A.10.0 Fraction of Contaminated Diet

A.10.1 Description

Organisms near areas of potential release could be exposed to contaminants. Exposure and bioaccumulation depend on movement of an organism in space and time. This, in turn, is related to migration between feeding and reproductive habitats. Knowledge of these movement patterns provided information of the fractions of contaminated organisms ingested by consumers.

A.10.2 Current Knowledge

The following discusses the distribution and abundance of several fish species and Steller sea lions in the vicinity of Amchitka Island. Annual population or biomass estimates for groundfish (fishes in the commercial fishery other than halibut or salmon) are generated from commercial fisheries and research vessel data from defined, bounded reporting areas (Figure A.15). The bounds of reporting areas encompassing Amchitka vary with the type of fishery and agency monitoring it. The National Marine Fisheries Service (NMFS) establishes boundaries for groundfish and invertebrates and censuses marine mammal populations. The International Pacific Halibut Commission (IPHC) and North Pacific Anadramous Fish Commission, respectively, designate reporting areas for Pacific halibut and monitor salmon fisheries. These two agencies also share information with NMFS divisions to assess the size of halibut and salmon stocks.

Because many organisms inhabit specific depth ranges or distances from shore, abundance by area is predicted by reducing population estimates from whole reporting areas to cover only portions of the ocean where organisms are known to occur. The actual distribution of organisms in natural environments is patchy and variable, corresponding to the distribution of prey resources and reproductive habitats. However, to predict the number and mass of organisms occurring during a year in specific locations near Amchitka, populations are modeled as evenly dispersed. Abundance, mass, and life expectancy estimates for selected fishes and the Steller sea lions are discussed in Section A.10.2.1 and Section A.10.2.2 and are summarized in Table A-8.

Table A-8
Summary of Abundance, Biomass, and Life Expectancy Estimates for Species Inhabiting Areas Near the Amchitka Coast

Species	Abundance	Biomass	Life Expectancy (years)
Pacific halibut	101/km^2	376 kg/km^2	40
Atka mackerel	4,643/km^2	6,500 kg/km^2	15
Pacific ocean perch	365/km^2	380 kg/km^2	30
Walleye pollock	143/km^2	110 kg/km^2	15
Pink, chum, and sockeye salmon	252/km^2	974 kg /km^2	6
Dolly varden	110/km^2	55 kg/km^2	6
Steller sea lion	0.065/km^2	20 kg/km^2	20

km^2 = Square kilometers
kg/km^2 = Kilograms per square kilometer

A.10.2.1 Marine Fish

Pacific Halibut, Hippoglossus stenolepis

Pacific halibut biology discussed below follows that provided by the IPHC (1998). The Pacific halibut is one of the largest teleost (bony) fishes in the world, attaining lengths as great as 9 ft (2.7 m). Adults tend to remain on the same feeding grounds, year after year, at depths ranging between 25 and 275 m. Spawning occurs at greater depths (185 to 455 m) on the edge of the continental shelf. By the time they are 8-years old, a majority of males are sexually mature, whereas females do not mature until reaching an average age of 12 years. Eggs and larvae are denser than surface water and drift with deep ocean currents. As larvae grow, they move upward through the water column and by six months postlarval young settle on the bottom, occupying shallow habitats between the surface and 60 m. The maximum recorded age of Pacific halibut is 55 years for a male and 42 years for a female (IPHC, 2000). Therefore, it is reasonable to assume that halibut generations are depleted by a maximum of 40 years.

The IPHC used NMFS trawl data to estimate Pacific halibut abundance from Area 4B (Figure A.15), the reporting area that encompasses Amchitka Island (Hoag et al., 1997). As with estimates for groundfish populations, IPHC inferences about abundance are made from samples within the area reduced to include only the depth strata halibut are known to occupy. The Pacific halibut abundance

estimate based on 1991 trawl data in Area 4B was 4,176,623 fish per 51,571 km^2 of sampled area (Clark et al., 1997). If halibut were evenly dispersed, they were at a density of 81 fish/km^2. The IPHC notes estimates are relative to sampling effort and are not measures of total halibut present in the reporting area (i.e., they calculate abundance as the mean number of fish captured in trawl nets per total area swept). In addition, they note that trawl gear cannot cover areas of very rough bottom that are preferred by halibut and are prevalent in the Aleutians west of 170° W longitude. A conservative estimate of Pacific halibut abundance in the waters surrounding Amchitka is generated by assuming that trawl gear detects only a portion of the actual population. For example, assuming 25 percent of individuals avoided capture during sampling runs results in an estimate of the total number of halibut. The number caught combined with the number missed is shown in the following calculation:
81 halibut/km^2 + 0.25 × 81 halibut/km^2 = 101 halibut/km^2.

Biomass estimates for Area 4B are reported only for the exploitable portion of the halibut population, which IPHC designates as age 8 years and greater (8+). The biomass estimate for age 8 + halibut is 15,921,360 kg. The distribution of abundance by age is not available for the immature portion of the population, so it is arbitrarily assumed that two-thirds of halibut in Area 4B are younger than 8-years old. In 1999, 19,000,000 halibut in the Bering Sea population that were less than 65 cm long weighed 19,000,000 kg, equal to 1 kg/young halibut. Assuming again that trawls missed 25 percent of halibut in Area 4B, a total of 5,220,778 halibut were present (4,176,623 halibut × 0.25 + 4,176,623 halibut = 5,220,778 halibut). Multiplying two-thirds by the total halibut yields 3,480,518 individuals in the immature segment of the population. Summing the estimated weight of the mature segment of the population and the estimated weight of the immature halibut gives a total halibut weight estimate of 19,401,878 kg. Dividing this weight by the surface area sampled provides a biomass estimate of 376 kg halibut/km^2.

Atka Mackerel, Pleurogrammus monopterygius

The demographics of Atka mackerel are described in Fritz and Lowe (1998). An abundant member of the epipelagic (open water near the surface) community along the Aleutian Islands, Atka mackerel travel in dense schools at depths ranging from the surface to 200 m. During the summer months, they move to in-shore demersal (bottom) habitats to spawn. In the fishery off the south coast of Amchitka, the ratio of females to males increases between May and August, indicating the duration of the spawning period. Hatched larvae are pelagic and are dispersed with currents. Although their early life history is not known, it is assumed that young Atka mackerel remain away from the coast until they return to the fishery as reproductive adults after an average of 3 years. No Atka mackerel over 15-years old were present in Aleutian Island catches in year 2000 (Lowe and Fritz, 2000). Therefore, 15 years is likely the maximum life expectancy of Atka mackerel.

Amchitka populations of Atka mackerel are within NMFS statistical reporting Area 542 (Figure A.15). In this reporting area, the NMFS estimate of adult Atka mackerel biomass was 330,255 metric tons in year 2000 (Lowe and Fritz, 2000). The ocean surface of Area 542 calculated by SAIC from the National Oceanographic and Atmospheric Administration's (NOAA) (1976) navigation chart, Bering Sea (Southern Part), is approximately 300,000 km^2. In 1997, 80 percent of the Atka mackerel catch in the Aleutian Islands was within Steller sea lion critical habitat, the surface area of which is 40,587 km^2 in Section 542 (NMFS, 2000). Assuming 80 percent of the Atka mackerel population was evenly dispersed in sea lion-critical habitat in a year, there is a density of 6.5 metric tons (mT) (6,500 kg) of fish/km^2 of ocean surface for the year 2000 population (330,255 mT × 0.80 = 264,204 mT and 264,204 mT/40,587 km^2 = 6.5 metric tons per square kilometers [mT/km^2]).

The most frequently occurring length class of Atka mackerel captured off the coast of Amchitka was 35 to 40 cm (Fritz and Lowe, 1998). Information on the length-weight relationship was not provided, so it is assumed that the weight of an average-sized adult Atka mackerel is 1.4 kg (3 pounds). Dividing the biomass estimate by the average weight per fish (6500 kg/km^2/1.4 kg) yields an abundance estimate of 4,643 Atka mackerel/km^2.

Pacific Ocean Perch, Sebastes alutus

Pacific Ocean perch inhabit outer continental shelf and upper slope regions, mainly at depths from 100 to 400 m (Witherell, 2000). Spencer et al. (2000) indicate Pacific Ocean perch are most concentrated between 200 and 800 m because this is the depth range where fishing vessels apply most of their effort. Females are viviparous, giving birth to swimming larvae. Pacific Ocean perch have a long life span, with a recorded maximum age of 90 years. Biomass and abundance data are reported only for year classes up to age 25. Therefore, it is assumed that a majority of each Pacific Ocean generation expires by the end of 30 years.

Biomass and numbers of Pacific Ocean perch inhabiting Aleutian Islands reporting areas (Figure A.15) have been estimated (Spencer et al., 2000). Biomass estimates are reported separately for Areas 541, 542, and 543, but abundance (number of fish) estimates are given only for the three areas combined. The Area 42 biomass estimate for year 2000 was 114,319 mT, accounting for approximately 25 percent of the total Pacific Ocean perch biomass in the three reporting areas. The total number of Pacific Ocean perch in the three areas combined was 437,805,000.

If the spatial distribution of weight classes is representative of the spatial distribution of perch abundance, then 25 percent, or 109,451,250 individuals, in the Aleutian Island Pacific Ocean perch population inhabit Area 542 (0.25 × 437,805,000 perch = 109,451,250 perch). Dividing the number of perch by the surface area of Area 542 yields 365 Pacific Ocean perch/km^2 (109,451,250 perch/ 300,000 km^2 = 365 perch km^2). The biomass estimate is 0.38 mT (380 kg) of Pacific Ocean perch/km^2 (114,319 mT/300,000 km^2 = 0.38 mT/km^2).

Walleye Pollock, Theragra chalcogramma

Although walleye pollock are a specific target of some commercial fisheries operations in the Aleutian Islands, most research has focused on populations in the Bering Sea. Because fishery assessments indicate that Aleutian Islands and Bering Sea populations likely belong to a single stock (Ianelli et al., 2000), it is reasonable to assume that the biology of walleye pollock in the Aleutians is similar to that in the Bering Sea.

Aspects of walleye pollock biology are discussed in Witherell (2000). Walleye pollock are the most abundant groundfish in the Bering Sea and Aleutian Islands fisheries. They become mature (reproductive) between the ages of 4 and 5 years. In April, they migrate to shallow (90 to 140 m) spawning grounds from deeper (400 m) continental shelf regions. A single female walleye pollock produces 60,000 to 400,000 eggs, which are released in the water column where they are suspended and then transported by currents. Age-specific information for pollock is reported for generations up to 15 years old, so it is assumed that the life expectancy of most walleye pollock does not exceed 15 years.

Estimates of walleye pollock biomass are reported only from Areas 541, 542, and 543 combined. The year 2000 estimate for these areas is 105,554 mT (Ianelli et al., 2000). Distributing this biomass evenly throughout the three Aleutian Islands reporting areas, which together occupy a surface area of

1,001,780 km^2, results in an estimate of 0.11 mT (110 kg) of pollock/km^2 (105,554 mT/1,001,780 km^2 = 0.11 mT/km^2).

Average weights of different year classes (generations separated by one year) of walleye pollock are reported from Bering Sea populations (Ianelli et al., 2000). Although abundance by age shifts from year to year, a majority of the catch consists of 3- to 8-year old pollock. The average weight of a pollock from year classes 3 to 8 is 0.67 kg. For 9- to 15-year old pollock, it is 1.4 kg. Assuming a population of pollock where 75 percent are age 3 to 8 and 25 percent are age 9 to 15, and coupling this assumption with the biomass estimate of 0.11 mT/km^2, the abundance estimate is 143 walleye pollock/km^2 (i.e., [0.75 × 110 kg/0.67 kg] + [0.25 × 110kg/1.4 kg] = 142.7).

Salmonidae, Salmon and Trout

Four salmonids, pink salmon (*Oncorhynchus gorbuscha*), sockeye salmon (*Oncorhynchus nerka*), chum salmon (*Oncorhynchus keta*), and dolly varden trout (*Salvelinus malma*), inhabit areas off the coast of Amchitka. After hatching in freshwater streams, pink (Hard et al., 1996) and chum salmon (Johnson et al. 1997) migrate almost immediately to the marine environment. Juveniles remain near shore or in estuaries, where they grow rapidly. After several weeks to a few months, both species move farther offshore. Pink salmon reach maturity at 2 years, and chum salmon mature, on average, after 4 years. Sockeye salmon stocks exhibit a variety of life-cycle patterns. Most sockeye migrate from lakes to spawning grounds in rivers. However, there are stocks that migrate from the ocean to rivers. They may remain in lower reaches of rivers for 1 to 2 years ("river-type") after hatching or, alternatively, they may migrate to sea after only a few months ("sea-type"). Once at sea, sockeye remain for approximately 4 years until reaching maturity and returning to their natal streams to spawn.

Unlike other North Pacific fishery information, salmon population data are not reported from bounded areas. Therefore, estimates of abundance are derived from two salmon research trawl surveys conducted along the Aleutians in August 1996 and again in 1997 (Carlson et al., 1996 and 1997). Both surveys reported that catches from the central and western Aleutians, including Amchitka, consisted almost entirely of immature pink, chum, or sockeye salmon. "Immature" is the age category in which individuals are 1-year old or greater but are not yet of spawning age. Near Amchitka, some source populations of these immature salmon are from Asia, and the greatest numbers are probably from the Bristol Bay watershed in western Alaska. The preponderance of immature individuals and lack of juveniles (age 0 to 1) in the trawl samples indicates that populations near Amchitka consist mostly of fish that dispersed far from their natal streams. However, there is an annual spawning run of a small population of pink salmon in Amchitka streams (Valdez et al., 1977).

The surface area covered by trawls in 1997 was 247 nautical miles (458 km), and all samples were taken within 20 m of the ocean surface. The number of pink, chum, and sockeye caught was 1,336; 2,311; and 1,074, respectively. Multiplying the surface length of the trawl net (0.041 km) by the distance sampled yields a surface area of 18.7 km^2. Dividing the number of salmon caught by the surface area covered (4,721 salmon/18.7 km^2) yields an abundance measure of 252 salmon per km^2. Most of the salmon collected during the surveys were caught over, or shoreward of, the 200-m depth contour.

Estimates of salmon biomass are accomplished by multiplying the known average weight of each species (ADFG, 1994) by the number of salmon per area. The average weights reported for chum, sockeye, and pink salmon are 5.7 kg, 2.7 kg, and 1.6 kg, respectively. The mass estimate is as follows: (2,311 chum × 5.7 kg) + (1,074 sockeye × 2.7 kg) + (1,336 pink × 1.6 kg) = 18,210 kg salmon. Dividing this mass by the area sampled (18,210 kg/18.7 km^2) yields a biomass estimate of 974 kg salmon/km^2.

In contrast to salmon, dolly varden spend a majority of their lives in or near freshwater. Also, the source of the population potentially exposed to contaminants is local, inhabiting Amchitka streams. Growth and migration of Amchitka dolly varden populations are described in Valdez et al. (1977). On Amchitka, dolly varden spawned in streams during October and November and remained in freshwater habitats for 3 or 4 years, although immature fish close to the sea often ventured offshore but remained close to stream mouths. Individuals 3 or 4 years old migrated to the sea in June and July and remained there for an average of 73 days. Dolly varden do not stray far from shore, as none were captured farther away than 1 km. After returning to natal streams and spawning, about half of the adults survived and spawned the following year. Some individuals spawned three consecutive years.

The number of dolly varden occupying the ocean environment surrounding Amchitka is estimated by multiplying the number of migrating adults in one stream by the total number of streams on the island that do not have barriers (high cliffs or gravel-sand dikes) to the sea. In Midden Cove Stream on Amchitka, 812 downstream migrants were captured. There are 17 streams on the island that are free of barriers. Thus, 17 streams multiplied by 812 dolly varden yields an estimate of 13,804 dolly varden entering the sea each year. The surface area of the band of water within 1 km of the Amchitka coast is estimated from NOAA's navigation chart (NOAA, 1976) to be 125 km^2. Dividing the estimate of the number of dolly varden by this surface area (13,804) yields 110 dolly varden/km^2. The most frequently occurring size class of dolly varden at sea was 130 to 134 millimeters (mm). At this length, they would weigh significantly less than 0.5 kg. As a conservative estimate (overestimate), it is assumed that the average weight of a potentially exposed dolly varden is 0.5 kg. Multiplying 13,804 dolly varden by 0.5 kg gives an estimated weight of 6,902 kg (0.6902 mT) for dolly varden at sea. Thus, the biomass of evenly dispersed dolly varden is 6,902 kg/125 km^2 or 55 kg/km^2.

A.10.2.2 Marine Mammals

Steller Sea Lion, Eumetopias jubatus

Listed by the USFWS as a federally endangered species in 1997, Steller sea lions have undergone a significant amount of study over the past several years. The body of recent pertinent biological information is reviewed in NMFS (2000).

The distribution of Steller sea lions approximates a northward projecting arc, with its eastern terminus located off the coast of southern California and its western terminus located off the coast of northern Japan. The northern portion of the arc extends through the Aleutians and Bering Sea. Steller sea lions are large mammals, as adult females and males average 579 pounds (lbs) (263 kg) and 1,245 lbs (566 kg), respectively (ADFG, 1994). The average birth weight of a pup is 51 lbs (23 kg). Females give birth to a single pup at rookeries in early June. Mating occurs one to two weeks after birth, but implantation is delayed until early October. Most individuals return to their natal rookery when they attain maturity. The average age of female and male maturity is 6 years, but females attain maximum size by 7 years, whereas growth of males is not complete until they reach age 12. Maximum life expectancy for Steller sea lions is approximately 20 years.

Although much is known of the on-shore distribution of Steller sea lions at aggregation (haulout) and breeding (rookery) locations, their distribution at sea is not as well understood. Adult Steller sea lions are highly vagile, dispersing over broad areas to feed. Foraging forays extend from the shore out to the continental shelf break, the inner edge of which is along the 200-m isobath. Adult females are usually located closer to shore than males. Because they remain close to rookeries during breeding season or when they are nursing a pup, females remain within 20 nautical miles (37 km) of land.

Merrick and Loughlin (1997) described foraging patterns of 14 females. In the summer, duration of offshore trips ranged between 18 and 25 hours (h), and the average trip length of five tracked individuals was 17 km. Dive time for these individuals was 4.7 hours per day (h/d). Females that were not supporting a pup in the winter spent up to 24 d at sea, and trip length and duration was longer for all females. Winter trip length averaged 133 km, and average trip duration was 204 h. Average home range estimates for females of 47,579 km^2 were very large in the winter, although confidence intervals ($\pm$ 1S.D.) of 26,704 km^2 also were large. Information regarding the at-sea distribution of males is not as well studied, but it is assumed that their home range is much greater than that of females. The distribution of males and females in the water column does not differ. Adults of both sexes regularly feed from the surface to a maximum depth of 250 m, and yearlings are capable of dives to 70 m.

The National Marine Mammal Laboratory maintains a database of Steller sea lion counts including censuses of Amchitka. Year 2000 counts from aerial photos showed groups of Steller sea lions at three of six rookeries or haulouts. There were 213 juvenile (nonpup) and adult sea lions counted from the 2000 census. The census was done in the June and July breeding season, so it is likely that a majority of individuals, especially females, in the Amchitka population were on shore. Assuming 10 percent of the population was feeding at sea results in a total population estimate of 234 nonpups ($213 \times 0.1 + 213 = 234$). Assuming equal sex ratios and an even age distribution (25 percent each of adult males, adult females, juvenile males, and juvenile females) results in an estimate of 72,745 kg for the total weight of the Amchitka Steller sea lion population. Juvenile weights are arbitrarily assigned as one-half the average adult male and female weights, 263 and 566 kg, respectively. Therefore, $0.25 \times (566\ kg + 263\ kg + 283\ kg + 131.5\ kg) \times 234 = 72{,}745\ kg$. The surface area of the 200-m isobath around Amchitka roughly estimated from NOAA's navigation chart (NOAA, 1976) is 3,570 km^2. Dispersing Steller sea lion mass evenly throughout this surface area ($72{,}745\ kg/3{,}570\ km^2$) results in a biomass measure of 20 kg sea lion/km^2. If all Steller sea lions disperse evenly between the shores of Amchitka to the 200-m isobath, then there are approximately 6.5 sea lions/100 km^2 (234 sea lions/$3{,}570\ km^2 = 0.065$ sea lions/km^2).

A.10.2.3 Derivation of Contaminated Fraction

When an organism comes into contact with chemicals that are dispersed in air, water, soil, or food, the organism will take some of the chemical into its body. The uptake process can be characterized by a rate that is different for each chemical and each kind of organism. Likewise, chemicals in the body of the organism are eliminated. When the rate going in is the same as the rate going out, the uptake/elimination process is at equilibrium. The ratio of the concentration in the organism to the concentration in the exposure medium is the BCF. If the organism is exposed for a brief period of time, the resulting concentration in the body will not be as high as the value calculated with the BCF because the uptake process if not instantaneous. Likewise, the elimination process is not instantaneous, so some time will be required before the chemical is eliminated after the organism leaves the contaminated zone.

Fish and marine mammals typically move from place to place rather than stay in a single location. Therefore, they are expected to move into the plume, where they take up radionuclides, and then move out again into noncontaminated water, where the radionuclides are removed from the body by natural elimination processes. As this occurs, different fish or marine mammals come into the plume and are exposed. It is assumed for this screening evaluation that the processes of uptake in the plume and removal outside the plume balance each other, so the sum of concentrations in fish that have just entered the plume and are taking up radionuclides and the concentrations in fish that have just left the plume and are eliminating radionuclides is the same as if a single group of fish remained within the plume. Some time is required for the uptake process within the plume to come to equilibrium, so it is likely that animals that are in the plume at any one time have not taken up as much of any radionuclide as the BCF indicates. Despite this it is assumed that the organisms are present for sufficient time (e.g., weeks and months) to bioconcentrate radionuclides. Therefore, the calculated concentrations in fish and marine mammals are likely overestimated.

The fraction of fish or other dietary items that are considered contaminated by exposure to radionuclides in the predicted CORMIX plume is calculated as follows:

$$\mathrm{FrC} = \mathrm{AP} \times \mathrm{BMDp} \times \mathrm{UF} / \mathrm{AFZ} \times \mathrm{BMDfz}$$

Where:

FrC = Fraction of fish that are contaminated by exposure in the plume

AP = Area of the plume (km^2)

BMDp = Biomass density in the plume, assumed to be the same as in the fishing zone (mT/km^2)

UF = Use factor for fraction of time spent fishing in the plume relative to other areas

AFZ = Area of the fishing zone (km^2)

BMDfz = Biomass density in the fishing zone (mT/km^2)

As an example, the fraction of mackerel caught in the assumed fishing zone that was calculated as exposed to radionuclides in the Long Shot CORMIX plume is as follows. It was assumed (Section A.10.2.2) that the zone in which Steller sea lions are found is bounded by the 200-m isobath around Amchitka Island. That zone has an area of approximately 3,570 km^2 (Section A.10.2.2). This corresponds to roughly 9 km from shore on the Bering Sea side and 15 km from shore on the Pacific Ocean side. For conservatism, it was assumed that the zone in which a subsistence fisher would fish (AFZ) around Amchitka Island is roughly half of that area, or 2,000 km^2. It was further assumed that a typical subsistence fisher in the Aleut culture and communication area would fish in the vicinity of Amchitka Island 10 percent of the year. It is unlikely that most subsistence fishers in the Aleut culture and communication area spend as much as 10 percent of their fishing time within the 200-m isobath of Amchitka Island. Therefore, the use factor (UF) of 0.1 is conservative. The area of the Long Shot plume (AP) was calculated to be 7.20E+06 m^2 (Table A-5) or 7.20E+00 km^2. The biomass density in the plume was assumed to be the same as throughout the fishing zone (i.e., 6.5 mT/km^2), as discussed in Section A.10.2.1. Biomass density of fish in the fishing zone is also assumed to be 6.5 mT/km^2 (Section A.10.2.1). Therefore, the fraction of harvested fish that are contaminated is (7.20E+00 km^2 × 6.5 mT/km^2 × 1.0E-01)/(2.0E+03 km^2 × 6.5 mT/km^2) = 3.60E-04. The fraction of fish that are contaminated by exposure in the plume (FrC) was calculated for each plume by using the foregoing equation.

A.10.3 Discussion of Uncertainties

It is explicitly assumed that the concentration of radionuclides in biota is the concentration calculated by using the BCF, which is the steady-state ratio of concentration in the biota to the concentration in the water. The steady state results when the rate of removal of the radionuclide from the body is the same as the rate of intake. If exposure is transient in the plume, there may not be enough time to reach the steady state. The DOE (2002) uses a kinetic model to calculate BCFs for mammals. This model predicts that in two days of exposure to the majority of the radionuclides of potential concern, the concentration in the body is 10 percent or less of the steady-state concentration, and it may take weeks or months to attain steady state. If exposed, marine mammals are moving about and staying in the plume for no more than a few days; therefore, this risk assessment, which assumes steady state, overestimates the concentration of those radionuclides in their tissues by at least an order of magnitude. It is also unlikely that steady state is reached in fish and other marine biota in a few days. Therefore, it is likely that the concentration in fish and other marine foods is also overestimated.

There is uncertainty in each of the terms of the equation used to calculate the contaminated fraction of the diet. Uncertainties about the area of the plume are discussed in Section A.6.3. The assumed biomass density found in the plume and in the remainder of the fishing zone are based on, or extrapolated from, the densities documented in large areas of the Bering Sea. Thus, the relative density of fish in the plumes and in the fishing zone is assumed to be the same. In the equation, the densities mathematically cancel each other. Therefore, this uncertainty has little consequence on the risk assessment results.

The use factor is uncertain because no data were available to indicate what fraction of the time subsistence fishers fish within the 200-m isobath of Amchitka Island. It was assumed that the fraction is 10 percent of the time, or about 36 days. It is unlikely that subsistence fishers in the Aleut culture and communication area spend as much as 10 percent of their fishing time within the 200-m isobath of Amchitka Island. Therefore, the UF of 0.1 contributes to an overestimate of the contaminated fraction. Further, the area of the fishing zone can be defined in a variety of ways. The assumed area, 2,000 km^2 (781 sq. mi.) is equivalent to a square roughly 45 km (28 mi.) on a side. It is approximately 0.1 percent of the Aleut culture and communication area. This further indicates the conservative nature of the screening risk assessment.

Combining the uncertainties of all terms, it is likely that the fraction of diet that is contaminated is overestimated, and is overestimated by at least one or two orders of magnitude.

A.10.4 Implementation

The ratio of fish calculated to be in the area of each plume to the number of fish in the hunting/fishing area, as discussed above in Section A.10.2 and Section A.10.4, was used as a conservative fraction of fish and marine mammals in the diet that were assumed to be contaminated by contact with radionuclides within each of the plumes (see Section 5.5 of the main text).