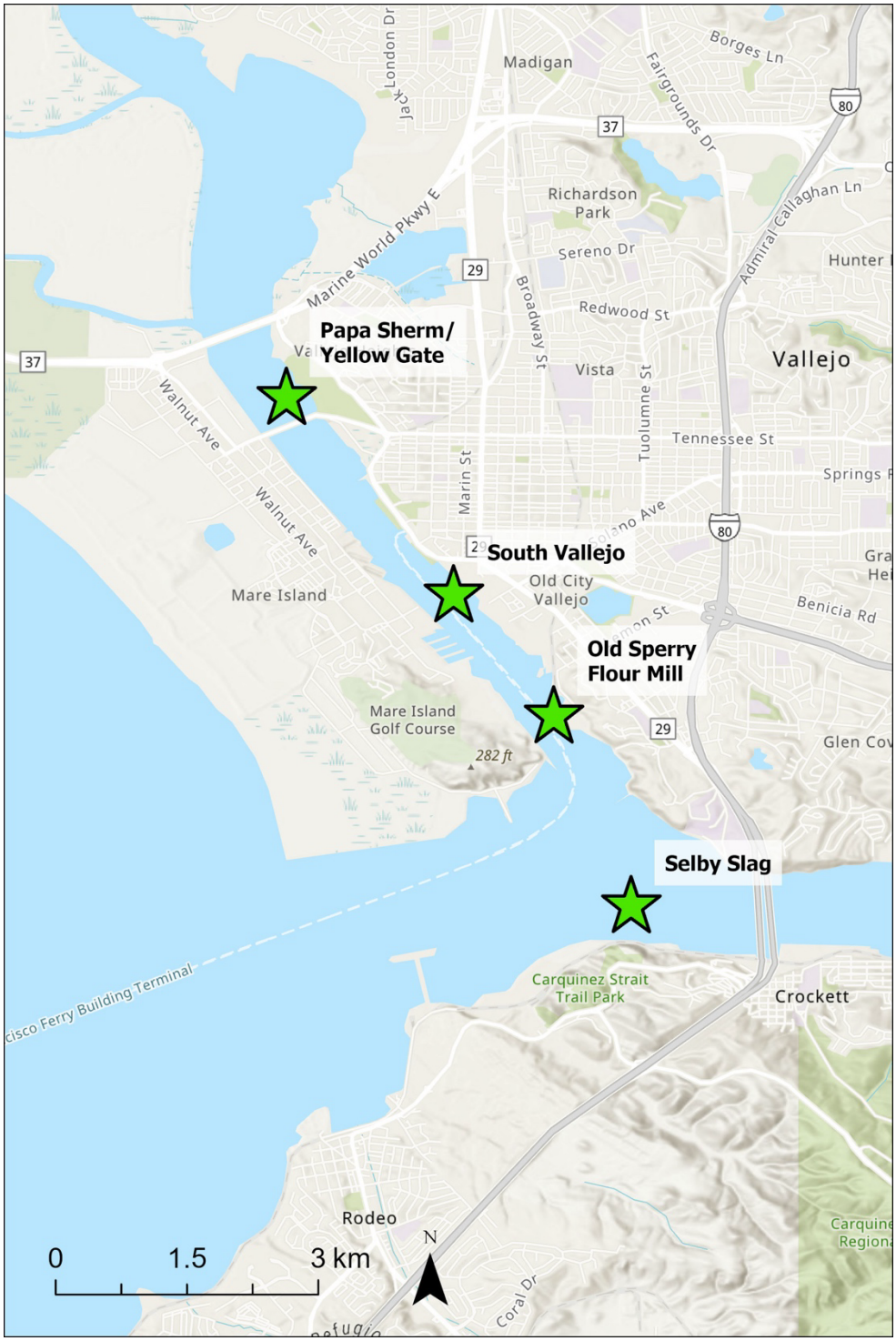

Figure 1. Locations sampled. The locations listed in the figure are the names used by APP. In the RMP database “Papa Sherm/Yellow Gate” was referred to as “Napa River at River Park”, “South Vallejo” as “Napa River at Mare Island Naval Shipyard (MINS)”, “Old Sperry Flour Mill” as “Napa River at Old Sperry Flour Mill (OSFM)”, and “Selby Slag” as “Carquinez at Selby”.

Laboratory Analysis

Sample Processing

Dissection and compositing of muscle tissue samples were performed following method MPSL-105. In general, fish were dissected skin-off, and only the fillet muscle tissue was used for analysis. This was done for consistency and comparability with the RMP dataset. Community members, however, do eat other tissues in addition to the fillet. Staghorn sculpin were too small to be filleted and were processed whole.

Fish samples were analyzed as either individuals or composites. Composites were created by combining equally-weighted aliquots from each fish, typically from the same sampling location and size class, and homogenizing these aliquots into a single composite, using methods established during previous rounds of RMP fish sampling (SFEI 2015; Davis et al. 1999). Equal-weight aliquots were not possible for staghorn sculpin, because they were processed as whole body samples. The length of the smallest fish in each composite was no less than 75% of the length of the largest fish (with the exception of staghorn sculpin, where the smallest fish was 68% of the length of the largest). Mercury analysis of select species were conducted on samples of individual fish. Further details about the compositing methods, including the number of fish per composite and number of composites analyzed per species, are presented in Table 1.

Table 1. Summary of fish samples collected, 2023-2024. Striped bass, leopard shark, and starry flounder were analyzed as individuals. Pacific staghorn sculpin and jacksmelt were analyzed as composites.

Common Name	Species Name	Total # of Fish Collected	Number of Locations Sampled	Number of Samples (Composites)	Number of Samples (Individuals)	Min Length (mm)	Median Length (mm)	Max Length (mm)
Starry Flounder	Platichthys stellatus	2	2	-	2	229	-	296
Striped Bass	Morone saxatilis	32	4	-	32	451	483	660
Pacific Staghorn Sculpin	Leptocottus armatus	182	3	9	-	100	129	205
Jacksmelt	Atherinopsis californiensis	33	3	6	-	201	249	343
Leopard Shark	Triakis semifasciata	4	2	-	4	660	787	812

Table 2. Summary of chemical analyses. Analytes included in this study, method detection limits, number of observations, and frequencies of detection and reporting. Frequency of detection includes all results above detection limits. Frequency of reporting includes all results that were reportable (above the detection limit and passing all quality assurance review). Units for the method detection limits (MDLs) are parts per million (ppm) for mercury and parts per billion (ppb) for all other organics. MDL field is blank for congeners that co-eluted with other congeners.

Laboratory	Class	Analyte	Method Detection Limit	Number of Samples	Frequency of Detection (%)	Frequency of Reporting (%)
MPSL-DFW	Mercury	Mercury	0.003	57	100	100
SGS AXYS	PCB	PCB 001	0.00	55	22	100
SGS AXYS	PCB	PCB 002	0.00	55	25	100
SGS AXYS	PCB	PCB 003	0.00	55	18	100
SGS AXYS	PCB	PCB 004	0.00	55	100	100
SGS AXYS	PCB	PCB 005	0.00	55	69	100
SGS AXYS	PCB	PCB 006	0.00	55	98	100
SGS AXYS	PCB	PCB 007	0.00	55	45	100
SGS AXYS	PCB	PCB 008	0.00	55	100	100
SGS AXYS	PCB	PCB 009	0.00	55	24	100
SGS AXYS	PCB	PCB 010	0.00	55	35	100
SGS AXYS	PCB	PCB 011	0.00	55	0	100
SGS AXYS	PCB	PCB 012		55	0	100
SGS AXYS	PCB	PCB 013	0.00	55	65	100

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Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 014	0.00	55	4	100
SGS AXYS	PCB	PCB 015	0.00	55	87	100
SGS AXYS	PCB	PCB 016	0.00	55	93	100
SGS AXYS	PCB	PCB 017	0.00	55	100	100
SGS AXYS	PCB	PCB 018	0.00	55	100	100
SGS AXYS	PCB	PCB 019	0.00	55	96	100
SGS AXYS	PCB	PCB 020		55	0	100
SGS AXYS	PCB	PCB 021		55	0	100
SGS AXYS	PCB	PCB 022	0.00	55	98	100
SGS AXYS	PCB	PCB 023	0.00	55	2	100
SGS AXYS	PCB	PCB 024	0.00	55	31	100
SGS AXYS	PCB	PCB 025	0.00	55	91	100
SGS AXYS	PCB	PCB 026	0.00	55	100	100
SGS AXYS	PCB	PCB 027	0.00	55	100	100
SGS AXYS	PCB	PCB 028	0.00	55	100	100
SGS AXYS	PCB	PCB 029		55	0	100
SGS AXYS	PCB	PCB 030		55	0	100
SGS AXYS	PCB	PCB 031	0.00	55	100	100
SGS AXYS	PCB	PCB 032	0.00	55	100	100
SGS AXYS	PCB	PCB 033	0.00	55	100	100
SGS AXYS	PCB	PCB 034	0.00	55	82	100
SGS AXYS	PCB	PCB 035	0.00	55	9	100
SGS AXYS	PCB	PCB 036	0.00	55	5	100
SGS AXYS	PCB	PCB 037	0.00	55	91	100
SGS AXYS	PCB	PCB 038	0.00	55	0	100
SGS AXYS	PCB	PCB 039	0.00	55	4	100
SGS AXYS	PCB	PCB 040	0.00	55	100	100
SGS AXYS	PCB	PCB 041		55	0	100
SGS AXYS	PCB	PCB 042	0.00	55	100	100
SGS AXYS	PCB	PCB 043	0.00	55	87	100
SGS AXYS	PCB	PCB 044	0.00	55	100	100

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Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 045	0.00	55	98	100
SGS AXYS	PCB	PCB 046	0.00	55	98	100
SGS AXYS	PCB	PCB 047		55	0	100
SGS AXYS	PCB	PCB 048	0.00	55	100	100
SGS AXYS	PCB	PCB 049	0.00	55	100	100
SGS AXYS	PCB	PCB 050		55	0	100
SGS AXYS	PCB	PCB 051		55	0	100
SGS AXYS	PCB	PCB 052	0.00	55	100	100
SGS AXYS	PCB	PCB 053	0.00	55	100	100
SGS AXYS	PCB	PCB 054	0.00	55	80	100
SGS AXYS	PCB	PCB 055	0.00	55	22	100
SGS AXYS	PCB	PCB 056	0.00	55	100	100
SGS AXYS	PCB	PCB 057	0.00	55	67	100
SGS AXYS	PCB	PCB 058	0.00	55	78	100
SGS AXYS	PCB	PCB 059	0.00	55	93	100
SGS AXYS	PCB	PCB 060	0.00	55	100	100
SGS AXYS	PCB	PCB 061		55	0	100
SGS AXYS	PCB	PCB 062		55	0	100
SGS AXYS	PCB	PCB 063	0.00	55	98	100
SGS AXYS	PCB	PCB 064	0.00	55	100	100
SGS AXYS	PCB	PCB 065		55	0	100
SGS AXYS	PCB	PCB 066	0.00	55	100	100
SGS AXYS	PCB	PCB 067	0.00	55	96	100
SGS AXYS	PCB	PCB 068	0.00	55	100	100
SGS AXYS	PCB	PCB 069		55	0	100
SGS AXYS	PCB	PCB 070	0.00	55	100	100
SGS AXYS	PCB	PCB 071		55	0	100
SGS AXYS	PCB	PCB 072	0.00	55	100	100
SGS AXYS	PCB	PCB 073	0.00	55	93	100
SGS AXYS	PCB	PCB 074		55	0	100
SGS AXYS	PCB	PCB 075		55	0	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 076		55	0	100
SGS AXYS	PCB	PCB 077	0.00	55	96	100
SGS AXYS	PCB	PCB 078	0.00	55	0	100
SGS AXYS	PCB	PCB 079	0.00	55	29	100
SGS AXYS	PCB	PCB 080	0.00	55	7	100
SGS AXYS	PCB	PCB 081	0.00	55	29	100
SGS AXYS	PCB	PCB 082	0.00	55	95	100
SGS AXYS	PCB	PCB 083		55	0	100
SGS AXYS	PCB	PCB 084	0.00	55	100	100
SGS AXYS	PCB	PCB 085	0.00	55	100	100
SGS AXYS	PCB	PCB 086		55	0	100
SGS AXYS	PCB	PCB 087	0.00	55	100	100
SGS AXYS	PCB	PCB 088		55	0	100
SGS AXYS	PCB	PCB 089	0.00	55	71	100
SGS AXYS	PCB	PCB 090		55	0	100
SGS AXYS	PCB	PCB 091	0.00	55	100	100
SGS AXYS	PCB	PCB 092	0.00	55	100	100
SGS AXYS	PCB	PCB 093		55	0	100
SGS AXYS	PCB	PCB 094	0.00	55	96	100
SGS AXYS	PCB	PCB 095	0.00	55	98	100
SGS AXYS	PCB	PCB 096	0.00	55	89	100
SGS AXYS	PCB	PCB 097		55	0	100
SGS AXYS	PCB	PCB 098		55	0	100
SGS AXYS	PCB	PCB 099	0.00	55	100	100
SGS AXYS	PCB	PCB 100		55	0	100
SGS AXYS	PCB	PCB 101	0.00	55	100	100
SGS AXYS	PCB	PCB 102		55	0	100
SGS AXYS	PCB	PCB 103	0.00	55	100	100
SGS AXYS	PCB	PCB 104	0.00	55	80	100
SGS AXYS	PCB	PCB 105	0.00	55	100	100
SGS AXYS	PCB	PCB 106	0.00	55	0	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 107		55	100	100
SGS AXYS	PCB	PCB 108		55	0	100
SGS AXYS	PCB	PCB 109	0.00	55	0	100
SGS AXYS	PCB	PCB 110	0.00	55	100	100
SGS AXYS	PCB	PCB 111	0.00	55	85	100
SGS AXYS	PCB	PCB 112	0.00	55	0	100
SGS AXYS	PCB	PCB 113		55	0	100
SGS AXYS	PCB	PCB 114	0.01	55	98	100
SGS AXYS	PCB	PCB 115		55	0	100
SGS AXYS	PCB	PCB 116		55	0	100
SGS AXYS	PCB	PCB 117		55	0	100
SGS AXYS	PCB	PCB 118	0.00	55	100	100
SGS AXYS	PCB	PCB 119		55	0	100
SGS AXYS	PCB	PCB 120	0.00	55	100	100
SGS AXYS	PCB	PCB 121	0.00	55	93	100
SGS AXYS	PCB	PCB 122	0.00	55	89	100
SGS AXYS	PCB	PCB 123	0.04	55	96	100
SGS AXYS	PCB	PCB 124	0.00	55	100	100
SGS AXYS	PCB	PCB 125		55	0	100
SGS AXYS	PCB	PCB 126	0.01	55	84	100
SGS AXYS	PCB	PCB 127	0.00	55	0	100
SGS AXYS	PCB	PCB 128	0.01	55	100	100
SGS AXYS	PCB	PCB 129		55	0	100
SGS AXYS	PCB	PCB 130	0.01	55	100	100
SGS AXYS	PCB	PCB 131	0.01	55	93	100
SGS AXYS	PCB	PCB 132	0.01	55	100	100
SGS AXYS	PCB	PCB 133	0.01	55	100	100
SGS AXYS	PCB	PCB 134	0.01	55	100	100
SGS AXYS	PCB	PCB 135		55	0	100
SGS AXYS	PCB	PCB 136	0.00	55	100	100
SGS AXYS	PCB	PCB 137	0.01	55	100	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 138	0.01	55	100	100
SGS AXYS	PCB	PCB 139	0.01	55	100	100
SGS AXYS	PCB	PCB 140		55	0	100
SGS AXYS	PCB	PCB 141	0.01	55	96	100
SGS AXYS	PCB	PCB 142	0.01	55	0	100
SGS AXYS	PCB	PCB 143		55	0	100
SGS AXYS	PCB	PCB 144	0.00	55	100	100
SGS AXYS	PCB	PCB 145	0.00	55	5	100
SGS AXYS	PCB	PCB 146	0.01	55	100	100
SGS AXYS	PCB	PCB 147		55	0	100
SGS AXYS	PCB	PCB 148	0.00	55	100	100
SGS AXYS	PCB	PCB 149	0.01	55	100	100
SGS AXYS	PCB	PCB 150	0.00	55	100	100
SGS AXYS	PCB	PCB 151	0.00	55	100	100
SGS AXYS	PCB	PCB 152	0.00	55	0	100
SGS AXYS	PCB	PCB 153	0.00	55	100	100
SGS AXYS	PCB	PCB 154		55	0	100
SGS AXYS	PCB	PCB 155	0.00	55	100	100
SGS AXYS	PCB	PCB 156	0.01	55	100	100
SGS AXYS	PCB	PCB 157		55	0	100
SGS AXYS	PCB	PCB 158	0.00	55	100	100
SGS AXYS	PCB	PCB 159	0.00	55	60	100
SGS AXYS	PCB	PCB 160		55	0	100
SGS AXYS	PCB	PCB 161	0.00	55	0	100
SGS AXYS	PCB	PCB 162	0.00	55	100	100
SGS AXYS	PCB	PCB 163		55	0	100
SGS AXYS	PCB	PCB 164	0.00	55	100	100
SGS AXYS	PCB	PCB 165	0.00	55	98	100
SGS AXYS	PCB	PCB 166		55	0	100
SGS AXYS	PCB	PCB 167	0.00	55	100	100
SGS AXYS	PCB	PCB 168		55	0	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 169	0.01	55	18	100
SGS AXYS	PCB	PCB 170	0.00	55	100	100
SGS AXYS	PCB	PCB 171	0.00	55	100	100
SGS AXYS	PCB	PCB 172	0.00	55	100	100
SGS AXYS	PCB	PCB 173		55	0	100
SGS AXYS	PCB	PCB 174	0.00	55	100	100
SGS AXYS	PCB	PCB 175	0.00	55	100	100
SGS AXYS	PCB	PCB 176	0.00	55	100	100
SGS AXYS	PCB	PCB 177	0.00	55	100	100
SGS AXYS	PCB	PCB 178	0.00	55	100	100
SGS AXYS	PCB	PCB 179	0.00	55	100	100
SGS AXYS	PCB	PCB 180	0.00	55	100	100
SGS AXYS	PCB	PCB 181	0.00	55	87	100
SGS AXYS	PCB	PCB 182	0.00	55	100	100
SGS AXYS	PCB	PCB 183	0.00	55	100	100
SGS AXYS	PCB	PCB 184	0.00	55	89	100
SGS AXYS	PCB	PCB 185		55	0	100
SGS AXYS	PCB	PCB 186	0.00	55	0	100
SGS AXYS	PCB	PCB 187	0.00	55	100	100
SGS AXYS	PCB	PCB 188	0.00	55	100	100
SGS AXYS	PCB	PCB 189	0.00	55	98	100
SGS AXYS	PCB	PCB 190	0.00	55	100	100
SGS AXYS	PCB	PCB 191	0.00	55	100	100
SGS AXYS	PCB	PCB 192	0.00	55	0	100
SGS AXYS	PCB	PCB 193		55	0	100
SGS AXYS	PCB	PCB 194	0.00	55	100	100
SGS AXYS	PCB	PCB 195	0.00	55	100	100
SGS AXYS	PCB	PCB 196	0.00	55	100	100
SGS AXYS	PCB	PCB 197		55	0	100
SGS AXYS	PCB	PCB 198		55	0	100
SGS AXYS	PCB	PCB 199	0.00	55	100	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PCB	PCB 200	0.00	55	100	100
SGS AXYS	PCB	PCB 201	0.00	55	100	100
SGS AXYS	PCB	PCB 202	0.00	55	100	100
SGS AXYS	PCB	PCB 203	0.00	55	100	100
SGS AXYS	PCB	PCB 204	0.00	55	25	100
SGS AXYS	PCB	PCB 205	0.00	55	98	100
SGS AXYS	PCB	PCB 206	0.00	55	100	100
SGS AXYS	PCB	PCB 207	0.00	55	100	100
SGS AXYS	PCB	PCB 208	0.00	55	100	100
SGS AXYS	PCB	PCB 209	0.00	55	100	100
SGS AXYS	PFAS	Perfluorobutanoate	0.392	56	1.8	100
SGS AXYS	PFAS	Perfluoropentanoate	0.196	56	0.0	100
SGS AXYS	PFAS	Perfluorohexanoate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluoroheptanoate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluorooctanoate	0.098	56	14.3	100
SGS AXYS	PFAS	Perfluorononanoate	0.098	56	26.8	100
SGS AXYS	PFAS	Perfluorodecanoate	0.098	56	83.9	100
SGS AXYS	PFAS	Perfluoroundecanoate	0.098	56	69.6	100
SGS AXYS	PFAS	Perfluorododecanoate	0.0784	56	78.6	100
SGS AXYS	PFAS	Perfluorotridecanoate	0.098	56	44.6	100
SGS AXYS	PFAS	Perfluorotetradecanoate	0.098	56	51.8	100
SGS AXYS	PFAS	Perfluorobutanesulfonate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluoropentanesulfonate	0.0985	56	0.0	100
SGS AXYS	PFAS	Perfluorohexanesulfonate	0.113	56	7.1	100
SGS AXYS	PFAS	Perfluoroheptanesulfonate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluorooctanesulfonate	0.098	56	100.0	100
SGS AXYS	PFAS	Perfluorononanesulfonate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluorodecanesulfonate	0.098	56	26.8	100
SGS AXYS	PFAS	Perfluorododecanesulfonate	0.098	56	0.0	100
SGS AXYS	PFAS	Perfluorooctanesulfonamide	0.098	56	82.1	100
SGS AXYS	PFAS	Methyl-perfluorooctanesulfonamide, N-	0.098	56	0.00	100

Lab	Class	Analyte	MDL	n	Detection (%)	Reporting (%)
SGS AXYS	PFAS	Ethyl-perfluorooctanesulfonamide, N-	0.275	56	0.00	100
SGS AXYS	PFAS	Methyl Perfluorooctane Sulfonamido Acetic Acid, N-	0.098	56	8.9	100
SGS AXYS	PFAS	Ethyl Perfluorooctane Sulfonamido Acetic Acid, N-	0.098	56	8.9	100
SGS AXYS	PFAS	Methyl-perfluorooctanesulfonamidoethanol, N-	0.98	56	0.00	100
SGS AXYS	PFAS	Ethyl-perfluorooctanesulfonamidoethanol, N-	0.98	56	0.00	100
SGS AXYS	PFAS	Fluorotelomer Sulfonate, 4:2-	0.392	56	0.00	100
SGS AXYS	PFAS	Fluorotelomer Sulfonate, 6:2-	0.353	56	0.00	100
SGS AXYS	PFAS	Fluorotelomer Sulfonate, 8:2-	0.333	56	0.00	100
SGS AXYS	PFAS	Dioxa-3H-Perfluorononanoate Acid, 4,8-	0.392	56	0.00	100
SGS AXYS	PFAS	Chlorohexadecafluoro-3-Oxanonane-1- Sulfonic Acid, 9-	0.393	56	0.00	100
SGS AXYS	PFAS	Chloroeicosafluoro-3-Oxaundecane-1- Sulfonic Acid, 11-	0.393	56	0.00	100
SGS AXYS	PFAS	Perfluoro-2-Propoxypropanoic Acid	0.392	56	0.00	100

Chemical Analyses

Analyses were conducted using USEPA methods in accordance with the 2024 RMP Quality Assurance Program Plan (QAPP) (Yee et al. 2024). The comprehensive analyte list, analytical laboratories, method detection limits, and analyte detection and reporting statistics are shown in Table 2. Quality assurance analyses to assess precision, accuracy, and recovery were performed for each batch.

Data that met all measurement quality objectives (MQOs) as specified in the QAPP are classified as “compliant” and considered usable without further evaluation. Data that failed to meet one or more of the program MQOs specified in the QAPP were classified as “qualified” but considered usable for the intended purpose. Results that were greater than two times the MQO requirements or outside MQO requirements due to blank contamination were classified as “rejected” and considered unusable. Additional details about the data management process are documented in Appendix 2.

Data that were considered usable and reportable (i.e., classified as “compliant,” “qualified,” or “estimated”) are available at cd3.sfei.org and are labeled by the project name “2024 Carquinez Strait Fish”. Detailed quality assurance/quality control summaries for each analysis can be found in the 2024 Carquinez Strait Fish Samples Quality Assurance Report (Appendix 3).

Data Analysis

Assessment Thresholds

This report compares new data on fish tissue concentrations to numeric thresholds for human health concern for pollutants in fish that were developed by the California Office of Environmental Health Hazard Assessment (OEHHA) (OEHHA 2017) - advisory tissue levels (ATLs) (Table 3) - as well as regulatory thresholds established by the SFBRWQCB. OEHHA (2017) described ATLs as follows.

“Advisory Tissue Levels (ATLs), while still conferring no significant health risk to individuals consuming sport fish in the quantities shown over a lifetime, were developed with the recognition that there are unique health benefits associated with fish consumption and that the advisory process should be expanded beyond a simple risk paradigm in order to best promote the overall health of the fish consumer. ATLs provide numbers of recommended fish servings that correspond to the range of contaminant concentrations found in fish and are used to provide consumption advice to prevent consumers from being exposed to more than the

average daily reference dose for non-carcinogens or to a risk level greater than $1x10^{-4}$ for carcinogens (not more than one additional cancer case in a population of 10,000 people consuming fish at the given consumption rate over a lifetime).

ATLs are designed to encourage consumption of fish that can be eaten in quantities likely to provide significant health benefits, while discouraging consumption of fish that, because of contaminant concentrations, should not be eaten or cannot be eaten in amounts recommended for improving overall health (eight ounces total, prior to cooking, per week). ATLs are but one component of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of fish consumption risks. The nature of the contaminant data or omega-3 fatty acid concentrations in a given species in a water body, as well as risk communication needs, may alter strict application of ATLs when developing site specific advisories. For example, OEHHA may recommend that consumers eat fish containing low levels of omega-3 fatty acids less often than the ATL table would suggest based solely on contaminant concentrations. OEHHA uses ATLs as a framework, along with best professional judgment, to provide fish consumption guidance on an ad hoc basis that best combines the needs for health protection and ease of communication for each site."

Consistent with this description of ATLs, the assessments presented in this report are not intended to represent consumption advice.

In this report, thresholds reported for mercury are specific to the sensitive population (i.e., women 18-49 years and children 1-17 years) (Table 3). The OEHHA thresholds shown in the figures indicate the lower end of the ATL range. The Carquinez Strait results were also compared to thresholds developed for the Bay by the SFBRWQCB, including mercury and PCB TMDL targets for fish tissue.

Since California has not yet established fish consumption advisory thresholds for PFAS, this study compared contaminant concentrations in fish to advisory thresholds set by the state of Massachusetts (Massachusetts Department of Public Health 2023).

Summary Statistics

All data are presented on a wet weight basis, unless otherwise noted, in order to compare values against ATLs and regulatory thresholds. This report uses the arithmetic mean (or "average") as a measure of central tendency. OEHHA also uses arithmetic means in developing consumption guidelines (OEHHA 2011). Table 4 presents average concentrations for each species and analyte.

Table 3. Human consumption risk thresholds. These thresholds were established in an assessment of human health risk from these pollutants by OEHHA (OEHHA 2017). All values are presented in ppb wet weight. One serving is defined as 8 ounces (227 g) prior to cooking. The advisory tissue levels shown for methylmercury are for the sensitive population (women aged 18 to 49 years and children aged 1 to 17 years).

Pollutant	Advisory Tissue Level (7 servings/week)	Advisory Tissue Level (6 servings/week)	Advisory Tissue Level (5 servings/week)	Advisory Tissue Level (4 servings/week)	Advisory Tissue Level (3 servings/week)	Advisory Tissue Level (2 servings/week)	Advisory Tissue Level (1 serving/week)	Advisory Tissue Level (No Consumption)
Methylmercury	≤31	>31-36	>36-44	>44-55	>55-70	>70-150	>150-440	>440
PCBs	≤9	>9-10	>10-13	>13-16	>16-21	>21-42	>42-120	>120

Table 4. Summary statistics by species.

Species	Tissue Type	Approximate # of Fish per Composite [1]	Number of Samples [2]	Sum of 208 PCBs (ppb)	Sum of PFAS (ppb)	PFOS (ppb)	Hg (ppm)
		Water Board Thresholds		**10**			**0.2**
Jacksmelt	Muscle fillet	6	6	7.8	0.67	0.65	0.082
Leopard Shark	Muscle fillet	1	4	2.7	0.81	0.37	0.31
Staghorn Sculpin	Whole body	20	9	43	5.9	2.7	0.063
Starry Flounder	Muscle fillet	1	2[a]	7.0	5.7	4.2	0.053
Striped Bass	Muscle fillet	1	32	13	3.3	2.1	0.35

1– In cases in which the number of fish per composite is 1, contaminants were analyzed in individual fish.
2- Samples refer to composite or individual fish samples. The number of samples included in the average concentration may vary slightly, in cases in which analytical results have not met all QA/QC criteria and have been excluded from data analysis.

a - Two starry flounder were collected. Only one of these was analyzed for PCBs.

Results

Mercury

Mercury exposure is one of the primary concerns driving the fish consumption advisory for the Bay. Mercury is a toxic heavy metal that, in the form of methylmercury, can biomagnify in the aquatic food web, leading to high concentrations in upper trophic level fish species that are commonly caught for human consumption. The majority of mercury (> 95%) accumulated in fish tissue is methylmercury (Bloom 1992). In 2008, the USEPA approved the San Francisco Bay TMDL for mercury (SFBRWQCB 2006), which established a numerical target of 0.2 ppm in fish muscle tissue for protection of human health. This TMDL target was subsequently adopted as a water quality objective in the Basin Plan. OEHHA has established advisory tissue levels that are lower than this water quality objective (e.g., one serving/week ATL of >0.15-0.44 ppm and two servings/week ATL of >0.07-0.15 ppm for the sensitive population [women 18 to 49 years and children 1-17 years]). The TMDL also established a wildlife target of 0.03 ppm in small prey fish for the protection of piscivorous species, which has also been adopted as a water quality objective in the Basin Plan.

Mercury contamination of the Bay and its watershed occurred largely as a result of mining activity during the 1800s, and mercury continues to wash into the Bay from many of these mining regions today. Other pathways of mercury input into the Bay include urban runoff, atmospheric deposition, and wastewater discharges. Recent studies also indicate that the large amount of historically-released mercury currently stored in the sediment of the Bay may be the dominant supply of methylmercury (Greenfield et al. 2013; Davis et al. 2014). As a result, current mercury load reductions are expected to be reflected gradually in the food web.

Substantial efforts are underway to reduce ongoing sources of mercury inputs and methylmercury production in the Bay. Continuing to monitor mercury in fish will be crucial to assessing the effectiveness of the TMDL and identifying additional mercury reductions required to meet the water quality objective. In this report, total mercury measurements in fish tissue are used as proxies for methylmercury concentrations.

Comparison to Thresholds and Variation Among Species

Mercury concentrations exceeded thresholds of concern in Carquinez Strait fish (Figure 2, Tables 4 and 5). No species had an average concentration that exceeded the no consumption advisory tissue level (for the sensitive population) of >0.44 ppm, five out of 32 striped bass caught for the project exceeded this value. The average mercury concentration in striped bass (0.35 ppm) and leopard shark (0.31 ppm) exceeded the water quality objective of 0.2 ppm (ranges = 0.17 ppm – 0.63 ppm and 0.28 ppm – 0.34 ppm, respectively). Lower concentrations were measured in other fish species. The average jacksmelt concentration (0.082 ppm) was under the water quality objective of 0.2 ppm but over the two servings per week ATL of 0.07 ppm (range = 0.055 ppm to 0.12 ppm). The average mercury concentrations of staghorn sculpin (0.063 ppm) and starry flounder (0.053 ppm) were lower than the two servings per week ATL (ranges = 0.054 ppm – 0.071 ppm and 0.052 ppm – 0.053 ppm, respectively.

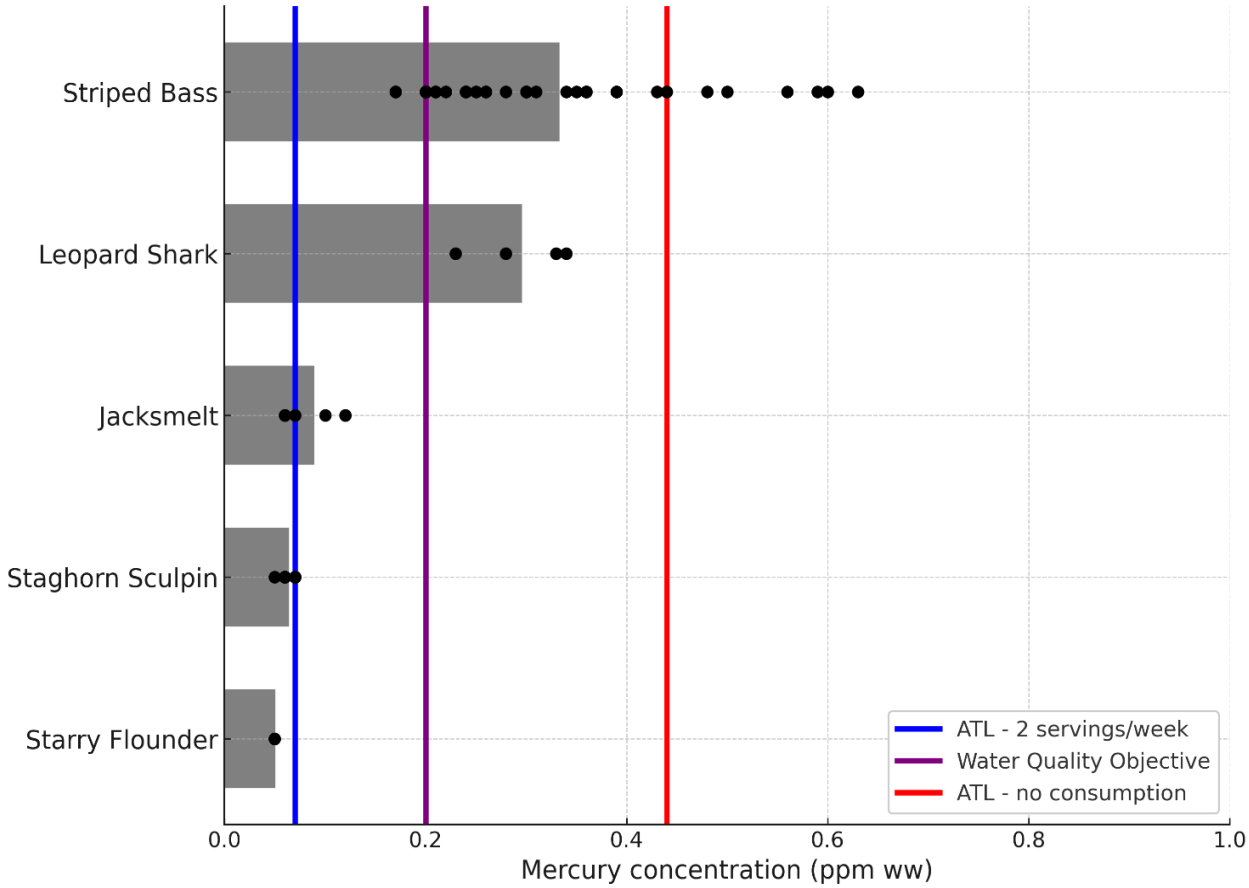

Figure 2. Mercury concentrations (ppm ww) in Carquinez Strait fish species, 2023-2024. Bars indicate average concentrations. Points represent individual samples (individual fish), except for jacksmelt and sculpin. Concentrations in striped bass are not length-adjusted. The colored lines indicating ATL thresholds show the lower end of the advisory tissue level ranges (see Table 3 for ranges).

Table 5. Exceedances of water quality thresholds. Counts of samples exceeding water quality objectives (mercury and PCBs) established by the San Francisco Bay Regional Water Quality Control Board (number of samples above the threshold / number of total samples analyzed.

Common Name	Sample Type	Mercury	Sum of PCBs
Threshold		0.2 ppm	10 ppb
Leopard Shark	Individual	3/3	0/10
Jacksmelt	Composite	0/3	2/6
Staghorn Sculpin	Composite	0/3	9/9
Starry Flounder	Individual	0/2	0/1
Striped Bass	Individual	29/32	26/32

Mercury in Striped Bass

Striped bass are perhaps the most important human health indicator of mercury contamination in the Bay-Delta as a result of their abundance, popularity among fishers, and life-history characteristics that cause them to accumulate relatively high mercury levels. Striped bass are also popular with Carquinez Strait shoreline fishers. Striped bass are high trophic-level predators and therefore highly susceptible to accumulating high concentrations of mercury in their tissues. Striped bass are also good integrative indicators of mercury contamination in the Bay-Delta Estuary because they use the entire ecosystem, including fresh and saline waters. Although some striped bass spend most of their lives in San Francisco Bay, they also move into freshwater and the coastal ocean, and their use of these different habitats can be quite variable. While this extensive movement makes striped bass good integrative indicators of the estuarine ecosystem, it generally makes them less valuable as indicators of small-scale spatial variation within the Bay-Delta and may confound attempts to interpret long-term trends.

The TMDL established the use of length-adjusted mercury concentrations to compare striped bass mercury concentrations over time or across locations, in order to correct for variation in the size of fish collected each year (Greenfield et al. 2005).The striped bass collected in this study (Figure 3) spanned a relatively narrow size range (mostly between 450-550 mm) making it difficult to

establish the length-mercury relationship based on this dataset. The data were therefore not adjusted for length.

The results for the 17 striped bass collected by APP and the 15 striped bass collected by ICF can be compared in Figure 3. The distributions of the two datasets were very similar, both in terms of fish length and mercury concentration.

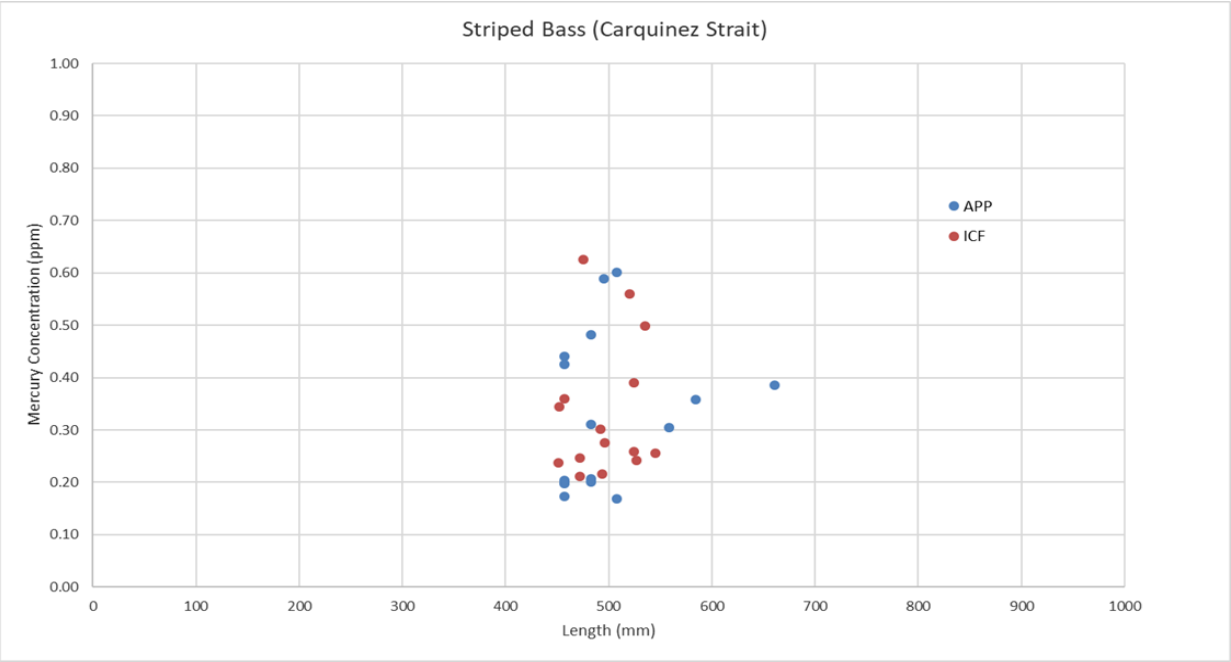

Figure 3. Mercury concentrations (ppm ww) versus total length (mm) in striped bass collected in Carquinez Strait, 2023-2024. Points represent individual samples.

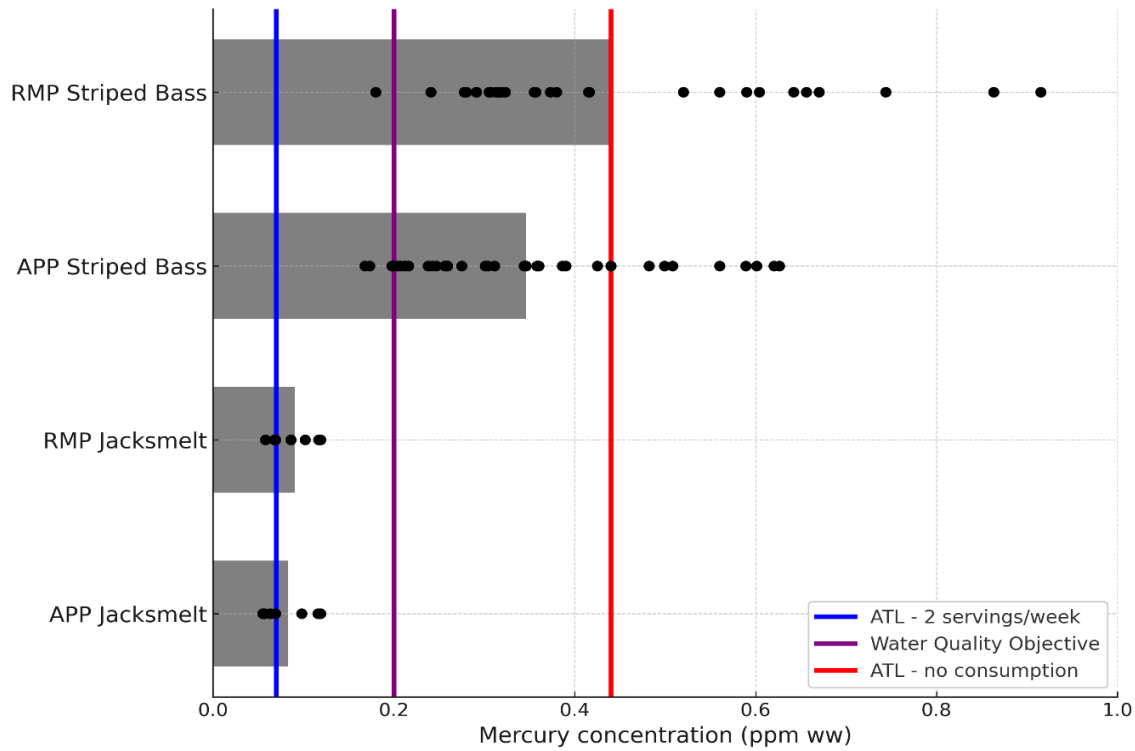

Figure 4. Mercury concentrations in striped bass and jacksmelt collected for the Carquinez Strait Project (2023-2024) and the 2019 RMP fish sampling effort.

For striped bass, the 2019 RMP fish dataset had an average of 0.44 ppm (range = 0.18 ppm - 0.92 ppm), matching OEHHA's no consumption threshold, with 10 out of 29 samples exceeding this limit. The Carquinez Strait striped bass' average mercury concentration (0.35 ppm, range = 0.17 ppm - 0.63 ppm) was lower than the RMP average and under the no consumption threshold, but still exhibited numerous samples above the threshold (five out of 32).

For jacksmelt, both datasets produced relatively low concentrations, with all samples falling below the Water Quality Objective of 0.2 ppm - yet many still above the two servings per week ATL of 0.07 ppm. Average concentrations were similar for the RMP jacksmelt (0.09 ppm, range = 0.058 ppm - 0.122 ppm) and the APP jacksmelt (0.082 ppm, range = 0.055 ppm - 0.122 ppm). These results indicate that jacksmelt pose comparatively lower risk for mercury exposure.

The Carquinez Strait effort addressed some of the mercury data gaps identified by APP for this part of the Bay. Striped bass are a key species for mercury and a robust number of samples was analyzed. Additional data would be valuable for

leopard shark, which had moderately high concentrations in the four fish analyzed in this study and have had very high concentrations in past RMP sampling.

PCBs

PCB exposure is another primary concern behind the fish consumption advisory for the Bay. The San Francisco Bay TMDL for PCBs, approved by USEPA in February 2010, established a fish tissue target of 10 ppb as a cleanup goal to protect human health (SFBRWQCB 2008).

PCBs are extremely persistent synthetic chemicals that were heavily used from the 1930s to the 1970s in electrical equipment and a wide variety of other applications. Awareness of their presence in the environment and their toxicity to humans and wildlife grew in the 1960s and 1970s, leading to a 1979 federal ban on their sale and production. However, some PCBs are currently still legally used in products produced prior to the ban. Since the ban, PCB concentrations in some Bay biota and sediment have gradually declined (Davis et al. 2014), but PCBs in some fish species are still more than ten times higher than the water quality objective. Due to their widespread use, PCB sources are diffuse, including both in-Bay sediment and watershed contamination on land, particularly in historically industrialized areas. Continuing to monitor PCBs in Bay fish is crucial to assessing the effectiveness of the TMDL in reducing additional sources of external PCB inputs to the Bay food web. Attaining this target will require a substantial reduction in PCBs in the Bay food web that is anticipated to also result in protection of wildlife from risks due to PCB exposure.

PCBs and other synthetic organic pollutants accumulate in fatty tissue, and have been shown to accumulate in higher concentrations in species with high lipid content.

Comparisons to thresholds and analyses of spatial patterns in this study were conducted using a total sum of all PCB congeners measured, which included 208 congeners (Tables 2, 4, and 5).

Comparison to Thresholds and Variation Among Species

PCB concentrations in fish collected for this study varied across species, with several species exceeding thresholds of concern for human health (Figure 5).

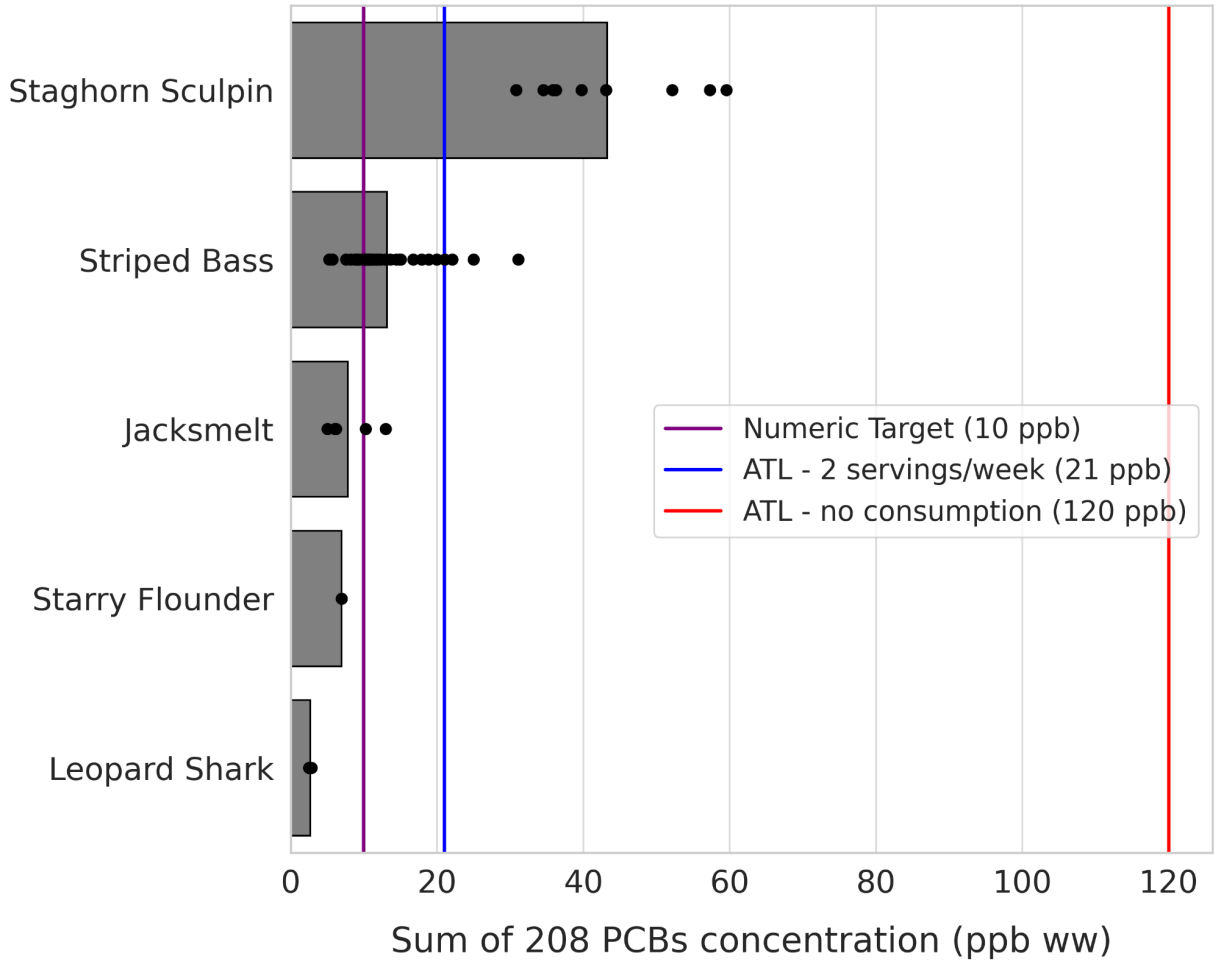

Figure 5. PCB concentrations (ppb ww, sum of 208 congeners) in Carquinez Strait fish. Points for sculpin and jacksmelt represent composite samples, points for other species represent individual fish. Colored lines indicating ATL thresholds show the lower end of the ATL ranges.

PCB concentrations exceeded thresholds of concern in some Carquinez Strait fish (Figure 5). Although no species had average concentrations that exceeded the no consumption ATL of 120 ppb, the average PCB concentration in staghorn sculpin (average = 43 ppb, range = 31 ppb - 60 ppb) exceeded the two servings per week ATL of 21 ppb. Average PCB concentrations in striped bass (average = 13 ppb, range = 5.3 ppb - 31 ppb) were under the two servings per week ATL, but some samples were over this threshold and average concentrations exceeded the Water Board numeric target of 10 ppb. Average jacksmelt concentrations (7.8 ppb, range = 5.1 ppb - 13 ppb) were under the 10 ppb numeric target, but some samples were higher than this threshold. Starry flounder and leopard shark both had average concentrations and ranges below the numeric target (7.0 ppb, n = 1 [only one starry flounder sample was analyzed for PCBs]; and average 2.7 ppb, range = 2.5 ppb - 2.9 ppb, n = 4, respectively).

A comparison of Carquinez Strait samples with samples from the rest of the Bay revealed lower concentrations in the Carquinez Strait compared to concentrations in the rest of the Bay (Figure 6).

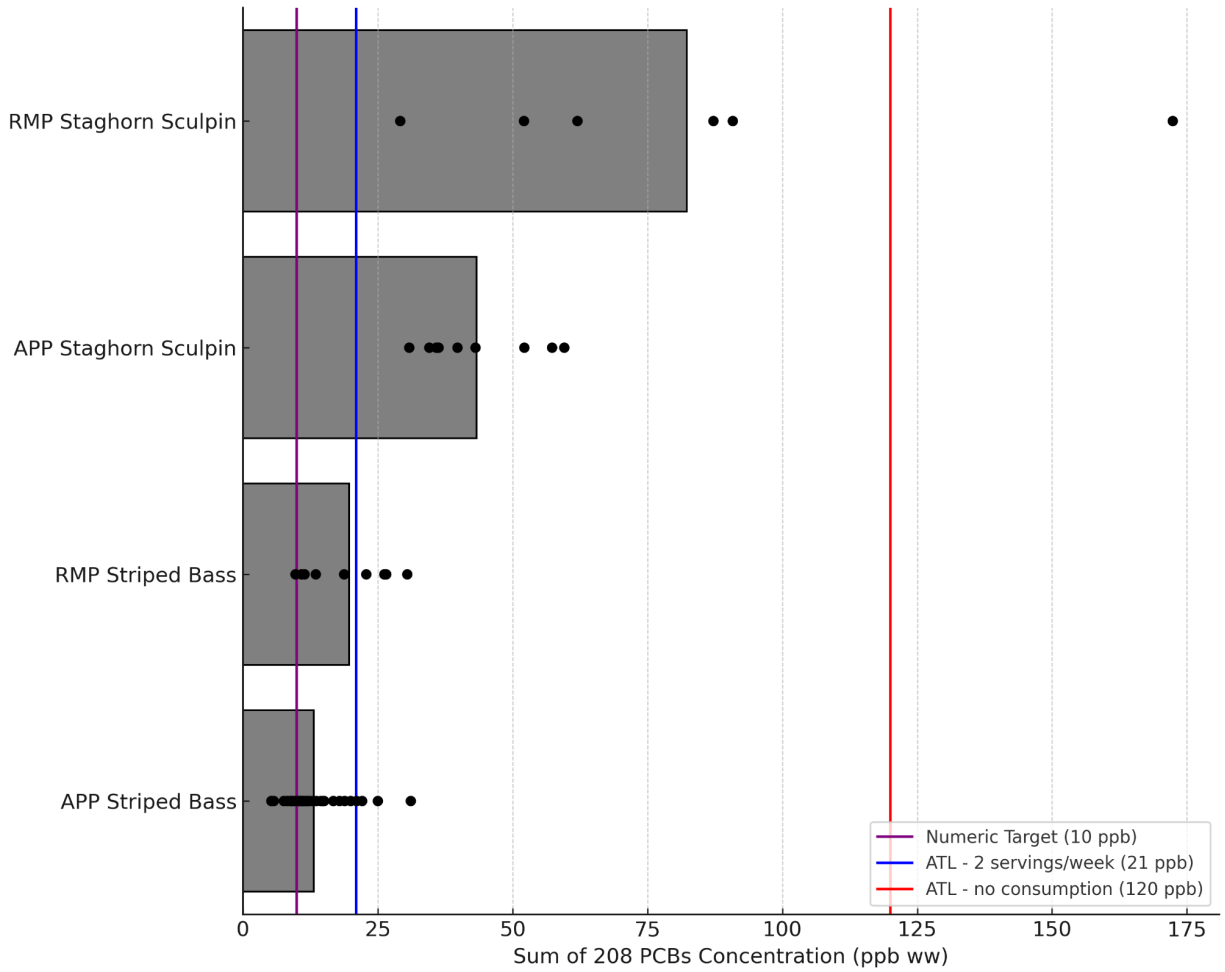

Figure 6. PCB concentrations in staghorn sculpin and striped bass collected for the Carquinez Strait Project (2023-2024) and the 2019 RMP fish sampling effort. Bars indicate average concentrations. Data shown are the sum of PCBs for all congeners analyzed; the number of congeners analyzed and included in the sums increased from 47 in 1994, to 52 in 2014, to 208 in 2019. The colored lines indicating ATL thresholds show the lower end of the advisory tissue level ranges.

Shiner surfperch is the primary indicator species for PCBs in the Bay because they accumulate high concentrations and are a benthic species with small home ranges. Although staghorn sculpin have some characteristics that are similar to shiner surfperch (benthic foraging, probably relatively localized home ranges, and higher accumulation of PCBs than most other species), they are not as strong an indicator species as shiner surfperch because they do not accumulate PCBs to quite the same high levels. Staghorn sculpin are moderately strong PCB accumulators though, with the fourth highest average among 16 species in the RMP in 2019 and a sample that reached 172 ppb in Oakland Harbor. The RMP uses staghorn sculpin as an alternative indicator in places where shiner surfperch are not available. This same strategy was used in this study and found to be valuable because neither the APP or ICF fish collectors were able to collect shiner surfperch in this study.

For staghorn sculpin, the average concentration from the Carquinez Strait (43 ppb) exceeded the numeric target and the two-servings per week ATL. The RMP average (82 ppb) was almost double the average found in Carquinez Strait fish. Striped bass exhibited lower but more similar concentrations between the RMP (20 ppb) and Carquinez Strait project (13 ppb), with averages below the two servings per week ATL but some individual samples above this threshold (ranges = 10 ppb - 30 ppb and 5.3 ppb - 31 ppb, respectively). These comparisons reflect PCB concentrations that are lower in the Carquinez Strait than other locations in the Bay, but still above thresholds for concern.

Spatial Patterns

Although shiner surfperch are excellent indicators of spatial variability in PCB concentrations in the Bay, both APP fishers and ICF were unable to catch shiner surfperch for this study. Spatial variation in PCB concentrations was assessed using staghorn sculpin, another species thought to have relatively high site fidelity, collected at three locations along the Napa River (Figure 7).

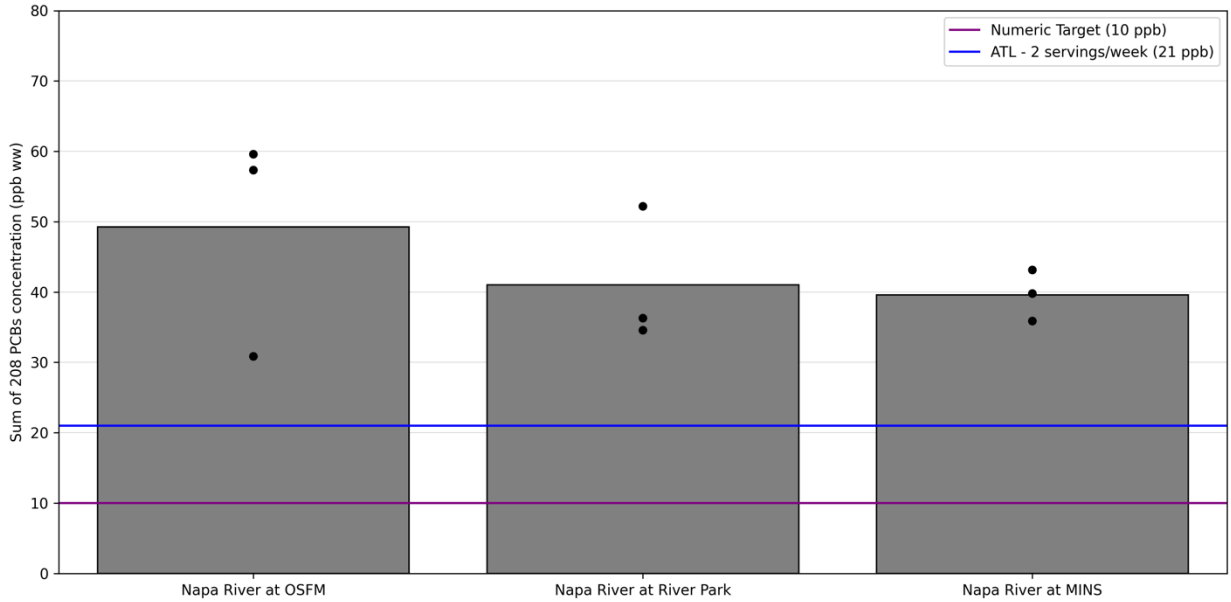

Figure 7. PCB concentrations (ppb ww) in staghorn sculpin in each Carquinez Strait location, 2023-2024. Bars indicate average concentrations. Points represent composite samples with 20 fish in each composite.

Average PCB concentrations were very similar across the three stations, ranging from 40 ppb at the Mare Island Naval Shipyard (MINS) location to 49 ppb at the Old Sperry Flour Mill (OSFM) location. All three stations - Napa River at OSFM, River Park, and MINS - exceeded the Water Board numeric target and the two servings per week ATL.

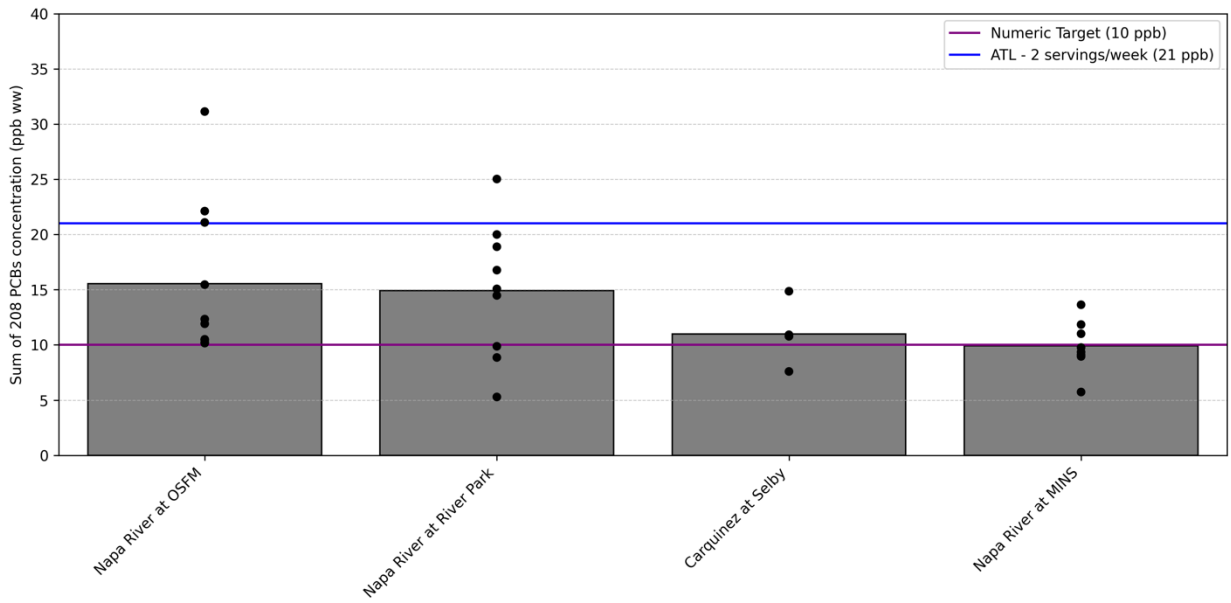

Figure 8. PCB concentrations (ppb ww) in striped bass at each location in the Carquinez Strait, 2023-2024.

For striped bass, average concentrations at all four locations exceeded the numeric target of 10 ppb but were under the two servings per week ATL of 21 ppb, despite some samples at the Napa River at OSFM and River Park above the higher threshold. The spatial pattern is similar to that observed in staghorn sculpin, with averages in the following descending order: OSFM, River Park, Selby, and MINS, but these differences are not statistically significant.

Temporal Trends

Striped bass caught at the Napa River at Mare Island location for the first Bay-wide fish contaminant study in 1994 (Fairey et al. 1997) had a concentration of 16 ppb (in one composite sample containing three fish). The striped bass caught for this study had an average concentration of 13 ppb, very similar to the level observed in 1994. Three composite samples of white croaker from this location in 1994 had very high concentrations: 259, 529, and 567 ppb (Fairey et al. 1997). Both striped bass and white croaker move widely in the Bay, so their concentrations may not be representative of local conditions.

PCB concentrations in staghorn sculpin and striped bass are at levels of concern in the Carquinez Strait. The concentrations observed in the Carquinez Strait were lower than those observed by the RMP at other Bay locations, but the primary indicator species for PCBs (shiner surfperch) was not monitored in the Strait. Additional sampling would be

valuable to better assess whether PCBs are relatively low in this area that historically appeared to have high concentrations.

PFAS

Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic chemicals used to resist heat, oil, stains, grease, and water in a wide range of consumer and industrial products, including food packaging materials, waterproof textiles, stain-resistant carpets and furniture, fire-suppression foams, processing aids for the production of fluoropolymers like Teflon, mist suppressants in metal-plating, and hydraulic aviation fluids (Sedlak et. al. 2018). As a result of their chemical stability and widespread use, PFAS such as perfluorooctane sulfonate (PFOS) have been detected in the environment, including in fish, bird eggs, and seals monitored over the past 20 years by the RMP in San Francisco Bay (Sedlak et al. 2018).

Comparison to Thresholds and Variation Among Species

PFAS concentrations in fish collected for this study showed substantial variation among species, with several species exhibiting elevated levels of PFOS and other long-chain perfluorinated compounds (Figure 9). The PFAS profiles showed that PFOS was the dominant compound across all species.

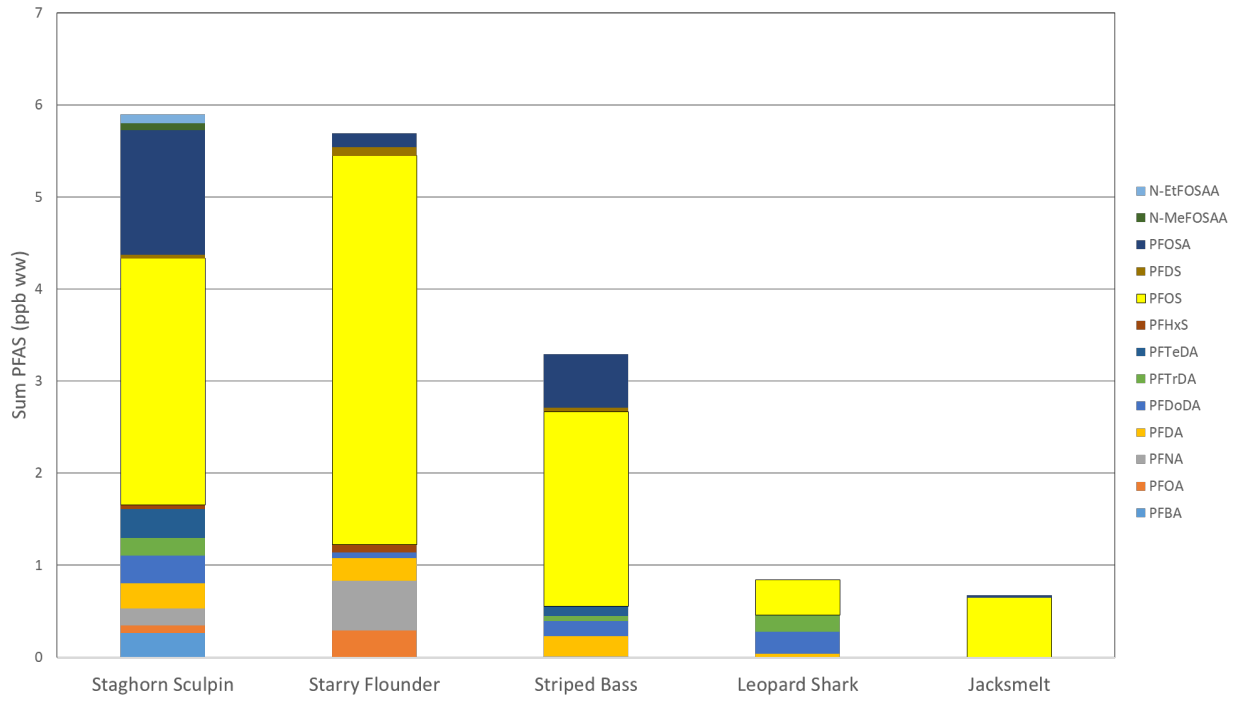

Figure 9. Sum of PFAS concentrations (ppb ww) and analyte contributions in Carquinez Strait fish, 2023-2024. Bars represent average concentrations, with the numbers of fish represented n = 182 for staghorn sculpin, n = 2 for starry flounder, n = 32 for striped bass, n = 4 for leopard shark, and n = 33 for jacksmelt.

Staghorn sculpin (5.9 ppb) and starry flounder (5.7 ppb) showed the highest average concentrations, with ranges of 5.2 ppb - 7.3 ppb and 3.5 ppb - 7.2 ppb respectively. Striped bass (3.3 ppb) exhibited a moderate average concentration (range = 1.6 ppb - 6.9 ppb) and jacksmelt (0.67 ppb) and leopard shark (0.81 ppb) averages fell at the lower end of the distribution, with ranges of 0.45 ppb - 0.93 ppb and 0.71 ppb - 0.87 ppb, respectively.

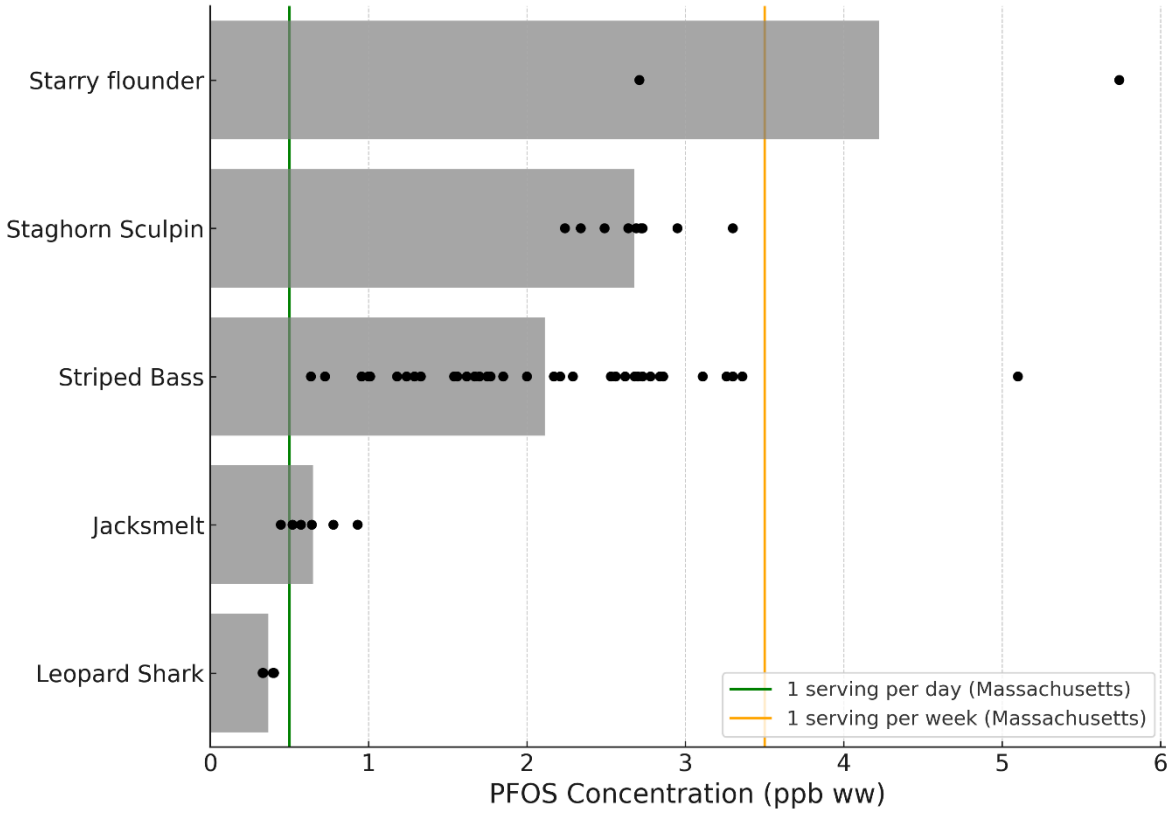

Figure 10. PFOS concentrations (ppb ww) in Carquinez Strait fish, 2023-2024. Bars indicate average concentrations. Points represent individual or composite samples. Advisory thresholds shown were set by the state of Massachusetts (California has not established PFOS thresholds).

PFOS is the most frequently detected PFAS compound in fish. It likely poses the greatest human health threat from consumption of fish. Starry flounder (4.2 ppb) and staghorn sculpin (2.7 ppb) exhibited the highest average PFOS concentrations among the species evaluated, with ranges of 2.7 ppb - 5.7 ppb and 2.2 ppb - 3.3 ppb, respectively (Figure 10). Striped bass (2.1 ppb) showed moderate concentrations, with individuals ranging between 0.64 ppb - 5.1 ppb. Jacksmelt (0.65 ppb) and leopard shark (0.37 ppb) had the lowest average PFOS concentrations among the species evaluated, with ranges of 0.45 ppb - 0.93 ppb and 0.33 ppb - 0.40 ppb respectively.

Starry flounder were included for the first time in the Bay-wide PFAS dataset, and one individual exhibited the highest PFOS concentration measured in this study, while the other individual showed a moderate level near the upper threshold adopted by Massachusetts. These two samples suggest starry flounder are a species of potential concern. Striped bass exhibited lower PFOS concentrations than those measured in the rest of the Bay, with average concentrations notably lower than values previously reported for fish collected in the North Bay. Leopard shark showed low PFOS

concentrations. Very low PFAS concentrations were measured in jacksmelt, with most compounds other than PFOS either not detected or present at trace levels.

While California has not yet established fish consumption advisory thresholds for PFAS, the concentrations measured in several species exceed advisory levels adopted by the state of Massachusetts (Massachusetts Department of Public Health 2023).

The continued prominence of PFOS - a compound whose production has been phased out in the United States - reinforces that existing environmental reservoirs, long residence times, and ongoing inputs from consumer products may contribute to sustained contamination levels.

A comparison of PFOS concentrations measured in striped bass collected for the 2019 RMP S&T sampling (Mendez et al. 2025) to the Carquinez Strait showed substantial differences between the two efforts (Figure 11). The average concentration in RMP striped bass (7.5 ppb) was higher than the average for the APP samples (2.1 ppb). The average PFOS concentration in RMP striped bass was more than three times the APP average, with only one APP fish having a higher concentration than the lowest RMP composite. It is important to note that the striped bass caught for the RMP effort were all from the Lower South Bay, a part of the Bay that has been shown to have relatively high PFAS contamination. PFOS and sum-PFAS concentrations in staghorn sculpin were also lower than those reported in a 2023 RMP prey fish study (Mendez et al. 2023).

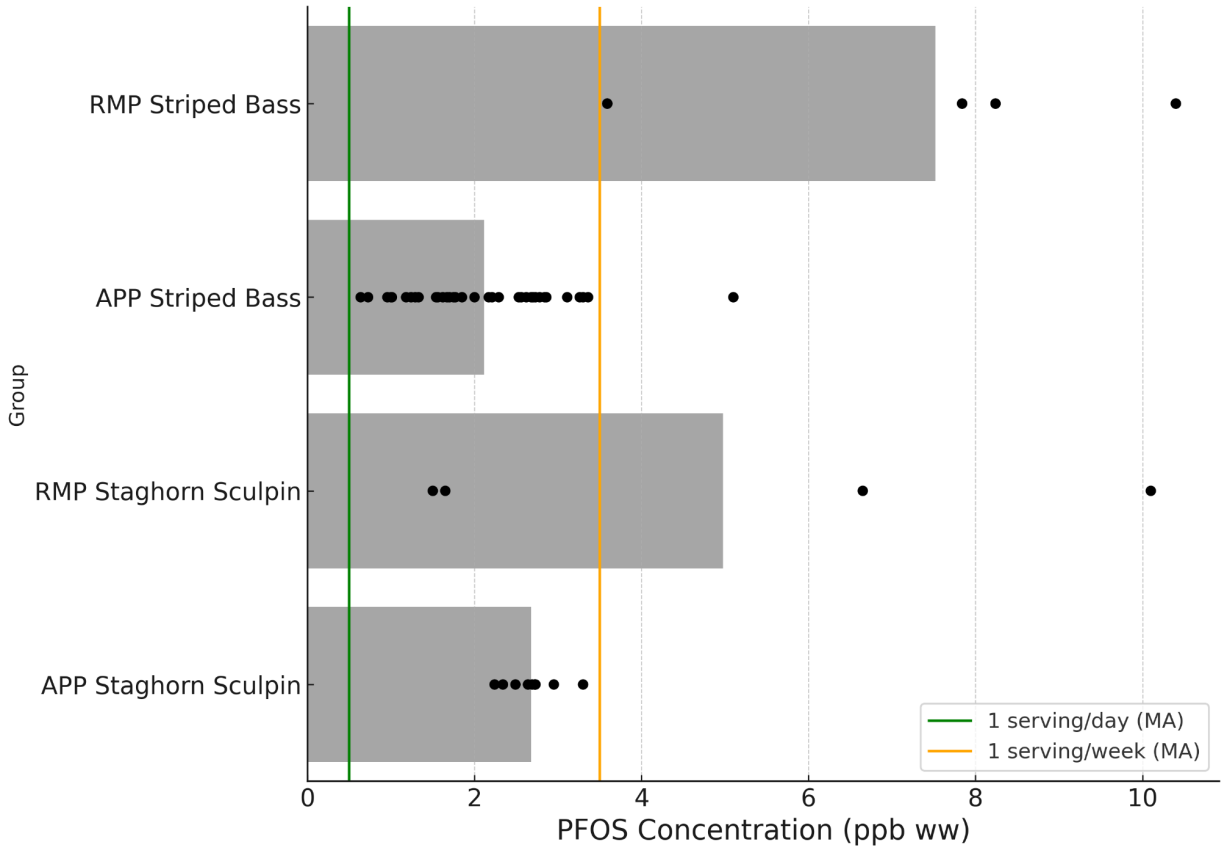

Figure 11. PFOS concentrations in striped bass collected for the 2019 RMP fish sampling effort and the Carquinez Strait Project (2023-2024). RMP striped bass were analyzed as composites and APP striped bass were analyzed as individuals.

The results of this study indicate that PFAS are detectable in multiple fish species in the Carquinez Strait, with PFOS as the dominant compound of concern. Concentrations measured in several species exceeded health thresholds established by other states, indicating that PFOS may pose a risk to frequent consumers of Bay fish, particularly those who rely on locally caught species as a dietary staple. These PFAS results underscore the importance of continued monitoring and management attention to this emerging contaminant class.

Conclusions and Potential Next Steps

The engagement of community members in the collection of fish in this study was novel for the Bay Area, and this has only been done in a handful of studies nationally. This element of the project was successfully implemented. This required development of new logistics to coordinate among team members, and training of community members in protocols for handling and storing fish specimens. The fish collected by community members yielded results that were similar to the results for the fish collected by the ICF environmental consultants. The similarity of these two datasets also indicates that the contaminant concentrations in fish collected by ICF via boat are similar to those for fish collected from the shoreline, indicating that fish collected by boat still provide a good index of contaminant exposure of shoreline fishers.

This study provided a thorough spatial assessment of contaminants in the Vallejo area, with four stations along a four-mile stretch of shoreline. Concentrations of mercury, PCBs, and PFAS were at levels of concern in Carquinez Strait fish. However, concentrations of contaminants in this area were generally lower than those observed in the most recent Bay-wide sampling by the RMP. Fish in the Carquinez Strait area are not clean, but they appear to be less contaminated than fish from other parts of the Bay.

A broader range of species and larger numbers of fish are needed for a more definitive assessment of contaminants in fish in this area. Due to the timing of the availability of the grant funds and initiation of the project, sampling was conducted in September-October for ICF and December-February for APP, rather than the summer period when more fishing occurs and when other species may be present. Sampling during the summer with consideration of methods to obtain additional species (especially shiner surfperch, if possible) would provide a better characterization of community exposure in this area. Analysis of prey fish, which have been shown in RMP studies to accumulate all of the contaminants measured in this study, would be a good way of confirming the relatively low levels observed to date.

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Appendix 1 - 2023 Fish Collection Cruise Report

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Appendix 2 - Data Management

1. Data Management and Reporting

Data received from the analytical laboratories are formatted, summed (see Section 2 below), QA/QC reviewed, and uploaded to the local Regional Data Center. These data are not publicly published to CD3 or CEDEN until the report is published. Data used for statistical analysis, figure development, and reporting are obtained only through Regional Data Center queries. Standard data query requests, rules, and additional data processing steps that were used in the current report are detailed below.

Standard Data Query Rules

1. Non-detect results are reported as half the method detection limit for inorganic compounds (mercury, selenium) and as zero for organic compounds (PCBs, dioxins, PBDEs, and PFASs). Organic sums are calculated by assuming non-detect results are equal to zero.
2. Rejected results are not reported (i.e., censored). Organic sums that are classified as “no reportable sum,” are not reported, but results for the individual congeners for those samples are reported if they are not themselves rejected. For PCBs and dioxins, other sums calculated by the lab for those samples are not reported. Qualified results are reported, along with the QACode field.
3. Laboratory replicates are not reported in this report. Replicates are not averaged, but are used only for evaluation of analytical precision. If the analytical precision meets data quality objectives in the RMP QAPP, results will not be qualified and only the first laboratory replicate (i.e., LabReplicate field = 1) is reported. If results from the first laboratory replicate are rejected, results from the second laboratory replicate should be reported, if they are not also rejected.
4. QA/QC results are not reported. Staff can review QA/QC results separately from data queries that are used for statistical analysis and figure development.

Standard Data Query Requests

Two standard data queries are produced – one with all data from the current year of sampling, and one with all historical data for species used in trend analysis. Data query requests should include the project codes, analyte names and/or groups (typically all individual congeners and the sums described in Section 2 are

reported), and fish species to be reported. Any deviations from the query rules above or fields listed in Table A-1 should be specified.

Additional Data Processing Steps

Several additional standard data processing steps are needed to ensure data are properly compared. The TissueCode and TissueName fields are FIL, MUSC, NADS or fillet, muscle, and gonads for muscle fillet, muscle plugs, and ovary samples, respectively. Samples collected in tissues not relevant to a particular analysis (i.e., comparison to OEHHA or Water Board thresholds) should be excluded.

2. Organic Contaminant Sums

Sums of organic contaminant classes are calculated by summing the concentrations of individual congeners within each contaminant class. Although some sums are provided by the laboratories, all organic sums are recalculated by the RMP using the rules described below. Six organics sums are calculated:

- Sum of 40 PCBs
- Sum of PCBs
- Sum of PFAS

Due to changes in analytical methods, different numbers of congeners are included in the "Sum of PCBs" measured each year.

Congeners included in all other sums are listed in Table 2 of the main report. These sums are calculated using a Summing Table saved in an Access Database that includes all current and historically reported congeners.

Organic sums are calculated by assuming non-detect results are equivalent to zero.

Table A-3. Sum of 40 PCBs analyte list. IUPAC numbers are listed

Polychlorinated Biphenyls (PCBs)			
PCB 008	PCB 066	PCB 118	PCB 170
PCB 018	PCB 070	PCB 128	PCB 174
PCB 028	PCB 074	PCB 132	PCB 177
PCB 031	PCB 087	PCB 138	PCB 180
PCB 033	PCB 095	PCB 141	PCB 183
PCB 044	PCB 097	PCB 149	PCB 187
PCB 049	PCB 099	PCB 151	PCB 194
PCB 052	PCB 101	PCB 153	PCB 195
PCB 056	PCB 105	PCB 156	PCB 201
PCB 060	PCB 110	PCB 158	PCB 203

Appendix 3 - Quality Assurance Report

2024 Carquinez Strait Sport Fish Tissue Data Quality Assurance Report

Introduction

In 2024, fish tissue samples were collected from four sites in the Carquinez Strait General descriptions of the sample collection methods are provided in the RMP Quality Assurance Program Plan, cruise plans, cruise reports, and field sampling reports. These documents are available from the SFEI website (http://www.sfei.org/content/status-and-trends- monitoring-documents).

Sport fish samples were analyzed for the following parameters by the laboratories indicated:

- MPSL-DFW : Mercury
- SGS-AXYS – PCBs and PFAS

The SFEI Data Services Team checked the laboratory results using the methods and data quality objectives in the RMP Quality Assurance Project Plan (QAPP).

This memo provides a high-level summary of the quality assurance assessment for each dataset. Non-conformances with the QAPP and possible indicators of variability and uncertainty in reported values, are highlighted in gray shading. The details of the quality assurance assessment for each dataset are provided in Appendix A.

The data have been approved by the RMP Manager and Lead Scientist, and all results have been uploaded to the San Francisco Regional Data Center and CEDEN.