OFFICE OF ENVIRONMENTAL HEALTH HAZARD ASSESSMENT

GOOD CATCH CALIFORNIA
Your Fish Advisor

Health Advisory and Guidelines for Eating Fish from the Central and South Sacramento-San Joaquin Delta (Contra Costa, Sacramento, and San Joaquin Counties)

Updated November 2022

Fish, Ecotoxicology, and Water Section
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LIST OF ACRONYMS AND ABBREVIATIONS

ATL	Advisory Tissue Level
CALFED	California Bay-Delta Program
CDFW	California Department of Fish and Wildlife
CVAA	Cold Vapor Atomic Association
DDT(s)	dichlorodiphenyltrichloroethane (DDT) and its metabolites dichlorodiphenyldichloroethane (DDD) and dichlorodiphenyldichloroethylene (DDE)
DHA	docosahexaenoic acid
EPA	eicosapentaenoic acid
FDA	United States Food and Drug Administration
FMP	Fish Mercury Project
Hg	mercury
MDL	method detection limit
MeHg	methylmercury
MLML	Moss Landing Marine Laboratories
mm	millimeters
OEHHA	Office of Environmental Health Hazard Assessment
PBDEs	polybrominated diphenyl ethers
PCBs	polychlorinated biphenyls
ppb	parts per billion
RL	reporting limit
Se	selenium
SFEI	San Francisco Estuary Institute
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
TSMP	Toxic Substances Monitoring Program
UCD	University of California, Davis
USDA	United States Department of Agriculture
USDHHS	United States Department of Health and Human Services
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 Sport Fishing Regulations in the section on public health advisories.

This report presents updated guidelines for eating fish from the Central and South Sacramento-San Joaquin Delta, hereafter called the "Central and South Delta," in Contra Costa, Sacramento, and San Joaquin 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).

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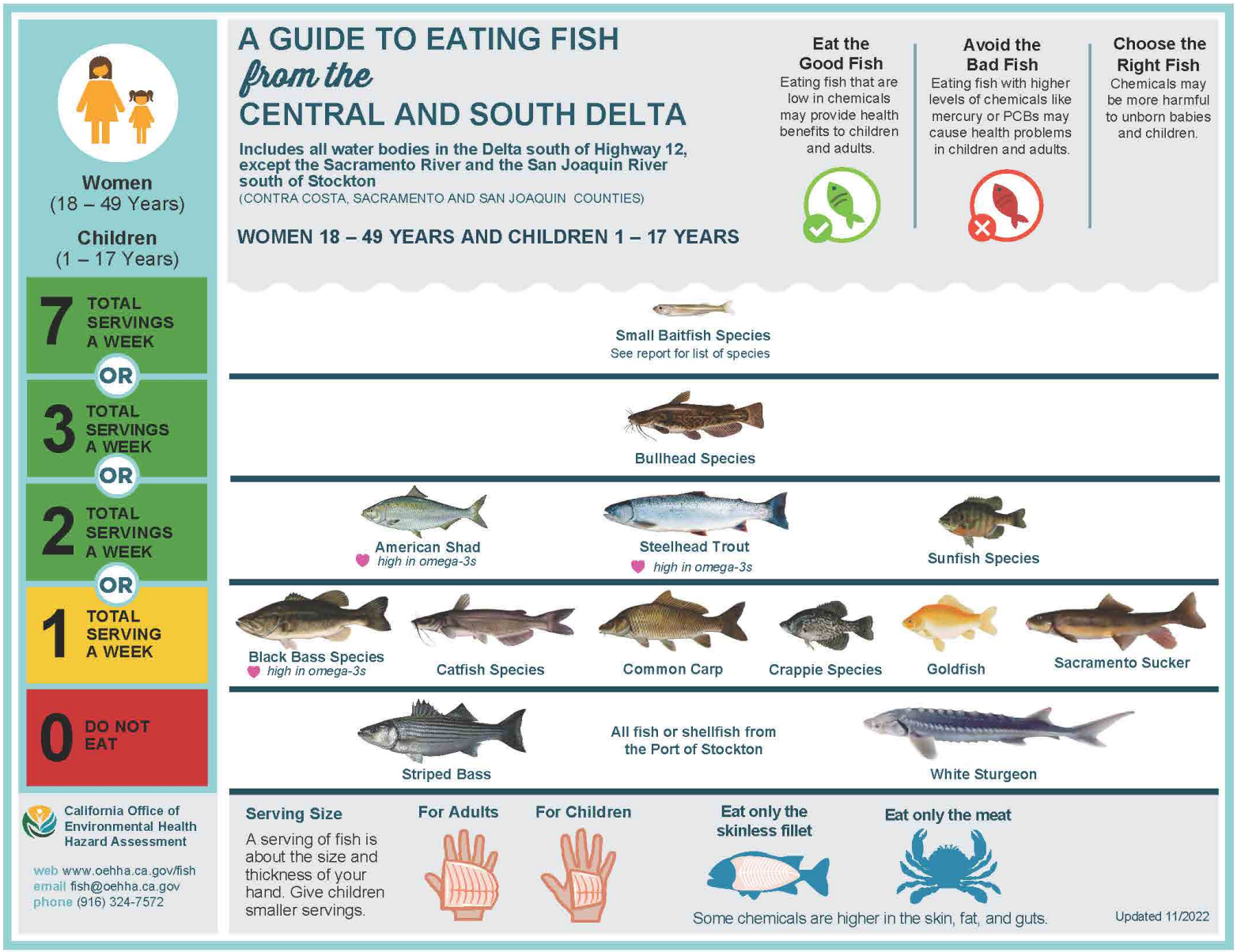
A GUIDE TO EATING FISH
from the
CENTRAL AND SOUTH DELTA
Includes all water bodies in the Delta south of Highway 12, except the Sacramento River and the San Joaquin River south of Stockton
(CONTRA COSTA, SACRAMENTO AND SAN JOAQUIN COUNTIES)
WOMEN 18 – 49 YEARS AND CHILDREN 1 – 17 YEARS
Eat the Good Fish
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)
7 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
Small Baitfish Species
See report for list of species
Bullhead Species
American Shad
high in omega-3s
Steelhead Trout
high in omega-3s
Sunfish Species
Black Bass Species
high in omega-3s
Catfish Species
Common Carp
Crappie Species
Goldfish
Sacramento Sucker
Striped Bass
All fish or shellfish from the Port of Stockton
White Sturgeon
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 11/2022
California Office of Environmental Health Hazard Assessment
web www.oehha.ca.gov/fish
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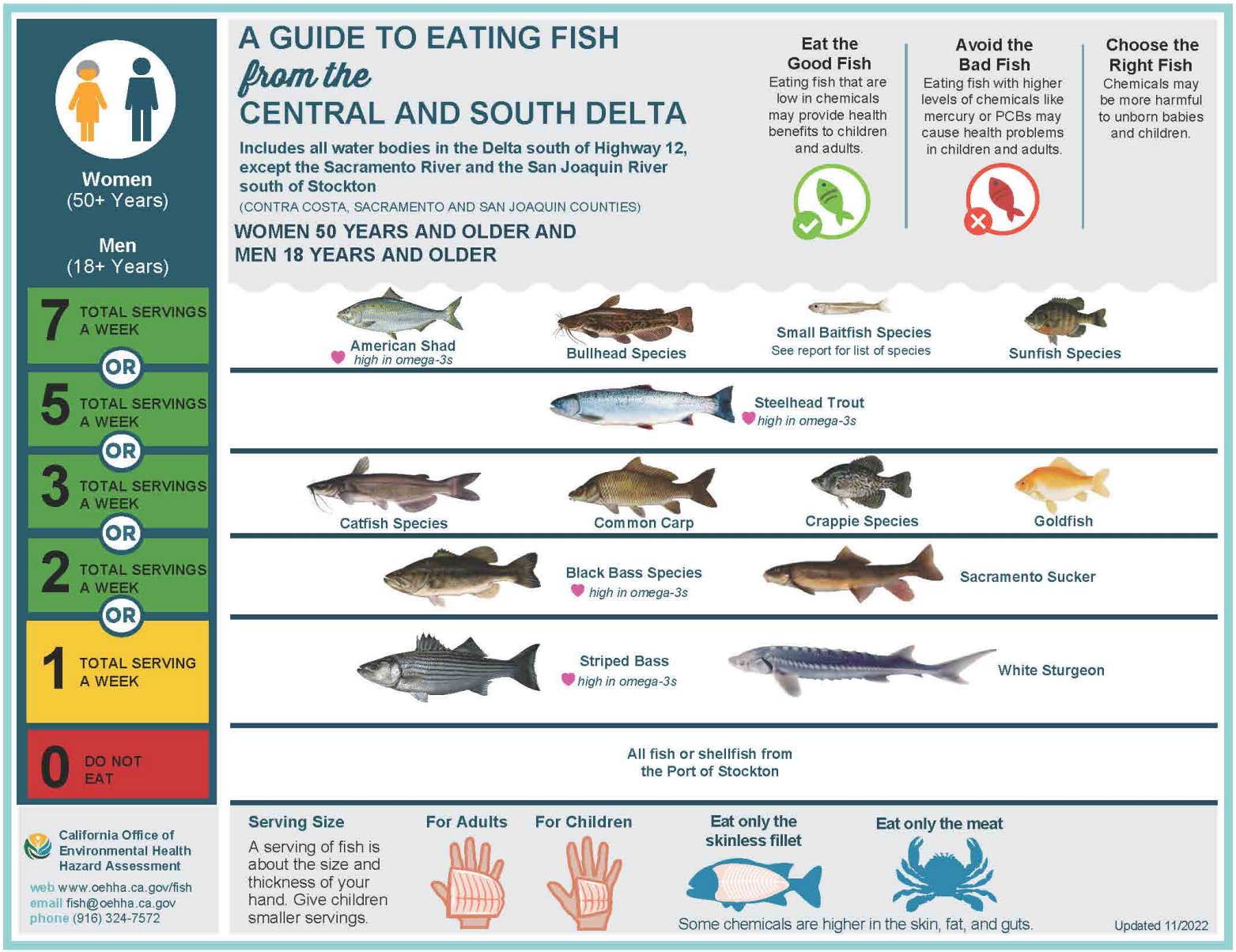
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Includes all water bodies in the Delta south of Highway 12, except the Sacramento River and the San Joaquin River south of Stockton
(CONTRA COSTA, SACRAMENTO AND SAN JOAQUIN COUNTIES)
WOMEN 50 YEARS AND OLDER AND MEN 18 YEARS AND OLDER
Eat the Good 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
Bullhead Species
Small Baitfish Species
See report for list of species
Sunfish Species
Steelhead Trout
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INTRODUCTION

This report updates and supersedes the previous guidelines developed by the Office of Environmental Health Hazard Assessment (OEHHA, 2012) for eating fish from the Central and South Sacramento-San Joaquin Delta, hereafter called the "Central and South Delta," located in Contra Costa, Sacramento, and San Joaquin counties (Figure 1). This advisory includes all water bodies in the Delta south of Highway 12, except the Sacramento River and the San Joaquin River south of Stockton. The collection of additional data made it possible to update this advisory with the inclusion of Goldfish, bullhead species, and small baitfish species. Additionally, guidelines for catfish species consumed by the sensitive population, and catfish species and Common Carp consumed by the general population, have been changed because more data became available. Consumption advice for eating black bass species, bullhead species, catfish species, Common Carp, crappie species, Goldfish, Sacramento Sucker, small baitfish species, and sunfish species is based on levels of mercury found in fish collected from the Central and South Delta. Advice for species that migrate[2] between inland and coastal waters, including those of the Central and South Delta, is also provided in the posters and in Table 4. See the statewide advisory for fish that migrate[3] for the data analysis and information used to develop consumption advice for American Shad, Steelhead Trout, Striped Bass, and White Sturgeon.

LOCATION

The San Joaquin River watershed,[4] including the Sacramento-San Joaquin Delta, drains more than 31,000 square miles of the San Joaquin Valley and serves as a critical resource for drinking water and agriculture, as well as habitat for many fish species. The San Joaquin River originates at high elevations in the Sierra, east of Fresno, and emerges from the foothills where Friant Dam, completed in 1942, forms Millerton Lake. From Friant Dam, the river flows west to Mendota and then flows north from Fresno County, passing through Madera, Merced, Stanislaus, San Joaquin, and Contra Costa counties where it joins the Sacramento River near Antioch. The confluence of these two rivers forms the Sacramento-San Joaquin Delta, and the combined rivers flow into the San Francisco Estuary. The Delta also consists of numerous other natural and man-made channels and sloughs, and a system of levees has created a large area of lowlands and wetlands popular with recreational boaters and fishers.

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[2] Chinook (King) Salmon are not legal to take from the Central and South Delta.
[3] 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.
[4] Information regarding the Central and South Delta was obtained from the following sites: California Department of Water Resources: The Delta, Water Education Foundation Sacramento-San Joaquin Delta, NOAA San Joaquin River Basin, and American Rivers: Sacramento and San Joaquin Rivers.

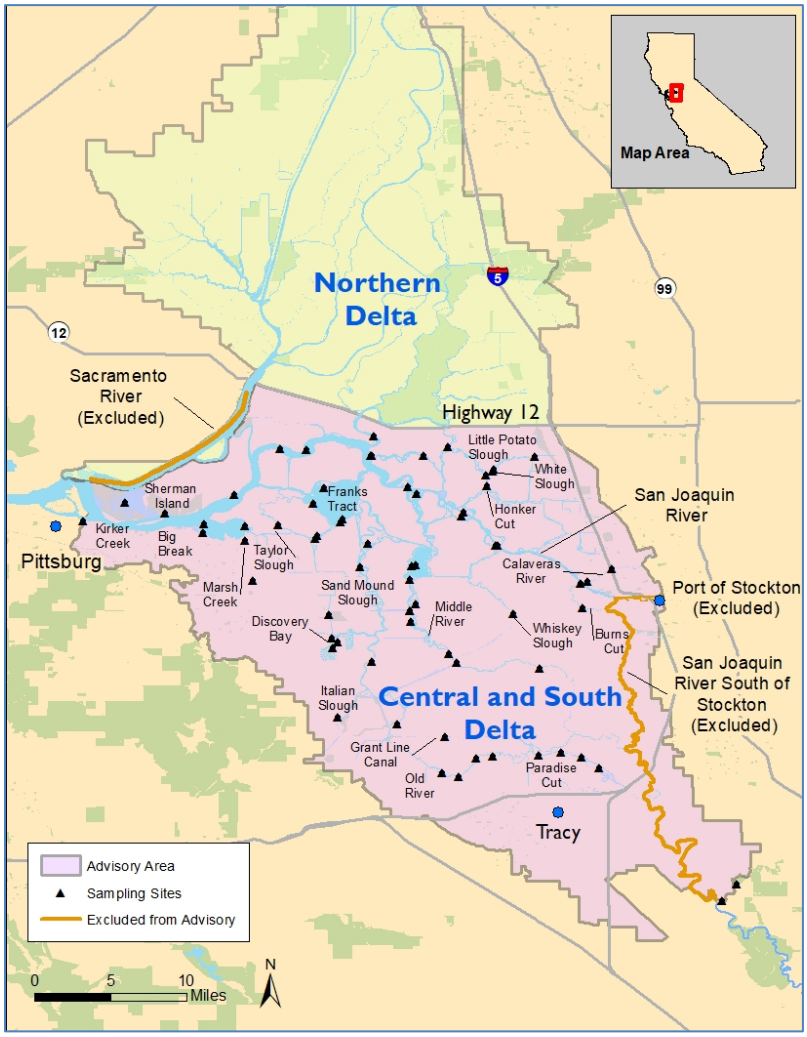
This advisory applies to the central and southern portions of the legal boundary of the Sacramento-San Joaquin River Delta, which includes all waters south of Highway 12, except for the Sacramento River, the Port of Stockton, and the San Joaquin River south of Stockton. For additional fish species found in the Central and South Delta that are legal to take and not included in this advisory, OEHHA recommends following the *Statewide Health Advisory and Guidelines for Eating Fish from California's Rivers, Streams, and Creeks without Site-Specific Advice*.[5] Chinook (King) Salmon are not legal to take from the Central and South Delta per CDFW regulations.[6] No consumption is advised for all fish and shellfish from the Port of Stockton, based on polychlorinated biphenyls (PCBs).[7] Several small water bodies, creeks, and sloughs are associated with the Central and South Delta, including:

Big Break
Burns Cut
Calaveras River
Discovery Bay
Franks Tract
Grant Line Canal
Honker Cut
Italian Slough
Kirker Creek
Little Potato Slough
Marsh Creek
Middle River
Old River
Paradise Cut
Sand Mound Slough
Sherman Island
San Joaquin River[8]
Taylor Slough
Whiskey Slough
White Slough

This advisory does not include any lakes or reservoirs in the Central and South Delta watershed. Site-specific advice has previously been developed for other portions of the Sacramento-San Joaquin Delta watershed, including the Sacramento River and Northern Delta[9] for waters north of Highway 12, the San Joaquin River from the Friant Dam to the Port of Stockton,[10] and the Port of Stockton.

[5] Online at: https://oehha.ca.gov/advisories/statewide-advisory-eating-fish-california-rivers-streams-and-creeks-without-site-specific.
[6] Online at: https://wildlife.ca.gov/.
[7] Includes Smith Canal in Stockton. Online at: https://oehha.ca.gov/advisories/port-stockton.
[8] Port of Stockton to confluence with the Sacramento River.
[9] Online at: https://oehha.ca.gov/advisories/sacramento-river-and-northern-delta.
[10] Online at: https://oehha.ca.gov/advisories/san-joaquin-river-friant-dam-port-stockton.

FIGURE 1. SAMPLE LOCATIONS IN THE CENTRAL AND SOUTH DELTA



APPROACH USED

OEHHA used the results from eight monitoring studies described in this report to develop the Central and South Delta 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)[11] 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.

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 included consideration of health benefits associated with including fish in the diet (OEHHA, 2008). The ATLs should not be interpreted as static "bright lines," but 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 are of potential concern for people who eat fish because of their toxicity and their ability to accumulate in fish tissue. The majority of fish consumption advisories in California are issued because of mercury (Hg), followed by 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

[11] 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.

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, dichlorodiphenyltrichloroethane (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 and references are 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 from the Central and South Delta and used in advisory development were analyzed for mercury. Some fish were analyzed for PCBs, PBDEs, selenium, and legacy pesticides as indicated in Table 1. Fish species that do not typically accumulate PCBs or other organic chemicals were not analyzed for these contaminants.

DATA SOURCES

The updated guidelines for eating fish from the Central and South Delta are based on the chemicals detected in the fish collected for the eight 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.

CALIFORNIA BAY-DELTA PROGRAM (CALFED)

The California Bay-Delta Program was a state and federal interagency group, established in 1994, to develop strategies and provide funding for projects that improve water quality, increase water supply, and support ecosystem restoration and levee improvement in the San Francisco Bay-Delta. CALFED sampled a wide variety of species throughout the Delta from 1998 – 2000 to evaluate potential human health

concerns from mercury in sport fish, establish baseline mercury levels to assist with long-term trend monitoring, examine spatial patterns in mercury contamination, and to evaluate how age/size and trophic level influence mercury concentrations (Davis and Greenfield, 2004). Species collected from the Central and South Delta regions included Black Bullhead, Bluegill, Channel Catfish, crappie species, Largemouth Bass, Redear Sunfish, Sacramento Sucker, and White Catfish.

Contaminants in Fish from California Lakes and Reservoirs, 2007 – 2008 (SWAMP)

The Surface Water Ambient Monitoring Program (SWAMP) operated by the State Water Resources Control Board (SWRCB) in cooperation with the Central Valley Regional Water Board (RWB5), monitors water quality in California's surface waters. The program collected Largemouth Bass from the Central and South Delta regions in 2007 as part of a SWAMP statewide sampling effort to survey contaminants in sport fish found in California lakes and reservoirs (SWRCB, 2010).

Contaminants in Fish from California Rivers and Streams, 2011 (SWAMP)

In 2011, SWAMP performed a statewide survey of California rivers and streams to evaluate contaminants in commonly consumed sport fish. The study had two primary goals: to determine the geographic extent of contamination in fish in relation to assessment thresholds and to identify locations for future sampling to assist with the development of fish consumption advisories (SWRCB, 2011). Species collected from the Central and South Delta regions included Common Carp, Largemouth Bass, and Sacramento Sucker.

Delta Regional Monitoring Program (RMP)

The Delta RMP sampled sport fish from 2016 – 2018 to provide critical information to aid in the implementation of the Total Maximum Daily Load (TMDL) for methylmercury for the Sacramento-San Joaquin Delta Estuary. Three fish species, Golden Shiner, Largemouth Bass, and Mississippi Silverside, were targeted due to the linkage of methylmercury concentrations in these fish species and water, thereby providing an indicator of waterbody impairment. These efforts were used to contribute spatial and temporal fish data to inform the TMDL conceptual model developed by the Department of Water Resources for the Delta and Yolo Bypass (Davis et al., 2018).

Fish Mercury Project (FMP)

The FMP was a three-year (2005 to 2007) sampling program funded by CALFED. Monitoring of sport fish from Central Valley water bodies was planned and conducted by staff at the California Department of Fish and Wildlife (CDFW), OEHHA, the California Department of Public Health, the University of California, Davis, and the San Francisco Estuary Institute (SFEI). More than 4,000 fish, including 31 sport fish species from 146 popular fishing locations in the Delta watershed, were collected to help characterize

spatial and temporal trends in mercury in fishery resources (SFEI, 2009). Species collected from the Central and South Delta regions included Black Crappie, Bluegill, Brown Bullhead, Channel Catfish, Common Carp, Goldfish, Largemouth Bass, Redear Sunfish, Sacramento Sucker, and White Catfish.

Regional Monitoring Program For Water Quality In San Francisco Bay, Exposure And Effects Pilot Study, (EEPS)

The San Francisco Bay Regional Monitoring Program developed the EEPS to address questions on beneficial use management developed by the San Francisco Bay Regional Water Quality Control Board. The EEPS evaluated the effects and exposure of contaminants at different spatial scales throughout the bay. The goal of this study was to monitor mercury concentrations in sediment and small fish to locate hotspots of methylmercury bioavailability (Greenfield et al., 2013; SFEI, 2010). Golden Shiner and Mississippi Silverside were collected for this study in 2008 and analyzed for mercury.

Toxic Substances Monitoring Program (TSMP)

The TSMP operated from 1976 to 2003 as a state water quality-monitoring program managed by the SWRCB (SWRCB, 2007 and 2013). Its objective was to provide statewide information on the occurrence of toxic substances by monitoring water bodies with known or suspected water quality impairment. CDFW staff collected Black Crappie, Channel Catfish, Common Carp, Golden Shiner, Largemouth Bass, Redear Sunfish, and White Catfish from the Central and South Delta regions as part of the program to analyze for mercury levels.

University of California, Davis (UCD)

UCD conducted a CALFED-funded, survey-level study between 1995 and 2000 to assess the production and bioaccumulation of methylmercury in relation to wetland restoration efforts in the Sacramento-San Joaquin Delta. The study provided an initial understanding of ambient mercury trends in the Delta and how wetland restoration sites may impact trends (Slotton et al., 2002). Species collected from the Central and South Delta regions included Bigscale Logperch, Bluegill, Golden Shiner, Inland Silverside, Mosquitofish, Prickly Sculpin, Shimofuri Goby, Threadfin Shad, and Yellowfin Goby.

CHANGES FROM THE 2012 ADVISORY

This update includes the following changes and additions to the previous 2012 Central and South Delta Advisory:

1) Consumption advice for bullhead species, Goldfish, and small baitfish species was added to the advisory based on data from samples collected by the Fish Mercury Project (2005, 2007), the Toxic Substances Monitoring Project (1987), the University of California at Davis (1998 – 2000), and the Delta Regional Monitoring Project (2008). Advice for bullhead species was

previously grouped under recommendations for "catfish" (*see point 4)*. Goldfish are currently grouped with Common Carp.

2) Asian Clam and crayfish advice was removed while OEHHA evaluates other contaminants in these species that may affect advice.

3) This advisory contains the statewide advice for consumption of American Shad, Steelhead Trout, Striped Bass, and White Sturgeon from waters with access to the ocean. OEHHA refers consumers to the advisory for fish that migrate,[12] for the data analysis and most up-to-date recommendations for these species.

4) Catfish advice was previously developed based on the analysis of combined data for bullhead (Black, Brown) and catfish species (Channel, White). Bullhead are considered part of the greater catfish "family" (Cingolani et al., 2007); however, OEHHA typically develops separate advice for each species group when the data do not support similar advice. Based on the lower mercury concentrations found in bullhead species versus other "catfish" species caught from the Central and South Delta, OEHHA developed one set of advice for bullhead species and one set for catfish species. Catfish species (Channel, White) advice changed for both the sensitive and general populations from 2 and 5 meals per week to 1 and 3 meals per week, respectively, because consumption recommendations for bullhead and catfish species were no longer combined.

5) Common Carp and crappie species advice changed for the general population from 2 meals per week to 3 meals per week because of more recently available data.

FISH SAMPLED FROM THE CENTRAL AND SOUTH DELTA

The fish sampling data used in this advisory were retrieved from the California Environmental Data Exchange Network (CEDEN)[13], the state's repository for environmental data. Samples were excluded when the fish were not of 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). A summary of all fish species evaluated for this advisory is shown in Table 1, including the name of the species, number of samples collected, total number of fish, project name, year sampled, and contaminants analyzed.

[12] Online at: https://oehha.ca.gov/advisories/advisory-fish-migrate.
[13] Online at: https://ceden.waterboards.ca.gov/AdvancedQueryTool.

TABLE 1. FISH SAMPLES EVALUATED FOR THE CENTRAL AND SOUTH DELTA ADVISORY

Species	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[d]
Bigscale Logperch	*Percina macrolepida*	1	3	UCD[c]	1999	Hg
Black Bullhead	*Ameiurus melas*	1	5	CALFED[b]	1999	Hg
		1	4	CALFED[b]	1998	Se
Black Crappie	*Pomoxis nigromaculatus*	23	23	FMP	2005	Hg
		1	6	TSMP[a]	1984	Hg
Bluegill	*Lepomis macrochirus*	9	45	CALFED[b]	1999	Hg
		76	76	FMP	2005	Hg
		4	4	UCD	1995 – 1996	Hg
Brown Bullhead	*Ameiurus nebulosus*	42	42	FMP	2005, 2007	Hg
Channel Catfish	*Ictalurus punctatus*	3	13	CALFED	1999 – 2000	Hg
		17	17	FMP	2005, 2007	Hg
		4	16	TSMP[a]	1979,1981,1982, 1984	Hg
Common Carp	*Cyprinus carpio*	34	34	FMP	2005, 2007	Hg
		1	5	SWAMP	2011	Chlordanes, DDTs, Dieldrin, Hg, PCBs, Se
		1	6	TSMP[a]	1986	Hg, Se
Crappie spp.	*Pomoxis spp.*	2	7	CALFED[b]	2000	Hg
Golden Shiner	*Notemigonus crysoleucas*	3	15	EEPS[c]	2008	Hg
		2	19	TSMP[ac]	1987	Hg, Se
		19	221	UCD[c]	1999	Hg
Goldfish	*Carassius auratus*	4	4	FMP	2005	Hg
Inland Silverside	*Menidia beryllina*	129	832	UCD[c]	1998 - 2000	Hg
Largemouth Bass	*Micropterus salmoides*	43	43	RMP	2016, 2018	Hg
		126	126	CALFED[b]	1999 - 2000	Hg
		8	40	CALFED[b]	1998	Se
		155	155	FMP	2005, 2007	Hg
		1	5	SWAMP	2007	Chlordanes, DDTs, Dieldrin, PBDEs, PCBs, Se

Species	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[d]
		12	12	SWAMP	2007	Hg
		8	8	SWAMP	2011	Hg
		1	5	SWAMP	2011	Se
		6	31	TSMP[a]	1987, 1999	Hg, Se
		5	30	TSMP[a]	1996	Se
		1	5	TSMP[a]	2000	Chlordanes, DDTs, Dieldrin, Toxaphene
Mississippi Silverside	*Menidia audens*	4	20	EEPS[c]	2008	Hg
Mosquitofish	*Gambusia affinis*	9	51	UCD[c]	1998 - 1999	Hg
Prickly Sculpin	*Cottus asper*	2	2	UCD[cd]	1998	Hg
Redear Sunfish	*Lepomis microlophus*	12	56	CALFED[b]	1999 – 2000	Hg
		108	108	FMP	2005, 2007	Hg
		2	17	TSMP[a]	1987	Hg, Se
		1	6	TSMP[a]	1996	Se
Sacramento Sucker	*Catostomus occidentalis*	1	4	CALFED[b]	1999	Hg
		11	11	FMP	2005	Hg
		1	5	SWAMP	2011	Chlordanes, DDTs, Dieldrin, Hg, PCBs, Se
Shimofuri Goby	*Tridentiger bifasciatus*	2	2	UCD[c]	1998	Hg
Threadfin Shad	*Dorosoma petenense*	14	130	UCD[c]	1998 - 1999	Hg
White Catfish	*Ameiurus catus*	37	37	CALFED	1999 – 2000	Hg
		5	25	CALFED	1998	Se
		90	90	FMP	2005, 2007	Hg
		4	23	TSMP[a]	1986, 1996, 1998	Se
		6	34	TSMP[a]	1978, 1980, 1984, 1986, 1998	Hg

Species	Scientific Name	Number of Samples	Total Number of Fish	Project	Year Collected	Contaminants Analyzed[d]
Yellowfin Goby	*Acanthogobius flavimanus*	8	10	UCD[c]	1998 – 1999	Hg, Se

Samples were analyzed as skinless fillets, with the following exceptions:
[a]Study report did not specify whether skin was removed from fillets prior to tissue analysis.
[b]CALFED samples were analyzed as skin-on fillets, except for catfish samples (skinless fillets).
[c]Samples were analyzed as whole organisms, including head, skin, internal organs, muscle, and bones.
[d]Organic data (chlordanes, DDTs, dieldrin, PBDEs, PCBs, or toxaphene) generated prior to 2000 were excluded from the analysis because more recent data are considered more reliable due to improved analytical methods and are likely to be more representative of fish caught today.

CHEMICAL CONCENTRATIONS

As shown in Table 1, samples were analyzed for one or more of the following: total mercury, selenium, chlordanes, DDTs, dieldrin, toxaphene, PBDEs (7 congeners), and PCBs (51–54 congeners).[14] Among the chemicals analyzed in fish tissue samples from the Central and South Delta, only mercury levels were sufficiently high to impact consumption advice. PCB levels were high enough to require consideration during the advisory development, but did not impact advice.

All fish samples were prepared as skinless fillets, except for the CALFED study where samples were prepared as skin-on fillets (except for Channel Catfish and White Catfish samples that were prepared as skinless fillets) and the baitfish species, which were analyzed as whole bodies due to their small size. The TSMP study did not report the fillet preparation method for Channel Catfish, Common Carp, Largemouth Bass, and Redear Sunfish. Samples were analyzed as individual fish or composites.

For this advisory, 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.

[14] Congeners are related compounds with similar chemical forms. Of the 209 possible PBDE and PCB congeners, 6–7 and 48–54 are generally analyzed, respectively.

MERCURY

Samples were analyzed for total mercury, as either individual fish or composite samples. For the FMP, RMP, and SWAMP studies, analyses were performed at the CDFW Moss Landing Marine Laboratories (MLML) using a direct mercury analyzer (DMA). The DMA method utilizes thermal decomposition and atomic absorption. The DMA method detection limit (MDL)[15] and the reporting limit (RL)[16] for total mercury were reported at 1 – 19 parts per billion (ppb) and 9 – 12 ppb, respectively, depending on the study.

For the CALFED and UCD studies, analyses were performed using cold vapor atomic absorption (CVAA) spectrometry, which determines the concentration of mercury by measuring the amount of radiation it absorbs. The CVAA MDL and the RL for total mercury were reported at 15 and 20 parts per billion (ppb), respectively.

Although mercury was detected at commonly found concentrations in the TSMP study, the MDL and RL for mercury were not reported. The TSMP study also did not report the mercury analysis method. 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). Table 2 shows the averages and ranges for total length,[17] as well as mercury concentrations in each fish species.

PCBS, PBDES, AND PESTICIDES

Pesticides, PBDEs, and PCBs were analyzed by gas chromatography at the CDFW Water Pollution Control Laboratory. 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 (≤ 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 3 shows the averages and ranges for total length, as well as PCB concentrations in each fish species. Because PCBs did not impact advice, they are not discussed further in this report.

SELENIUM

The CDFW MLML analyzed species collected from the Central and South Delta for selenium as composite samples, using inductively coupled plasma-mass spectrometry

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[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.
[17] 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.

(ICP-MS). 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 and the RL for total selenium were reported at 100 or 150 and 300 or 400 ppb, respectively, depending on the study.

Concentrations of chlordanes, dieldrin, DDTs, PBDEs, selenium, and toxaphene were lower than the corresponding ATL threshold values for daily consumption (OEHHA, 2008 and 2011). With the exception of assessing for multiple chemical exposures, these chemicals were therefore not considered further for developing consumption advice and are not shown in this report.

TABLE 2. MERCURY CONCENTRATIONS IN FISH FROM THE CENTRAL AND SOUTH DELTA

Species	Number of Samples[a]	Total Number of Fish	Mean Total Length* (mm)	Range of Total Lengths** (mm)	Mercury (ppb)	
					Mean*	Range**
Bullhead Species	43	47	309	221 – 390	69	25 – 198
Black Bullhead	1	5	306	nr	53	n/a
Brown Bullhead	42	42	309	221 – 390	71	25 – 198
Carp and Goldfish	40	49	601	290 – 879	176	25 – 459
Common Carp	36	45	625	361 – 879	188	47 – 459
Goldfish	4	4	333	290 – 399	37	25 – 47
Catfish Species	157	207	332	204 – 600	172	31 – 1071
Channel Catfish	24	46	406	270 – 571	263	49 – 1071
White Catfish	133	161	311	204 – 600	146	31 – 419
Crappie Species	26	36	251	180 – 330	152	32 – 420
Black Crappie	24	29	250	180 – 330	145	32 – 420
Crappie Species (Unidentified)	2	7	254	237 – 277	180	54 – 347
Largemouth Bass	350	375	382	305 – 574	336	82 – 1260
Sacramento Sucker	13	20	461	410 – 511	254	152 – 392
Small Baitfish Species	193	1305	65[d]	29 – 164	27	11 – 111
Bigscale Logperch[b]	1	3	58	nr	41	n/a

Species	Number of Samples[a]	Total Number of Fish	Mean Total Length* (mm)	Range of Total Lengths** (mm)	Mercury (ppb)	
					Mean*	Range**
Golden Shiner[b,]	24	255	70[e]	61 – 152	15	11 – 26
Inland Silverside[b]	129	832	63	31 – 102	31	14 – 88
Mississippi Silverside[c]	4	20	nr	nr	31	27 – 33
Mosquitofish[b]	9	51	32	29 – 39	30	14 – 41
Prickly Sculpin[b]	2	2	68	44 – 91	84	57 – 111
Shimofuri Goby[b]	2	2	47	41 – 52	19	18 – 19
Threadfin Shad[b]	14	130	76	55 – 89	21	14 – 33
Yellowfin Goby	8	10	128	101 – 164	21	13 – 31
Sunfish Species	211	306	174	102 – 294	83	0 – 392
Bluegill	89	125	149	102 – 258	76	21 – 367
Redear Sunfish	122	181	192	130 – 294	88	0 – 392

[a]Samples were prepared as skinless fillets, except as noted in the footnotes to Table 1.
[b]Baitfish species length data reported as fork length.
[c]No length data reported for this species.
[d]Includes only baitfish species for which length data were reported (n = 186 composite samples).
[e]Based on length data provided for a subset of samples for this species.
*Means are an arithmetic average of individual values, and/or a weighted average of composites.
**Range of individuals and/or range of the composites.
nr = not reported
n/a = not applicable due to a single sample

TABLE 3. PCB CONCENTRATIONS IN FISH FROM THE CENTRAL AND SOUTH DELTA

Species	Number of Samples[a]	Total Number of Fish	Mean Total Length* (mm)	Range of Total Lengths** (mm)	PCBs (ppb)	
					Mean*	Range**
Common Carp	1	5	785	680 – 879	9	n/a
Largemouth Bass	1	5	364	338 – 390	2	n/a
Sacramento Sucker	1	5	436	410 – 466	16	n/a

[a]Samples were prepared as skinless fillets.
*Means are an arithmetic average of individual values and/or a weighted average of composites.
**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 THE CENTRAL AND SOUTH DELTA

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[18] per week. Young children need less, depending on their age and calorie needs."[19] According to the 2020–2025 Dietary Guidelines, "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" (USDA/USDHHS, 2020). 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 Environmental Protection Agency (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

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

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 to 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.

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 could be 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 exposures (DDTs, mercury, and PCBs) was assessed in Common Carp, Largemouth Bass, and Sacramento Sucker and did not affect advice. Advice for all species in this advisory was based solely on mercury.

OEHHA recommends that individuals strive to meet the US Dietary Guidelines' seafood consumption recommendations[20] 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

[20] Online at: https://www.dietaryguidelines.gov/.

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[21] 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 THE CENTRAL AND SOUTH DELTA

OEHHA's advisory 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 water body but where available data may be limited. Generally, this practice applies when the advice supports no consumption of that species. For the Central and South Delta, the sample size criterion was increased to 20 individuals because of the large geographic area encompassed by the advisory. This criterion was met for the primary contaminant of concern (mercury) for the following species or species groups: Black Crappie, Bluegill, Brown Bullhead, Channel Catfish, Common Carp, Largemouth Bass, Redear Sunfish, Sacramento Sucker, small baitfish (Golden Shiner, Inland Silverside, Mississippi Silverside, Mosquitofish, and Threadfin Shad), and White Catfish. There were not sufficient data to evaluate other species that may be found in this water body. For fish species (American Shad, Steelhead Trout, Striped Bass, and White Sturgeon) that migrate between inland and coastal waters and may be found in the Central and South Delta, OEHHA recommends following the advisory for fish that migrate.[22]

The following advice is based solely on mercury concentrations. The sensitive population is defined as women ages 18 to 49 years and children ages 1 to 17 years, and the general population is defined as women 50 years and older and men 18 years and older.

[21] Fish species within the same genus are most closely related, and family is the next level of relationship.
[22] Online at https://oehha.ca.gov/advisories/advisory-fish-migrate.

BLACK BASS SPECIES (LARGEMOUTH BASS)

Black bass species are one of the most targeted species of freshwater game fish in California. OEHHA groups black bass species because they have similar predatory diets which suggests a comparable chemical uptake (Long and Fisher, 2000). They are also known to hybridize (Pierce and Van Den Avyle, 1997), largely due to species introductions for angling purposes and weak genetic barriers between members of the genus (Thongda et al., 2020). OEHHA has also evaluated mercury concentrations in black bass species in many water bodies in California and has found a similar range of mercury concentrations when two or more of these species were caught from the same water body. Therefore, OEHHA extends the consumption advice for Largemouth Bass to other black bass species, including Redeye, Smallmouth, and Spotted Bass.

The mean mercury concentration in Largemouth Bass from the Central and South Delta was 336 ppb. OEHHA recommends a maximum of one serving a week of black bass species for the sensitive population, and a maximum of two servings a week for the general population.

BULLHEAD SPECIES (BLACK BULLHEAD AND BROWN BULLHEAD)

Black and Brown Bullhead are benthic, opportunistic omnivores, with adults feeding primarily on plants, invertebrates, and small fish. They can tolerate a wide range of conditions, including waters with low oxygenation and high pollution levels.[23] Bullhead species are bottom-dwellers, which can expose them to chemical contaminants in bottom sediments. The species are also known to hybridize in some water bodies where they are co-located (Cingolani et al., 2007). Although there are not sufficient data to state conclusively, due to their similar diet and habitat preferences, it is expected that Black and Brown Bullhead would have similar levels of contaminant uptake. OEHHA has evaluated mercury concentrations in Black Bullhead and Brown Bullhead in water bodies in California and has found a similar range of mercury concentrations when both of these species were caught from the same water body. These two species also have a similar statewide mean mercury concentration. For these reasons, OEHHA extends the consumption advice for Brown Bullhead to Black Bullhead.

The mean mercury concentration in bullhead species from the Central and South Delta was 69 ppb. Mercury concentrations for individual bullhead species were as follows: Black Bullhead, 53 ppb; and Brown Bullhead, 71 ppb. OEHHA recommends a

[23] Species profiles for Black and Brown Bullhead can be found on the University of Michigan website, online at: https://animaldiversity.org/accounts/Ameiurus_nebulosus/, and https://animaldiversity.org/accounts/Ameiurus_melas/.

maximum of three servings a week of these species for the sensitive population, and a maximum of seven servings a week for the general population.

Catfish Species (Channel Catfish and White Catfish)

The mean mercury concentration in catfish species from the Central and South Delta was 172 ppb. Mercury concentrations for individual catfish species were as follows: Channel Catfish, 263 ppb; and White Catfish, 146 ppb. OEHHA recommends a maximum of one serving a week of these species for the sensitive population, and a maximum of three servings a week for the general population.

Common Carp and Goldfish

Common Carp and Goldfish were grouped because they are very closely related and frequently hybridize when they are co-located, making them difficult to distinguish (Halas et al., 2018). Further, statewide analysis of Common Carp and Goldfish data show similar mean mercury and PCB concentrations.

The mean mercury concentration in Common Carp and Goldfish from the Central and South Delta was 176 ppb. Mercury concentrations for individual species were as follows: Common Carp, 188 ppb; and Goldfish, 37 ppb. OEHHA recommends a maximum of one serving a week for the sensitive population for these species, and a maximum of three servings a week for the general population.

Crappie Species (Black Crappie, Crappie Species Unidentified)

Black Crappie and the “unidentified” crappie species were grouped because Black and White Crappie, the two species of crappie that are typically found in California, have similar diets and may hybridize when they are co-located, making them difficult to distinguish (Dunham et al., 1994; Kelly and Baumhoer, 2014). Further, statewide analysis of Black and White Crappie data shows similar mean mercury concentrations. Therefore, OEHHA extends the consumption advice for Black Crappie and unidentified crappie species to White Crappie.

The mean mercury concentration in crappie species from the Central and South Delta was 152 ppb. Mercury concentrations for individual crappie species were as follows: Black Crappie, 145 ppb; and crappie species unidentified, 180 ppb. OEHHA recommends a maximum of one serving a week of these species for the sensitive population. To improve risk communication through the reduction of different meal frequency categories for species from the Central and South Delta, OEHHA reduced the number of recommended servings a week of crappie species from four to three for the general population.

Sacramento Sucker

The mean mercury concentration in Sacramento Sucker in the Central and South Delta was 254 ppb. 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.

Small Baitfish Species (Bigscale Logperch, Golden Shiner, Inland Silverside, Mississippi Silverside, Mosquitofish, Prickly Sculpin, Shimofuri Goby, Threadfin Shad, and Yellowfin Goby)

The mean mercury concentration in small baitfish species from the Central and South Delta was 27 ppb. Mercury concentrations for individual baitfish species were as follows: Bigscale Logperch, 41 ppb; Golden Shiner, 15 ppb; Inland Silverside, 31 ppb; Mississippi Silverside, 31 ppb; Mosquitofish, 30 ppb; Prickly Sculpin, 84 ppb; Shimofuri Goby, 19 ppb; Threadfin Shad, 21 ppb; and Yellowfin Goby, 21 ppb. OEHHA recommends a maximum of seven servings a week of these species for both the sensitive population and the general population.

Sunfish Species (Bluegill and Redear Sunfish)

OEHHA groups sunfish species due to extensive diet overlap (Kirby, 1982), which suggests a similar contaminant uptake, and a known ability to hybridize (Avise and Smith, 1974). OEHHA has evaluated mercury concentrations in sunfish species in many water bodies in California and has found a similar range of mercury concentrations when two or more of these species were caught from the same water body. Therefore, OEHHA extends the consumption advice for sunfish species (Bluegill and Redear Sunfish) to other sunfish species, including Green Sunfish and Pumpkinseed.

The mean mercury concentration in sunfish species from the Central and South Delta was 83 ppb. Mercury concentrations for individual sunfish species were as follows: Bluegill, 76 ppb; and Redear Sunfish, 88 ppb. OEHHA recommends a maximum of two servings a week of these species for the sensitive population, and a maximum of seven servings a week for the general population.

RECOMMENDED MAXIMUM NUMBER OF SERVINGS

The recommended maximum numbers of servings per week for fish from the Central and South Delta are shown in Table 4.

TABLE 4. RECOMMENDED MAXIMUM NUMBER OF SERVINGS PER WEEK FOR FISH FROM THE CENTRAL AND SOUTH DELTA

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
Black Bass Species	1	2
Bullhead Species	3	7
Catfish Species	1	3
Common Carp, Goldfish	1	3
Crappie Species	1	3
Sacramento Sucker	1	2
Small Baitfish Species	7	7
*Steelhead Trout	2	5
*Striped Bass	0	1
Sunfish Species	2	7
*White Sturgeon	0	1
All fish or shellfish from the Port of Stockton	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.

Avise, J.C. and M.H. Smith. 1974. Biochemical Genetics of Sunfish II. Genic Similarity between Hybridizing Species. The American Naturalist. 108 (962). Online at: https://www.journals.uchicago.edu/doi/pdf/10.1086/282926.

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.

Cingolani, Jr., J.K., J.R. Stauffer, Jr., and B.A. Porter. 2007. Investigation into the Hybridization of Ameiurus catfish in Presque Isle Bay, Erie, Pennsylvania. U.S. Environmental Protection Agency, Chicago, IL. Online at: https://pawalter.psu.edu/sites/default/files/resources/Bullhead%20Hybridization%20Report%20%282007%29.pdf.

Davis, J.A., and B.K. Greenfield. 2004. Mercury in sport fish from the Delta Region (Task 2A). Final Report Submitted to the CALFED Bay-Delta Program for the Project: An Assessment of the Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed. Online at: http://loer.tamug.edu/calfed/Report/Final/Task%202A%20Final%20Report.pdf.

Davis, J.A., D. Yee, and W.A. Heim. 2018. Mercury and Methylmercury in Fish and Water from the Sacramento - San Joaquin Delta August 2016 - April 2017. Delta Regional Monitoring Program. Online at: https://www.sfei.org/sites/default/files/biblio_files/Delta%20RMP%20Mercury%20Data%20Report%202016_1.pdf.

Dunham, R.A., K.G. Norgren, L. Robison, R.O. Smitherman, T. Steeger, D.C. Peterson, and M. Gibson. 1994. Hybridization and Biochemical Genetics of Black and White Crappies in the Southeastern USA. Trans. Am. Fish. Soc. 123:141–149. Online at: https://afspubs.onlinelibrary.wiley.com/doi/abs/10.1577/1548-8659%281994%29123%3C0141%3AHABGOB%3E2.3.CO%3B2.

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., D.G. Slotton, and K.H. Harrold. 2013. Predictors of mercury spatial patterns in San Francisco Bay Forage Fish. Environ Tox Chem. 32(12): 2728-2737. Online at: https://setac.onlinelibrary.wiley.com/doi/full/10.1002/etc.2335.

Halas, D., N. Lovejoy, and N.E. Mandrak. 2018. Undetected Diversity of Goldfish (*Carassius* spp.) in North America. Aquatic Invasions. 13(2): 211–219. Online at: http://www.aquaticinvasions.net/2018/AI_2018_Halas_etal.pdf.

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.

Kelly, A.M. and B. Baumhoer. 2014. Species Profile: Hybrid Crappie. Southern Regional Aquaculture Center, Publication Number 7212. Online at: http://aquaculture.ca.uky.edu/sites/aquaculture.ca.uky.edu/files/srac_7212_species_profile_hybrid_crappie.pdf.

Kirby, J.M. 1982. Prey Utilization among Four Sympatric Species of Sunfish. Proc. PA. Acad. of Sci. 56(2):147–150. Online at: http://www.jstor.org/stable/44111415.

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.

Long, J.M. and W.L. Fisher. 2000. Inter-Annual and Size-Related Differences in the Diets of Three Sympatric Black Bass in an Oklahoma Reservoir. J. Freshw. Ecol. 15(4): 465–474. Online at: https://www.tandfonline.com/doi/abs/10.1080/02705060.2000.9663768.

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. 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. 2022. Protocol for Fish Sampling and Analysis to Support the Development of Fish Advisories in California. 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.

Pierce, P.C., and M.J. Van Den Avyle. 1997. Hybridization between Introduced Spotted Bass and Smallmouth Bass in Reservoirs. Trans. Am. Fish. Soc. 126(6):939–947. Online at: https://www.tandfonline.com/doi/abs/10.1577/1548-8659%281997%29126%3C0939%3AHBISBA%3E2.3.CO%3B2.

Slotton, D.G., S.M. Ayers, T.H. Suchanek, R.D. Weyland, A.M. Liston, C. Asher, D.C. Nelson, and B. Johnson. 2002. The Effects of Wetland Restoration on the Production and Bioaccumulation of Methylmercury in the Sacramento-San Joaquin Delta, California. Draft Final Report. Submitted in collaboration with the CALFED Bay-Delta Program Project: Assessment of Ecologiacal and Human Health Impacts of Mercury in the San Francisco Bay-Delta Watershed. October 1999 – March 2003. Online at: https://loer.tamug.edu/calfed/report/draftfinal/ucd_delta_report.pdf.

SFEI. 2009. Fish Mercury Project. A collaborative effort of the San Francisco Estuary Institute, the University of California, Davis, the California Department of Fish and Game, the Moss Landing Marine Laboratory, the California Department of Health Services, and the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment. Online at: http://www.sfei.org/cmr/fishmercury/index.php#sthash.puWVjPvC.dpbs.

SWRCB. 2007. Bioaccumulation of Pollutants in California Waters: A Review of Historic Data and Assessment of Impacts on Fishing and Aquatic Life. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/bop/cw117_swrcb_report.pdf.

SWRCB. 2010. Contaminants in Fish from California Lakes and Reservoirs, 2007–2008: Summary Report on a Two-Year Screening Survey. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/lakes_study/lake_survey_yr2_no_app.pdf.

SWRCB. 2011. Contaminants in Fish from California Rivers and Streams, 2011. Surface Water Ambient Monitoring Program. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at:

http://www.waterboards.ca.gov/water_issues/programs/swamp/docs/rivers_study/rs_rpt only.pdf.

SWRCB. 2013. State Mussel Watch (SMW) Program/Toxic Substances Monitoring (TSM) Program. State Water Resources Control Board, California Environmental Protection Agency, Sacramento, California. Online at: http://www.waterboards.ca.gov/water_issues/programs/swamp/mussel_watch.shtml.

Thongda, W., M. Lewis, H. Zhao, B. Bowen, D.J. Lutz-Carrillo, B.K. Peoples, and E. Peatman. 2020. Species-diagnostic SNP markers for the black basses (*Micropterus spp*.): a new tool for black bass conservation and management. *Cons. Genet. Resour.* 12:319–328. Online at: https://link.springer.com/article/10.1007%2Fs12686-019-01109-8.

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[24] 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 are followed, exposure to chemicals in fish 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	≤ 1000	>1,000–1200	>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.

[24] 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.