OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Health Advisory and Guidelines for Eating Fish from San Francisco Bay (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties)

Updated April 2023

Fish, Ecotoxicology, and Water Section
Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

LIST OF CONTRIBUTORS

Office of Environmental Health Hazard Assessment

Project Leads

Huyen Tran Pham, M.P.H.
Lori Chumney, M.S.

Primary Reviewers

Wesley Smith, Ph.D.
Shannon R. Murphy, Ph.D.
Susan A. Klasing, Ph.D., Section Chief

Final Reviewers

Elaine Khan, Ph.D., Pesticide and Environmental Toxicology Branch Chief
Vincent Cogliano, Ph.D., Deputy Director for Scientific Programs
David Edwards, Ph.D., Chief Deputy Director

Director

Lauren Zeise, Ph.D.

ACKNOWLEDGMENTS

Developing fish consumption advisories depends on sampling and analysis of fish. The Office of Environmental Health Hazard Assessment acknowledges the contribution of information from the following entities: the California Department of Fish and Wildlife and its Water Pollution Control Laboratory, the Marine Pollution Studies Laboratory at Moss Landing Marine Laboratories, the San Francisco Bay Regional Monitoring Program (Steering Committee and Advisory Committee), the San Francisco Bay Regional Water Quality Control Board, the University of California Davis, and the San Francisco Estuary Institute. Data were obtained from a technical memorandum from CH2M HILL to United States Environmental Protection Agency and the California Environmental Data Exchange Network. The map was created using ArcMap (10.5) from Environmental Systems Resource Institute (ESRI, Redlands, California).

For further information, contact:

Pesticide and Environmental Toxicology Branch
Office of Environmental Health Hazard Assessment
California Environmental Protection Agency

1001 I Street, P.O. Box 4010
Sacramento, CA 95812-4010
Telephone: (916) 324-7572
Email address: fish@oehha.ca.gov

1515 Clay Street, 16th Floor
Oakland, CA 94612
Telephone: (510) 622-3170

LIST OF ACRONYMS AND ABBREVIATIONS

ATL	Advisory Tissue Level
BPTCP	Bay Protection and Toxic Cleanup Program, Regional Monitoring Program
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
DDT(s)	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE)
DHA	docosahexaenoic acid
DMA	direct mercury analyzer
EPA	eicosapentaenoic acid
FDA	United States Food and Drug Administration
Hg	mercury
ICP-MS	inductively coupled plasma-mass spectrometry
MDL	method detection limit
MeHg	methylmercury
MPSL	Marine Pollution Studies Laboratory at Moss Landing Marine Laboratories
mm	millimeters
NBB	North Bay Biosentinels Mercury Monitoring Project
OEHHA	Office of Environmental Health Hazard Assessment
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyls
ppb	parts per billion
RL	reporting limit
RMP	Regional Monitoring Program for Water Quality in San Francisco Bay
RMP EEPS	Regional Monitoring Program Exposure and Effects Pilot Study
RMP SEP	Regional Monitoring Program San Leandro Bay PCB Special Study
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
Se	selenium
UH	United Heckathorn Superfund 2008 Data Gaps Investigation
USDA	United States Department of Agriculture

US EPA United States Environmental Protection Agency

PREFACE

The Office of Environmental Health Hazard Assessment (OEHHA), a department in the California Environmental Protection Agency, is responsible for evaluating potential public health risks from chemical contamination of sport fish.[1] This includes issuing fish consumption advisories, when appropriate, for the State of California. OEHHA's authorities to conduct these activities are based on mandates in the:

- California Health and Safety Code
  - Section 59009, to protect public health
  - Section 59011, to advise local health authorities
- California Water Code
  - Section 13177.5, to issue health advisories.

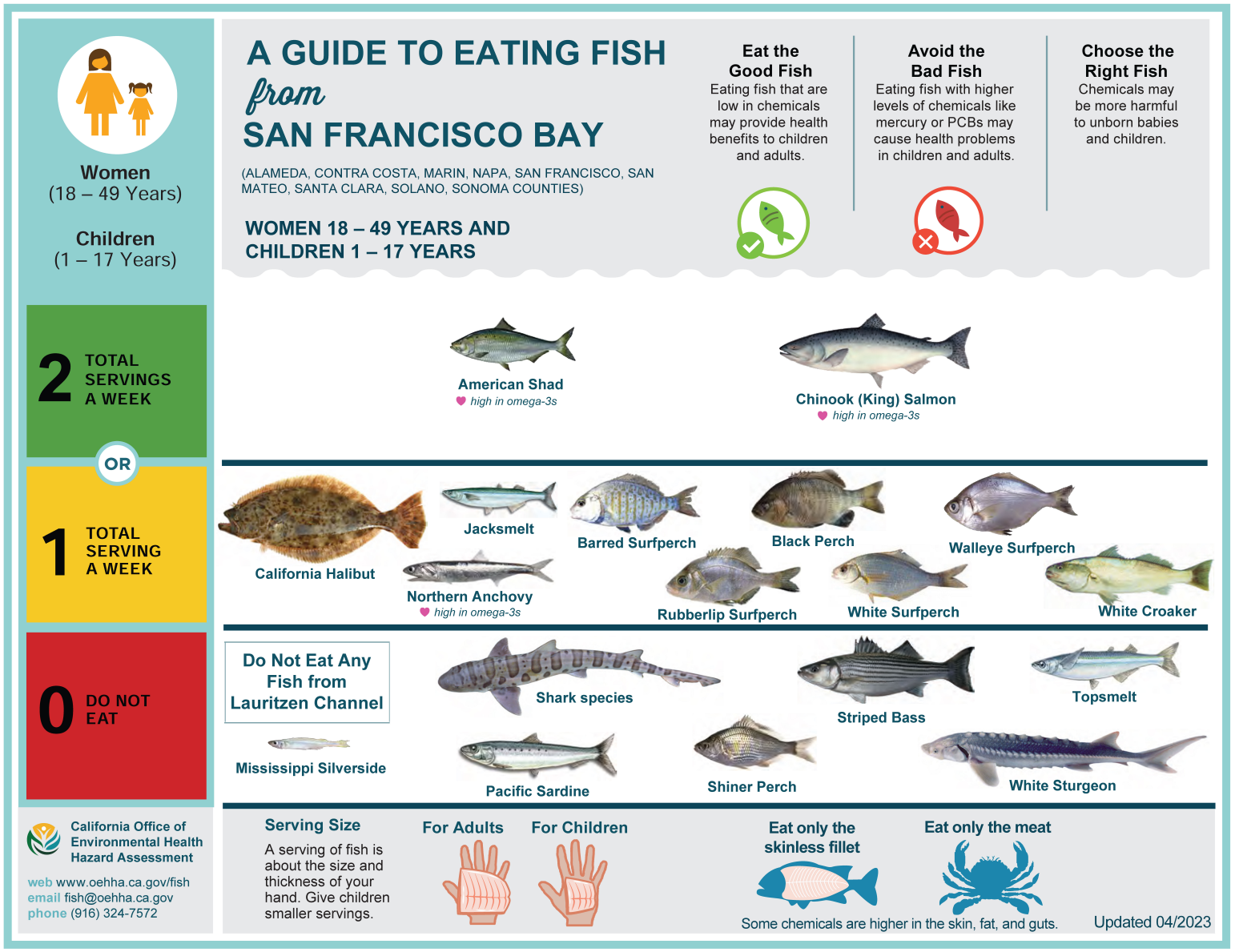
The health advisories are published in the California Department of Fish and Wildlife's (CDFW) Inland and Ocean Sport Fishing Regulations in their respective sections on public health advisories.[2]

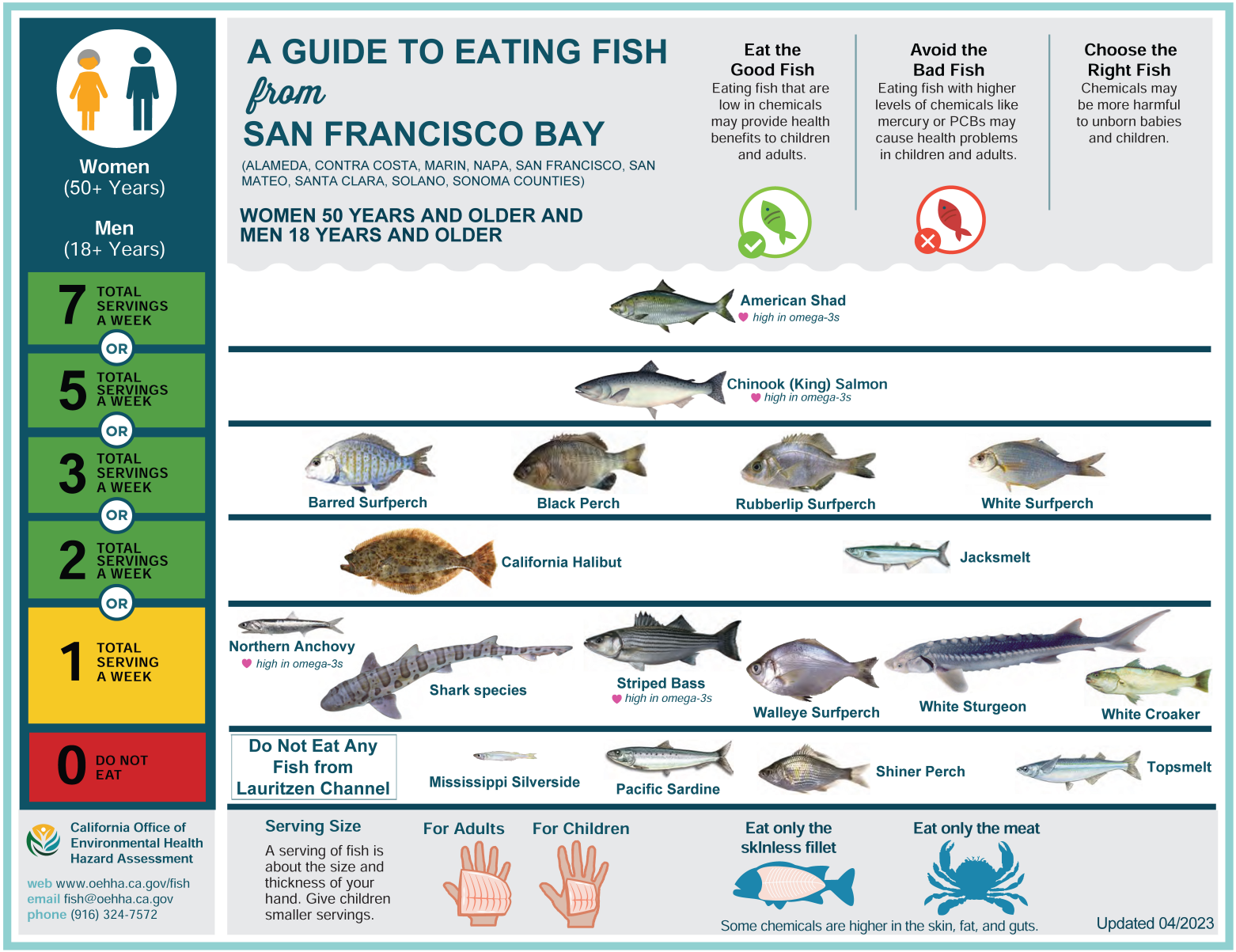
This report presents guidelines for eating fish from San Francisco Bay in Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma Counties. The report provides background information and a technical description of how the guidelines were developed. The resulting advice is summarized in the illustrations after the Table of Contents and the List of Figures and Tables.

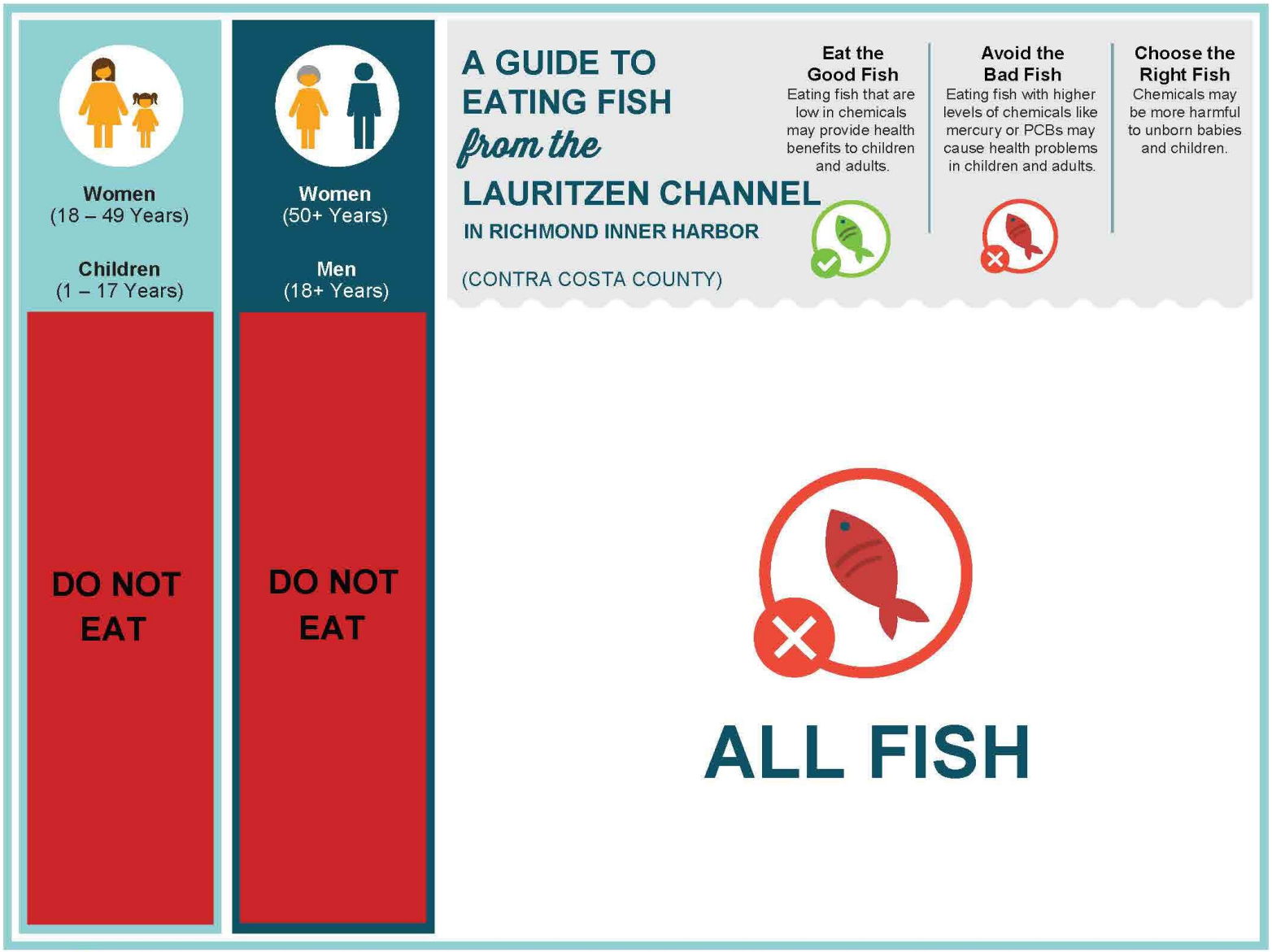
[1] Sport fish includes all fish and shellfish caught from California waters for non-commercial purposes (e.g., recreational, tribal/cultural, and subsistence practices).
[2] CDFW's Inland and Ocean Sport Fishing Regulations can be found online at: https://wildlife.ca.gov/Fishing/Inland and https://wildlife.ca.gov/Fishing/Ocean, respectively.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES


A GUIDE TO EATING FISH
from
SAN FRANCISCO BAY
(ALAMEDA, CONTRA COSTA, MARIN, NAPA, SAN FRANCISCO, SAN MATEO, SANTA CLARA, SOLANO, SONOMA COUNTIES)
WOMEN 18 – 49 YEARS AND CHILDREN 1 – 17 YEARS
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals like mercury or PCBs may cause health problems in children and adults.
Choose the Right Fish
Chemicals may be more harmful to unborn babies and children.
Women
(18 – 49 Years)
Children
(1 – 17 Years)
2 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
0 DO NOT EAT
American Shad
high in omega-3s
Chinook (King) Salmon
high in omega-3s
California Halibut
Jacksmelt
Barred Surfperch
Black Perch
Walleye Surfperch
Northern Anchovy
high in omega-3s
Rubberlip Surfperch
White Surfperch
White Croaker
Do Not Eat Any Fish from Lauritzen Channel
Mississippi Silverside
Shark species
Striped Bass
Topsmelt
Pacific Sardine
Shiner Perch
White Sturgeon
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572
Serving Size
A serving of fish is about the size and thickness of your hand. Give children smaller servings.
For Adults
For Children
Eat only the skinless fillet
Eat only the meat
Some chemicals are higher in the skin, fat, and guts.
Updated 04/2023


A GUIDE TO EATING FISH
from
SAN FRANCISCO BAY
(ALAMEDA, CONTRA COSTA, MARIN, NAPA, SAN FRANCISCO, SAN MATEO, SANTA CLARA, SOLANO, SONOMA COUNTIES)
WOMEN 50 YEARS AND OLDER AND MEN 18 YEARS AND OLDER
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals like mercury or PCBs may cause health problems in children and adults.
Choose the Right Fish
Chemicals may be more harmful to unborn babies and children.
Women (50+ Years)
Men (18+ Years)
7 TOTAL SERVINGS A WEEK
OR
5 TOTAL SERVINGS A WEEK
OR
3 TOTAL SERVINGS A WEEK
OR
2 TOTAL SERVINGS A WEEK
OR
1 TOTAL SERVING A WEEK
0 DO NOT EAT
American Shad
high in omega-3s
Chinook (King) Salmon
high in omega-3s
Barred Surfperch
Black Perch
Rubberlip Surfperch
White Surfperch
California Halibut
Jacksmelt
Northern Anchovy
high in omega-3s
Shark species
Striped Bass
high in omega-3s
Walleye Surfperch
White Sturgeon
White Croaker
Do Not Eat Any Fish from Lauritzen Channel
Mississippi Silverside
Pacific Sardine
Shiner Perch
Topsmelt
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572
Serving Size
A serving of fish is about the size and thickness of your hand. Give children smaller servings.
For Adults
For Children
Eat only the skinless fillet
Eat only the meat
Some chemicals are higher in the skin, fat, and guts.
Updated 04/2023


Women
(18 – 49 Years)
Children
(1 – 17 Years)
DO NOT EAT
Women
(50+ Years)
Men
(18+ Years)
DO NOT EAT
A GUIDE TO EATING FISH
from the
LAURITZEN CHANNEL
IN RICHMOND INNER HARBOR
(CONTRA COSTA COUNTY)
Eat the Good Fish
Eating fish that are low in chemicals may provide health benefits to children and adults.
Avoid the Bad Fish
Eating fish with higher levels of chemicals like mercury or PCBs may cause health problems in children and adults.
Choose the Right Fish
Chemicals may be more harmful to unborn babies and children.
ALL FISH
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
email fish@oehha.ca.gov
phone (916) 324-7572

SUMMARY

This report updates and supersedes the Office of Environmental Health Hazard Assessment's (OEHHA) 2011 advisory for consumption of fish caught from San Francisco Bay. It provides advice for safe consumption of eighteen species, of which four species were incorporated from the statewide advisory for fish that migrate: American Shad, Chinook (King) Salmon, Striped Bass, and White Sturgeon. Advice for two species, Red Rock Crab and Brown Rockfish, were removed from the advisory. Separate advice is provided for the sensitive population (women 18 to 49 years and children 1 to 17 years) and the general population (women 50 years and older and men 18 years and older).

To develop this advisory, OEHHA compared chemical levels in fish caught from more than 200 sampling locations to levels that are considered safe for human consumption. OEHHA's consumption guidelines balance the risks and benefits of fish consumption, as low-contaminant fish are part of a healthy, well-balanced diet. Fish are a good source of protein and vitamins, and are a primary dietary source of heart-healthy omega-3 fatty acids.

OEHHA recommends the number of servings of each covered species that may be eaten safely. A serving is about the size and thickness of your hand for fish fillets. Children should be given smaller servings. For small fish species, several individual fish may make up a serving. The advice is as follows:

Women 18–49 years and children 1–17 years

- **Should not eat:** Mississippi Silverside, Pacific Sardine, shark species, Shiner Perch, Striped Bass, Topsmelt, White Sturgeon, or any fish from the Lauritzen Channel.

- **May eat:**
  - One serving per week of California Halibut, Jacksmelt, Northern Anchovy, Barred Surfperch, Black Perch, Rubberlip Surfperch, Walleye Surfperch, White Surfperch, or White Croaker, or
  - Two servings per week of American Shad or Chinook (King) Salmon.

Women 50 years and older and men 18 years and older

- **Should not eat:** Mississippi Silverside, Pacific Sardine, Shiner Perch, Topsmelt, or any fish from the Lauritzen Channel.

- **May eat:**
  - One serving per week of Northern Anchovy, shark species, Striped Bass, Walleye Surfperch, White Sturgeon, or White Croaker, or
  - Two servings per week of California Halibut, Jacksmelt, or
  - Three servings per week of Barred Surfperch, Black Perch, Rubberlip Surfperch, White Surfperch, or
  - Five servings per week of Chinook (King) Salmon, or

- Seven servings per week of American Shad.

INTRODUCTION

This report updates and supersedes the previous guidelines developed in 2011 by the Office of Environmental Health Hazard Assessment (OEHHA) for eating fish from San Francisco Bay (Figure 1). The collection of additional data made it possible to update this advisory with the inclusion of Mississippi Silverside, Northern Anchovy, Pacific Sardine, and Topsmelt. Consumption advice for eating Barred Surfperch, Black Perch, California Halibut, Jacksmelt, Mississippi Silverside, Northern Anchovy, Pacific Sardine, Rubberlip Surfperch, shark species, Shiner Perch, Walleye Surfperch, White Surfperch, Topsmelt, and White Croaker is based on levels of mercury and/or PCBs found in fish collected from San Francisco Bay. American Shad, Chinook (King) Salmon, Striped Bass, and White Sturgeon are species that migrate between inland and coastal waters,[3] including those in the San Francisco Bay. Advice for these species, based on levels of mercury and/or PCBs, is also provided in the posters and in Table 6. See the statewide advisory for fish that migrate[4] for the data analysis and information used to develop the consumption advice for American Shad, Chinook (King) Salmon, Striped Bass, and White Sturgeon. The data for the Lauritzen Channel were analyzed separately; consumption advice for all fish from the Lauritzen Channel in Richmond Inner Harbor is based on the levels of dichlorodiphenyltrichloroethane and its metabolites (DDTs) and dieldrin.

OEHHA analyzed available data to see if advice could be provided regionally within the Bay (e.g., north or south of specific bridges). In general, mercury concentrations did not show regional trends. Although PCB levels were highly variable in some species, concentrations were not consistently elevated across multiple species in a particular region. Additionally, sample sizes were limited in certain areas of the Bay. Thus, with the exception of Lauritzen channel, regional advice within the Bay is not feasible at this time.

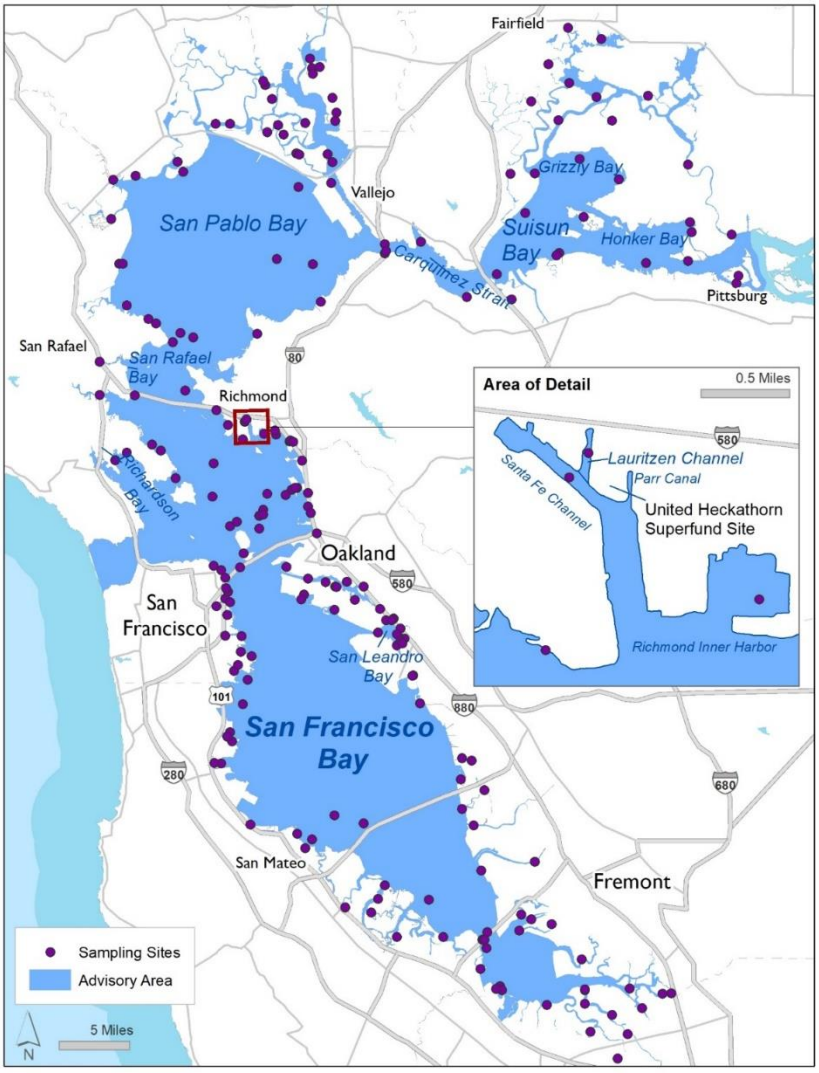
LOCATION

The San Francisco Bay and Delta region of California forms the largest estuary on the Pacific coast of the United States, covering up to about 1,600 square miles and draining more than 40 percent of the state, or 60,000 square miles.[5] San Francisco Bay consists of three parts: North, Central, and South. The northern part, San Pablo Bay, is connected to Suisun Bay by the Carquinez Strait, which receives water from the Sacramento and San Joaquin Rivers. The water then flows into the central, largest

[3] Steelhead Trout also migrate between inland and coastal waters but are not legal to take from the San Francisco Bay.
[4] The statewide advisory for fish that migrate between California rivers, estuaries, and coastal waters is online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.
[5] Information regarding the San Francisco Bay was obtained from the San Francisco Estuary Partnership and US EPA San Francisco Bay Delta Watershed.

portion, San Francisco Bay itself, and joins the Pacific Ocean by the Golden Gate strait. The southern part of the bay extends south of Highway 80 to the city of San Jose. The entire San Francisco Bay estuary includes San Pablo Bay, Suisun Bay, San Francisco Bay, and five other bays: Honker, Richardson, San Rafael, San Leandro, and Grizzly. This report and advisory covers the entire San Francisco Bay estuary, hereafter simply called "San Francisco Bay." Site-specific advice has previously been developed for rivers that flow into the San Francisco Bay, including the Sacramento River and Northern Delta[6] as well as for the Central and South Delta,[7] and is not part of this advisory.

FIGURE 1. LOCATION OF SAN FRANCISCO BAY



[6] Online at: https://oehha.ca.gov/advisories/sacramento-river-and-northern-delta
[7] Online at: https://oehha.ca.gov/fish/advisories/delta-central-and-south-0

The Lauritzen Channel is part of the United Heckathorn Superfund site, which encompasses five acres of land and approximately 15 acres of marine sediments in the Lauritzen Channel and Parr Canal of Richmond Inner Harbor.[8] United Heckathorn and other companies processed pesticides from 1947 to 1966 at the site, the majority of which was DDT. The California Department of Health Services documented contamination of soil samples with chlorinated pesticides and metals in 1980, more than a decade after United Heckathorn declared bankruptcy in 1966. In 1982, the area was designated a State Superfund site and, by 1990, it was placed on the National Priorities List by the US Environmental Protection Agency (US EPA). Remedial actions occurred from 1990 to 1999, which included excavating heavily contaminated areas, dredging the Lauritzen Channel and Parr Canal, and constructing a sand cap over the site. Monitoring and evaluation was conducted after remediation to assess effectiveness, which included fish tissue sampling in Richmond Inner Harbor in 2008. The results of the 2008 sampling event were incorporated in OEHHA's San Francisco Bay Advisory issued in 2011. DDT and dieldrin levels in fish collected from the Lauritzen Channel were much higher than the rest of Richmond Inner Harbor and San Francisco Bay overall; thus, separate advice recommending no consumption of all fish was developed for the Lauritzen Channel in 2011, and remains in effect for this update.

Approach Used

OEHHA used the results from six monitoring studies described in this report to develop the San Francisco Bay Advisory. OEHHA uses the following general process in developing consumption advice for sport fish:

1) Evaluation of all fish contaminant data available from a water body and selection of appropriate data that meet data quality criteria and sampling plan guidelines.
2) Determination of fish species for which adequate data are available to issue fish consumption advice.
3) Calculation of an appropriate measure of central tendency (often a weighted arithmetic mean)[9] and other descriptive statistics of the contaminant data, as appropriate, for a chemical of potential concern for the selected fish species.
4) Comparison of the chemical concentrations with the OEHHA Advisory Tissue Levels (ATLs) for each chemical of potential concern.
5) Development of final advice based on a thorough review of the data and best professional judgment relating to the benefits and risks of consuming a particular fish species.

[8] Information obtained from the US Department of Interior United Heckathorn NPL Site and US EPA United Heckathorn Superfund Site.

[9] Means are an arithmetic average of individual values and/or composites weighted by number of fish. A weighted average of composites is calculated by multiplying the chemical concentration in each composite by the number of fish in that composite for each species. Products are then summed and divided by the total number of fish in all composites for that species.

The ATLs (discussed further in a subsequent section of this report) are chemical levels in fish tissue that are considered acceptable, based on chemical toxicity, for a range of consumption rates. Development of the ATLs also includes consideration of health benefits associated with including fish in the diet (OEHHA, 2008). The ATLs should not be interpreted as static "bright lines," but as one component of a complex process of data evaluation and interpretation used by OEHHA in the assessment and communication of the benefits and risks of consuming sport fish.

CHEMICALS OF POTENTIAL CONCERN

Certain chemicals, because of their toxicity and their ability to accumulate in fish tissue, are of potential concern for people who eat fish. The majority of fish consumption advisories in California are issued because of mercury (Hg), followed by polychlorinated biphenyls (PCBs) and, in a few cases, selenium (Se), polybrominated diphenyl ethers (PBDEs), or some legacy pesticides (pesticides that are no longer used but remain in the environment).

Mercury is an element found in some rocks and soil. Human activities, such as burning coal and the historical use of mercury to mine gold, also add mercury to the environment. If mercury enters waterways, it can be converted to a more toxic form known as methylmercury – which can pass into and build up in fish. High levels of methylmercury can harm the brain, especially in fetuses and children, whose brains are still developing.

PCBs are industrial chemicals previously used in electrical transformers, plastics, and lubricating oils, and were often used as flame retardants or electrical insulators. Their use was banned in the 1970s, but they can accumulate in fish because they do not break down easily and they persist in the environment. Depending on the exposure level, PCBs may cause cancer or other health effects, including neurotoxicity, in humans.

Selenium is an element and at low doses is an essential nutrient for many important human health processes, including thyroid regulation and vitamin C metabolism. Higher doses cause selenium toxicity, which can include symptoms ranging from hair loss and gastrointestinal distress to dizziness and tremors.

PBDEs are a class of flame retardants historically used in a variety of consumer products, including furniture, textiles, automotive parts, and electronics. The use of PBDEs in new products was largely phased out by 2013 but, due to their wide usage and persistence in the environment, they are still being detected in fish tissues. PBDEs may affect hormone levels or learning and behavior in children.

Chlordanes, DDT, dieldrin, and toxaphene are pesticides that were banned from use in 1973 (DDT), the late 1980s (chlordanes and dieldrin) and 1990 (toxaphene), but are still found in some fish in certain California water bodies. Depending on the exposure level, these chemicals may cause cancer or adverse effects on the nervous system.

A detailed discussion of the toxicity of these chemicals is presented in "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene" (OEHHA, 2008) and "Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)" (OEHHA, 2011).

All fish species collected and used in advisory development for San Francisco Bay were analyzed for mercury and PCBs. Some fish were analyzed for PBDEs, selenium, and legacy pesticides as indicated in Table 1. For the Lauritzen Channel, all fish were analyzed for DDTs and dieldrin as indicated in Table 2.

DATA SOURCES

The guidelines for eating fish from San Francisco Bay are based on the chemicals detected in the fish collected for the six monitoring studies described below. These studies met OEHHA's data quality criteria, including adequate documentation of sample collection, fish preparation methods (e.g., skinning or filleting), chemical analyses, quality assurance, and sufficiently low detection limits. "Sample," as used in this report, refers to an individual fish or a composite of multiple fish for which contaminant data were reported. "Sampling" or "sampled" refers to the act of collecting fish for chemical analysis. The studies or entities contributing data to this advisory are described below.

Bay Protection and Toxic Cleanup Program, Regional Monitoring Program (BPTCP)

The BPTCP funded a pilot study in 1994 to identify chemicals, fish species, and geographical regions of concern in San Francisco Bay (SFBRWQCB, 1995). This study was managed by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) and conducted by the California Department of Fish and Wildlife (CDFW, formerly the CA Department of Fish and Game). Sites were sampled throughout the Bay to characterize the extent and severity of contamination. Brown Smooth-Hound Shark, California Halibut, Leopard Shark, Shiner Perch, Walleye Surfperch, White Croaker, and White Surfperch were collected in 1994 and analyzed for mercury and selenium.

Regional Monitoring Program for Water Quality in San Francisco Bay (RMP)

Established in 1993, the RMP is a partnership between regulatory agencies and the regulated community in the San Francisco Bay Area. Program activities, including sport fish monitoring, are planned and overseen by committees composed of waste dischargers, industry representatives, regulators, scientists, and community advocates. One of the objectives for the RMP is to produce the information needed for developing and updating fish consumption advisories. RMP contaminant monitoring data for Barred Surfperch, Black Perch, Brown Smooth-Hound Shark, California Halibut, Jacksmelt, Leopard Shark, Northern Anchovy, Pacific Sardine, Rubberlip Surfperch,

Shiner Perch, Walleye Surfperch, White Croaker, and White Surfperch in San Francisco Bay were collected from 1997 to 2014 and analyzed for mercury and PCBs. Some species were additionally analyzed for selenium, PBDEs, and legacy pesticides.

RMP Exposure and Effects Pilot Study (RMP EEPS)

The San Francisco Bay Regional Monitoring Program created the Exposure and Effects Pilot Study (EEPS) to address questions on beneficial use management developed by the SFBRWQCB. The EEPS evaluated the effects and exposure of mercury at different spatial and temporal scales throughout the bay (SFEI, 2010). Mississippi Silverside, Northern Anchovy, and Topsmelt were collected and analyzed for mercury between 2005 and 2010. In 2007 and 2010, sampling for PCBs was added to the study to evaluate the potential for forage fish (Mississippi Silverside, Topsmelt) to be used as a biosentinel indicator of PCB contamination (Greenfield and Allen, 2013). PBDEs and legacy pesticides were also analyzed in Topsmelt in 2007.

United Heckathorn Superfund 2008 Data Gaps Investigation (UH)

In 2008, US EPA contracted CH2M HILL to evaluate DDT and dieldrin concentrations in fish near the former United Heckathorn facility: Lauritzen Channel, Richmond Inner Harbor, Santa Fe Channel, and Parr Canal. Using these data, US EPA performed human and ecological health assessments for use in evaluating clean-up alternatives for the remaining contamination (CH2M Hill, 2008). Larger fish were prepared as skin-on fillets and smaller fish were prepared as whole organisms. Results suggest that only samples from the Lauritzen Channel were highly contaminated with dieldrin or DDTs. Thus, only results from the Lauritzen Channel will be shown in this report. Species collected in the Lauritzen Channel include anchovy, goby, Jacksmelt, sculpin, Shiner Perch, and Starry Flounder.

North Bay Biosentinels Mercury Monitoring Project (NBB)

The NBB was a joint project between the San Francisco Estuary Institute and the University of California at Davis to monitor methylmercury in wetland restoration projects in the North Bay (Robinson et al., 2018). Sampling was conducted in two phases, 2012–2013 and 2016–2017, to answer management questions identified by scientists and stakeholders. Mississippi Silverside, Northern Anchovy, and Topsmelt were analyzed for mercury as part of the program.

RMP San Leandro Bay PCB Special Study (RMP SEP)

The RMP developed a series of PCB special studies for the PCBs Total Maximum Daily Load review and Municipal Regional Permit for Stormwater reissuance (Davis et al., 2017). San Leandro Bay was selected as one of four high priority areas to monitor along the margins of the San Francisco Bay. Topsmelt was analyzed for PCBs in 2016 as part of this study.

CHANGES FROM THE 2011 ADVISORY

This update includes the following changes and additions to the 2011 San Francisco Bay advisory:[10]

1) This advisory contains updated advice for consumption of American Shad, Chinook (King) Salmon, Striped Bass, and White Sturgeon from waters with access to the ocean. American Shad is a newly added species and was not part of the 2011 advisory. OEHHA refers consumers to the advisory for fish that migrate[11] for the data analysis and most up-to-date recommendations for these species.

2) Red Rock Crab advice was removed while OEHHA evaluates other contaminants in this species that may affect advice. Brown Rockfish advice was removed because there was an insufficient number of samples of minimum edible size.

3) Consumption advice for Mississippi Silverside, Northern Anchovy, Pacific Sardine, and Topsmelt was added to the advisory because additional data became available.

4) Consumption advice for Jacksmelt decreased from 2 servings a week for the sensitive population to 1 serving a week. The advice for the general population remained the same at 2 servings per week.

5) Consumption advice for all surfperch species was previously issued as a grouped category in 2011. Surfperch species advice is now categorized into three separate groups: Shiner Perch and Walleye Surfperch as individual species, and Barred Surfperch, Black Perch, Rubberlip Surfperch, White Surfperch as a group based on similar contaminant levels. White Surfperch is a newly added species to this group.

FISH SAMPLED FROM SAN FRANCISCO BAY

The fish sampling data used in this advisory were retrieved from the California Environmental Data Exchange Network,[12] the state's repository for environmental data, and from a technical memorandum from CH2M HILL to US EPA on the United Heckathorn Superfund tissue sampling results (CH2M Hill, 2008). Samples were excluded when the fish were not legal size to take or did not meet OEHHA's criteria for minimum "edible" size, based on species size at maturity and professional judgment (as described in OEHHA, 2022), except for the Northern Anchovy and Topsmelt samples

[10] In 2018, OEHHA updated the age ranges for women in each population group. The sensitive population changed from 18 – 45 years to 18 – 49 years, and the general population from changed from 46 years and older to 50 years and older.
[11] Online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.
[12] Online at: http://ceden.waterboards.ca.gov/AdvancedQueryTool.

from San Francisco Bay and all species collected from the Lauritzen Channel for the UH study.

There were three mercury samples of 28 fish and one PCB sample of 20 fish for Northern Anchovy that met the minimum edible length of 100 mm for this species. Since mercury and PCB levels in samples above and below the minimum edible length were similar, and the development of advice for Northern Anchovy would provide health-protective guidance for San Francisco Bay consumers, OEHHA elected to issue advice for Northern Anchovy based on a data set that includes samples without length data (for mercury) and those below the minimum edible length (for mercury and PCBs).

Samples used to develop advice for Topsmelt in San Francisco Bay were either below the minimum edible length of150 mm or length data were not reported. However, as the PCB levels observed in both undersized and missing length samples resulted in do-not-consume advice for both the sensitive and general populations, OEHHA elected to issue advice for Topsmelt based on samples without length data and those below the minimum edible length.

Only two Shiner Perch and five Jacksmelt individuals sampled in the Lauritzen Channel for the UH study were above OEHHA's minimum edible size of 100 mm and 150 mm, respectively. However, given the elevated levels of DDTs and/or dieldrin in all species of all lengths in the Lauritzen Channel, OEHHA deemed it appropriate to develop advice based on the full set of available data for these species.

A summary of all fish species evaluated for San Francisco Bay and the Lauritzen Channel is shown in Tables 1 and 2, respectively, including the name of the species, number of samples collected, total number of fish, project name, year sampled, and contaminants analyzed.

TABLE 1. FISH SAMPLES EVALUATED FOR THE SAN FRANCISCO BAY ADVISORY

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[a]
Barred Surfperch	*Amphistichus argenteus*	3	10	RMP	2003, 2006, 2014	Hg, PCBs
		1	3	RMP	2006	PBDEs
Black Perch	*Embiotoca jacksoni*	11	53	RMP	2003, 2006, 2014	Hg, PCBs
		6	18	RMP	2006	PBDEs
Brown Smooth-Hound Shark	*Mustelus henlei*	4	12	BPTCP	1994	Hg, Se
		3	9	RMP	2003	PCBs
		9	9	RMP	2003	Hg
California Halibut	*Paralichthys californicus*	1	3	BPTCP[b]	1994	Hg, Se
		20	20	RMP	1997, 2000, 2003	Hg
		3	9	RMP	2000	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Toxaphene
		2	5	RMP	2003	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Toxaphene
		1	3	RMP	2009	Dieldrin
		3	9	RMP	2009	Chlordanes, DDTs, Hg, PBDEs, PCBs, Se
		2	6	RMP	2014	Hg, Se
Jacksmelt	*Atherinopsis californiensis*	2	10	RMP	2009	Dieldrin
		4	20	RMP	2009	Chlordanes, DDTs, Hg, PBDEs, PCBs, Se
		12	60	RMP[c]	1997	Hg
		20	110	RMP[c]	2000, 2003	PCBs
		19	95	RMP[c]	2000, 2003	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, Toxaphene
		6	49	RMP[c]	2014	Hg, Se
Leopard Shark	*Triakis semifasciata*	3	8	BPTCP[b]	1994	Hg, Se
		54	68	RMP	1997, 2000, 2003, 2009	Hg
		11	33	RMP	2000, 2003	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Toxaphene

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[a]
Leopard Shark	*Triakis semifasciata*	3	9	RMP	2009	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Se
Mississippi Silverside[c]	*Menidia audens*	389	1738	RMP EEPS	2005, 2007– 2010	Hg
		123	4997	NBB	2012–2013, 2016–2017	Hg
		11	246	RMP EEPS	2010	PCBs
Northern Anchovy[c]	*Engraulis mordax*	24	101	RMP EEPS	2008–2010	Hg
		19	138	NBB	2016–2017	Hg
		2	16	RMP	2003	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, PCBs, Toxaphene
		3	80	RMP	2006	Hg, PBDEs, PCBs
		9	338	RMP	2009	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Se
		6	140	RMP	2014	Hg, PCBs
Pacific Sardine[c]	*Sardinops sagax*	1	10	RMP	2003	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, PCBs, Toxaphene
		1	10	RMP	2014	PCBs
Rubberlip Surfperch	*Rhacochilus toxotes*	3	9	RMP	2006	Hg, PBDEs, PCBs
Shiner Perch[c]	*Cymatogaster aggregata*	8	160	BPTCP	1994	Hg, Se
		15	300	RMP	1997	Hg
		29	579	RMP	2000, 2003	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, PCBs, Toxaphene
		9	180	RMP	2006	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs
		6	110	RMP	2009	Dieldrin
		14	243	RMP	2009	Chlordanes, DDTs, Hg, PBDEs, PCBs, Se
		7	140	RMP	2014	Hg, PBDEs, PCBs, Se

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[a]
Topsmelt[c]	*Atherinops affinis*	30	2709	NBB	2012–2013, 2016	Hg
		6	60	RMP EEPS	2007	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs
		698	3060	RMP EEPS	2005, 2007–2010	Hg
		17	186	RMP EEPS	2010	PCBs
		24	480	RMP SEP	2016	PCBs
Walleye Surfperch	*Hyperprosopon argenteum*	1	5	BPTCP[b]	1994	Hg, Se
		2	10	RMP[b]	2003	Hg, PCBs
		2	6	RMP[b]	2006	Hg, PBDEs, PCBs
		1	7	RMP	2014	Hg, PCBs
White Croaker	*Genyonemus lineatus*	25	125	BPTCP[b]	1994	Hg, Se
		12	60	RMP[b]	1997	Hg
		15	75	RMP[b]	2000	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, PCBs, Toxaphene
		11	55	RMP[b]	2003	Chlordanes, DDTs, Dieldrin, Hg, PBDEs, PCBs, Toxaphene
		9	45	RMP[b]	2006	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs
		12	60	RMP	2009	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Se
		11	54	RMP[c]	2014	PCBs
		12	59	RMP[c]	2014	Hg, Se
White Surfperch	*Phanerodon furcatus*	3	15	BPTCP[b]	1994	Hg, Se
		2	20	RMP	2014	Hg, PCBs

Samples were analyzed as skinless fillets, with the following exceptions:

[a] Data for organic chemicals (chlordanes, DDTs, dieldrin, PCBs or toxaphene) generated prior to 2000 were excluded from the analysis because data that are more recent are considered more reliable due to improved analytical methods and are likely to be more representative of fish caught today.

[b] Study analyzed fillets with skin-on.

[c] Samples were analyzed as whole organisms, including the head, skin, internal organs, muscle, and bones or whole organisms without the head, tail, and guts.

TABLE 2. FISH SAMPLES EVALUATED FOR THE UNITED HECKATHORN STUDY IN LAURITZEN CHANNEL

Common Name	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed
Anchovy	*Engraulidae spp.*	3	129	UH	2008	DDTs, Dieldrin
Goby	*Gobiiformes spp.*	1	2	UH	2008	DDTs, Dieldrin
Jacksmelt[a]	*Atherinopsis californiensis*	5	5	UH	2008	DDTs, Dieldrin
Sculpin	*Cottoidea spp.*	4	9	UH	2008	DDTs, Dieldrin
Shiner Perch	*Cymatogaster aggregata*	5	7	UH	2008	DDTs, Dieldrin
Starry Flounder	*Platichthys stellatus*	2	6	UH	2008	DDTs, Dieldrin

Samples were analyzed as whole organisms, including the head, skin, internal organs, muscle, and bones, with the following exception:
[a] Jacksmelt were analyzed as skin-on fillets.

CHEMICAL CONCENTRATIONS

As shown in Table 1, samples were analyzed for one or more of the following: total mercury, selenium, chlordanes (3–5 congeners), DDTs (5–6 congeners), dieldrin, toxaphene, PBDEs (3–26 congeners), and PCBs (3–158 congeners).[13] With the exception of the Lauritzen Channel, only mercury and PCB levels were sufficiently high in fish tissue samples to impact consumption advice. DDTs and dieldrin were the primary contaminants of concern only in the Lauritzen Channel, where the United Heckathorn Superfund site is located.

All fish samples were prepared as skinless fillets, except as noted in Tables 1 and 2, where certain species were analyzed as skin-on fillets or whole organisms. Jacksmelt and White Croaker were analyzed as both fillets and whole organisms without the head, tail, and guts. Mississippi Silverside, Northern Anchovy, Pacific Sardine, Shiner Perch, and Topsmelt were analyzed as whole organisms or whole organisms without the head, tail, and guts. All species analyzed in the Lauritzen Channel as part of the UH study were whole organisms except Jacksmelt, which were analyzed as skin-on fillets. Samples were analyzed as individual fish or composites.

[13] Congeners are related compounds with similar chemical forms. Five and six congeners are typically analyzed for chlordanes and DDTs, respectively. Of the 209 possible PBDE and PCB congeners, 6–7 and 48–54 are generally analyzed, respectively. Only 10% of PCB samples were analyzed for 158 congeners as part of the 2010 RMP EEPS study.

For San Francisco Bay and the Lauritzen Channel, OEHHA used the weighted (by the number of individual fish) average (arithmetic mean) of the chemical concentrations (in wet weight) for each fish species to estimate average human exposure.

MERCURY

Samples were analyzed for total mercury, as either individual fish or composite samples, using a direct mercury analyzer (DMA) at the Marine Pollution Studies Laboratory at Moss Landing Marine Laboratories (MPSL). Some studies used other laboratories for analyses. The DMA method utilizes thermal decomposition and atomic absorption. OEHHA assumed all mercury detected was methylmercury, which is the most common form found in fish and is also the more toxic form (Bloom, 1992). Some samples were analyzed for mercury using cold vapor atomic fluorescence spectrometry or a flow injection mercury system. Table 3 shows the tissue type, averages, and ranges for total length,[14] as well as mercury concentrations in each fish species from San Francisco Bay. Depending on the study, the method detection limits (MDLs)[15] for total mercury ranged from 0.3 to 38.6 parts per billion (ppb), and reporting limits (RLs)[16] ranged from 0.8 to 50 ppb.

PCBS, PBDES, AND PESTICIDES

Pesticides, PBDEs, and PCBs in either individual fish or composite samples were analyzed by gas chromatography at the CDFW Water Pollution Control Laboratory. Some studies used other laboratories for analyses. For chlordanes, DDTs, PCBs, and PBDEs, each of the concentrations presented was the sum of the detected parent compound, congeners, or metabolites, where applicable. Because the MDLs or RLs were relatively low (generally less than ≤ 5 ppb), individual congeners or metabolites with concentrations reported as non-detects were assumed to be zero. This is a standard method of handling non-detect values for PCBs and other chemicals with multiple congeners or metabolites in a given sample when detection levels are adequate (US EPA, 2000a). Table 4 shows the tissue type, averages and ranges for total length, as well as PCB concentrations in each fish species in San Francisco Bay. Table 5 shows tissue type, ranges for length, and DDT and dieldrin concentrations in fish species in the Lauritzen Channel. Only minimum and maximum lengths were reported in samples collected for the UH study, thus average lengths are omitted in Table 5.

[14] Total length is the maximum length of the fish, measured from the tip of the closed mouth to the tip of the pinched tail fin.
[15] The MDL is the lowest quantity of a chemical that can be distinguished (as greater than zero) in a sample.
[16] The RL is the lowest quantity of a chemical that can be accurately quantified in a sample.

SELENIUM

The MPSL analyzed species collected from San Francisco Bay for selenium as composite samples, using inductively coupled plasma-mass spectrometry (ICP-MS). Some studies used other laboratories for analyses. The ICP-MS method uses desolvation, atomization, and ionization with ion separation based on a mass-to-charge ratio to detect the total selenium concentration in a sample. The MDL for total selenium ranged from 30 to 150 ppb, depending on the study, and the RL was 400 ppb.

Concentrations of chlordanes, dieldrin, DDTs, PBDEs, selenium, and toxaphene in San Francisco Bay were lower than the corresponding ATL threshold values for daily consumption (OEHHA, 2008 and 2011). With the exception of the Lauritzen Channel, where dieldrin and DDT levels were elevated (Table 5), and the multiple chemical exposure assessment for San Francisco Bay, these chemicals were not considered further for developing consumption advice and are not shown in this report.

TABLE 3. MERCURY CONCENTRATIONS IN FISH FROM SAN FRANCISCO BAY

Species from San Francisco Bay	Tissue Type[a]	Number of Samples	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	Mercury (ppb)	
						Mean[b]	Range[c]
California Halibut	F, combined[d]	26	38	754	570 – 1,020	320	174 – 2,060
	F, skin-off	25	35	749	570 – 1,020	331	174 – 2,060
	F, skin-on	1	3	807	n/a	197	n/a
Jacksmelt	F, skin-off[e]	4	20	263	240 – 279	85	73 – 103
	WOHTG	37	204	262	180 – 342	69	15 – 255
Mississippi Silverside[f]	W	512	6,735	54	40 – 87	82	13 – 343
Northern Anchovy[f]	W and WOHTG	54	475	74	45 – 131	67	14 – 328
Black Perch, Barred, Rubberlip, and White Surfperch Group	F, combined[d]	22	107	247	154 – 400	162	68 – 427
Barred Surfperch	F, skin-off	3	10	259	180 – 310	366	287 – 405
Black Perch	F, skin-off	11	53	225	154 – 300	112	68 – 178
Rubberlip Surfperch	F, skin-off	3	9	378	350 – 400	349	268 – 427
White Surfperch	F, combined[d]	5	35	242	182 – 290	132	98 – 162
	F, skin-off	2	20	232	182 – 290	129	98 – 159
	F, skin-on	3	15	255	235 – 272	137	102 – 162
Pacific Sardine	WOHTG	1	10	211	190 – 220	0	n/a

Species from San Francisco Bay	Tissue Type[a]	Number of Samples	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	Mercury (ppb)	
						Mean[b]	Range[c]
Sharks species	F, combined[d]	70	97	980	630 – 1,360	933	235 – 2,020
Brown Smooth-Hound Shark	F, skin-off	13	21	689	630 – 800	698	235 – 1,380
Leopard Shark	F, combined[d]	57	76	1,060	920 – 1,360	998	495 – 2,020
	F, skin-off	54	68	1,037	920 – 1,360	975	495 – 2,020
	F, skin-on	3	8	1,262	1,219 – 1,296	1,190	1,010 – 1,260
Shiner Perch	WOHTG	73	1,422	118	100 – 199	108	39 – 420
Topsmelt[e]	W	728	5,769	44	26 – 112	39	15 – 235
Walleye Surfperch	F, combined[d]	6	28	247	170 – 340	142	84 – 184
	F, skin-off	1	7	224	204 – 256	152	n/a
	F, skin-on	5	21	255	170 – 340	138	84 – 184
White Croaker	F, skin-on	63	315	252	167 – 320	207	69 – 414
	WOHTG[e]	12	59	229	200 – 314	149	72 – 453

[a] W = whole organism, WOHTG = whole organism without head, tail, guts, F = fillet
[b] Means are an arithmetic average of individual values and/or a weighted average of composites
[c] Range of individuals and/or range of the composites
[d] "Combined" includes data for both skin-on and skin-off samples
[e] Shown for reference only, not taken into consideration for serving advice
[f] Includes samples missing length; lengths shown are where reported
n/a = not applicable due to a single sample

TABLE 4. PCB CONCENTRATIONS IN FISH FROM SAN FRANCISCO BAY

Species from San Francisco Bay	Tissue Type[a]	Number of Samples	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	PCBs (ppb)	
						Mean[b]	Range[c]
California Halibut	F, skin-off	8	23	707	570 – 910	18	5 – 33
Jacksmelt	F, skin-off[d]	4	20	263	240 – 279	22	9 – 40
	WOHTG	20	110	267	200 – 300	33	0--106
Mississippi Silverside	W	11	246	60	46 – 76	341	30 – 1,337
Northern Anchovy	WOHTG	20	574	90	65 – 131	104	37 – 419
Black Perch, Barred, Rubberlip, and White Surfperch Group	F, skin-off	19	92	245	154 – 400	8	2 – 21
Barred Surfperch	F, skin-off	3	10	259	180 – 310	14	5 – 21
Black Perch	F, skin-off	11	53	225	154 – 300	6	2 – 12
Rubberlip Surfperch	F, skin-off	3	9	378	350 – 400	8	8 – 9
White Surfperch	F, skin-off	2	20	232	182 – 290	9	7 – 10
Pacific Sardine	WOHTG	2	20	234	190 – 276	137	27 – 247
Sharks species	F, skin-off	17	51	1,009	630 – 1,360	15	2 – 44
Brown Smooth-Hound Shark	F, skin-off	3	9	721	630 – 800	9	4 – 18
Leopard Shark	F, skin-off	14	42	1,071	915 – 1,360	17	2 – 44
Shiner Perch	WOHTG	59	1,142	116	100 – 199	131	33 – 365
Topsmelt[e]	W	47	726	80	53 – 105	218	77 – 1,347

Species from San Francisco Bay	Tissue Type[a]	Number of Samples	Total Number of Fish	Mean[b] Total Length (mm)	Range of Total Lengths[c] (mm)	PCBs (ppb)	
						Mean[b]	Range[c]
Walleye Surfperch	F, combined[f]	5	23	254	170 – 340	43	3 – 105
	F, skin-off	1	7	224	204 – 256	8	n/a
	F, skin-on	4	16	267	170 – 340	58	3 – 105
White Croaker	F, skin-off	12	60	256	200 – 300	52	8 – 123
	F, skin-on[d]	35	175	271	190 – 340	244	80 – 519
	WOHTG[d]	11	54	229	200 – 314	167	81 – 410

[a] W = whole organism, WOHTG = whole organism without head, tail, guts, F = fillet
[b] Means are an arithmetic average of individual values and/or a weighted average of composites
[c] Range of individuals and/or range of the composites
[d] Shown for reference only, not taken into consideration for serving advice
[e] Includes samples missing length; lengths shown are where reported
[f] "Combined" includes data for both skin-on and skin-off samples
n/a = not applicable due to a single sample

TABLE 5. DIELDRIN AND DDT CONCENTRATIONS IN FISH FROM LAURITZEN CHANNEL SAMPLED IN THE UNITED HECKATHORN SUPERFUND DATA GAPS INVESTIGATION 2008

Species from Lauritzen Channel	Tissue Type[a]	Number of Samples	Total Number of Fish	Range of Lengths (mm)[b]	DDTs (ppb)		Dieldrin (ppb)	
					Mean[c]	Range[d]	Mean[c]	Range[d]
Anchovy	W	3	129	25 – 51	640	497 – 733	63	55 – 69
Goby	W	1	2	32 – 64	5,863	n/a	320	n/a
Jacksmelt	F, skin-on	5	5	203 – 305	194	28 – 398	56	10 – 96
Sculpin	W	4	9	64 – 127	1,085	745 –1,648	110	72 – 130
Shiner Perch	W	5	7	89 – 114	4,879	602 – 11,000	280	130 – 550
Starry Flounder	W	2	6	38 – 102	3,406	2,743 – 6,721	200	180 – 300

[a] W = whole organism, F = fillet
[b] UH study did not report how length was measured, i.e., total, fork, or standard; average length is not shown since only minimum and maximum lengths were reported
[c] Means are an arithmetic average of individual values and/or a weighted average of composites
[d] Range of individuals and/or range of the composites
n/a = not applicable due to a single sample

DEVELOPMENT OF GUIDELINES FOR EATING FISH FROM SAN FRANCISCO BAY

The OEHHA fish advisory process considers the health benefits of fish consumption as well as the risk from exposure to the chemical contaminants found in fish. Benefits are included in the advisory process because there is considerable evidence and scientific consensus that fish should be part of a healthy well-balanced diet. Fish contain many nutrients that are important for general health and, in particular, help promote optimal growth and development of babies and young children, and may reduce the incidence of heart disease in adults (FDA/US EPA, 2017; American Heart Association, 2016; OEHHA, 2008; Institute of Medicine, 2007; Kris-Etherton et al., 2002). Fish are a significant source of the beneficial omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) (USDA/USDHHS, 2020; Weaver et al., 2008).

The US Department of Agriculture (USDA) recommends “including at least 8 ounces of cooked seafood[17] per week. Young children need less, depending on their age and calorie needs.”[18] According to the “Dietary Guidelines for Americans, 2020–2025”

[17] Seafood as used here refers to fish and shellfish from freshwater and marine environments.
[18] Online at: https://www.myplate.gov/.

(USDA/USDHHS, 2020), “women who are pregnant or lactating should consume at least 8 and up to 12 ounces of a variety of seafood per week from choices that are lower in methylmercury.” Additionally, “based on FDA and EPA’s advice, depending on body weight, some women should choose seafood lowest in methylmercury or eat less seafood than the amounts in the Healthy U.S.-Style Dietary Pattern” (USDA/USDHHS, 2020). For more detailed information, see USDA/USDHHS (2020) and other USDA MyPlate.gov materials. The particular fish that people eat is an important factor in determining the net beneficial effects of fish consumption. For example, studies have shown that children of mothers who ate low-mercury fish during pregnancy scored better on cognitive tests compared to children of mothers who did not eat fish or ate high-mercury fish (Oken et al., 2005 and 2008). Accordingly, because of the high mercury content of certain fish species, the US Food and Drug Administration (FDA) and the US EPA recommend that women who are pregnant (or might become pregnant) or breastfeeding, and young children avoid consuming shark, Swordfish, tilefish (Gulf of Mexico), Bigeye Tuna, marlin, Orange Roughy, and King Mackerel (FDA/US EPA, 2017).

To address the potential health concerns associated with exposure to contaminants in sport fish, OEHHA has established ATLs for chemicals that are known to accumulate in the edible tissues of fish. ATLs consider both the toxicity of the chemical and potential benefits of eating fish. OEHHA uses the ATLs to determine the maximum number of servings per week that consumers can eat safely, for each species and from each location, to limit their exposure to these contaminants. Consumers can use OEHHA’s guidance when choosing which fish and how much to eat as part of an overall healthy diet.

There are two sets of ATLs for methylmercury in fish because of the age-related toxicity of this chemical (OEHHA, 2008). The fetus and children are more sensitive to the toxic effects of methylmercury. Thus, the ATLs for the sensitive population, including women who might become pregnant (typically 18–49 years of age) and children 1–17 years of age, are lower than those for women 50 years and older and men 18 years and older. The lower ATL values for the sensitive population provide additional protection to allow for normal growth and development of the brain and nervous system of unborn babies and children. Detailed discussion about the toxicity of common fish contaminants and health benefits of fish consumption, as well as derivation of the ATLs, are provided in “Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene” (OEHHA, 2008) and “Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Polybrominated Diphenyl Ethers (PBDEs)” (OEHHA, 2011). A list of the ATLs used in this report is presented in the Appendix.

With the exception of anadromous species, for each fish species in this advisory, OEHHA compared the mean chemical concentrations detected in the fillet to the corresponding ATLs to establish the maximum number of servings per week that can be safely consumed (see Appendix). For fish fillets, a serving size is considered to be 8

ounces, prior to cooking, or about the size and thickness of a hand. Children should be given smaller servings. For smaller fish species, several individual fish may be required to yield a serving.

The consumption advice for a fish species is initially based on the chemical with the lowest allowable number of servings per week. Because some chemicals, such as mercury and PCBs, are known to have similar adverse effects, additivity of toxicity is assumed in such cases and may be assessed using multiple chemical exposure methodology (US EPA, 1989 and 2000b). If two or more chemicals with similar adverse effects are present in fish tissue, multiple chemical exposure methodology involving hazard index calculations is employed. This may result in advising fewer servings per week than would be the case for the presence of either chemical alone, in a similar concentration. The potential effect of multiple chemical exposure of mercury and PCBs was assessed in all species, with the addition of DDTs when available, and was found to impact advice only for Jacksmelt analyzed as whole organisms without the head, tail, and guts. Advice for all other species in this advisory was based solely on mercury, PCB, DDT, or dieldrin concentrations.

OEHHA recommends that individuals strive to meet the US dietary guidelines' seafood consumption recommendations,[19] while also adhering to federal and OEHHA recommendations to limit the consumption of fish with higher contaminant levels. The advice discussed in the following section represents the maximum recommended number of servings per week for different fish species. People should eat no more than the recommended number of servings for each fish species or species group. When noted, OEHHA's consumption advice for a particular fish species can be extended to other closely related fish species[20] known to accumulate similar levels of contaminants.

Consumption advice should not be combined. That is, if a person chooses to eat a serving of fish from the "one-serving-a-week'' category, then they should not eat any other fish from any source (including commercial) until the next week. If a person chooses to eat a serving of fish from the "two-servings-per-week" category, they can combine fish species from that category, or eat one serving of fish from that category and one from a category that recommends more than two servings per week (if available), for a total of two servings in that week. Then they should not eat any other fish from any source (including commercial) until the following week.

CONSUMPTION ADVICE FOR FISH FROM SAN FRANCISCO BAY

OEHHA's sampling and analysis protocol (OEHHA, 2022) requires at least nine fish of a species to be collected from a water body before an advisory can be developed for the primary contaminant of concern. This is to ensure the sample dataset is representative of the fish species population in the water body. In some cases, an exception is made to develop advice for species that are commonly caught and consumed from a given

[19] Online at: https://www.dietaryguidelines.gov/.
[20] Fish species within the same genus are most closely related, and family is the next level of relationship.

water body but where available data may be limited. Generally, this practice applies when the advice supports no consumption of that species. For San Francisco Bay, the sample size criterion was increased to 20 individuals because of the large geographic area encompassed by the advisory. The criterion was met for the primary contaminant of concern for the surfperch species group (Black Perch, Barred, Rubberlip, and White Surfperch) and the following individual species: California Halibut, Jacksmelt, Mississippi Silverside, Northern Anchovy, Pacific Sardine, Brown Smooth-Hound Shark, Leopard Shark, Shiner Perch, Topsmelt, Walleye Surfperch, and White Croaker. There were not sufficient data to evaluate other species that may be found in San Francisco Bay. For the Lauritzen Channel, an exception was made to the typical sample size criterion of 9 for smaller water bodies because of the high DDT and/or dieldrin levels observed in all species. For fish species (American Shad, Chinook (King) Salmon, Striped Bass, and White Sturgeon) that migrate between inland and coastal waters and may be found in the San Francisco Bay, OEHHA recommends following the advisory for fish that migrate.[21]

The following advice is based on mercury, PCB, DDT, or dieldrin concentrations and covers both the sensitive and general population. The sensitive population is defined as women ages 18–49 years and children ages 1–17 years, and the general population is defined as women 50 years and older and men 18 years and older.

California Halibut

The mean mercury and PCB concentrations in California Halibut fillets from the San Francisco Bay were 320 ppb and 18 ppb, respectively. Based on mercury concentrations, OEHHA recommends a maximum of one serving a week for the sensitive population and a maximum of two servings a week for the general population.

Jacksmelt

Jacksmelt samples were analyzed as either fillets or whole organisms without the head, tail, and guts. The mean mercury and PCB concentrations in fillets were 85 ppb and 22 ppb, respectively. The mean mercury and PCB concentrations in whole organisms without the head, tail, and guts were 69 ppb and 33 ppb, respectively. Due to the slender body type of Jacksmelt, it may not be practical for consumers to prepare the fish as fillets. Thus, the serving advice for Jacksmelt is based on contaminant levels in samples prepared as whole organisms without the head, tail, and guts, which is more health-protective for the sensitive population than advice based on fillet contaminant levels. OEHHA recommends a maximum of one serving a week for the sensitive population based on multiple-chemical exposure analysis of mercury and PCBs, and a maximum of two servings a week for the general population based on PCBs.

[21] Online at https://oehha.ca.gov/advisories/advisory-fish-migrate.

MISSISSIPPI SILVERSIDE

The mean mercury and PCB concentrations in Mississippi Silverside from San Francisco Bay were 82 ppb and 341 ppb, respectively. Based on the concentration of PCBs, OEHHA recommends no consumption of Mississippi Silverside for both the sensitive and general populations.

NORTHERN ANCHOVY

The mean mercury and PCB concentrations in Northern Anchovy from San Francisco Bay were 67 ppb and 104 ppb, respectively. OEHHA recommends a maximum of one serving a week for both the sensitive and general populations, based on PCBs.

BARRED SURFPERCH, BLACK PERCH, RUBBERLIP SURFPERCH, AND WHITE SURFPERCH

OEHHA grouped Barred Surfperch, Black Perch, Rubberlip Surfperch, and White Surfperch because they exhibit similar PCB levels, compared to the other surfperch species. Further, several of these species were likewise combined as a species group in the Statewide Advisory for California Coastal Locations for the same reason (OEHHA, 2016).

The group mean mercury and PCB concentrations in Barred Surfperch, Black Perch, Rubberlip Surfperch, and White Surfperch was 162 ppb and 8 ppb, respectively. Mercury and PCB concentrations for individual species were as follows, Barred Surfperch (Hg: 366 ppb, PCB: 14 ppb), Black Perch (Hg: 112 ppb, PCB: 6 ppb), Rubberlip Surfperch (Hg: 349 pbb, PCB: 8 ppb), White Surfperch (Hg: 132 ppb, PCB: 9). Based on mercury, OEHHA recommends a maximum of one serving a week for the sensitive population and a maximum of three servings a week for the general population for Barred Surfperch, Black Perch, Rubberlip Surfperch, and White Surfperch.

PACIFIC SARDINE

The mean mercury and PCB concentrations in Pacific Sardine from San Francisco Bay were 0 ppb and 137 ppb, respectively. OEHHA recommends no consumption of Pacific Sardine for both the sensitive and general populations, based on PCBs.

SHARK SPECIES (BROWN SMOOTH-HOUND SHARK, LEOPARD SHARK)

The mean mercury and PCB concentrations in shark species from San Francisco Bay were 933 ppb and 15 ppb, respectively. Mercury and PCB concentrations for individual species were as follows, Brown Smooth-Hound Shark (Hg: 698 ppb, PCB: 9 ppb) and Leopard Shark (Hg: 998 ppb, PCB: 17 ppb). OEHHA recommends no consumption of shark species the sensitive population, and a maximum of one serving a week for the general population, based on mercury.

Shiner Perch

The mean mercury and PCB concentrations in Shiner Perch from San Francisco Bay were 108 ppb and 131 ppb, respectively. OEHHA recommends no consumption of Shiner Perch for both the sensitive and general populations, based on PCBs.

Topsmelt

The mean mercury and PCB concentrations in Topsmelt from San Francisco Bay were 39 ppb and 218 ppb, respectively. OEHHA recommends no consumption of Topsmelt for both the sensitive and general populations, based on PCBs.

Walleye Surfperch

Walleye Surfperch samples were analyzed as skin-on or skin-off fillets. Although OEHHA typically issues advice based on concentrations in skin-off fillets (the recommended preparation method to minimize exposure to organic contaminants), the number of samples analyzed by either method alone was insufficient to meet the sample size criterion. In this case, OEHHA chose to combine the skin-on and skin-off samples to be able to provide advice for this species. The mean mercury and PCB concentrations in the combined Walleye Surfperch samples from San Francisco Bay were 142 ppb and 43 ppb, respectively. Thus, OEHHA recommends a maximum of one serving a week of Walleye Surfperch for both the sensitive and general populations, based on PCBs.

White Croaker

White Croaker samples were analyzed as skin-on or skin-off fillets, or as whole organisms without the head, tail, and guts. The mean mercury and PCB concentrations in skin-on fillets were 207 ppb and 244 ppb, respectively. The mean PCB concentration in skin-off fillets was 52 ppb. Mercury was not analyzed in skin-off fillets. Mean mercury and PCB concentrations in whole organisms without the head, tail, and guts were 149 ppb and 167 ppb, respectively. PCB concentrations in White Croaker prepared as skin-on fillets and as whole organisms were above the do-not-consume threshold. PCB levels in skin-off fillets were approximately 80% less than levels in skin-on fillets, and 70% less than levels in samples prepared as whole organisms without the head, tail, and guts. This difference between contaminant levels in skin-off fillets and other types of sample preparations was also observed when the skin was removed from White Croaker samples collected along the coast from Ventura Harbor to San Mateo Point (OEHHA, 2009). OEHHA strongly recommends that consumers only eat fish of any species prepared as skin-off fillets because exposure to PCBs and other organic chemicals is likely to be much greater when the skin or whole organism is consumed. Based on the PCB concentrations in skin-off White Croaker fillets, OEHHA recommends a maximum of one serving a week for both the sensitive and general populations.

LAURITZEN CHANNEL

All fish species sampled in the Lauritzen Channel had mean dieldrin levels above 46 pbb, which would result in do-not-consume advice. Additionally, three out of six species (goby, Shiner Perch, and Starry Flounder) in the Lauritzen Channel had mean DDT levels above the do-not-consume cutoff of 2,100 pbb. Due to the elevated levels of dieldrin and/or DDTs, OEHHA recommends no consumption of all fish from the Lauritzen Channel for both the sensitive and general populations.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish from San Francisco Bay and the Lauritzen Channel are shown in Table 6.

TABLE 6. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH FROM SAN FRANCISCO BAY AND LAURITZEN CHANNEL

Fish Species	Women 18–49 years and Children 1–17 years	Women 50 years and older and Men 18 years and older
American Shad*	2	7
Barred Surfperch, Black Perch, Rubberlip Surfperch, White Surfperch	1	3
California Halibut	1	2
Chinook (King) Salmon*	2	5
Jacksmelt	1	2
Mississippi Silverside	0	0
Northern Anchovy	1	1
Pacific Sardine	0	0
Shark species	0	1
Shiner Perch	0	0
Striped Bass*	0	1
Topsmelt	0	0
Walleye Surfperch	1	1
White Croaker	1	1
White Sturgeon*	0	1
All fish from Lauritzen Channel	0	0

*See advisory for fish that migrate online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.

REFERENCES

American Heart Association. 2016. Fish and Omega-3 Fatty Acids. Online at: http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/HealthyDietGoals/Fish-and-Omega-3-Fatty-Acids_UCM_303248_Article.jsp#.WI57BnlG2Uk.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. Can. J. Fish. Aquat. Sci. 49(5):1010–1017.

CH2M Hill. 2008. Technical memorandum from Tamara Frank, E2 CH2M Hill, to Sharon Lin, U.S. EPA, October 21, 2008: Summary of Fish Tissue Sampling and Analysis, United Heckathorn Superfund Site, Richmond, California, May – June 2008.

Davis, J.A., D. Yee, R. Fairey, and M. Sigala. 2017. San Leandro Bay Priority Margin Unit Study: Phase Two Data Report. San Francisco Estuary Institute, Richmond, CA. SFEI Contribution #855. Online at: https://www.sfei.org/sites/default/files/biblio_files/San%20Leandro%20Bay%20PCB%20Study%20Data%20Report%20Final.pdf.

FDA/US EPA. 2017. Eating Fish: What pregnant women and parents should know. Advice by FDA and US EPA/January, 2017. Online at: https://www.fda.gov/food/consumers/advice-about-eating-fish.

Greenfield, B.K. and R.M. Allen. 2013. Polychlorinated biphenyl spatial patterns in San Francisco Bay forage fish. Chemosphere. 90(5):1693–1703. Online at: https://doi.org/10.1016/j.chemosphere.2012.09.066.

Institute of Medicine. 2007. Seafood choices, balancing benefits and risks. Committee on Nutrient Relationships in Seafood: Selections to Balance Benefits and Risks. Institute of Medicine, Food and Nutrition Board. The National Academies Press, Washington, D.C.

Kris-Etherton, P.M., W.S. Harris, and L.J. Appel. 2002. Fish consumption, fish oil, omega-3 fatty acids, and cardiovascular disease. Circ. 106:2747–2757.

OEHHA. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California. Online at: http://oehha.ca.gov/media/downloads/fish/report/atlmhgandothers2008c.pdf.

OEHHA. 2009. Health Advisory and Safe Eating Guidelines for Fish from Coastal Areas of Southern California: Ventura Harbor to San Mateo Point. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency,

Sacramento, California. Online at: https://oehha.ca.gov/media/downloads/advisories/socaladvisoryl61809.pdf.

OEHHA. 2011. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common Contaminants in California Sport Fish: Polybrominated diphenyl ethers (PBDEs). Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California. Online at: http://oehha.ca.gov/media/downloads/fish/report/pbdes052311.pdf.

OEHHA. 2016. Statewide Advisory for Eating Fish from California Coastal Locations Without Site-Specific Advice. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California. Online at: https://oehha.ca.gov/media/downloads/advisories/californiacoastaladvisory110916.pdf.

OEHHA. 2022. General Protocol for Sport Fish Sampling and Analysis. Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Sacramento, California. Online at: https://oehha.ca.gov/media/downloads/fish/report/fishadvisorysamplinganalysisprotocolreport2022.pdf.

Oken, E., R.O. Wright, K.P. Kleinman, D. Bellinger, C.J. Amarasiriwardena, H. Hu, J.W. Rich-Edwards, and M.W. Gillman. 2005. Maternal fish consumption, hair mercury, and infant cognition in a U.S. cohort. Environ. Health Perspect. 113(10):1376–1380.

Oken, E., J.S. Radesky, R.O. Wright, D. Bellinger, C.J. Amarasiriwardena, K.P. Kleinman, H. Hu, J.W. Rich-Edwards, and M.W. Gillman. 2008. Maternal fish intake during pregnancy, blood mercury levels, and infant cognition at age 3 years in a U.S. cohort. Am. J. Epidemiol. 167(10):1171–1181.

Robinson, A., A. Richey, D. Slotton, J. Collins, and J. Davis. 2018. North Bay Mercury Biosentinel Project 2016–2017. Contribution # 868. San Francisco Estuary Institute and the Aquatic Science Center. Richmond, CA. Online at: https://www.sfei.org/sites/default/files/biblio_files/NBB2016_2017_Final_Report_.pdf.

SFEI. 2010. 2008 Annual Monitoring Results. The Regional Monitoring program for Water Quality in the San Francisco Estuary (RMP). Contribution No. 604. San Francisco Estuary Institute, Oakland, CA. Online at: https://www.sfei.org/sites/default/files/biblio_files/2008_AMR_FINAL_0.pdf.

SFBRWQCB. 1995. Contaminant Levels in Fish Tissue from San Francisco Bay. A collaborative effort of the San Francisco Bay Regional Water Quality Control Board, the State Water Resources Control Board, the California Department of Fish and Game, and the Marine Pollution Studies Laboratory. Online at: https://www.sfei.org/sites/default/files/programs/SFBRWQCB1995_FishReport.pdf.

USDA/USDHHS. 2020. Dietary Guidelines for Americans, 2020–2025. 9th Edition. U.S. Department of Health and Human Services and U.S. Department of Agriculture. Online at: https://www.dietaryguidelines.gov/.

US EPA. 1989. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part A) Interim Final. EPA/5401-89/002, December 1989. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, D.C. Online at: https://rais.ornl.gov/documents/HHEMA.pdf.

US EPA. 2000a. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1. Fish Sampling and Analysis, 3rd Edition. EPA 823-B00-007. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

US EPA. 2000b. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 2. Risk Assessment and Fish Consumption Limits, 3rd Edition. EPA 823-B-00-007. Office of Water, U.S. Environmental Protection Agency, Washington, D.C.

Weaver, K.L., P. Ivester, J.A. Chilton, M.D. Wilson, P. Pandey, and F.H. Chilton. 2008. The content of favorable and unfavorable polyunsaturated fatty acids found in commonly eaten fish. J. American Dietetic Assoc. 108:1178–1185.

APPENDIX. ADVISORY TISSUE LEVELS

Advisory Tissue Levels (ATLs; OEHHA, 2008 and 2011) guide the development of advice for people eating sport fish. ATLs are levels of contaminants found in fish that correspond to the maximum numbers of recommended fish servings. OEHHA uses ATLs to provide advice to prevent consumers from being exposed to:

- More than the reference dose[22] on an average daily basis for chemicals not known to cause cancer, such as methylmercury, or
- For cancer-causing chemicals, a risk level greater than one additional cancer case in a population of 10,000 people consuming fish at the given consumption rate over a lifetime. This cancer risk level is the maximum acceptable risk level recommended by the US EPA (2000b) for fish advisories.

For each chemical, ATLs were determined for both cancer and non-cancer risk, if appropriate, for one to seven eight-ounce servings per week. The most health-protective ATLs for each chemical, selected from either cancer or non-cancer based risk, are shown in the table below for zero to seven servings per week. When the guidelines for eating fish from a water body are followed, exposure to chemicals in fish from that water body would be at or below the average daily reference dose or the cancer risk probability of one in 10,000.

ADVISORY TISSUE LEVELS FOR SELECTED ANALYTES

Contaminant	Consumption Frequency Categories (8-ounce servings/week)[a] and ATLs (in ppb)							
	7	6	5	4	3	2	1	0
Chlordanes	≤ 80	>80–90	>90–110	>110–140	>140–190	>190–280	>280–560	>560
DDTs	≤ 220	>220–260	>260–310	>310–390	>390–520	>520–1,000	>1,000–2,100	>2,100
Dieldrin	≤ 7	>7–8	>8–9	>9–11	>11–15	>15–23	>23–46	>46
MeHg (Women 18–49 and children 1–17)	≤ 31	>31–36	>36–44	>44–55	>55–70	>70–150	>150–440	>440
MeHg (Women ≥ 50 and men ≥ 18)	≤ 94	>94–109	>109–130	>130–160	>160–220	>220–440	>440–1,310	>1,310
PBDEs	≤ 45	>45–52	>52–63	>63–78	>78–100	>100–210	>210–630	>630
PCBs	≤ 9	>9–10	>10–13	>13–16	>16–21	>21–42	>42–120	>120
Selenium	≤ 1,000	>1,000–1,200	>1,200–1,400	>1,400–1,800	>1,800–2,500	>2,500–4,900	>4,900–15,000	>15,000
Toxaphene	≤ 87	>87–100	>100–120	>120–150	>150–200	>200–300	>300–610	>610

[a] Serving sizes (prior to cooking, wet weight) are based on an average 160-pound person. Individuals weighing less than 160 pounds should eat proportionately smaller amounts.

[22] The reference dose is an estimate of the maximum daily exposure to a chemical likely to be without significant risk of harmful health effects over a lifetime.