SECTION 3

DEVELOPMENT AND USE OF RISK-BASED CONSUMPTION LIMITS

3.1 OVERVIEW AND SECTION ORGANIZATION

This section describes the derivation and use of the risk-based consumption limit tables provided in Section 4. Consumption limit tables were developed for each of the 25 target analytes listed in Table 1-1 and described in further detail in Volume 1 of this series. This section discusses

- Equations used to calculate the consumption limit tables
- Default values used in developing the consumption limit tables
- Modifications to the consumption limit calculations to allow for different input values and for multiple species consumption and/or multiple contaminant exposure.

Methods for deriving consumption limits for chemical contaminants with carcinogenic and/or noncarcinogenic effects are described. When available data indicate that a target analyte is associated with both carcinogenic and noncarcinogenic health effects, consumption limits based on both types of effects are calculated. In these cases, it is recommended that the toxicological effect resulting in the more conservative consumption limits be used to issue an advisory since resulting limits would be protective of both types of health effects. Methods for calculating consumption limits for a single contaminant in a multiple species diet or for multiple contaminants causing the same chronic health effects endpoints are also discussed. Species-specific consumption limits are calculated as fish meals per month, at various fish tissue concentrations, for noncancer and cancer health endpoints.

Developing fish consumption limits also requires making assumptions about the edible portions of fish because most chemical contaminants are not evenly distributed throughout the fish. The portion of the fish typically eaten may vary by fish species and/or the dietary habits of the fisher population of concern. Most fishers in the United States consume fish fillets. Therefore, it is recommended that contaminant concentrations be measured using skin-on fillets for scaled fish species and skinless fillets for scaleless fish species (e.g., catfish) (see Section 6.1.1.6 in Volume 1 of this series for further discussion of edible fish and shellfish sample types). However, for populations that ingest whole fish, consumption values corresponding to whole fish contaminant concentrations are more appropriate. Fish consumption patterns are discussed in more detail in Appendix B.

People may be exposed to one or more fish contaminants through sources or pathways other than through consumption of recreationally or subsistence caught fish. These sources include ingestion of contaminated commercially caught fish, other contaminated foods, or contaminated drinking water; inhalation of the contaminant; or dermal contact with contaminated materials including soil and sediment. Caution should be used in setting health safety standards that do not take these other sources into account (see Section 2 for further discussion). Methods for quantifying exposure via sources other than consumption of recreationally or subsistence caught fish are not discussed in detail in this series.

3.2 EQUATIONS USED TO DEVELOP RISK-BASED CONSUMPTION LIMITS

Two equations are required to derive meal consumption limits for either carcinogenic or noncarcinogenic health effects. The first equation (3-1 for carcinogenic effects or Equation 3-3 for noncarcinogenic effects) is used to calculate daily consumption limits in units of milligrams of edible fish per kilogram of consumer body weight per day (mg/kg-d); the second equation (3-2) is used to convert daily consumption limits to meal consumption limits over a specified period of time (e.g., 1 month). Toxicological benchmark values for carcinogenic and noncarcinogenic health effects used in the calculation of risk-based consumption limits are summarized in Table 3-1.

3.2.1 Calculation of Consumption Limits for Carcinogenic Effects

To calculate consumption limits for carcinogenic effects, it is necessary to specify an "acceptable" lifetime risk level (ARL). The appropriate risk level for a given population is determined by risk managers; see Volume 3 for further discussion of selection of appropriate risk level. This document presents consumption limits that were calculated using a risk level of 1 in 100,000 (10^{-5}). Equations 3-1 and 3-2 were used to calculate risk-based consumption limits for the 12 target analytes with cancer slope factors (see Table 3-1), based on an assumed 70-yr exposure. A 70-yr lifetime is used in keeping with the default value provided in EPA's *Exposure Factors Handbook* (U.S. EPA, 1990a). This is a normative value; individuals may actually be exposed for greater or lesser periods of time, depending on their lifespan, consumption habits, and residence location. It should be noted that no populations were identified as being particularly susceptible to the carcinogenic effects of the target analytes.

3.2.1.1 Calculation of Daily Consumption Limits—

Equation 3-1 calculates an allowable daily consumption of contaminated fish based on a contaminant's carcinogenicity, expressed in kilograms of fish consumed per day:

Table 3-1. Risk Values Used in Risk-Based Consumption Limit Tables

	Noncarcinogens	Carcinogens
Target Analyte	**Chronic RfD[a] (mg/kg-d)**	**CSF[a] $(mg/kg\text{-}d)^{-1}$**
Metals		
Arsenic (inorganic)[c]	3×10^{-4}	1.5
Cadmium	1×10^{-3}	NA
Mercury (methylmercury)[d]	1×10^{-4}	NA
Selenium	5×10^{-3}	NA
Tributyltin[b]	3×10^{-4}	NA
Organochlorine Pesticides		
Total chlordane (sum of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane)[e]	5×10^{-4}	0.35
Total DDT (sum of 4,4'- and 2,4'-isomers of DDT, DDE, and DDD)[f]	5×10^{-4}	0.34
Dicofol[g]	4×10^{-4}	withdrawn
Dieldrin	5×10^{-5}	16
Endosulfan (I and II)	6×10^{-3}	NA
Endrin	3×10^{-4}	NA
Heptachlor epoxide	1.3×10^{-5}	9.1
Hexachlorobenzene	8×10^{-4}	1.6
Lindane (γ-hexachlorocyclohexane; γ-HCH)[i]	3×10^{-4}	1.3
Mirex	2×10^{-4}	NA
Toxaphene[h,j]	2.5×10^{-4}	1.1
Organophosphate Pesticides		
Chlorpyrifos[k]	3×10^{-4}	NA
Diazinon[l]	7×10^{-4}	NA
Disulfoton	4×10^{-5}	NA
Ethion	5×10^{-4}	NA
Terbufos[m]	2×10^{-5}	NA
Chlorophenoxy Herbicides		
Oxyfluorfen[n]	3×10^{-3}	7.32×10^{-2}
PAHs[o]	NA	7.3
PCBs		
Total PCBs	2×10^{-5}	2.0[p]
Dioxins/furans[q]	NA	1.56×10^{5}

CSF = Cancer slope factor $(mg/kg\text{-}d)^{-1}$.
DDD = p,p' -dichlorodiphenyldichloroethane.
DDE = p,p' -dichlorodiphenyldichloroethylene
DDT = p,p' -dichlorodiphenyltrichloroethane.
NA = Not available in EPA's Integrated Risk Information System (IRIS, 1999).
PAH = Polycyclic aromatic hydrocarbon.
PCB = Polychlorinated biphenyl.
RfD = Oral reference dose (mg/kg-d).

(continued)

Table 3-1 (continued)

[a] Unless otherwise noted, values listed are the most current oral RfDs and CSFs in EPA's IRIS database (IRIS, 1999).
[b] The RfD value listed is for the IRIS (1999) value for tributyltin oxide.
[c] Total inorganic arsenic should be determined.
[d] Because most mercury in fish and shellfish tissue is present primarily as methylmercury (NAS, 1991; Tollefson, 1989) and because of the relatively high cost of analyzing for methylmercury, it is recommended that total mercury be analyzed and the conservative assumption be made that all mercury is present as methylmercury. This approach is deemed to be most protective of human health and most cost-effective. The National Academy of Sciences (NAS) conducted an independent assessment of the RfD and concluded, "On the basis of its evaluation, the committee consensus is that the value of EPA's current RfD for methylmercury, 0.1 µg/kg per day, is a scientifically justifiable level for the protection of human health."
[e] The RfD and CSF values listed are derived from studies using technical-grade chlordane (IRIS, 1999). No RfD or CSF values are given in IRIS (1999) for the *cis*- and *trans*-chlordane isomers or the major chlordane metabolite, oxychlordane, or for the chlordane impurities *cis*- and *trans*-nonachlor. It is recommended that the total concentration of *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, and oxychlordane be determined.
[f] The RfD value listed is for DDT. The CSF value is 0.34 for total DDT (sum of DDT, DDE, and DDD). The CSF value for DDD is 0.24. It is recommended that the total concentration of the 2,4′- and 4,4′-isomers of DDT and its metabolites, DDE and DDD, be determined.
[g] The RfD value is from the Registration Eligibility Decision (RED). Dicofol (U.S. EPA, 1998a).
[h] The RfD value listed is from the Office of Pesticide Program's Reference Dose Tracking Report (U.S. EPA, 1997c).
[i] IRIS (1999) has not provided a CSF for lindane. The CSF value listed for lindane is from HEAST, 1997.
[j] The RfD value has been agreed upon by the Office of Pesticide Programs and the Office of Water.
[K] Because of the potential for adverse neurological developmental effects, EPA recommends the use of a Population Adjusted Dose (PAD) of $3x10^{-5}$ mg/k-d for infants, children to the age of six, and women ages 13-50 (U.S. EPA, 2000b).
[l] The RfD value is from a memo data April 1, 1998, Diazinon: Report of the Hazard Identification Assessment Review Committee. HED DOC. NO. 012558 (U.S. EPA, 1998c).
[m] The RfD value listed is from a memorandum dated September 25, 1997; Terbufos-FQPA Requirement Report of the Hazard Identification Review (U.S. EPA, 1997h).
[n] The CSF value is from a memo dated 9/24/98; REVISED Oxyfluorfen (GOAL) Quantitative Risk Assessment (Q1*) Based on CD-1 Male Mouse Dietary Study With 3/4's Interspecies Scaling Factor. HED Document No. 012879 (U.S. EPA, 1998c).
[o] The CSF value listed is for benzo[*a*]pyrene. Values for other PAHs are not currently available in IRIS (1999). It is recommended that tissue samples be analyzed for benzo[*a*]pyrene and 14 other PAHs and that the order-of-magnitude relative potencies given for these PAHs (Nisbet and LaGoy, 1992; U.S. EPA, 1993b) be used to calculate a potency equivalency concentration (PEC) for each sample (see Section 5.3.2.4 of Volume 1).
[p] The CSF is based on a carcinogenicity assessment of Aroclors 1260, 1254, 1242, and 1016. The CSF presented is the upper-bound slope factor for food chain exposure. The central estimate is 1.0 (IRIS, 1999).
[q] The CSF value listed is for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) (HEAST, 1997). It is recommended that the 17 2,3,7,8-substituted tetra- through octa-chlorinated dibenzo-*p*-dioxins and dibenzofurans and the 12 dioxin-like PCBs be determined and a toxicity-weighted total concentration be calculated for each sample, using the method for estimating Toxicity Equivalency Concentrations (TEQs) (Van den Berg et al., 1998).

$$CR_{lim} = \frac{ARL \cdot BW}{CSF \cdot C_m} \tag{3-1}$$

where

CR_{lim} = maximum allowable fish consumption rate (kg/d)
ARL = maximum acceptable individual lifetime risk level (unitless)
BW = consumer body weight (kg)
CSF = cancer slope factor, usually the upper 95 percent confidence limit on the linear term in the multistage model used by EPA [(mg/kg-d)$^{-1}$], (see Section 2 for a discussion of this value)
C_m = measured concentration of chemical contaminant *m* in a given species of fish (mg/kg).

The calculated daily consumption limit (CR_{lim}) represents the amount of fish (in kilograms) expected to generate a risk no greater than the maximum ARL used, based on a lifetime of daily consumption at that consumption limit.

3.2.1.2 Calculation of Meal Consumption Limits—

Daily consumption limits may be more conveniently expressed as the allowable number of fish meals of a specified meal size that may be consumed over a given time period. The consumption limit is determined in part by the size of the meal consumed. An 8-oz (0.227-kg) meal size was assumed. Equations 3-1 and 3-2 can be used to convert daily consumption limits, the number of allowable kilograms per day (calculated using Equation 3-1), to the number of allowable meals per month:

$$CR_{mm} = \frac{CR_{lim} \cdot T_{ap}}{MS} \tag{3-2}$$

where

Cr_{mm} = maximum allowable fish consumption rate (meals/mo)
Cr_{lim} = maximum allowable fish consumption rate (kg/d)
MS = meal size (0.227 kg fish/meal)
T_{ap} = time averaging period (365.25 d/12 mo = 30.44 d/mo).

Equation 3-2 was used to convert daily consumption limits, in kilograms, to meal consumption limits over a given time period (month) as a function of meal size. Monthly consumption limits for carcinogenic effects in adults in the general population were derived for 13 of the 25 target analytes in Section 4.

Other consumption rates, such as meals per week, could also be calculated using this equation by substituting, for example, 7 d/wk for 30.44 d/mo. In using

Equation 3-2 in the table calculations in Section 4, the reader should note that 1 month was expressed as 365.25 d/12 mo or 30.44 d/mo.

3.2.1.3 Input Parameters—

Calculating risk-based consumption limits for carcinogenic effects requires developing appropriate values for the parameters in the equations. The default values used to calculate the consumption limits listed in Section 4 are shown in Table 3-2; a range of values is provided for the measured contaminant concentration in fish tissue (C_m) to represent a broad spectrum of contaminant concentrations. See consumption limit tables in Section 4. Development and modification of these values are discussed in Section 3.3.

EXAMPLE 1: Calculating Monthly Consumption Limits for Carcinogenic Health Endpoints in the General Population for Chlordane

Table 3-2. Input Parameters for Use in Risk Equations

Equation Parameter[a]	Values
Maximum acceptable risk level (ARL)	10^{-5} (unitless)
Cancer slope factor (CSF)[b] Reference dose (RfD)	$(mg/kg\text{-}d)^{-1}$ mg/kg-d
Consumer body weight (BW)	70 kg (general adult population)
Average fish meal size (MS)	8 oz (0.227 kg)
Measured contaminant concentration in edible fish and shellfish tissue (C_m)[c]	mg/kg (ppm) varies with local conditions for each chemical contaminant, for each species, and for each size (age) class within a species
Time-averaging period (T_{ap})	30.44 d/mo (monthly limit)

[a] Selection of the appropriate maximum acceptable risk level, consumer body weight, and average fish meal size are considered risk management decisions. For information regarding these values, see Sections 2 and 5 of this document and Volume 3.

[b] Most of the CSFs and RfDs were obtained from EPA's Integrated Risk Information System (IRIS, 1999). The RfDs not listed in IRIS were obtained from EPA's Office of Pesticide Programs. The CSFs and RfDs used in the risk equations are listed in Table 3-1 and are discussed in Section 5.

[c] Values for contaminant concentrations should be determined from local fish sampling and analysis programs conducted in the waterbody of concern as described in Volume 1.

Using Equations 3-1 and 3-2, the monthly meal consumption limits were calculated for the carcinogenic effects of chlordane for adults in the general population as shown in Table 3-3. **Note**: In this section, the monthly consumption limits for chlordane for both carcinogenic and chronic (noncarcinogenic) health effects are used to illustrate various modifications to the monthly consumption limit tables.

3.2.2 Calculation of Consumption Limits for Noncarcinogenic Effects

Noncarcinogenic health effects caused by consumption of contaminated fish include systemic effects such as liver, kidney, neurological, muscular, ocular, reproductive, respiratory, circulatory, or other organ toxicities and adverse developmental/reproductive effects from acute and chronic exposure. Risk-based consumption limit tables for chronic exposure health effects were developed for adults and young children for 23 of the 25 target analytes using RfDs for chronic systemic health effects.

3.2.2.1 Calculation of Daily Consumption Limits—

Equation 3-3 calculates an allowable daily consumption (CR_{lim}) of contaminated fish, based on a contaminant's noncarcinogenic health effects, and is expressed in kilograms of fish per day:

$$CR_{lim} = \frac{RfD \bullet BW}{C_m} \tag{3-3}$$

where

CR_{lim} = maximum allowable fish consumption rate (kg/d)
RfD = reference dose (mg/kg-d)
BW = consumer body weight (kg)
C_m = measured concentration of chemical contaminant *m* in a given species of fish (mg/kg).

CR_{lim} represents the maximum lifetime daily consumption rate (in kilograms of fish) that would not be expected to cause adverse noncarcinogenic health effects. Most RfDs are based on chronic exposure studies (or subchronic studies used with an additional uncertainty factor). Because the contaminant concentrations required to produce chronic health effects are generally lower than those causing acute health effects, the use of chronic RfDs in developing consumption limits is expected to also protect consumers against acute health effects. They are designed to protect the most sensitive individuals.

To calculate weekly fish meal consumption limits, Equation 3-3 was modified as follows:

$$C_m = \frac{RfD \times BW}{CR_{lim}} \quad . \tag{3-4}$$

Using this equation, one can calculate the level of chemical contamination (C_m) in a given species of fish assuming that a 70-kg adult consumes a maximum of one 8-oz (0.227-kg) meal/wk.

3.2.2.2 Calculation of Meal Consumption Limits—

Equation 3-2 is used to convert daily consumption limits, in kilograms, to meal consumption limits over given time periods as a function of meal size. An 8-oz meal size was assumed in the calculations. Monthly consumption limits were derived for all target analytes in Section 4 except PAHs and dioxins, for which RfD values are not available. Monthly consumption limits pertain to recreational fishers (see Section 2.4.5.4). Where appropriate, risk assessors may choose to derive consumption limits based on a shorter time-averaging period such as a 14-d period (see Section 3.3.6). Note that, irrespective of the time-averaging period selected (e.g., 7-d, 10-d, 14-d, monthly), the same chronic systemic RfDs are applicable; the difference is in the averaging periods used in Equation 3-2.

Note: This approach does not expressly limit the amount of fish that may be consumed in a given day during the specified time period, so care must be taken to inform consumers of the dangers of eating large amounts of contaminated fish in one meal when certain acute or developmental toxicants are of concern.

3.2.2.3 Input Parameters—

For noncarcinogenic effects, calculating risk-based consumption limits requires developing appropriate values for similar parameters to those required for carcinogenic effects (see Table 3-2).

3.2.3 Developmental Effects

This guidance document does not calculate consumption limits specifically for developmental effects. For the majority of target analytes, sufficiently detailed developmental toxicity data are not available. For two analytes, methylmercury and PCBs, sufficient data are available demonstrating that women exposed to these chemicals may transfer sufficient amounts in utero or through breast feeding to induce pre- or postnatal developmental damage in their offspring. The interim RfD for methylmercury (1×10^{-4} mg/kg-d) is based on developmental effects in humans (i.e., neurologic changes in Iraqi children who had been exposed in utero).

EXAMPLE 2: Calculating Monthly Consumption Limits for Chronic Systemic Health Endpoints for Recreational Fishers for Chlordane

Using Equations 3-3 and 3-2, the monthly meal consumption limits were calculated for the noncarcinogenic and carcinogenic health effects of chlordane for recreational fishers as shown in Table 3-3. Note: In comparing the consumption limit tables for chlordane based on carcinogenic and noncarcinogenic effects for the general population, it is apparent that the carcinogenic endpoint results in a more conservative consumption limit assuming an ARL of 10^{-5} and equivalent meal sizes and contaminant concentrations in fish tissues. For example, based on a chemical contaminant level in fish tissue of 0.1 ppm, an adult could eat seven 8-oz fish meals assuming an ARL of 10^{-5}. Given the same level of tissue contamination, an adult could eat >30 8-oz meals per month based on noncarcinogenic effects of chlordane. To protect consumers from both the carcinogenic and noncarcinogenic effects of chlordane, a risk assessor may choose to base consumption limits on the more conservative meal sizes derived for carcinogenic effects. In this situation, a risk assessor or risk manager may wish to issue the consumption advisory based on the carcinogenic effects of chlordane, which would be protective of chronic health effects given the above-stated assumptions.

Thus, the consumption limits would be protective against developmental effects for methylmercury.

3.3 DEFAULT AND ALTERNATIVE VALUES FOR CALCULATING CONSUMPTION LIMITS

The consumption limit tables provided in Section 4 are based on default values for consumer body weights and average meal sizes. This section describes the default values shown in Tables 3-1 and 3-2 and provides alternative input values and multipliers for use in modifying and/or recalculating the consumption limit tables.

Seven variables are involved in calculating the values in the consumption limit tables (see Equations 3-1 through 3-3):

- Maximum acceptable risk level (ARL)
- Cancer slope factor (CSF)
- Chronic reference dose (RfD)
- Consumer body weight (BW)
- Fish meal size (MS)
- Contaminant concentration in edible fish tissue (C_m)
- Time-averaging period (30-d period).

Monthly meal consumption limit tables for both the carcinogenic and noncarcinogenic health effects of chlordane are used as examples to illustrate the effects of modifying one or more of the variables listed above.

Table 3-3. Monthly Fish Consumption Limits for Carcinogenic and Noncarcinogenic Health Endpoints - Chlordane

Risk Based Consumption Limit[a]	Noncancer Health Endpoints[b]	Cancer Health Endpoints[c]
Fish Meals/Month	**Fish Tissue Concentrations (*ppm, wet weight*)**	**Fish Tissue Concentrations (*ppm, wet weight*)**
Unrestricted (>16)	0 - 0.15	0 - 0.0084
16	>0.15 - 0.29	>0.0084 - 0.017
12	>0.29 - 0.39	>0.017 - 0.022
8	>0.39 - 0.59	>0.022 - 0.034
4	>0.59 - 1.2	>0.034 - 0.067
3	>1.2 - 1.6	>0.067 - 0.089
2	>1.6 - 2.3	>0.089 - 0.13
1	>2.3 - 4.7	>0.13 - 0.27
0.5	>4.7 - 9.4	>0.27 - 0.54
None (<0.5)	>9.4	>0.54

[a] The assumed meal size is 8 oz (0.227 kg). The ranges of chemical concentrations presented are conservative, e.g., the 12-meal-per-month levels represent the concentrations associated with 12 to 15.9 meals.
[b] Chronic, systemic effects.
[c] Cancer values represent tissue concentrations at a 1 in 100,000 risk level.

Notes:
1. Consumption limits are based on an adult body weight of 70 kg, an RfD of $5x10^{-4}$ mg/kg-d, and a cancer slope factor (CSF) of 0.35 $(mg/kg\text{-}d)^{-1}$
2. None = No consumption recommended.
3. In cases where >16 meals per month are consumed, refer to Equations 3-1 and 3-2, Section 3.2.1.2, for methods to determine safe consumption limits.
4. The detection limit for chlordane is 5×10^{-3} mg/kg.
5. Instructions for modifying the variables in this table are found in Section 3.3.
6. Monthly limits are based on the total dose allowable over a 1-month period (based on the RfD). When the monthly limit is consumed in less than 1 month (e.g., in a few large meals), the daily dose may exceed the RfD (see Section 2.3).

3.3.1 Maximum Acceptable Risk Level

The consumption limit tables shown in Section 4 for target analytes with carcinogenic effects were calculated for maximum individual ARL of 10^{-5}. Note that the variable ARL appears in the numerator of Equation 3-1, the equation for calculating the daily consumption limit for carcinogens. Because ARL appears in multiples of 10, one may derive new meal consumption limits from the existing tables by multiplying or dividing the existing meal consumption limits by factors of 10, as appropriate. In the same way, changing the ARL by a factor of 10 would cause the same meal consumption limits to be valid for chemical concentrations 10 times higher or 10 times lower than those associated with the original ARL (see Table 3-4).

Table 3-4. Monthly Fish Consumption Limits for Carcinogenic Health Endpoints - Chlordane

Risk Based Consumption Limit[a]	Recommended Risk-Based Consumption Limit (meals per month, 8-oz meal size) Fish tissue Concentrations (*ppm, wet weight*)			
Fish Meals/Month	**ARL 10^{-4}**	**ARL 10^{-5}**	**ARL 10^{-6}**	**ARL 10^{-7}**
Unrestricted (>16)	0 - 0.084	0 - 0.0084	0 - 0.00084	0 - 0.000084
16	>0.084 - 0.17	>0.0084 - 0.017	>0.00084 - 0.0017	>0.000084 - 0.00017
12	>0.17 - 0.22	>0.017 - 0.022	>0.0017 - 0.0022	>0.00017 - 0.00022
8	>0.22 - 0.34	>0.022 - 0.034	>0.0022 - 0.0034	>0.00022 - 0.00034
4	>0.34 - 0.67	>0.034 - 0.067	>0.0034 - 0.0067	>0.00034 - 0.00067
3	>0.67 - 0.89	>0.067 - 0.089	>0.0067 - 0.0089	>0.00067 - 0.00089
2	>0.89 - 1.3	>0.089 - 0.13	>0.0089 - 0.013	>0.00089 - 0.0013
1	>1.3 - 2.7	>0.13 - 0.27	>0.013 - 0.027	>0.0013 - 0.0027
0.5	>2.7 - 5.4	>0.27 - 0.54	>0.027 - 0.054	>0.0027 - 0.0054
None (<0.5)	>5.4	>0.54	>0.054	>0.0054

[a] The assumed meal size is 8 oz (0.227 kg). The ranges of chemical concentrations presented are conservative, e.g., the 12-meal-per-month levels represent the concentrations associated with 12 to 15.9 meals.

Notes:
1. Consumption limits are based on adult body weight of 70 kg and a cancer slope factor of 0.35 (mg/kg-d^{-1}).
2. None = No consumption recommended.
3. In cases where >16 meals per month are consumed, refer to Equations 3-1 and 3-2, Section 3.2.1.2, for methods to determine safe consumption limits.
4. The detection limit for chlordane is 1 x 10^{-3} mg/kg.
5. Instructions for modifying the variables in this table are found in Section 3.3.
6. ARL = Acceptable risk level.

3.3.2 Cancer Potencies and Chronic Reference Doses (q_1*s and RfDs)

Table 3-1 contains the risk values used in the development of the consumption limit tables shown in Section 4. All of the CSFs and RfDs were obtained from EPA databases, primarily from IRIS (1999). Preference was given to IRIS values because these values represent consensus within EPA. When IRIS values were not available, RfDs from other EPA sources were used (see Section 5).

3.3.3 Consumer Body Weight (BW)

The consumption limit tables in Section 4 are based on fish consumer body weight of 70 kg (156 lb), the average body weight of male and female adults in the U.S. population (U.S. EPA, 1990a).

As Equation 3-3 shows, consumption limits are linearly related to body weight. That is, the higher the body weight assumed for the population of concern, the higher the consumption limits. EPA's *Exposure Factors Handbook* (U.S. EPA, 1990a) provides additional specific body weight information that can be used to adjust the body weight component of Equation 3-3. The values can also be used to develop a set of multipliers to directly adjust consumption limits for body weight variations.

Table 3-5 provides a range of average body weights (based on age and sex) for the U.S. population and their associated multipliers. Values in bold are those values used in the calculation of the consumption limit tables in Section 4. A **multiplier** is provided for each age group, which represents the number by which the meal consumption limits in the **general adult population** tables may be multiplied to calculate new meal consumption limits using an alternative body weight.

3.3.3.1 Derivation of Multipliers for Body Weight Adjustment—

Body weight multipliers represent the ratio of the alternative body weight to the standard 70-kg adult body weight. Body weight multipliers were calculated as follows:

$$\text{Multiplier}_{BW} = \frac{\text{Alternative Consumer Body Weight}}{\text{General Adult Body Weight}} \qquad (3\text{-}5)$$

To derive modified consumption limits using alternative values for body weight, multiply the existing consumption limits (in meals per month) found in the tables for the **70-kg adult fisher consumer** by the multiplier associated with the new body weight:

$$\text{New } CR_{mm} = CR_{mm_{70\text{-kg BW}}} \cdot \text{Multiplier}_{BW} \qquad (3\text{-}6)$$

where

Cr_{mm} = maximum allowable fish consumption rate (meals/mo)
$CR_{mm_{70\text{-kg BW}}}$ = maximum allowable fish consumption rate of a 70-kg fish consumer (meals/mo)
BW = consumer body weight (kg)
Multiplier_{BW} = body weight multiplier (unitless).

3.3.4 Meal Size

Meal size is defined as the amount of fish (in kilograms) consumed at one meal. EPA has identified a value of 8 oz (227 g) of uncooked fish fillet per 70-kg consumer body weight as an average meal size for adults in the general population assuming consumption of noncommercially caught fish only. At this

Table 3-5. Average Body Weights and Associated Multipliers

Age Group (yr)[a]	Average Male Body Weight (kg)	Average Female Body Weight (kg)	Average Body Weight for Males and Females Combined (kg)	Multiplier[b]
<3	11.9	11.2	11.6	0.17
3 to 6	17.6	17.1	17.4	0.25
0 to 6	14.8	14.2	14.5	0.21
6 to 9	25.3	24.6	25.0	0.36
9 to 12	35.7	36.2	36.0	0.51
12 to 15	50.5	50.7	50.6	0.72
15 to 18	64.9	57.4	61.2	0.87
18 to 25	73.8	60.6	67.2	0.96
25 to 35	78.7	64.2	71.5	1.0
35 to 45	80.9	67.1	74.0	1.1
45 to 55	80.9	68.0	74.5	1.1
55 to 65	78.8	67.9	73.4	1.0
65 to 75	74.8	66.6	70.7	1.0
18 to 45	—	64	—	0.91
18 to 75	**78.1**	**65.4**	**71.8[c] (70)[c]**	**1.0**

[a] Numbers in bold represent the default values used to calculate the consumption limit tables.
[b] The body weight multiplier is multiplied by the consumption limits associated with 72-kg adult fish consumers to obtain new consumption limits using the alternative body weight (see Section 3.3.3). The body weight multiplier represents the alternative body weight divided by the adult body weight.
[c] Per recommendations in the Exposure Factors Handbook, the body weight value of 71.8 kg was rounded to 70 kg (U.S. EPA, 1990a).

EPA recommends that the same default value be used for shellfish. However, EPA is currently investigating this issue and a different default value may be recommended in the future. Readers may wish to develop fish consumption limits using other meal sizes obtained from data on local fish consumption patterns and/or other fish consumption surveys as appropriate (see Appendix B). Table 3-6 provides alternative meal sizes and their associated multipliers. To obtain modified consumption limits using alternative values for meal size, multiply the existing consumption limits found in the tables for the **8-oz meal size** by the multiplier associated with the new meal size:

$$New\ CR_{mm} = CR_{mm_{8\text{-}oz\ MS}} \cdot Multiplier_{MS} \qquad (3\text{-}7)$$

where variables are as previously defined.

In addition, if specific meal consumption limits are desired for consumers ages 4 to adult, modifications can be made for both body weight and meal size using the following equation:

$$\text{New } CR_{mm} = CR_{mm_{70\ kg\ BW, 8-oz\ MS}} \cdot \text{Multiplier}_{BW} \cdot \text{Multiplier}_{MS} \quad (3\text{-}8)$$

where the parameters are as previously defined.

3.3.5 Contaminant Concentration in Fish Tissue

Chemical contaminant concentrations in fish tissue are influenced by the specific species and age (size) class of the fish sampled, the chemical properties of the chemical contaminant (e.g., degradation rate, solubility, bioconcentration potential), and the contaminant level in the waterbody. A detailed discussion of selection of target species for use in fish sampling and analysis programs is presented in Section 3 of Volume 1 of this guidance series. In addition, the reader may obtain some indication of the range of contaminant concentrations possible for a specific target analyte in a specific species by reviewing results of regional and national fish sampling programs such as the EPA *National Study of Chemical Residues in Fish* (U.S. EPA, 1991b), The National Contaminant Biomonitoring Program (Kidwell et al., 1995), the U.S. Fish and Wildlife Service National Contaminant Biomonitoring Program (Lowe et al., 1985; Schmitt et al., 1990), and the National Oceanic and Atmospheric Association (NOAA) Status and Trends Program (NOAA, 1989).

Note: The chemical contaminant concentration in fish tissue values used in calculating the risk-based consumption limits should be derived from monitoring data obtained from fish sampling and analysis programs and be specific to the waterbody, fish species, and fish size (age) class that were sampled.

3.3.6 Modifying Time-Averaging Period (T_{ap})

Calculated daily consumption limits represent the maximum amount of fish (in kilograms) expected to generate a risk no greater than the maximum ARL used for carcinogens or the maximum amount of fish (in kilograms) that would be expected not to cause adverse noncarcinogenic health effects based on a lifetime of daily consumption at that consumption rate. Most fish consumers, however, do not think about consumption in kilograms per day. Therefore, consumption limits may be more conveniently communicated to the fish-consuming public expressed as the allowable number of fish meals of a specified meal size that may be consumed over a given time period.

Monthly consumption limits were derived for all target analytes as shown in Section 4. For chemical contaminants with carcinogenic properties, there is no current methodology for evaluating the difference in cancer risks between consuming a large amount of the carcinogenic contaminant over a short period of time and consuming the same amount over the course of a lifetime. Therefore, EPA's current cancer risk assessment guidelines recommend prorating exposure over the lifetime of the exposed individual (U.S. EPA, 1986a). To provide usable and easily understood consumption guidance, the time-averaging period of 1 month was used as the basis for expressing meal consumption limits in Section 4. In certain situations, risk managers may wish to calculate alternate consumption limits for different time intervals. For example, the state of Minnesota calculates consumption limits for mercury for 3-week (vacation), 3-month (seasonal), and annual time periods. This is done for mercury because it is eliminated from the body in a relatively short time period (half-life of approximately 50 days) and also because of seasonal fish consumption patterns in the state.

3.4 MODIFICATION OF CONSUMPTION LIMITS FOR A SINGLE CONTAMINANT IN A MULTISPECIES DIET

Equations 3-1 and 3-3 may be modified to calculate consumption limits for exposure to a single contaminant through consumption of several different fish species. This section describes the modifications required to do this.

Individuals often eat several species of fish in their diets. Equations 3-1 and 3-3, however, are based on contaminant concentrations in a single species of fish. Where multiple species of contaminated fish are consumed by a single individual, such limits may not be sufficiently protective. If several fish species are contaminated with the same chemical, then doses from each of these species must first be summed across all species eaten in proportion to the amount of each fish species eaten. This is described by Equation 3-9:

$$C_{tm} = \sum_{j=1}^{n} C_{mj} \cdot P_j \qquad (3\text{-}9)$$

where

C_{tm} = total concentration of chemical contaminant *m* in an individual's fish diet (mg/kg)
C_{mj} = concentration of chemical contaminant *m* in species *j* (mg/kg)
P_j = proportion of species *j* in the diet (unitless).

Note: This equation requires that the risk assessor know or be able to estimate the proportion of each fish species in the exposed individual's diet. Equation 3-9 yields the weighted average contaminant concentration across all fish species consumed (C_{tm}), which then may be used in modified versions of Equations 3-1 to 3-3 to calculate overall and species-specific risk-based consumption limits for carcinogenic and noncarcinogenic effects as shown in Sections 3.4.1 and 3.4.2.

3.4.1 Carcinogenic Effects

The equation to calculate an overall daily consumption limit based on exposure to a single carcinogen in a multiple species diet is very similar to Equation 3-1. However, in place of C_m, which indicates the average chemical contaminant concentration in one species, Equation 3-10 uses the equation for C_{tm}, the weighted average chemical contaminant concentration across all of the species consumed:

$$CR_{lim} = \frac{ARL \cdot BW}{\sum_{j=1}^{n} (C_{mj} \cdot P_j) \cdot CSF} \tag{3-10}$$

where

CR_{lim}	=	maximum allowable fish consumption rate (kg/d)
ARL	=	maximum acceptable lifetime risk level (unitless)
BW	=	consumer body weight (kg)
C_{mj}	=	concentration of chemical contaminant *m* in fish species *j* (mg/kg)
P_j	=	proportion of a given species in the diet (unitless)
CSF	=	cancer slope factor, usually the upper 95 percent confidence limit on the linear term in the multistage model used by EPA ($[mg/kg\text{-}d])^{-1}$).

The daily consumption limit for each species is then calculated as:

$$CR_j = CR_{lim} \cdot P_j \tag{3-11}$$

where

Cr_j	=	consumption rate of fish species *j* (kg/d)
CR_{lim}	=	maximum allowable fish consumption rate (kg/d)
P_j	=	proportion of a given species in the diet (unitless).

Meal consumption limits may then be calculated for each species as before using Equation 3-2 (see Section 3.2), with CR_j substituted for CR_{lim} in the equation. Note that Equation 3-11 may be used before or after Equation 3-2, with the same results.

3.4.2 Noncarcinogenic Effects

For noncarcinogenic effects, the equation to calculate an overall daily consumption limit based on exposure to a single noncarcinogenic chemical in a multiple species diet is similar to Equation 3-3 for a single species. However, in place of C_m, which indicates the chemical contaminant concentration in one species, Equation 3-12 uses the equation for C_{tm}, the weighted average chemical contaminant concentration across all of the species consumed:

$$CR_{lim} = \frac{RfD \cdot BW}{\sum_{j=1}^{n} (C_{mj} \cdot P_j)} \tag{3-12}$$

where the parameters are as defined above. The consumption rate for each species is then calculated using Equation 3-11. Meal consumption limits for each species may then be calculated as before using Equation 3-2.

3.5 MODIFICATION OF CONSUMPTION LIMITS FOR MULTIPLE CONTAMINANT EXPOSURES

Equations 3-10 and 3-12 discussed in Section 3.4 can be further modified to develop consumption limits for multiple chemical exposures across single or multiple fish species. Section 2.3.4 provides additional information on exposure to multiple chemical contaminants.

Individuals who ingest chemically contaminated fish may be exposed to a number of different chemicals simultaneously. This could occur when: (1) a single fish species is contaminated with several different chemical contaminants; (2) an individual consumes a mixture of species in his or her diet, each contaminated with a different chemical; or (3) some combination of the above circumstances occurs.

EXAMPLE 10: Calculating Consumption Limits for a Single Contaminant in a Multispecies Diet

The combined results from a fish sampling and analysis program and a local fish consumption survey determine that local fishers eat a diet of 30 percent catfish contaminated with 0.006 mg/kg chlordane and 70 percent trout contaminated with 0.008 mg/kg chlordane. The RfD for chlordane reported in IRIS is 0.00005 mg/kg/d (IRIS, 1999). Because chlordane causes both chronic health and carcinogenic effects, consumption limits must be calculated for both health endpoints. The CSF for chlordane reported in IRIS is 0.35 per (mg/kg-d)$^{-1}$ (IRIS, 1999). The average body weight of an adult is estimated to be 70 kg.

Carcinogenic Effects: Using a risk level of 10^{-5} and the values specified above, Equation 3-5 yields a daily consumption rate of 0.028 kg/d, based on carcinogenic endpoints:

$$CR_{lim} = \frac{10^{-5} \bullet 70\ \text{kg}}{(0.006\ \text{mg/kg} \bullet 0.3 + 0.008\ \text{mg/kg} \bullet 0.7) \bullet 0.35\ \text{per mg/kg-d}}$$

$$= 0.029\ \text{kg/d}\ .$$

Equation 3-2 is then used as before to calculate a monthly meal consumption limit, based on a meal size of 8 oz (0.227 kg):

$$CR_{mm} = \frac{0.029\ \text{kg-d} \bullet 30.44\ \text{d/mo}}{0.227\ \text{kg/meal}} = 38.8 \approx 39\ \text{meals/mo}\ .$$

(continued)

EXAMPLE 10 (continued)

Equation 3-2 yields a meal consumption limit of 39 8-oz meals per month based on chlordane's carcinogenicity.

Based on a diet of 70 percent trout and 30 percent catfish:

$$CR_{trout} = 39\ 8\text{-}oz\ meals/mo \cdot 0.7 = 27\ 8\text{-}oz\ meals/mo\ .$$

An adult may safely consume 27 8-oz meals of trout and 12 8-oz meals of catfish per month.

Note: In both cases the meal consumption limits were rounded down. This is a conservative approach. One might also **round up** the number of meals of the species with the **lower** contaminant concentration, and **round down** the number of meals of the species with the **higher** contaminant concentration, so that the total number of fish meals per month equals that found by using Equations 3-6 and 3-2.

Noncarcinogenic Effects: Equation 3-8 is used to calculate the daily consumption limit based on chlordane's noncarcinogenic health effects using the RfD rather than the CSF

$$CR_{lim} = \frac{5 \times 10^{-4}\ mg/kg\text{-}d \cdot 70\ kg}{0.006\ mg/kg \cdot 0.3 + 0.008\ mg/kg \cdot 0.7} = 4.73\ kg/d\ .$$

As with carcinogenic effects, Equation 3-2 is used to convert the daily consumption limit of 0.570 kg fish to a meal consumption limit:

$$CR_{mm} = \frac{4.73\ kg/d \cdot 30.44\ d/mo}{0.227\ kg/meal} = 634.3 \approx 634\ meals/mo\ .$$

This analysis indicates that 4.73 kg/d is equivalent to 634 8-oz fish meals per month or over two 8-oz fish meals per day under this mixed-species diet. This is categorized as safe fish consumption (represented by ">16" meals/ month) and has been defined as an intake limit of 16 meals per month for the monthly consumption limit tables in Section 4. Thus, based on the above results, risk managers might choose to issue a consumption advisory for adults based on chlordane's carcinogenic effects, the more sensitive of the two health endpoints.

Possible toxic interactions in mixtures of chemicals are usually placed in one of three categories:

- **Antagonistic**—the chemical mixture exhibits less toxicity than the chemicals considered individually
- **Synergistic**—the chemical mixture is more toxic than the sum of the individual toxicities of the chemicals in the mixture
- **Additive**—the toxicity of the chemical mixture is equal to the sum of the toxicities of the individual chemicals in the mixture.

Using available data is especially important in cases where mixtures exhibit synergistic interactions, thereby increasing toxicity. Very little data are available on the toxic interactions between multiple chemicals, however, and no quantitative data on interactions between any of the target analytes considered in this document were located. Some qualitative information is provided in Section 2.3.4.

If all of the chemicals in a mixture induce the same health effect by similar modes of action (e.g., cholinesterase inhibition), contaminants may be assumed to contribute additively to risk (U.S. EPA, 1986c), unless specific data indicate otherwise. Chemicals in a particular class (e.g., organochlorine or organophosphate pesticides) usually have similar mechanisms of toxicity and produce similar effects. Effects of chemicals and chemical groups are discussed in more detail in Section 5. For mixtures of chemicals that produce similar toxicological endpoints, EPA recommends dose addition. This procedure involves scaling the doses of the components for potency and adding the doses together; the mixtures response is then estimated for the combined dose (U.S. EPA, 1999a).

Some chemical mixtures may contain chemicals that produce dissimilar health effects. For these chemicals, EPA recommends response addition. This procedure involves first determining the risks for the exposure for the individual components; the mixture risk is then estimated by adding the individual risks together (U.S. EPA, 1999a).

3.5.1 Carcinogenic Effects

Few empirical studies have considered response addition in any depth, and few studies have modeled cancer risk from joint exposure. If interactions data are available on the components of the chemical mixture, EPA recommends that they be incorporated into the risk assessment by using the interactions-based hazard index or by including a qualitative assessment of the direction and magnitude of the impact of the interaction data (U.S. EPA, 1999a).

A detailed discussion of the interactions-based hazard index approach is available in EPA's proposed guidance for conducting health risk assessment of chemical mixtures (U.S. EPA, 1999a). For calculating consumption limits, additivity will be assumed for both carcinogenic and noncarcinogenic effects of components of chemical mixtures.

Equation 3-13 can be used to calculate a daily consumption rate for chemical mixtures of carcinogens in single or multiple fish species. It is similar to

Equation 3-1, with the summation of all species and all chemicals substituted for C_m in the denominator:

$$CR_{lim} = \frac{ARL \cdot BW}{\sum_{m=1}^{x} \left(\sum_{j=1}^{n} C_{mj} \cdot P_j \right) \cdot CSF} \tag{3-13}$$

where

CR_{lim} = maximum allowable fish consumption rate (kg/d)
ARL = maximum acceptable lifetime risk level (unitless)
BW = consumer body weight (kg)
C_{mj} = concentration of chemical contaminant *m* in species *j* (mg/kg)
P_j = proportion of a given species in the diet (unitless)
CSF = cancer slope factor, usually the upper 95 percent confidence limit on the linear term in the multistage model used by EPA ($[mg/kg\text{-}d]^{-1}$).

Meal consumption limits for mixtures of carcinogens are then calculated using Equation 3-2. When only one fish species is involved, Equation 3-13 may be simplified to Equation 3-14:

$$CR_{lim} = \frac{ARL \cdot BW}{\sum_{m=1}^{x} C_m \cdot CSF} \tag{3-14}$$

where the variables are as previously defined.

3.5.2 Noncarcinogenic Effects

Equation 3-15 can be used to calculate a daily consumption rate for noncarcinogenic chemical mixtures in single or multiple fish species. It is similar to Equation 3-3, with the summation of all species and all chemicals assumed to act additively. Equation 3-3 has been modified with the respective summation of concentrations (C_{mj}) substituted in the denominator and their respective RfDs in the numerator.

$$CR_{lim} = \sum_{\substack{m=1 \\ j=1}}^{x} \left(\frac{RfD_m \cdot P_m}{(C_{mj} \cdot P_j)} \right) \cdot BW \tag{3-15}$$

where the parameters are as previously defined and P_m = proportion by weight of chemical in diet. Meal consumption limits are then calculated using Equation 3-2, as above. Again, when only one fish species is involved, Equation 3-15 can be simplified to Equation 3-16:

$$CR_{lim} = \sum_{m=1}^{x} \left(\frac{RfD_m \cdot P_m}{C_m} \right) \cdot BW \qquad (3\text{-}16)$$

where the variables are as previously defined. Note that Equations 3-15 and 3-16 may **not** be used for contaminants causing dissimilar noncarcinogenic health effects.

EXAMPLE 11: Calculating Consumption Limits for Multiple Contaminants in a Single Species Diet

A single fish species is contaminated with 0.04 mg/kg chlordane and 0.01 mg/kg heptachlor epoxide. A maximum acceptable risk level of 10^{-5} and an adult body weight of 72 kg are used. Because chlordane and heptachlor epoxide cause both carcinogenic and chronic systemic health effects, both health endpoints must be considered in establishing consumption limits for these chemicals.

Carcinogenic Effects: The CSF for chlordane reported in IRIS is 0.35 per (mg/kg-d) (IRIS, 1999). The CSF for heptachlor epoxide reported in IRIS is 9.1 per (mg/kg-d) (IRIS, 1999). Equation 3-10 is used to calculate daily consumption rate based on the combined carcinogenic effects of both contaminants:

$$CR_{lim} = \frac{10^{-5} \cdot 70}{(0.04 \cdot 0.35) + (0.01 \cdot 9.1)} = 0.007 \text{ kg/d} \text{ .}$$

A daily consumption rate of 0.007 kg fish per day is calculated. Using Equation 3-2, this daily consumption rate is converted to a meal consumption limit of one 4-oz meal per month (or six 8-oz meals per year).

Noncarcinogenic Effects: Chlordane and heptachlor are both organochlorine pesticides and cause many similar noncarcinogenic effects. Heptachlor epoxide is a metabolite of the organochlorine pesticide, heptachlor. When heptachlor is released into the environment, it quickly breaks down into heptachlor epoxide. Therefore, the toxicity values used in this document are for heptachlor epoxide, not heptachlor (see Section 5.3.7). Adverse liver effects formed the basis of the RfDs for both chemicals (IRIS, 1999). A combined daily consumption limit based on an RfD of 5×10^{-4} mg/kg-d for chlordane and 1.3×10^{-5} mg/kg-d for heptachlor was calculated using Equation 3-12:

(Continued)

EXAMPLE 11 (continued)

$$CR_{lim} = \left(\frac{5 \text{ x } 10^{-4} \text{ mg/kg-d}}{0.04 \text{ mg/kg}} + \frac{1.3 \text{ x } 10^{-5} \text{ mg/kg-d}}{0.01 \text{ mg/kg}} \right) \cdot 70 \text{ kg} = 0.97 \text{ kg/d} .$$

Equation 3-12 yields a daily consumption rate of 0.97 kg fish/d at the contaminant concentrations described above. Using Equation 3-2, a meal consumption limit of 130 4-oz meals per month is calculated. Therefore, based on the carcinogenic and chronic systemic consumption limits calculated for combined heptachlor epoxide and chlordane contamination, a risk manager may choose to advise (1) limiting fish consumption to six 8-oz meals per year, based on the combined carcinogenic effects; or (2) limiting fish consumption to 133 4-oz-meals/month, based on noncarcinogenic effects. **In general, EPA advises that the more protective meal consumption limit (in this case, the limit for the carcinogenic effect) serve as the basis for a fish consumption advisory to be protective of both health effects endpoints.**

3.5.3 Species-Specific Consumption Limits in a Multiple Species Diet

Equation 3-11 is used to calculate the risk-based consumption limits for each species in a multiple species diet, for both carcinogenic and noncarcinogenic toxicity where the variables are as defined above. CR_{lim} is calculated using Equations 3-13 or 3-15, for carcinogenic and noncarcinogenic toxicity, respectively. As with the consumption limits for single chemicals, these consumption limits are valid only if the assumed mix of species in the diet is known and if the contaminant concentrations in each species are accurate.

EXAMPLE 12: Calculating Consumption Limits for Multiple Contaminants in a Multispecies Diet

Chlorpyrifos and diazinon both cause cholinesterase inhibition, so are considered together when developing meal consumption limits. The RfD for chlorpyrifos is 0.0003 mg/kg-d, (EPA, 2000b), and the RfD for diazinon is 0.0007 mg/kg/d (U.S. EPA, 1998b).

A local fish consumption survey reveals that adult fishers consume trout and catfish at a ratio of 70:30, respectively. A fish sampling and analysis program reports chlorpyrifos and diazinon contamination in both species. Trout fillets are contaminated with 4.0 mg/kg chlorpyrifos and 0.3 mg/kg diazinon. Catfish fillets are contaminated with 6.0 mg/kg chlorpyrifos and 0.8 mg/kg diazinon. Given an adult body weight of 70 kg, a risk-based consumption rate of 0.15 kg fish per day is calculated using Equation 3-11:

(Continued)

EXAMPLE 12 (continued)

$$CR_{lim} = \left(\frac{0.0003}{(4.0 \cdot 0.7) + (6.0 \cdot 0.3)} + \frac{0.0007}{(0.3 \cdot 0.7) + (0.8 \cdot 0.3)} \right) \cdot 70$$

$$= 0.11\ kg/d\ .$$

Using Equation 3-2, a meal consumption limit of 15 8-oz meals per month is derived. **Note**: If chlorpyrifos and diazinon did not cause the same health endpoint, then separate meal consumption limits would have to be calculated for each as described in Section 3.4.2, with the more protective meal consumption limit usually serving as the basis for a fish consumption advisory (see Section 3.5.2).

Based on a diet of 70 percent trout and 30 percent catfish:

$$CR_{trout} = 15\ 8\text{-}oz\ meals/mo \cdot 0.7 = 10\ 8\text{-}oz\ meals/mo\ .$$

An adult may safely consume 10 8-oz meals of trout and 5 8-oz meals of catfish per month. Again, as mentioned in Section 3.4.2, rounding down both species-specific consumption limits is a conservative approach.