Section 5:
Potential Tissue Thresholds For California SQO{ TC "Potential Tissue Thresholds For California SQO" \f C \l "1" }

General Overview

The California Water Code indicates that water and sediment quality objectives must be protective of beneficial uses. Given the requirement to protect ecosystem functions as well as human health, separate effects thresholds must be identified to protect humans and piscivorous wildlife. The focus of this section is on the potential effects to wildlife, and humans from persistent and bioaccumulative compounds (e.g., PCBs and legacy pesticides). This section of the report recommends a methodology for determining effects thresholds in tissue concentrations for use in indirect effects SQOs. These thresholds are to be used in the fish tissue line of evidence. These tissue concentrations would also be used in combination with the BSAFs developed in section XX, for the sediment chemistry LOE. This section also summarizes some recent syntheses on potential effects to fish (*nb: will be written shortly*), which may be useful in future iterations of the SQO.

Sediments will be evaluated based on a weight of evidence approach, using three lines of evidence: 1. concentrations in field-caught fish or invertebrates; 2. concentrations in laboratory bioaccumulation test organisms (e.g., 28 day clam uptake experiments); 3. concentrations in sediments. Due to practical considerations, we recommend a standardized statewide set of prey tissue concentration thresholds for evaluation of SQOs. We have developed a generic set of tissue thresholds for consideration for potential use in the fish tissue line of evidence. This section presents these thresholds.

For the SQO, tissue concentrations will be classified into three categories, indicating progressive categories of risk from consumption of fish or shellfish (Table 5.1). The use of three categories is intended to account for the uncertainty inherent in the process of evaluating tissue contamination for the protection of multiple mobile species in a water body. For wildlife, we will use two tissue thresholds that are based on the use of low and high Toxicity Reference Values (TRVs). When low and high TRVs are available, low and high thresholds may be calculated, and both should be used to evaluate risk for a particular species of concern. Tissue thresholds for the protection of humans will be based on the Cancer Slope Factor (CSF) or noncarcinogen Reference Dose (RfD), whichever is more protective.

Calculation Methods For Protection of Sensitive and Endangered Wildlife

These thresholds are designed to protect sensitive and endangered wildlife that might consume fish exposed to contaminated sediments. These thresholds have been calculated by dividing toxicity reference values by ingestion rates appropriate for generic wildlife species of varying body sizes:

Threshold value concentration in fish or shellfish tissue =

Toxicity Reference Value * Predator Body Mass / Amount of food consumed per day

We recommend that a standardized set of Toxicity Reference Values (Table 5.2) be used statewide; modifications to effects thresholds would then be made based on body mass and consumption rate of target species (Table 5.3). To account for differences in wildlife species and body mass among different water bodies, Regional Water Boards and other regional regulatory agencies will be permitted to refine these thresholds using available local data on body mass for the species occurring in the water body of concern.

Each of these components will be treated in turn.

Toxicity Reference Values For Wildlife: Consensus-Based Values

Toxicity reference values are an important component of threshold determination. Due to the large impact of TRVs selected on threshold calculations, TRV development can be controversial. Due to budget and time constraints, it is outside the scope of our current work to develop new TRVs. Therefore, we selected TRVs that have already been developed and recommended elsewhere. To the extent possible, we selected these TRVs based on the following criteria:

1. Ecologically relevant endpoints which are likely to impact populations. These include mortality, growth, reproduction, and development (California DTSC Human and Ecological Risk Division 2000, U.S. EPA 2005).
2. A thorough review of all available literature.
3. A consensus approach in development. Specifically, toxicologists from multiple agencies should reach agreement on the TRVs in a team-based effort.

For birds and mammals, we have identified two sets of TRVs that fit the above criteria. These are the Navy/BTAG TRVs (California DTSC Human and Ecological Risk Division 2000) and the USEPA ECO-SSL values (U.S. EPA 2005). For dieldrin, Navy/BTAG TRVs, are not available, and we recommend USEPA ECO-SSL values (U.S. EPA 2005) (Table 5.2). For DDTs, PCBs, mercury, aldrin, and heptachlor, USEPA ECO-SSLs are not currently available. We recommend using Navy/BTAG TRVs for all of these contaminants. The derivation and basis for these TRVs may be found elsewhere (California DTSC Human and Ecological Risk Division 2000). For PCBs in mammals, we apply a value calculated for mink (further discussed below).

The California SQO in general, and indirect effects component in particular, should be able to incorporate additional findings via periodic reviews and updates (Beegan 2005). We recommend that these reviews include evaluation of the wildlife TRVs selected for SQO development. The Biological Technical Assistance Group has established a formal process for developing and refining TRVs based on additional available data (California DTSC Human and Ecological Risk Division 2000). Additionally, toxicologists on the SQO Sediment Quality Advisory Committee have expressed interest in the SQO wildlife risk thresholds. We recommend that BTAG or Sediment Quality Advisory Committee consider refining TRV values based on new available information to assist the indirect effect component of the SQO.

Additional Toxicity Reference Values

For a number of contaminants, we were unable to identify TRV-low or TRV-high developed using a multi-agency consensus approach. These include chlordanes and dieldrin, which were target contaminants for the case studies. We recommend the following TRVs for contaminants not established by BTAG or EPA ECO-SSLs.

Dieldrin

As indicated above, we recommend using the USEPA ECO-SSL value for a TRV-Low for Dieldrin (values are presented for birds and mammals in Table 5.2). The ECO-SSL TRV is based on NOAELs, and is therefore not appropriate for calculating a TRV-High. To obtain a TRV-High for dieldrin, we used the synthesis of appropriate studies conducted to generate the ECO-SSL (U.S. EPA 2005). Specifically, we determined the geometric mean of all avian and mammalian LOAELs for survival, growth, and reproductive effects. Based on this calculation, the TRV-High for dieldrin in mammals is 1.80 mg/kg/d (N = 34 studies) and the TRV–High for dieldrin in birds is 1.05 mg/kg/d (N = 37) (Table 5.2).

PCBs

The Navy/BTAG TRVs for PCBs in mammals are based on rodents, whereas SQO target species are pinnepeds. To achieve a TRV - Low, based on a more appropriate target species, we recommend using a PCB prey concentration TRV developed to be protective of mink (500 ng/g) (Chapman 2003).

Chlordanes

Chlordane TRV development presents a challenge, because there have been few studies of dietary uptake in animals, and no consensus evaluations. For total chlordanes in birds, we recommend using TRVs based on Stickel et al. (1983). This set of values is based on dietary uptake of chlordanes by red-winged blackbird, and has been recommended for TRV calculation by Sample et al. (1996), and used subsequently by von Stackelberg (2003). It has also been recommended by staff members of the CA Department of Toxic Substances Control for use in ecological risk assessments, and has been used in a number of military base ecological risk assessments in California (M. Anderson, DTSC, *pers. comm.*).

Chlordane calculations for birds were as follows. Stickel et. al (1983) reports a mortality NOAEL of 10 mg chlordane/kg food and a mortality LOAEL of 50 mg chlordane/kg food. The study exposure duration was 84 days, which may be interpreted as chronic or subchronic exposure (Sample et al. 1996). Food intake rate is 9 g/day based on allometric calculations for omnivorous birds and a reported body mass of 64 g (Nagy 2001). We calculate TRV-High based on the LOAEL, and assuming that 84 days represents chronic exposure, as:

(50 mg chlordane/kg food)*(0.009 kg food intake/day)/0.064 kg body mass
= 7.0 mg/(kg body weight*day)

We calculate TRV-Low based on the NOAEL, assuming that exposure was subchronic and reducing by a factor of 10 as a conservative estimate of chronic exposure from the subchronic exposure (Sample et al. 1996):

(10 mg chlordane/kg food)*(0.009 kg food intake/day)/
(0.064 kg body mass * 10 correction factor)
= 0.14 mg/(kg body weight*day)

For total chlordanes in mammals, we recommend using TRV - Low based on Khasawinah and Grutsch (1989a, 1989b) and a TRV – High based on World Health Organization (1984) (primary citation Keplinger et al. 1968). These values are based on dietary uptake of chlordanes by mice. Khasawinah and Grutsch (1989a, 1989b) were recommended for TRV calculation by staff members of CA Department of Toxic Substances Control for use in ecological risk assessments, and have been used in a number of military base ecological risk assessments in California (M. Anderson, DTSC, *pers. comm.*). Keplinger et al. (1968) were recommended for TRV calculation by Sample et al. (1996), and subsequently used by von Stackelberg (2003).

The chronic LOAEL in Keplinger et al. (1968) is 50 mg chlordane/kg food. Food intake rate is 4.6 g/day based on allometric calculations for rodents and a reported body mass of 30 g (Nagy 2001). We calculate TRV-High based on this LOAEL as:

(50 mg chlordane/kg food)*(0.0046 kg food intake/day)/0.030 kg body mass
= 7.7 mg/(kg body weight*day)

Khasawinah and Grutsch (1989a, 1989b) report a chronic NOAEL of 1 mg chlordane/kg food. Food intake rate is 4.6 g/day based on allometric calculations for rodents and a reported body mass of 30 g (Nagy 2001). We calculate TRV-Low based on this NOAEL as:

(1 mg chlordane/kg food)*(0.0046 kg food intake/day)/0.030 kg body mass
= 0.15 mg/(kg body weight*day)

Our observations indicate that exceedance of these chlordane thresholds (both low and high) is highly unlikely for California fishes collected in the recent past.

Heptachlor and Aldrin

The BTAG has previously developed mammalian TRVs for the pesticides, Heptachlor and Aldrin (Table 5.2). However, avian TRVs have not been developed for these pesticides by BTAG or by Sample et al. (1996), and published dose-response studies on these compounds are lacking. Heptachlor and Aldrin are not currently present in detectable concentrations in fish in California waters (Davis et al. 1999, Greenfield et al. 2000, Allen et al. 2004, Greenfield et al. 2004). Therefore, it is not necessary to develop avian TRVs for these contaminants.

Wildlife Consumption Rates and Body Masses

We calculate daily food consumption rates based on body mass using allometric equations presented in Nagy (2001). An illustrative example calculating DDT low and high thresholds for Least Tern may be found in Figure 5.1.

To simplify development and application of protective thresholds for statewide application, participants of the BTAG group have provided us with generic body mass estimates (Table 5.3) (B. Stanton, R. Donohue, and J. Yamamoto, CDFG-OSPR, *Pers. comm.*). These estimates were used to generate protective prey fish tissue concentrations using the equation presented on page 1 of this section, with results from these calculations presented in Table 5.4. Local agencies will be permitted to revise protective tissue concentration estimates using body mass data, when available for local target species.

Thresholds For Protection of Humans That Consume Fish

The SQO must protect against risk of contamination as a result of dietary exposure to finfish and shellfish associated with contaminated sediments (Beegan 2005). Following is the methodology and calculation of human health thresholds for consumption of carcinogens or non-carcinogens, as described in U.S. EPA guidance documentation (U. S. EPA 2000b, 2000a):

For carcinogens:

$$Threshold = \frac{RF * BW}{q1 * FC} \qquad \text{(Equation 1)}$$

where:

RF = Risk Factor (Maximum acceptable risk level - dimensionless)
BW = Body Weight = 70 kg
q1 = Oral cancer slope factor (kg*d)/mg
FC = Total Fish and Shellfish Consumption per Day (kg/d)

The methodology for calculating human health thresholds for non-carcinogens is:

$$Threshold = \frac{RfD * BW}{FC}$$

where RfD = oral reference dose (mg/(kg*d)).

Development of human consumption based thresholds is facilitated by standardized guidance on contaminant toxicity. In particular, the USEPA Integrated Risk Information System provides a consistent and updated data source, including reference doses and cancer slope factors for use in human health risk evaluation (U. S. EPA 2006). For developing human health effects thresholds, we calculate all cancer and non-cancer effects based on USEPA IRIS cancer slope factors and reference doses (RfD).

However, other factors must be decided upon to determine appropriate thresholds. In particular, the target population to protect, and allowable risk factor for carcinogens, must be selected. Table 5.5 indicates a series of potential tissue thresholds for protection of human consumers of fish in the state SQO. Table 5.5 represents the primary range of assumptions by state and national regulatory agencies for protection of consumers of wild-caught fish in California (Brodberg and Pollock 1999, U.S. EPA 2000a, 2000b). All thresholds were calculated according to US EPA guidance (U.S. EPA 2000a), using the same assumptions regarding reference dose, cancer slope factor and body mass (70 kg). However, risk factor for carcinogens was varied from 10^{-5} to 10^{-6}, and consumption rates were varied from subsistence fishers, to sport fishers, to the general population. The risk calculation that uses a more conservative combination of assumptions is in the top row of the table, and each following row is increasingly less conservative.

Specifically, the following sets of thresholds are calculated:

- The risk calculation following U.S. EPA recommendations for screening values to protect subsistence fishers (U.S. EPA 2000a).
- The risk calculation that was legislated in the California Toxics Rule (U.S. EPA 2000b). The state is required to calculate and present this threshold as part of the Sediment Quality Objectives.
- The risk calculation presented by OEHHA as a screening value to protect human consumers of sport fish in California waters (Brodberg and Pollock 1999), and used in calculating many OEHHA consumption advisories (R. Brodberg, OEHHA, *pers. comm.*).
- The risk calculation following U.S. EPA recommendations for screening values to protect sport fishers and the general public in the US (U.S. EPA 2000a).

A standardized set of tissue concentrations for protection of human health will be included in the SQO policy. The draft Functional Equivalent Document for the SQO indicates as the baseline scenario that the State Water Board would propose values that protect sport fishers and the general public at a cancer risk factor of 10^{-5}. The use of sport fisher and general public consumption rates and a 10^{-5} cancer risk is consistent with the assumptions in Water Quality Control Plans, Basin Plans, and TMDLs throughout the state. It is also consistent with the values used by OEHHA in developing fish consumption advisories in California water bodies (Brodberg and Pollock 1999), and human health screening values for sport fish consumers and the general population recommended by US EPA (U.S. EPA 2000a).

The SQO indirect effects implementation framework includes two thresholds. Given state guidance to protect sportfishers and the general public at a cancer risk factor of 10^{-5}, we follow recommendations of OEHHA (OEHHA 2001) to calculate a threshold based on average intake and a threshold based on upper percentile intake rate from this population. For average intake rate, we follow US EPA recommended consumption rate of 17.5 g/d for the general adult population and recreational fishers (U.S. EPA 2000a) (Table 5.6).

US EPA does not provide recommendations for an upper percentile intake rate for recreational sport fishers or the general public. The most recent peer-reviewed study to calculate confidence distributions for sport fish consumers is the San Francisco Bay Seafood Consumption Study (SFEI 2000). This study calculates consumption rates based on 12 month recall or 4 week recall. We select the 4 week recall, as the 12 month recall is more likely prone to errors, and was not adjusted for avidity bias (a sampling bias introduced by positive correlation between consumption rate and frequency of fishing). For the upper threshold calculation we use a consumption rate of 32 g/d, which is the 95^{th} percentile consumption rate of all sport fish consumers surveyed (4 week recall), adjusted for avidity bias (Table 5.6).

The calculated thresholds are presented in Table 5.7. It should be pointed out that these thresholds would be protective of subsistence fishers at a 10^{-4} cancer risk factor. USEPA estimates consumption at 17.5 g/d for the general adult population and recreational fishers, and 142.4 g/d for subsistence fishers. High-end consumption rate estimates in California waters are similar to EPA subsistence fisher levels (Allen et al. 1996, SFEI 2000).

Regional Board staff and other regulators would be permitted to develop alternative thresholds that represent the most appropriate assumptions for the water body of concern. Site specific information that should be used in deciding which thresholds to use include fish consumption rate of target consumers and level of risk deemed acceptable to public stakeholders for the water body of interest. As indicated previously, for the SQO, sediments will ultimately be broken into multiple categories, indicating different probabilities of indirect effects. Therefore, regulators will apply two thresholds for categorizing local sediments according to progressive categories of risk.

Table 5.1. Description of three categories for fish tissue line of evidence for indirect effects to wildlife.

Fish Tissue Score	Basis	Toxicity Threshold	Interpretation
● Unlikely exposure	95% upper confidence limit of average fish tissue concentration is below the low toxicity threshold for most sensitive wildlife endpoint	Fish tissue threshold based on Toxicity Reference Values representing no-effects levels (TRV-Low) to wildlife (Table 4)	Using a conservative set of assumptions, dietary exposure to fish in water body is unlikely to pose a risk to the most sensitive wildlife endpoint.
◘ Possible exposure	Tissue concentration is intermediate between low and high threshold	Both thresholds are relevant	Dietary exposure to fish in a water body may pose a risk to the most sensitive wildlife endpoint
● Probable exposure	Average fish tissue concentration is above the high toxicity threshold for most sensitive wildlife endpoint	Fish tissue threshold based on Toxicity Reference Values representing mid-range adverse effects levels (TRV-High) to wildlife (Table 4)	Dietary exposure to fish in a water body is likely to pose a risk to the most sensitive wildlife endpoint

Table 5.2. Toxicity Reference Values (TRVs), reference doses, and cancer slope factors used in fish tissue thresholds for protecting birds, mammals, and humans in California bays and estuaries.

Contaminant	Mammal Low TRV mg dw/(kg ww*day)	Mammal High TRV mg dw/(kg ww*day)	Ref.	Avian Low TRV mg dw/(kg ww*day)	Avian High TRV mg dw/(kg ww*day)	Ref.	Human Noncarcinogen RfD (mg/kg*d)	Human Carcinogen CSF (mg/kg*d)^-1 More protective	Ref.
Sum 6 DDTs	0.8	16	1	0.009	0.6	1 d	5.00E-04	0.34	5
PCBs a	g	1.28	1	0.09	1.27	1	2.00E-05	2	5
Aldrin	0.1	1	1	NA	NA		3.00E-05	1.7	5
Heptachlor	0.13	6.8	1	NA	NA		5.00E-04	4.5	5
Total Chlordanes b	0.15	7.7	2, 6	0.14	7.0	3 i	5.00E-04	0.35	5 e
Dieldrin	0.015	1.80	4 h	0.0709	1.05	4 h	5.00E-05	16	5
Toxaphene								1.1	5
Mercury	0.027	0.27	1 c	0.039	0.18	1	1.00E-04	NA	5 f

Notes to Table 5.2:

a. Sum congenors or aroclors
b. Sum of cis and trans chlordane, cis and trans nonachlor and oxychlordane
c. BTAG value for large mammals (mink)
d. Avian high TRV for total DDTs based on DDE, which is the major congener. DDT (the other TRVH) is only found in <10% of fish tissue and is mostly below detection
e. Note that OEHHA CSF for chlordanes was different from USEPA IRIS, and was set at 1.3.
f. The mercury RfD is the value to protect the fetus from neurodevelopmental effects. It is applicable to women of childbearing age to protect the fetus.
g. PCB Mammal Low TRV is a tissue concentration reference value (500 mg/kg), rather than a dose-based TRV (mg/(kg*day)), as presented in Table 5.4.
h. TRV high is geometric mean of all avian or mammalian values for survival, growth, and reproductive LOAEL dose values, reported in U.S. EPA 2005
NA = Not available due to insufficient data

1. California DTSC Human and Ecological Risk Division (2000)
2. Khasawinah and Grutsch (1989b, 1989a)
3. Stickel et al (1983)
4. U.S. EPA (2005)
5. U.S. EPA (2000a) EPA IRIS Database. http://www.epa.gov/iris/index.html
6. World Health Organization (1984) (primary citation Keplinger et al. 1968)

Table 5.3. Generic size classes (based on mass) to calculate tissue concentration thresholds (B. Stanton, R. Donohue, and J. Yamamoto, CDFG-OSPR, *pers. comm.*). These masses may be replaced with site-specific information on likely species, when such information are available. IR = ingestion rate.

Birds	Size Range	Example Species	Body mass to use in generic calculations	Equation to use to estimate food ingestion rate (IR) for generic calculations
Small	25 - 300 g	Snowy Plover Western Sandpiper Killdeer Least Tern Forster's Tern Black Skimmer	25 g	Marine Birds (Nagy, 2001) IR (g fresh mass/d) = 3.221*(g body mass)$^{0.658}$
Medium	300 - 1000 g	Clapper Rail Lesser Scaup Surf Scoter Western Grebe Black-crowned Night Heron	300 g	
Large	>1000 g	Brown Pelican Bald Eagle Osprey Double-Crested Cormorant Great Blue Heron	1000 g	
Marine Mammals				
Small	20 – 90 kg	Southern Sea otter	20 kg	Carnivores (Nagy, 2001) IR (g fresh mass/d) = 0.469*(g body mass)$^{0.848}$
Large	>90 kg	Harbor seal California sea lion Steller sea lion	90 kg	

Table 5.4. Calculated fish tissue thresholds for protection of generic wildlife consumers of finfish and shellfish in California bays and estuaries. Thresholds are calculated based on information in Tables 2 and 3, following methodologies in the text. BM = Body Mass. NA = Not available due to insufficient data

Group	Body Mass (kg) [a]	Allometric Eqn [a]	Daily Ingestion Rate (kg ww food/day)	Ingestion Rate (kg ww food/(kg body weight*day))	DDT Low (ppb wet weight fish tissue)	DDT High (ppb wet weight)	PCB Low (ppb wet weight)	PCB High (ppb wet weight)	Chlordane Low (ppb ww)	Chlordane High (ppb ww)	Dieldrin Low (ppb ww)	Dieldrin High (ppb ww)	Heptachlor Low (ppb ww)	Heptachlor High (ppb ww)	Aldrin Low (ppb ww)	Aldrin High (ppb ww)	Mercury Low (ppb ww)	Mercury High (ppb ww)
Small Birds	0.025	3.221(BM g)^0.658	0.027	1.071	8	560	84	1,190	131	6,530	66	980	NA	NA	NA	NA	36	168
Medium Birds	0.3	3.221(BM g)^0.658	0.137	0.458	20	1,310	197	2,770	306	15,300	155	2,290	NA	NA	NA	NA	85	393
Large Birds	1	3.221(BM g)^0.658	0.303	0.303	30	1,980	297	4,190	461	23,100	234	3,460	NA	NA	NA	NA	129	593
Small Mammals	20	0.469(BM)^0.848	2.082	0.104	7,686	154,000	500 [b]	12,300	1,440	74,000	144	17,300	1,250	65,300	961	9,610	259	2,590
Large Mammals	90	0.469(BM)^0.848	7.454	0.08	9,660	193,000	500 [b]	15,500	1,810	93,000	181	21,700	1,570	82,100	1,210	12,100	326	3,260

a. From Table 5.3.
b. PCB Mammal Low TRV is a tissue concentration reference value (500 mg/kg)[SB1], rather than a dose-based TRV

Table 5.5. Selected fish tissue thresholds for protection of human consumers of finfish and shellfish in California bays and estuaries. Highlighted cells are the lower threshold among the cancer risk and non-cancer risk (Reference dose) approaches. All scenarios assume a consumer body mass of 70 kg (U.S. EPA 2000a).

Description of combination of assumptions	Risk Factor	Reference	Consumption Rate (kg/day)	Reference	Cancer DDT (ppb wet weight)	Non-cancer DDT (ppb wet weight)	Cancer PCB (ppb wet weight)	Non-cancer PCB (ppb wet weight)	Cancer Chlordane (ppb ww)	Non-cancer Chlordane (ppb ww)	Cancer Dieldrin (ppb ww)	Non-cancer Dieldrin (ppb ww)	Cancer Heptachlor (ppb ww)	Non-cancer Heptachlor (ppb ww)	Cancer Aldrin (ppb ww)	Non-cancer Aldrin (ppb ww)	Cancer Mercury (ppm ww)	Non-cancer Mercury (ppm ww)
USEPA SV for subsistance fishers	1.00E-05	1	0.1424	3	14	246	2.5	10	14	246	0.3	25	1.1	246	2.9	15	NA	0.05
California Toxics Rule Value	1.00E-06	2	0.0065	2	32	5385	5.4	215	31	5385	0.7	538	2.4	5385	6.3	323	NA	1.08
OEHHA Screening Value	1.00E-05	1	0.0210	4	98	1667	17	67	95	1667	2.1	167	7.4	1667	19.6	100	NA	0.33
USEPA SV sportfishers&general pop.	1.00E-05	1	0.0175	5	118	2000	20	80	114	2000	2.5	200	8.9	2000	23.5	120	NA	0.40

1. Used in OEHHA and USEPA screening values (Brodberg and Pollock 1999, U.S. EPA 2000a)
2. (U.S. EPA 2000b)
3. subsistance fisher consumption rate (U.S. EPA 2000a) (Table 5-2)
4. Santa Monica Bay Seafood Consumption Study (SCCWRP and MBC 1994, Allen et al. 1996). Recommended by OEHHA (OEHHA 2001).
5. recreational fisher and general public consumption rate (U.S. EPA 2000a) (Table 5-2)

Table 5.6. Description of three categories for fish tissue line of evidence for indirect effects to humans.

Fish Tissue Score	Basis	Toxicity Threshold	Interpretation
● Unlikely exposure	95% upper confidence limit of average fish tissue concentration is below the low toxicity threshold for sport fisher consumers	Fish tissue threshold based on protecting the 95 percentile of sport fish consumers such that no more than 1 in 100,000 faces an increased cancer risk	Using a conservative set of assumptions, dietary exposure to fish in water body poses a low risk to fishers who consume their catch and the general public
◘ Possible exposure	Tissue concentration is intermediate between low and high threshold	Both thresholds are relevant	Dietary exposure to fish in a water body may pose a risk to fishers who consume their catch
● Probable exposure	Average fish tissue concentration is above the high toxicity threshold for sport fishers and the general population	Fish tissue threshold based on protecting the average sport fish consumer such that no more than 1 in 100,000 faces an increased cancer risk	Dietary exposure to fish in a water body is likely to pose a risk to sport fish consumers

Table 5.7. Calculated fish tissue thresholds for protection of human consumers of finfish and shellfish in California bays and estuaries. Thresholds are calculated based on assumptions in Table 6, following methodologies in the text. NA = Not applicable

Threshold	Cancer DDT (ppb wet weight)	Non-cancer DDT (ppb wet weight)	Cancer PCB (ppb wet weight)	Non-cancer PCB (ppb wet weight)	Cancer Chlordane (ppb ww)	Non-cancer Chlordane (ppb ww)	Cancer Dieldrin (ppb ww)	Non-cancer Dieldrin (ppb ww)	Cancer Heptachlor (ppb ww)	Non-cancer Heptachlor (ppb ww)	Cancer Aldrin (ppb ww)	Non-cancer Aldrin (ppb ww)	Cancer Mercury (ppm ww)	Non-cancer Mercury (ppm ww)
Low	64	1094	10.9	44	63	1094	1.4	109	4.9	1094	12.9	66	NA	0.22
High	118	2000	20.0	80	114	2000	2.5	200	8.9	2000	23.5	120	NA	0.40

Figure 5.1. Example of calculations for small bird effects threshold

Bird effects thresholds were calculated following guidance in Sample et al. (1996) and Zeeman (2004)

Assuming small bird body mass = 25 g = 0.025 kg;

Threshold value concentration in prey fish =

Toxicity Reference Value * Predator Body Mass / Amount of food consumed per day

Cfish = TRV * Mass / Consumption

Amount of food consumed per day (in grams) = Allometric function of body mass (in grams) = ($3.221 * BW^{0.658}$); (Nagy 2001)

For PCBs in small birds

Low TRV = 0.09 mg/(kg*day); (California DTSC Human and Ecological Risk Division 2000)
High TRV = 1.27 mg/(kg*day); (California DTSC Human and Ecological Risk Division 2000)
Mass = 25 g;

Low threshold = $0.09 * 25 / (3.221 * 25^{0.658}) = 0.084$ mg/kg = 84 ppb

i.e., Prey fish low threshold = TRV_{low} * Mass / Consumption rate
$= 0.09_{mg/(kg*d)} * 25_{g} / 26.8_{g/d} = 0.084$ mg/kg = 84 ppb

High threshold = $1.27 * 25 / (3.221 * 25^{0.658}) = 1.186$ mg/kg = 1,186 ppb

i.e., Prey fish high threshold = TRV_{high} * Mass / Consumption rate
$= 1.27_{mg/(kg*d)} * 25_{g} / 26.8_{g/d} = 1.186$ mg/kg = 1,186 ppb

Figure 5.2: Additional potential sources of species life history information

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