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presented in Table 10-125 and the following equation:

$$IR_{dw} = IR_{ww} \left[\frac{100 - W}{100} \right]$$
 (Eqn. 10-4)

where:

$$IR_{dw} = dry$$
-weight intake rate,
 $IR_{ww} = wet$ -weight intake rate, and
 $W = percent water content.$

Alternately, dry-weight residue levels in fish may be converted to wet-weight residue levels for use with wet-weight (e.g., as-consumed) intake rates, as follows:

$$C_{ww} = C_{dw} \left[\frac{100 - W}{100} \right]$$
(Eqn. 10-5)

where:

$$C_{ww}$$
 = wet-weight concentration,
 C_{dw} = dry-weight concentration, and
 W = percent water content.

The moisture content data presented in Table 10-125 are for selected fish taken from USDA (2007). The moisture content is based on the percent of water present.

10.9.2. Conversion Between Wet-Weight and Lipid-Weight Intake Rates

In some cases, the residue levels of contaminants in fish are reported as the concentration of contaminant per gram of fat. This may be particularly true for lipophilic compounds. When using these residue levels, the assessor should ensure consistency in the exposure-assessment calculations by using consumption rates that are based on the amount of fat consumed for the fish product of interest.

The total fat content (percent) measured and/or calculated in various fish forms (i.e., raw, cooked, smoked, etc.) for selected fish species is presented in Table 10-125, based on data from USDA (2007). The total percent fat content is based on the sum of saturated, monounsaturated, and polyunsaturated fat.

If necessary, wet-weight (e.g., as-consumed) intake rates may be converted to lipid-weight intake

rates using the fat content percentages presented in Table 10-125 and the following equation:

$$IR_{lw} = IR_{ww} \left[\frac{L}{100} \right]$$
 (Eqn. 10-6)

where:

 IR_{lw} = lipid-weight intake rate, IR_{ww} = wet-weight intake rate, and L = percent lipid (fat) content.

Alternately, wet-weight residue levels in fish may be estimated by multiplying the levels based on fat by the fraction of fat per product as follows:

$$C_{ww} = C_{lw} \left[\frac{L}{100} \right]$$
 (Eqn. 10-7)

where:

$$C_{ww}$$
 = wet-weight concentration,

$$C_{lw}$$
 = lipid-weight concentration, and

L = percent lipid (fat) content.

The resulting residue levels may then be used in conjunction with wet-weight (e.g., as-consumed) consumption rates. The total fat content data presented in Table 10-125 are for selected fish taken from USDA (2007).

10.10. REFERENCES FOR CHAPTER 10

- ADEM (Alabama Department of Environmental Management). (1994). Estimation of daily per capita freshwater fish consumption of Alabama anglers. Montgomery, AL.
- Alcoa (Aluminum Corporation of America). (1998). Draft report for the finfish/shellfish consumption study Alcoa (Point Comfort)/Lavaca Bay Superfund Site, Volume B7b: Bay System Investigation Phase 2. Point Comfort, TX: Aluminum Company of America.
- Balcom, N; Capacchione, C; DW, H. (1999).
 Quantification of seafood consumption rates for Connecticut. (Contract No. CWF-332-R). Hartford, CT: Connecticut Department of Environmental Protection, Office of Long Island Sound Programs.

Exposure Factors Handbook

Chapter 10—Intake of Fish and Shellfish

- Benson, S; Crocker, C; Erjavec, J; Jensen, RR;
 Nyberg, CM; Wixo, CY; Zola, JM. (2001).
 Fish consumption survey: Minnesota and
 North Dakota. Washington, DC: U.S.
 Department of Energy.
- Burger, J. (2000). Gender differences in meal patterns: role of self-caught fish and wild game in meat and fish diets. Environ Res 83: 140-149.
- http://dx.doi.org/10.1006/enrs.2000.4060. Burger, J. (2002a). Consumption patterns and why
- people fish. Environ Res 90: 125-135. Burger, J. (2002b). Daily consumption of wild fish and game: Exposures of high end recreationists. Int J Environ Health Res 12:

343-354. http://dx.doi.org/10.1080/096031202100005 6393.

- Burger, J; Cooper, K; Gochfeld, M. (1992). Exposure assessment for heavy metal ingestion from a sport fish in Puerto Rico: estimating risk for local fishermen. J Toxicol Environ Health 36: 36:355-365.
- Burger, J; Gochfeld, M. (1991). Fishing a superfund site: Dissonance and risk perception of environmental hazards by fishermen in Puerto Rico. Risk Anal 11: 269-277.
- Burger, J; Sanchez, J; Gochfeld, M. (1998). Fishing, consumption, and risk perception in fisherfolk along an east coast estuary. Environ Res 77: 25-35. http://dx.doi.org/10.1006/enrs.1997.3819.
- Burger, J; Stephens, WL; Boring, CS; Kuklinski, M; Gibbons, JW; Gochfeld, M. (1999). Factors in exposure assessment: ethnic and socioeconomic differences in fishing and consumption of fish caught along the Savannah River. Risk Anal 19: 427-438.
- ChemRisk. (1992). Consumption of freshwater fish by Maine anglers. ChemRisk, a division of Mclaren/Hart.
- Chiang, A. (1998). A seafood consumption survey of the Laotian community of West Contra Costa County, CA. Oakland, CA: Asian Pacific Environmental Network.

Connelly, NA; Knuth, BA; Bisogni, CA. (1992). Effects of the health advisory and advisory changes on fishing habits and fish consumption in New York sport fisheries. (Report for the New York Sea Grant Institute Project No. R/FHD-2-PD.). Ithaca, NY: Cornell University.

Connelly, NA; Knuth, BA; Brown, TL. (1996). Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. North American Journal of Fisheries Management 16: 90-101.

- CRITFC (Columbia River Inter-Tribal Fish Commission). (1994). A fish consumption survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin.
- Degner, RL; Adams, CM; Moss, SD; Mack, SK. (1994). Per capita fish and shellfish consumption in Florida. Gainesville, FL: University of Florida.

Donatuto, J; Harper, BL. (2008). Issues in evaluating fish consumption rates for Native American tribes. 28: 1497-1506. http://dx.doi.org/10.1111/j.1539-6924.2008.01113.x.

- Duncan, M. (2000). Fish consumption survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region. Suquamish, WA: The Suquamish Tribe, Port Madison Indian Reservation. http://www.deq.state.or.us/wq/standards/doc s/toxics/suquamish2000report.pdf.
- Ebert, ES; Harrington, NW; Boyle, KJ; Knight, JW; Keenan, RE. (1993). Estimating consumption of freshwater fish among Maine anglers. North American Journal of Fisheries Management 13: 737-745.
- FASEB/LSRO (Federation of American Societies for Experimental Biology, Life Sciences Research Office). (1995). Third report on nutrition monitoring in the United States: Volume 1. Washington, DC: Interagency Board for Nutrition Monitoring and Related Research.
- Fiore, BJ; Anderson, HA; Hanrahan, LP; Olson, LJ; Sonzogni, WC. (1989). Sport fish consumption and body burden levels of chlorinated hydrocarbons: A study of Wisconsin anglers. Arch Environ Health 44: 82-88.

Fitzgerald, EF; Hwang, SA; Brix, KA; Bush, B; Cook, K; Worswick, P. (1995). Fish PCB concentrations and consumption patterns among Mohawk women at Akwesasne. J Expo Anal Environ Epidemiol 5: 1-19.

Florida State Department of Health and Rehabilitative Services. (1995). Health study to assess the human health effects of mercury exposure to fish consumed from the Everglades: Final report. http://www.ntis.gov/search/product.aspx?A BBR=PB95167276.

Forti, A; Bogdan, KG; Horn, E. (1995). Health risk assessment for the Akwesasne Mohawk

Exposure Factors Handbook

Chapter 10—Intake of Fish and Shellfish

population from exposure to chemical contaminants in fish and wildlife. Massena, NY: New York State Dept. of Health, Center for Environmental Health, Bureau of Toxic Substance Assessment.

- Harper, BL; Harris, SG. (2008). A possible approach for setting a mercury risk-based action level based on tribal fish ingestion rates. Environ Res 107: 60-68. http://dx.doi.org/10.1016/j.envres.2007.05.0
- 08. Hudson River Sloop Clearwater, Inc., . (1993).
- Hudson River angler survey. Poughkeepsie, NY.
- KCA Research Division. (1994). Fish consumption pattern of Delaware recreational fishermen and their households. Dover, DE: Delaware Department of Natural Resources.
- Mahaffey, KR; Clickner, RP; Jeffries, RA. (2009). Adult women's blood mercury concentrations vary regionally in the United States: Association with patterns of fish consumption (NHANES 1999-2004). Environ Health Perspect 117: 47-53. http://dx.doi.org/10.1289/ehp.11674.
- Mayfield, DB; Robinson, S; Simmonds, J. (2007). Survey of fish consumption patterns of King County (Washington) recreational anglers. J Expo Sci Environ Epidemiol 17: 604-612. http://dx.doi.org/10.1038/sj.jes.7500559.
- Moya, J; Itkin, C; Selevan, SG; Rogers, JW; Clickner, RP. (2008). Estimates of fish consumption rates for consumers of bought and self-caught fish in Connecticut, Florida, Minnesota, and North Dakota. Sci Total Environ 403: 89-98. http://dx.doi.org/10.1016/j.scitotenv.2008.05 .023.
- Moya, J; Phillips, L. (2001). Analysis of consumption of home-produced foods. J Expo Anal Environ Epidemiol 11: 398-406. http://dx.doi.org/10.1038/sj.jea.7500181.
- NCHS (National Center for Health Statistics). (1993). Joint policy on variance estimation and statistical reporting standards on NHANES III and CSFII reports: HNIS/NCHS Analytic Working Group recommendations. Riverdale, MD: Human Nutrition Information Service (HNIS)/Analytic Working Group. Agricultural Research Service, Survey Systems/Food Consumption Laboratory.
- NMFS (National Marine Fisheries Service). (1986a). Fisheries of the United States, 1985. Current Fisheries Statistics No. 8368. Washington,

DC: National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service.

- NMFS (National Marine Fisheries Service). (1986b). Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts, 1985. Current Fisheries Statistics No. 8327. Washington, DC: National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service.
- NMFS (National Marine Fisheries Service). (1986c). Marine Recreational Fishery Statistics Survey, Pacific Coast. Current Fisheries Statistics No. 8328. Washington, DC: National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service.
- NMFS (National Marine Fisheries Service). (1993). Data tapes for the 1993 NMFS provided to U.S. EPA. Washington, DC: U.S. Environmental Protection Agency.
- Pao, EM; Fleming, KH; Guenther, PM; Mickle, SJ. (1982). Foods commonly eaten by individuals: Amount per day and per eating occasion. (Home Economic Report No. 44). Washington, DC: U.S. Department of Agriculture.
- Peterson, DE; Kanarek, MS; Kuykendall, MA; Diedrich, JM; Anderson, HA; Remington, PL; Sheffy, TB. (1994). Fish consumption patterns and blood mercury levels in Wisconsin Chippewa Indians. Arch Environ Health 49: 53-58. http://dx.doi.org/10.1080/00039896.1994.99 34415.
- Pierce, D; Noviello, DT; Rogers, SH. (1981). Commencement Bay seafood consumption study: preliminary report.
- Polissar, NL; Neradilek, B; Liao, S; Toy, KA; Mittelstaedt, GD. (2006). A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region – Consumption rates for fish consumers only. Seattle, WA: Mountain-Whisper-Light Statistical Consulting.
- Price, P; Su, S; Gray, M. (1994). The effects of sampling bias on estimates of angler consumption rates in creel surveys. J Expo Anal Environ Epidemiol 4: 355-371.
- Puffer, HW; Azen, SP; Duda, MJ; Young, DR. (1982). Consumption rates of potentially hazardous marine fish caught in the metropolitan Los Angeles area. (EPA-600/3-82-070). Los Angeles: University of

Chapter 10—Intake of Fish and Shellfish

Southern California.

- Rouse Campbell, K; Dickey, RJ; Sexton, R; Burger, J. (2002). Fishing along the Clinch River arm of Watts Bar reservoir adjacent to the Oak Ridge Reservation, Tennessee: behavior, knowledge and risk perception. Sci Total Environ 299: 145-161.
- Ruffle, B; Burmaster, DE; Anderson, PD; Gordon, HD. (1994). Lognormal distributions for fish consumption by the general US population. Risk Anal 14: 395-404.
- Rupp, EM; Miller, FI; Baes, CF. (1980). Some results of recent surveys of fish and shellfish consumption by age and region of U.S. residents. Health Phys 39: 165-175.
- San Diego County. (1990). San Diego Bay health risk study. San Diego, CA: San Diego County Department of Health Services.
- SFEI (San Francisco Estuary Institute). (2000). San Francisco Bay seafood consumption report. Richmond, CA. http://www.sfei.org/node/2022.
- Shilling, F; White, A; Lippert, L; Lubell, M. (2010). Contaminated fish consumption in California's Central Valley Delta. Environ Res 110: 334-344. http://dx.doi.org/10.1016/j.envres.2010.02.0 02.
- SMBRP (Santa Monica Bay Restoration Project). (1995). Seafood consumption habits of recreational anglers in Santa Monica Bay. In Southern California Coastal Water Research Project 1993-94 annual report (pp. 55-62). Westminster, CA: Southern California Coastal Water Research Project. ftp://ftp.sccwrp.org/pub/download/DOCUM ENTS/AnnualReports/1993_94AnnualRepor t/ar07.pdf.
- Smiciklas-Wright, H; Mitchell, DC; Mickle, SJ; Cook, AJ; Goldman, JD. (2002). Foods commonly eaten in the United States: Quantities consumed per eating occasion and in a day, 1994–96 [pre-publication version]. (NFS Report No. 96-5). Beltsville, MD: U.S. Department of Agriculture. http://www.ars.usda.gov/sp2userfiles/place/1 2355000/pdf/portion.pdf.
- SRI (SRI Consulting). (1980). Seafood consumption data analysis [EPA Report]. Washington, DC: U.S. Environmental Protection Agency.
- Stern, AH; Korn, LR; Ruppel, BE. (1996). Estimation of fish consumption and methylmercury intake in the New Jersey population. J Expo Anal Environ Epidemiol 6: 503-525.
- Toy, KA; Polissar, NL; Liao, S; Mittelstaedt, GD.

(1996). A fish consumption survey of the Tulalip and Squaxin Island tribes of the Puget Sound region. Marysville, WA: Tulalip Tribes, Department of Environment. http://www.deq.state.or.us/wq/standards/doc s/toxics/tulalipsquaxin1996.pdf.

- U.S. EPA (U.S. Environmental Protection Agency). (1984). Ambient water quality criteria for 2, 3, 7, 8 - Tetrachloro-dibenzo - p - dioxin. (EPA-440/5-84-007).
- U.S. EPA (U.S. Environmental Protection Agency). (1995). Fish consumption estimates based on the 1991-1992 Michigan sport anglers fish consumption study: Final report. Washington, DC.
- U.S. EPA (U.S. Environmental Protection Agency). (1996). Descriptive statistics from a detailed analysis of the National Human Activity Pattern Survey (NHAPS) responses. (EPA/600/R-96/148). Washington, DC.
- U.S. EPA (U.S. Environmental Protection Agency). (1998). Guidance for conducting fish and wildlife consumption surveys. (EPA-823-B/98/007). Washington, DC.
- U.S. EPA (U.S. Environmental Protection Agency). (1999). Asian and Pacific Islander seafood consumption study in King County, WA. (EPA/910/R-99-003). Seattle, WA.
- U.S. EPA (U.S. Environmental Protection Agency). (2002). Estimated per capita fish consumption in the United States. (EPA/821/C-02/003). Washington, DC.
- U.S. EPA (U.S. Environmental Protection Agency). (2003). Exposure and human health reassessment of 2,3,7,8 tetrachlorodibenzo-p dioxin (TCDD) and related compounds [NAS review draft]. (EPA/600/P-00/001). Washington, DC: U.S. Environmental Protection Agency, National Center for Environmental Assessment. http://www.epa.gov/nceawww1/pdfs/dioxin/ nas-review/.
- U.S. EPA (U.S. Environmental Protection Agency). (2005). Guidance on selecting age groups for monitoring and assessing childhood exposures to environmental contaminants (final). (EPA/630/P-03/003F). Washington, DC: U.S. Environmental Protection Agency, Risk Assessment Forum. http://www.epa.gov/raf/publications/guidanc e-on-selecting-age-groups.htm.
- USDA (U.S. Department of Agriculture). (1992). Changes in food consumption and expenditures in American households during the 1980s. Statistical Bulletin No. 849.

Chapter 10—Intake of Fish and Shellfish

Washington, DC. USDA (U.S. Department of Agriculture). (1993). Food and nutrient intakes by individuals in the United States, 1 day, 1987–88. Nationwide Food Consumption Survey 1987-88: Report no. 87-I-1. (87-I-1). Washington, DC. http://www.ars.usda.gov/SP2UserFiles/Place /12355000/pdf/8788/nfcs8788_rep_87-i-1.pdf. USDA (U.S. Department of Agriculture). (2000). 1994-1996, 1998 continuing survey of food

1994-1996, 1998 continuing survey of food intakes by individuals (CSFII). Beltsville, MD: Agricultural Research Service, Beltsville Human Nutrition Research Center.

- USDA (U.S. Department of Agriculture). (2007). USDA nutrient database for standard reference, release 20. Riverdale, MD. http://www.ars.usda.gov/main/site_main.htm ?modecode=12-35-45-00.
- West, PC; Fly, JM; Marans, R; Larkin, F. (1989). 1991-1992 Michigan sport anglers fish consumption study. Ann Arbor, MI: Michigan Department of Natural Resources.
- West, PC; Fly, JM; Marans, R; Larkin, F; Rosenblatt,

D. (1993). 1991-1992 Michigan sport anglers fish consumption study. Ann Arbor, MI: Michigan Department of Natural Resources.

Westat. (2006). Fish consumption in Connecticut, Florida, Minnesota, and North Dakota. Rockville, MD.

Williams, R; O'Leary, J; Sheaffer, A; Mason, D. (1999). Consumption of Indiana sport caught fish: Mail survey of resident license holders. (Technical Report 99-D-HDFW-1). West Lafayette, IN: Indiana Department of Forestry and Natural Resources.

Williams, R; O'Leary, J; Sheaffer, A; Mason, D. (2000). An examination of fish consumption by Indiana recreational anglers: An onsite survey. (Technical Report 99-D-HDFW-2).
West Lafayette, IN: Indiana Department of Forestry and Natural Resources.

Wolfe, RJ; Walker, RJ. (1987). Subsistence economies in Alaska: productivity, geography, and development impacts. Arctic Anthropology56-81.