Abstract.—Contaminated fish in Santa Monica Bay, California, have raised concerns about health risks from local seafood consumption. In preparation for a new health risk analysis, a field study was undertaken to determine local angler consumption rates, consumption characteristics, and angler catch. During 1991–92, biologists interviewed 1,244 anglers on piers, party boats, private boats, and beaches; 555 provided consumption-rate estimates. In contrast to previous studies, non-English as well as English speaking anglers were interviewed. The median seafood consumption rate of 21 g/day for local anglers was less than the national average. Consumption-rate distributions were highly skewed, upper-decile consumption rates being several times higher than median rates. Upper-decile consumption rates were more useful than median rates in delineating demographic and species-specific differences in consumption rates. Angler consumption rates of potentially contaminated species and angler awareness of health risks varied by ethnic group; therefore communication of health risks should target habits and languages of high-risk anglers.

Demographic variability in seafood consumption rates among recreational anglers of Santa Monica Bay, California, in 1991–1992

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State and Federal regulatory agencies currently use seafood consumption rates in evaluations of health risks from contaminated seafood organisms (Murray and Burmaster, 1994). The United States Environmental Protection Agency (USEPA) estimates that United States recreational anglers consume a median of 30 g/day of fish and shellfish from national waters (USEPA, 1990). Regional medians range from 26 to 37 g/day (Puffer et al., 1981, 1982; Landolt et al., 1985, 1987; Humphrey, 1988; Murray and Burmaster, 1994; SDCDHS[1]). However, extrapolation of national or nonlocal rates to local angling populations can underestimate health risks (Humphrey, 1988). Consumption rates may vary between studies because angler populations differ demographically and in species preference or because rate-determination methods differ. In this study we examine the influence of variability in angler demography, species preference, and rate-determination

[1] SDCDHS (San Diego County Department of Health Services). 1990. San Diego Bay health risk study. Report prepared for Port of San Diego, San Diego, CA. San Diego County, Dep. Health Serv., San Diego, CA, 322 p.

method on seafood consumption rates in a diverse local angling population in Santa Monica Bay, California.

Santa Monica Bay is an embayment of the southern California coast that borders the Los Angeles metropolitan area, one of the largest urban areas in the United States. The presence of chemically contaminated seafood organisms in Santa Monica Bay has raised public concern about the health risk of eating seafood species caught in the Bay (Pollock et al.[2]; SCCWRP et al.[3], SCCWRP[4]). In particular, white croaker, *Genyonemus lineatus*, a species commonly caught by local recreational anglers, is contaminated in some areas of the Bay (Pollock et al.[2]; SCCWRP et al.[3]). Warnings advising restricted consumption of white croaker have been posted since 1985 (Stull et al., 1987; Pollock et al.[2])

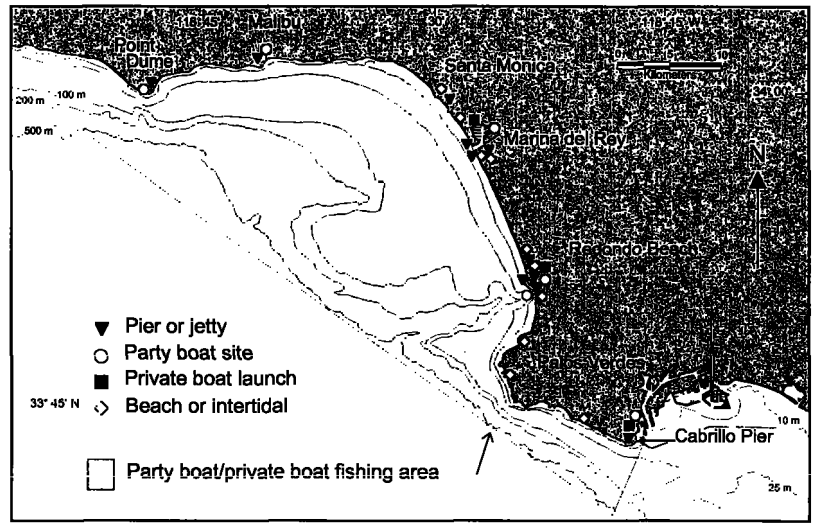

Figure 1

Recreational angler fishing sites sampled in the Santa Monica Bay Seafood Consumption Study, September 1991 to August 1992.

The only study of angler seafood consumption habits for the Los Angeles metropolitan area (including Santa Monica Bay) was conducted in 1980 (Puffer et al., 1981, 1982). The study surveyed more than 1,000 anglers but interviewed only those that spoke English. The median consumption rate of Los Angeles anglers in that study was higher (37 g/day) than the national median (which was 18.7 g/day) (Puffer et al., 1981).

Considering contaminant levels in fish collected in 1987, the State recommended restricted consumption of some species at certain fishing sites in southern California (including Santa Monica Bay) (Pollock et al.[2]). In anticipation of a new risk analysis for the area,[5] a study of seafood consumption habits of Santa Monica Bay recreational anglers was conducted in the early 1990's.[6] The objectives of this study were to describe the demographic and consumption characteristics of Santa Monica Bay anglers, to identify groups with high consumption rates, and to determine the most abundantly caught and consumed species in the early 1990's.

Materials and methods

Field survey

The study area consisted of Santa Monica Bay and adjacent areas, extending from Point Dume to Cabrillo Pier (Fig. 1). It included waters inshore of the 500-m isobath from Point Dume to Cabrillo Pier. We conducted 113 field survey trips at 29 sites on 99 days from 3 September 1991 to 30 August 1992. Interviewers surveyed anglers at piers and jetties (11 sites), party boats (5 sites), private boats (3 sites), and beach and intertidal zones (11 sites) (Fig. 1).

Previous studies indicated that more anglers fish during the summer than during the winter (Stull et al., 1987; NFSP, 1992). Thus, we separated the sampling period into summer (September 1991 and June through August 1992) and nonsummer (October 1991 through May 1992) periods. We conducted survey

[2] Pollock, G. A., I. J. Uhaa, A. M. Fan, J. A. Wisniewski, and I. Witherell. 1991. A study of chemical contamination of marine fish from Southern California. II: Comprehensive study. Calif. Environ. Protection Agency, Office Environ. Health Hazard Assess., Sacramento, CA, 393 p. (161 p. + append.)

[3] SCCWRP (Southern California Coastal Water Research Project), MBC Applied Environmental Sciences, and University of California, Santa Cruz, Trace Organics Facility. 1992. Santa Monica Bay seafood contamination study. Report prepared for Santa Monica Bay Restoration Project, Monterey Park, CA. Southern Calif. Coastal Water Res. Project, Long Beach, CA, 179 p.

[4] SCCWRP (Southern California Coastal Water Research Project). 1994. Contamination of recreational seafood organisms off Southern California. *In* J. N. Cross, C. Francisco, and D. Hallock (eds.), Southern California coastal water research project annual report 1992–1993, p. 100–110. Southern Calif. Coast. Water Res. Project, Westminster, CA.

[5] Santa Monica Bay Restoration Project, Monterey Park, CA, is funding this risk-analysis study.

[6] SCCWRP and MBC (1994) (Footnote 9 in the text) provides a detailed account of sampling protocols, analytical methods, and results of this study.

trips to pier-and-jetty, party-boat, and private-boat sites on two week days and two weekend days per month in summer and on one week day and one weekend day per month in nonsummer.

To minimize sampling bias, we used a stratified-random design to schedule and conduct the survey trips. Fishing modes, regions, sites, and sampling times were selected randomly to maximize spatial coverage of the Bay. For each month, we selected a sampling sequence at random for four regions and sites within each region, using a random numbers table; we surveyed each site in the selected sequence. If a site could not be sampled, we sampled the next site on the list. Sampling was conducted without replacement within a month and with replacement between months.

We chose survey-trip times at random for the three major fishing modes. Interviewers surveyed pier-and-jetty anglers in the morning (0800–1200 h), afternoon (1200–1600 h), or evening (1600–2000 h) with roving surveys. They surveyed party-boat anglers on half-day boats within the study area (full-day boats generally fished outside the area) in the morning (0700–1200 h) or afternoon (1230–1730 h). Private-boat anglers were interviewed at boat launches or hoists in the morning (1000–1400 h) or afternoon (1400–1800 h). Interviewers conducted 1-h beach survey trips before pier-and-jetty surveys and conducted 2-h rocky intertidal surveys on randomly selected afternoons (1300–1700 h) during low tides.

Interviewers tried to interview all anglers at a site. However, if too many anglers were present, they systematically selected every second or third angler. Interviewers censused (counted and characterized) anglers at each site and asked all (or a subset of the anglers) questions from a specially designed questionnaire. All interviewers spoke English; at least one interviewer per survey spoke Spanish; and others spoke Vietnamese, Chinese, or Pilipino. They interviewed a designated household head if two or more individuals from a household were present. Interviewers asked anglers 35 questions regarding their background, their fishing history, the types of fish they had eaten, their consumption habits, their methods of preparing fish, their awareness of health risk warnings, and their response to warnings (Table 1). Anglers chose the ethnic-group category best representing their background from a list used in the most recent United States census report (USBC, 1990).

Interviewers identified to species any fish possessed by anglers and measured its fork length to the nearest centimeter. They showed photographs of important species in order to enable anglers to identify other species consumed during the previous month. The species included bocaccio (*Sebastes paucispinis*), barred sand bass (*Paralabrax nebulifer*), kelp bass (*Paralabrax clathratus*), white croaker, queenfish (*Seriphus politus*), California corbina (*Menticirrhus undulatus*), chub (=Pacific) mackerel (*Scomber japonicus*), and California halibut (*Paralichthys californicus*). Interviewers also carried a balsa-wood model of a 150-g generic fish fillet (based on a fillet of that size obtained from a supermarket [the USEPA standard meal size; USEPA, 1989]). They asked anglers to estimate their meal size for each species (in hand or in photographs) in relation to the fillet model. The fillet model gave the angler a three-dimensional image of the standard meal size.

Data analysis

Questionnaire responses were numerically coded and entered into a computer database for analysis. We calculated consumption rates by two methods. The primary method used the angler's estimates of meal size based on a 150-g fillet model. The other method used consumable-portion sizes of fish possessed by an angler. For the latter method, we converted lengths of fish measured in the field to total and consumable-portion weights. These were estimated for each fish from weight-length regressions[7] and from consumable-portion information.[8] In both methods, we multiplied the amount consumed per meal or the consumable portion by the number of times an angler consumed that species during the previous four weeks. This gave a monthly consumption rate (in grams per month). We divided this rate by 28 days to get daily consumption rates (in grams per day). For the consumable-portion method, we divided the consumable portion by the number of consumers in the household. We did not do this for the fillet-model estimates because we obtained only information on the angler's meal size.

Consumption rate data were summarized by parametric (means, standard deviations, and 95% confidence limits) and nonparametric statistics (median and upper decile or 90th percentiles). We tested for consumption-rate differences among ethnic and income groups using a Kruskal-Wallis one-way analysis of variance on ranked data. We tested for differences between fillet-model and consumable-portion estimates of consumption rates using a Wilcoxon's sign-rank test or paired t-test, as appropriate.

[7] S. J. Crooke, Calif. Dep. Fish Game, Long Beach, CA, provided weight-length relationship information.

[8] W. Jacobson, U.S. Dep. Commer., Natl. Ocean. Atmos. Admin., Natl. Mar. Fish. Serv., Los Angeles Reg., Long Beach, CA, provided consumable-portion information.

Table 1

Information collected by a questionnaire administered to recreational anglers during the Santa Monica Bay seafood consumption study, September 1991 to August 1992.

No.	Information
1	Interviewer(s)
2	Date
3	Location
4	Interview time (begin and end)
5	Fishing technique used by angler — hook-and-line (number of poles), other
6	Observed gender of angler
7	Permission or not to interview angler
8	Angler previously or not interviewed for this study
9	Length of time angler fished at location during day of interview (number of hours)
10	Additional time angler expected to fish during day of interview (boat anglers excluded)
11	Number of years or months angler fished in Santa Monica Bay
12	Seasons angler fished
13	Number of times angler fished at location during past four weeks
14	Angler's fishing experience elsewhere in Santa Monica Bay during past four weeks (number of times, fishing mode, site)
15	Number of times angler consumed fish caught in Santa Monica Bay during past four weeks
16	Number of fish caught during day of interview
17	Permission or not to examine angler's catch
18	Species caught:
	a correct species name, angler's name for species
	b fish length (cm)
	c fate of fish (eat, throw back, give away, other)
	d parts of fish consumed (whole gutted, fillet/steak, whole with intestines, other)
	e how much consumed (relative to fillet model)
	f preparation method (fry, broil/barbecue, bake/boil/steam, raw/smoked/ceviche, soup, other)
19	Specific species (shown in photos): (a–f, same as in question 18)
20	Was angler aware of fish consumption health warnings for Santa Monica Bay?
21	How was angler informed of the health warnings (posted signs, TV, newspapers or magazines, anglers/friends, other)?
22	Did angler respond to warnings? (If yes, how? Eat less of all or specific species? Stopped eating all or specific species?)
23	Importance of warnings to angler
24	Angler's town and zip code of residence
25	Angler's occupation
26	Angler's age
27	Angler's racial or ethnic background
28	Number of angler's family members fishing at site that day
29	Others in angler's household: number, ages, participation in and frequency of consumption of catch from Santa Monica Bay, relative amounts eaten (compared with fillet model)
30	Angler's family income
31	Permission to call angler
32	Best time of day to call angler
33	Angler's phone number
34	Angler's name
35	Interviewer observations (quality of interview, survey type, comments, language used in interview)

Results

Angler characteristics and catch

During the survey year, interviewers counted 2,376 anglers and approached 1,740 for interviews. Of those approached, they did not interview 149 (9%) because of language barriers and 347 (20%) because they refused information. They interviewed 1,244 anglers; of these, 555 provided sufficient information for consumption-rate calculations (Table 2). Of these 555 consumers, 232 (42%) were interviewed on party boats, 210 (38%) on piers and jetties, 106 (19%) on private boats, and 7 (1%) at beach and intertidal areas. Hence, we did not consider beach and intertidal areas as a major fishing mode. On the average, they interviewed 52% of the anglers at a site. By mode, the mean percentage interviewed at a site was 59%

Table 2

Sampling success in surveys of recreational anglers by fishing mode and time of week, Santa Monica Bay seafood consumption study, September 1991 to August 1992.

Fishing mode and period	No. survey trips	Anglers						
		Counted	Approached		Interviewed		Used in study	
		No.	No.	%[1]	No.	%[2]	No.	%[3]
Piers								
Weekday	16	313	333	106	221	66	97	44
Weekend	16	571	453	79	299	66	113	38
Total	32	884	786	89	520	66	210	40
Party boats								
Weekday	16	365	264	72	190	72	101	53
Weekend	16	612	366	60	260	71	132	51
Total	32	977	630	64	450	71	233	52
Private boats								
Weekday	16	131	87	66	75	86	29	39
Weekend	16	350	217	62	183	84	77	42
Total	32	481	304	63	258	85	106	41
Beach								
Weekday	8	14	8	57	7	88	5	71
Weekend	5	8	7	88	4	57	1	25
Total	13	22	15	68	11	73	6	55
Intertidal								
Weekday	4	12	5	42	5	100	0	0
Grand total	113	2,376	1,740	73	1,244	71	555	45

[1] % approached = (no. approached/no. counted) × 100; number of anglers approached for interviews was higher than number initially counted when late-arriving anglers on pier were interviewed.
[2] % interviewed = (no. anglers approached/no. interviewed) × 100.
[3] % used in study (i.e. providing consumption information) = (no. used/no. interviewed) × 100.

at piers and jetties, 54% on private boats, 50% on beaches, 47% on party boats, and 42% at beach and intertidal sites.

Santa Monica Bay anglers comprised several demographic groups. Most were males (93%), 21–40 yr old (54%), and white (43%), with annual household incomes of $25,000–$50,000 (39%) (Fig. 2). Anglers were 8–86 yr old and less than 10% were younger than 21 years. Because we interviewed only household heads, we probably underestimated numbers of anglers below 21 years; therefore, we excluded these from the age-frequency summary (Fig. 2). The following ethnic groups were noted: white, black, Hispanic, and Asian (including Japanese, Koreans, Chinese, Filipinos, Vietnamese, Cambodians, Indonesians, Pakistanis, and Pacific Islanders). The second most abundant ethnic group was Hispanic, followed by Asian, and black (Fig. 2). "Others" included a native American, an Iranian, and an Egyptian, as well as anglers not providing ethnic information. Hispanics were the predominant group on piers and jetties, whereas whites were the predominant group on party boats and private boats (Fig. 3). Most (60%) anglers with incomes below $10,000 fished on piers and jetties. Most (46%) anglers had fished 5 yr or less in Santa Monica Bay, whereas 7% had fished more than 30 yr. Most (63%) anglers fished all year but 19% fished only in summer. About (33%) had not fished during the month (28 days) before the interview, but of those that had, most had fished 3–5 times per month and for 2–5 h at a time.

Interviewed anglers possessed at least 67 species of fish, two species of crustaceans, two species of mollusks, and one species of echinoderm from the study area. The most abundant species were chub mackerel, barred sand bass, kelp bass, white croaker,

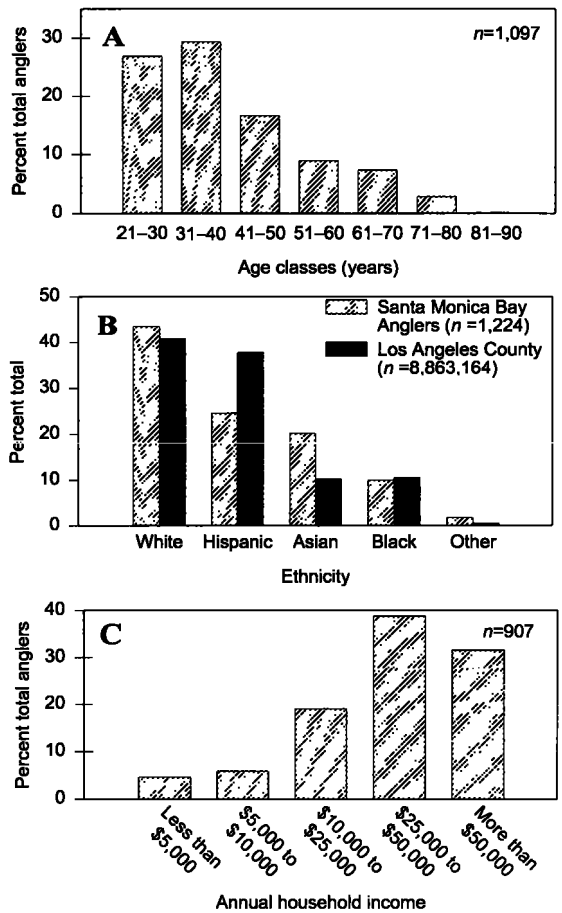

Figure 2

Characteristics of recreational anglers interviewed in the Santa Monica Bay seafood consumption study, September 1991 to August 1992: (**A**) age distribution (anglers older than 20 yr); (**B**) ethnic distribution (anglers and general population of Los Angeles County in 1990 [USBC, 1990]); and (**C**) annual household income distribution (non-respondents not included).

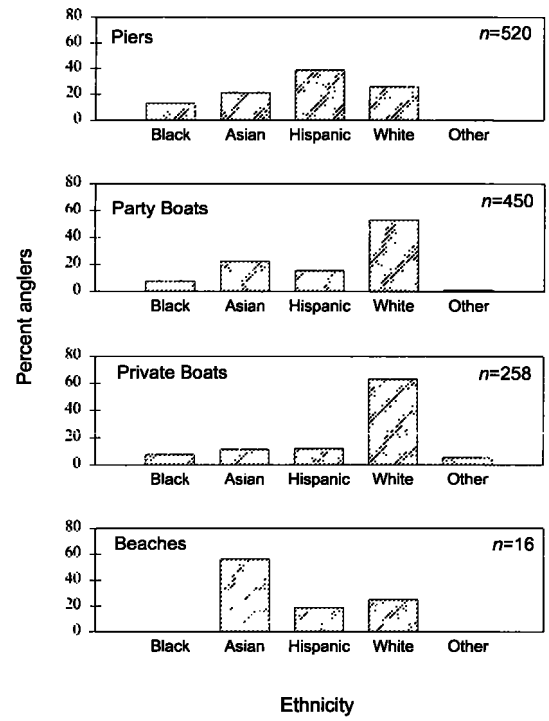

Figure 3

Ethnic distribution of recreational anglers by fishing mode, Santa Monica Bay seafood consumption study, September 1991 to August 1992.

Pacific barracuda (*Sphyraena argentea*), and Pacific bonito (*Sarda chiliensis*) (Table 3). Most anglers could not give the correct common name (Robins et al., 1991) (e.g. Pacific barracuda, chub mackerel) for fish species but generally could give the correct generic common names (e.g. barracuda, mackerel).

Only 45% of the respondents had eaten fish from the Bay within four weeks of the interview, and most anglers had caught fish on the interview day. More party-boat (76%) and private-boat (74%) anglers had caught fish on the interview day than had pier-and-jetty anglers (47%). About 63% of the anglers intended to eat their catch. Private-boat anglers were most likely (70%) and pier-and-jetty anglers least likely (58%) to eat their catch. Pacific bonito, Pacific barracuda, and California halibut were the species most frequently eaten if caught, whereas white croaker, chub mackerel, and queenfish were the species most frequently thrown back.

About 65% of the anglers ate fish steaks or fillets, whereas 33% ate their fish whole but gutted; only 1% ate whole ungutted fish. Whites, blacks, and Hispanics usually ate fish steaks or fillets, whereas Asians ate whole gutted fish with equal frequency. About 47% of the anglers fried their fish, 27% used a variety of cooking methods, and 17% broiled or barbecued their fish. Frying was the most common method of cooking fish for all ethnic groups. However, a combination of methods was important for all groups other than the Hispanic. Broiling and barbecuing was also an important cooking method for whites but less so for the other groups. We did not ask anglers if they consumed fish with or without skin.

Consumption rates

Consumption-rate distributions were strongly right-skewed (Fig. 4). From fillet-model estimates, Santa Monica Bay anglers had a median consumption rate

Table 3

Species most commonly caught by recreational anglers with different fishing modes, Santa Monica Bay seafood consumption study, September 1991 to August 1992.[1]

Common name	Scientific name	Number of organisms				
		Piers or jetties	Party boat	Private boat	Beach or intertidal	Total
chub mackerel	*Scomber japonicus*	476	356	215	0	1,047
barred sand bass	*Paralabrax nebulifer*	1	308	79	0	388
kelp bass	*Paralabrax clathratus*	1	250	76	0	327
white croaker	*Genyonemus lineatus*	167	3	149	0	319
Pacific barracuda	*Sphyraena argentea*	4	202	53	0	259
Pacific bonito	*Sarda chiliensis*	25	124	101	0	250
sea mussel, unidentified	*Mytilus* spp., unidentified	0	0	0	100	100
Pacific purple urchin	*Strongylocentrotus purpuratus*	0	0	0	90	90
jacksmelt	*Atherinopsis californiensis*	64	2	8	0	74
California scorpionfish	*Scorpaena guttata*	3	34	28	0	65
bocaccio	*Sebastes paucispinus*	0	46	16	0	62
California halibut	*Paralichthys californicus*	12	23	27	0	62
halfmoon	*Medialuna californiensis*	0	32	24	0	56
opaleye	*Girella nigricans*	31	0	12	9	52
rockfish, unidentified	*Sebastes* spp., unidentified	0	34	3	0	37
squarespot rockfish	*Sebastes hopkinsi*	0	29	0	0	29
surfperches, unidentified	*Embiotocidae* spp.	18	0	9	0	27
black perch	*Embiotoca jacksoni*	5	0	21	0	26
starry rockfish	*Sebastes constellatus*	0	18	6	0	24
yellowfin croaker	*Umbrina roncador*	16	0	1	3	20
other species combined		95	67	69	11	242
total		918	1,528	897	213	3,556
rockfishes, combined[2]	*Sebastes* spp., combined	4	166	28	0	198

[1] A complete list of observed species is given in SCCWRP and MBC (Footnote 9 in the text).
[2] Rockfishes combined included 15 identified and one unidentified species, some of which (i.e. boccacio, squarespot rockfish, rockfish unidentified, and starry rockfish) are included in the top 20 species shown in this table as separate species and others as other species combined. Because rockfishes are commonly combined in catch summaries, the catch of the group as a whole is also shown separately.

of 21 g/day and an upper-decile rate of 107 g/day (Table 4). Thus about 10% of the anglers had consumption rates more than five times the median (Fig. 4; Table 4).

Consumption rate distributions for ethnic and income groups were also strongly right-skewed. Median consumption rates for ethnic groups ranged from 16 g/day (Hispanics) to 24 g/day (blacks) (Table 4). Although median consumption rates among ethnic groups were not homogeneous (Kruskal-Wallis; H=10.759; df=3; P=0.0131), none differed significantly from each other (Dunn's method). Upper-decile consumption rates ranged from 64 g/day (Hispanics) to 137 g/day (Asians) (Table 4). Although anglers with annual household incomes less than $5,000 had higher median consumption rates (Table 4), these did not differ significantly from the others (Kruskal-Wallis; H=1.776; df = 4; P=0.7768). Upper-decile consumption rates by income group ranged from 48 g/day ($5,000–$10,000) to 129 g/day (>$50,000) (Table 4).

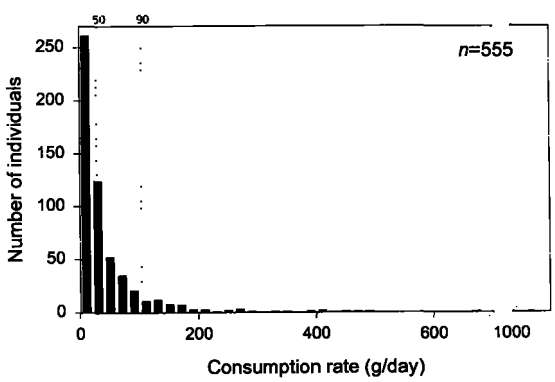

Figure 4

Distribution of seafood consumption rates (all fish species combined) for recreational anglers interviewed in the Santa Monica Bay seafood consumption study, September 1991 to August 1992. Median (50th percentile) and upper decile (90th percentile) are noted with vertical dotted lines.

Table 4

Angler consumption rates of all fish species by ethnic, income, and seasonal groups, Santa Monica Bay seafood consumption study, September–August 1992. CL = ± confidence limit (95%). UD = upper decile (90th percentile).

Category	Number of anglers	Consumption rate (g/day)			
		Mean	CL	Median	UD
Ethnicity[1]					
White	218	58	19	21	116
Hispanic	137	28	6	16	64
Black	57	49	19	24	99
Asian	135	60	20	21	137
Income[2]					
<$5,000	20	42	18	32	64
$5,000–$10,000	27	41	29	21	48
$10,000–$25,000	90	40	9	21	80
$25,000–$50,000	149	47	11	21	113
>$50,000	130	59	21	21	129
Fishing season					
Summer (June–September)	295	55	16	21	113
Nonsummer (October–May)	260	44	8	21	107
Total (all anglers)	555	50	9	21	107

[1] The eight anglers that gave no response to the ethnicity question were not included here. Ethnic categories are those used by USBC (1990).
[2] The 139 anglers that gave no response to the income question were not included here.

Consumption rates of anglers fishing in summer and nonsummer months did not differ significantly (Mann-Whitney rank sum test; T=72,857; n(small)= 260; n(large)=295; P=0.7597). Median consumption rates were 21 g/day for both groups (Table 4).

Median consumption rates of the most commonly caught species were similar (11–16 g/day) but upper-decile rates were more variable (27–80 g/day) (Table 5). Some individuals greatly exceeded average consumption rates for chub mackerel (Fig. 5). Median consumption rates were highest (16 g/day) for barred sand bass, kelp bass, combined rockfish species (*Sebastes* spp.), Pacific bonito, Pacific barracuda, and California halibut (Table 5). Upper-decile consumption rates were highest for kelp bass, barred sand bass, and combined rockfishes (80, 78, and 63 g/day, respectively). Rates of consumption of specific species varied by ethnic group (Table 5). Species with highest median and upper-decile consumption rates, respectively, by ethnic group were as follows: jacksmelt, *Atherinopsis californiensis*, and barred sand bass (white); barred sand bass and chub mackerel (Hispanic); rockfishes and chub mackerel (Asian); and Pacific bonito and California halibut (black).

Consumption rates estimated by the fillet-model and by the consumable-portion methods did not differ significantly for all species, chub mackerel, or kelp bass (Table 6). However, consumable-portion estimates were significantly higher for barred sand bass, Pacific bonito, Pacific barracuda, and California hali-

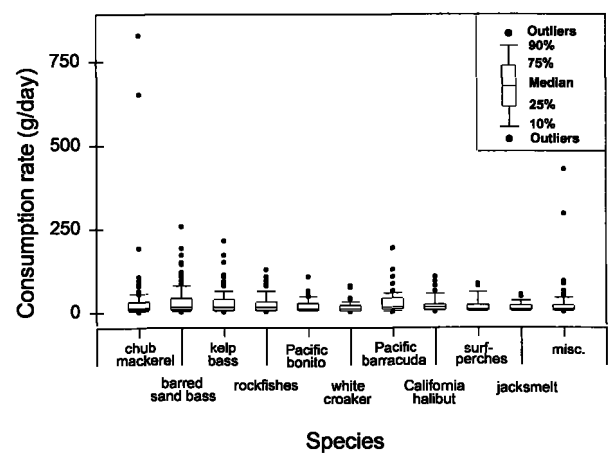

Figure 5

Seafood consumption rates (by fish species) for recreational anglers interviewed in the Santa Monica Bay seafood consumption study, September 1991 to August 1992.

Table 5

Consumption rates (g/day) by fish species for Santa Monica Bay anglers of different ethnic groups, September 1991 to August 1992. *n* = number of anglers. Md = median (50th percentile) consumption rate in g/day. UD = upper decile (90th percentile) consumption rate in g/day.

	White			Hispanic			Asian			Black			All[1]		
Fish species	*n*	Md	UD	*n*	Md	UD	*n*	Md	UD	*n*	Md	UD	*n*	Md	UD
chub mackerel	31	16	48	53	12	43	49	16	98	12	11	24	147	13	54
barred sand bass	72	19	86	20	16	32	35	11	54	16	16	58	144	16	78
kelp bass	75	16	55	14	11	37	34	12	80	16	19	64	140	16	80
rockfishes	50	16	43	13	8	24	28	23	64	10	16	32	101	16	63
Pacific bonito	24	11	30	23	11	36	23	11	44	4	28	54	77	11	44
white croaker	10	11	11	41	11	32	5	5	51	14	13	37	72	11	32
Pacific barracuda	42	21	54	8	11	36	16	11	55	4	24	79	71	16	54
California halibut	39	11	43	5	11	23	9	11	26	8	21	86	62	16	51
surfperches	7	21	44	4	11	14	6	11	32	3	8	59	20	11	27
jacksmelt	5	32	40	9	8	11	5	11	40	4	16	21	23	11	32

[1] Individuals giving no response to the ethnicity question were included in "All" but were not treated as a separate group.

Table 6

Results of Wilcoxon signed-rank test comparing angler seafood consumption rates estimated with fillet-model and consumable-portion methods, Santa Monica Bay seafood consumption study, September 1991 to August 1992. *n* = number of samples. T_s = smaller sum of ranks. *W* = difference between sums of ranks.

		Median consumption rate (g/day)		Absolute value		
Species	*n*	Fillet-model	Consumable-portion	T_s	*W*	*P*
chub mackerel	62	10.7	10.7	844	265	0.3547
barred sand bass	46	10.7	18.6	322	437	0.0017
kelp bass	55	10.7	11.8	729	82	0.7344
rockfish spp.	49	8.2	2.1	294	637	0.0016
Pacific bonito	33	10.7	22.5	90	381	<0.0001
white croaker	29	10.7	2.5	78	279	0.0027
Pacific barracuda	35	10.7	26.1	76	478	<0.0001
California halibut	6	10.7	55.7	0	21	0.0313
surfperch spp.	13	8.2	2.1	0	91	0.0017
jacksmelt	14	9.3	2.1	14	77	0.0171
all species[1]	406	10.7	8.2	40,639	1,343	0.7767

[1] Includes the above species and additional single species with both fillet-model and consumable-portion estimates.

but, and significantly lower for rockfishes, white croaker, surfperches, and jacksmelt.

Overall consumption rates were estimated for anglers with fish and for anglers that had consumed a species shown in a photograph during the previous month (Tables 4 and 5). However, consumable-portion estimates included only anglers with fish. Hence, fewer (406) anglers provided information for both estimates (Table 6). In addtion, we compared only individual species that had both consumable-portion and fillet-model estimates. Hence, the overall median (Table 6) was lower than the overall consumption rate according to all species consumed by an angler during the month (Table 4).

Health concerns

Anglers who consumed white croaker, a potentially contaminated species, were mostly male (92%), Hispanic (57%), 21 to 30 years old (26%), and with household incomes of from $10,000 to $25,000 (17%) (Fig. 6). Although more Hispanics consumed white croaker, blacks had the highest median (13 g/day) and Asians the highest upper-decile (51 g/day) consumption rates of this species (Table 5). Most anglers caught white croaker at piers (particularly Cabrillo Pier), fished all year, had fished less than six years, and had eaten this species at least once during the past four weeks. They generally ate the fish whole but gutted, ate about 150 g at a time, and generally fried their catch.

About 77% of anglers were aware of health warnings regarding consumption of Santa Monica Bay fish, most respondents citing television and newspaper or magazine articles as the major source of these warnings (Table 7). Of the anglers who were aware, 50% had altered their seafood consumption habits. The greatest percentage (46%) of these had stopped consuming some species. Most anglers of all ethnic groups were aware of the warnings. Black and Hispanic anglers generally became aware via television, whereas newspapers and magazines were the major source of health warnings for Asian and white anglers. Most Asian and white anglers altered their consumption behavior, but most black and Hispanic anglers did not. Of those responding, the pattern was similar for all ethnic groups: most stopped eating some species and somewhat fewer ate less of all species. White croaker consumers generally became aware of health warnings from a variety of media sources. Although most thought the warnings were very important, half did not alter their consumption habits (Fig. 7).

Discussion

Santa Monica Bay anglers in the early 1990's included relatively more whites and Asians and fewer Hispanics than the overall Los Angeles County popu-

Table 7

Response to health-risk awareness warnings by recreational anglers of different ethnic groups, Santa Monica Bay seafood consumption study, September 1991 to August 1992.

	Ethnic group					
Concern	Black	Asian	Hispanic	White	Other	Total
Number of respondents						
Total number	124	251	306	541	22	1,244
Number aware of warnings	95	185	179	473	10	942
Number affected by warnings	43	104	78	244	3	472
Warning awareness (percent respondents)						
Percent aware	77	74	58	87	45	76
Percent not aware/no response	23	26	42	13	55	24
Source of warnings (percent of aware)[1]						
Percent by television	61	46	64	51	20	53
Percent by newspaper or magazines, or both	45	47	30	58	30	49
Percent by posted signs	33	38	32	31	60	33
Percent by anglers or friends, or both	20	19	14	27	20	22
Percent by other	6	10	7	12	10	10
Response to warnings (percent of aware)						
Percent affected by warnings	45	56	44	52	30	50
Percent not affected	55	44	56	48	70	50
Type of response (percent of affected)						
Percent stopped eating some species	37	52	44	46	0	46
Percent ate less of all species	37	26	28	20	67	25
Percent stopped eating all species	19	13	18	21	0	19
Percent ate less of some species	7	9	10	12	33	11

[1] Respondents could say "yes" to more than one category; hence, percentages may sum to more than 100%.

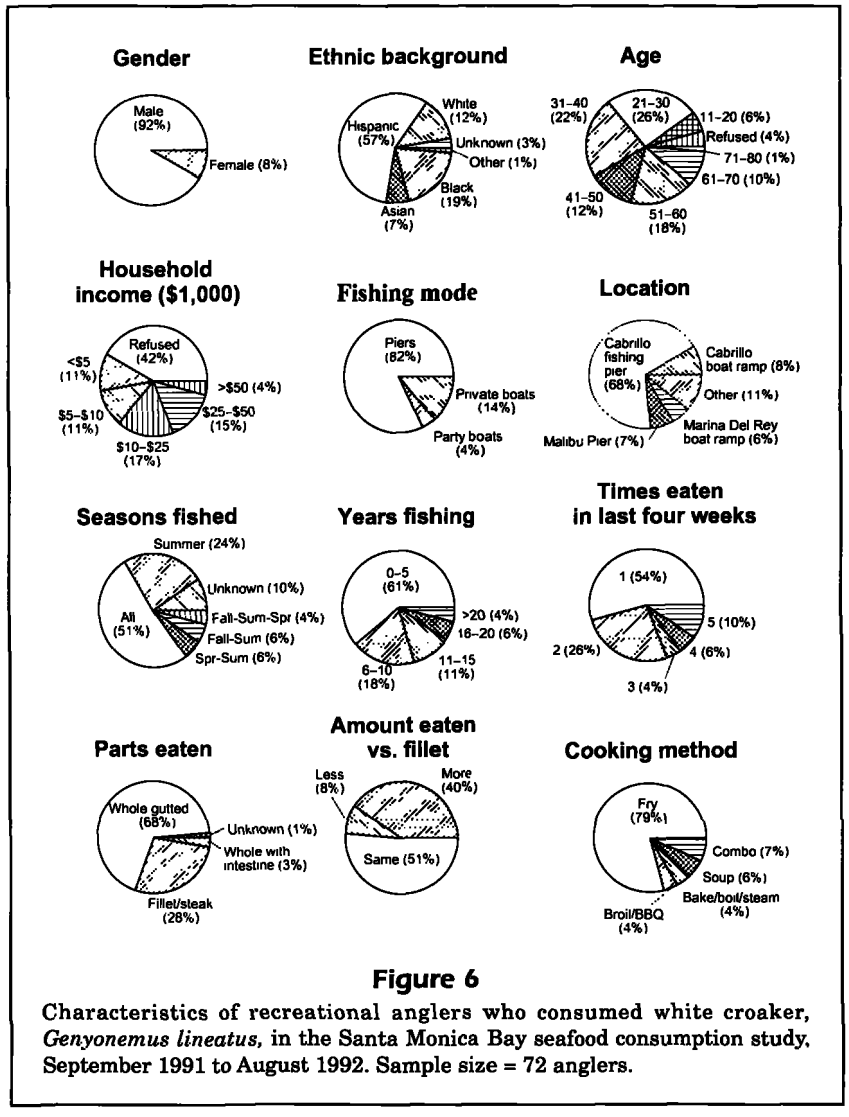

Figure 6

Characteristics of recreational anglers who consumed white croaker, *Genyonemus lineatus*, in the Santa Monica Bay seafood consumption study, September 1991 to August 1992. Sample size = 72 anglers.

lation (Fig. 2) (USBC, 1990; SCCWRP and MBC Applied Environmental Sciences[9]). Surprisingly, the gender, age, and ethnic characteristics of Santa Monica anglers in 1991–92 had not changed much since 1980 (Puffer et al., 1981, 1982).

Santa Monica Bay anglers commonly caught white croaker, chub mackerel, and Pacific bonito in 1980 (Puffer et al. 1981, 1982) and 1991–92. However, they caught fewer white croakers in 1991–92. Local anglers in 1991–92 caught similar species to southern California anglers in 1989, who primarily caught barred sand bass, Pacific bonito, and chub mackerel (NFSP, 1992). In all three surveys, similar survey methods were used and anglers were interviewed at piers and jetties, party boats, and private boats.

In seafood consumption studies, estimated rates are commonly based on consumable portions (Puffer et al., 1981, 1982; Landolt et al., 1985, 1987; SDCDHS[1]). However, in some studies (e.g. Murray and Burmaster, 1994) fillet-model estimates have been used. Of the two methods, we preferred the fillet-model method because the angler gave specific information on meal size. With the consumable-portion method, the number of household consumers influenced the estimated meal size. With consumable-portion estimates, we assumed that household consumers would eat the entire consumable portion and would catch similar-size fish on other fishing days. This resulted in unreasonably high estimates for large and less

[9] SCCWRP (Southern California Coastal Water Research Project) and MBC Applied Environmental Sciences. 1994. Santa Monica Bay seafood consumption study. Report prepared for Santa Monica Bay Restoration Project, Monterey Park, CA. Southern Calif. Coastal Water Res. Project, Westminster, CA, 199 p. (101 p. + appendices.)

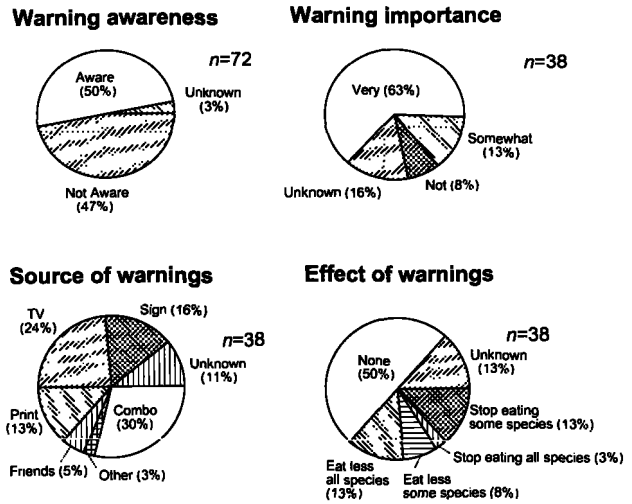

Figure 7

Responses to health risk warnings by Santa Monica Bay anglers who consumed white croaker, *Genyonemus lineatus*, in the Santa Monica Bay seafood consumption study, September 1991 to August 1992.

abundant species (e.g. California halibut). Consumable-portion method estimates were generally higher than fillet-model estimates for larger species and lower for smaller species. With the consumable-portion method, estimated rates were calculated only for species in an angler's possession at the time of the interview. In contrast, the fillet-model method also provided consumption-rate estimates for species not caught on the interview day.

Fillet-model medians varied less between species than did consumable-portion medians (Table 6) because the fillet-model method used fewer measurement units for meal size. The angler estimated meal size in relation to the model size (e.g. 0.5, 1.0, or 2.0 times the model). Thus, if the angler consumed a meal equal in size to the model twice a month, his or her consumption rate would be 10.7 g/day. The consumable-portion medians were more variable, in part because the consumable-portion weights had more divisions (i.e. grams).

Consumption-rate distributions were strongly right-skewed. Hence medians and upper-deciles provided more appropriate summaries than did arithmetic means and 95% confidence limits. The skewed distributions indicate that relatively few anglers had high consumption rates, whereas many had low consumption rates. All demographic groups examined had right-skewed consumption-rate distributions. This was true for all species or individual species. Similar consumption-rate distributions for Michigan anglers were lognormal (Murray and Burmaster, 1994). An upcoming paper[10] will describe statistically the consumption rate distributions from the present study.

In 1989, southern California anglers took 1.85, 1.66, and 1.13 million fishing trips on piers and jetties, private boats, and party boats, respectively (NFSP, 1992). Percentages of total anglers by fishing mode (piers, private boats, and party boats, respectively) were 40, 36, and 24% in 1989 and 42, 21, and 37% in the present study. Pier anglers represented about the same percentage of the population in both surveys. However, the present study differed in having more party-boat than private-boat anglers. Thus, there may be relatively fewer private-boat anglers in Santa Monica Bay than in southern California as a whole. Because the NFSP estimates were from fishing trips, some anglers may have repeated trips. Hence, the trips do not accurately represent the numbers of different anglers (which we needed for consumption rates).

We used only data collected in our study to calculate consumption rates. Where we summarized data for the whole study population, we combined data for each fishing mode (i.e. piers, party boats, and private boats). We did not adjust these estimates for

[10] Hill, M. D., and D. M. Lee. 1996. Estimated distributions of average daily fish consumption rates among Southern California marine anglers. Calif. Environ. Protection Agency, Sacramento, CA. In prep.

possible differences in numbers of anglers using each mode. We did not know how many anglers annually used each mode and could not estimate the numbers without conducting a special study. However, some weighting occurred naturally owing to the different numbers of anglers fishing (and hence being interviewed) in each mode. Given the limitations and available resources of the study, we believe that this natural weighting provided the best estimate of angler population size for each mode.

The median consumption rate (21 g/day) for Santa Monica Bay anglers was 70% of the national median of 30 g/day (USEPA, 1990). Only 45% of the anglers provided sufficient information for determination of consumption rates. Thus, relatively fewer Santa Monica Bay anglers may rely on their catch as a major food source. In 1980 the median consumption rate of Los Angeles anglers (estimated by the consumable-portion method) was higher (37 g/day) than the national median (which was 18.7 g/day) (Puffer et al., 1981). In that study, upper-decile consumption rates were 225 g/day; upper-decile consumption rates in this study were 107 g/day. Thus, seafood consumption rates among local anglers have decreased substantially (median 43% and upper-decile 52%) since 1980. This may be the result of health-risk warnings (posted since 1985) regarding DDT and PCB contamination of some species (Stull et al., 1987).

Santa Monica Bay anglers generally consumed the most commonly caught species at the highest rates. These species included barred sand bass, Pacific barracuda, kelp bass, combined rockfish species, and California halibut, all of which have low PCB and DDT levels (Pollock et al.[2]; SCCWRP et al.[3]). However, anglers also consumed white croaker at relatively high rates even in areas where it has high levels of PCB and DDT (Pollock et al.[2]; SCCWRP et al.[3]; SCCWRP[4]). Hispanic anglers were the primary consumers of white croaker, commonly catching it at Cabrillo Pier (where it is contaminated) (Pollock et al.[2]). However, although more Hispanics consumed white croaker, blacks and Asians had higher consumption rates for this species.

Although current advisories warn anglers not to consume white croaker in Santa Monica Bay and Los Angeles–Long Beach Harbor (Pollock et al.[2]), clearly many anglers still eat this species. Many anglers aware of the warnings did not alter their consumption rates, reasoning that if there was a health risk, they would experience ill effects within a day of eating the fish. Thus, agencies should improve communication of the risks by using a variety of media and languages. For Santa Monica Bay they should communicate risks in English and Spanish (at minimum) via television, newspapers and magazines, and posted signs, emphasizing piers and private boat launches where anglers catch white croaker for consumption.

Conclusions

In 1991–92, median seafood consumption rates for Santa Monica Bay anglers were lower than the national median. Consumption-rate distributions were skewed strongly to the right; upper-decile rates were often considerably higher than medians. Upper-decile rates varied more among demographic groups and species than did median rates; thus upper-decile rates are valuable in identifying high-risk groups. Overall, Asian and high-income anglers had the highest upper-decile consumption rates. Certain ethnic groups consumed more of the potentially contaminated species (e.g. white croaker). The lack of a strong response to health warnings by anglers indicates that health advisories should communicate the health risks from eating contaminated fish to specific ethnic groups at high-risk sites. Overall, consumption rates determined by consumable-portion and fillet-model methods were similar, but some species-specific rates did differ.

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Literature cited

Humphrey, H. E. B.
1988. Chemical contaminants in the Great Lakes: the human health aspect. *In* M. S. Evans (ed.), Toxic contaminants and ecosystem health: a Great Lakes focus, p. 153–165. John Wiley and Sons, New York, NY.

Landolt, M. F., F. R. Hafer, A. Nevissi, G. Van Belle, K. Van Ness, and C. Rockwell.
1985. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound. U.S. Dep. Commer., NOAA Tech. Memo. OMA 23, 104 p.

Landolt, M. F., D. Kalman, A. Nevissi, G. Van Belle, K. Van Ness, and F. Hafer.
1987. Potential toxicant exposure among consumers of recreationally caught fish from urban embayments of Puget Sound: final report. U.S. Dep. Commer., NOAA Tech. Memo. OMA 33, 111 p.

Murray, D. M., and D. E. Burmaster.
1994. Estimated distributions for average daily consumption of total and self-caught fish for adults in Michigan angler households. Risk Anal. 14(4):513–519.

NFSP (National Fishery Statistics Program).
1992. Marine recreational fishery statistics survey, Pacific Coast, 1987–1989. U.S. Dep. Commer., Current Fishery Statistics 9205, 367 p.

Puffer, H. W., S. P. Azen, and D. R. Young.
1981. Consumption rates of potentially hazardous marine fish caught in the metropolitan Los Angeles area. U.S. Environ. Protection Agency, Environ. Res. Lab., Corvallis, OR, EPA Grant 807 120010, 34 p.

Puffer, H. W., M. J. Duda, and S. P. Azen.
1982. Potential health hazards from consumption of fish caught in polluted coastal waters of Los Angeles County. N. Am. J. Fish. Manage. 2:74–79.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott.
1991. Common and scientific names of fishes from the United States and Canada, 5th ed. Am. Fish. Soc. Spec. Publ. 20, 183 p.

Stull, J. K., K. A. Dryden, and P. A. Gregory.
1987. A historical review of fisheries statistics and environmental and societal influences off the Palos Verdes Peninsula, California. Calif. Coop. Oceanic Fish. Invest. Rep. 28:135–154.

USBC (United States Department of Commerce, Bureau of Census).
1990. 1990 census of population and housing: census tracts Los Angeles–Long Beach, Calif. U.S. Dep. Commer., Bur. Census, Washington, D.C.

USEPA (United States Environmental Protection Agency).
1989. Assessing human health risks from chemically contaminated fish and shellfish: a guidance manual. U.S. Environ. Protection Agency, Office Mar. Estuar. Protection and Office Water Regulation and Standards, Washington, D.C., EPA-503/8-89-002.
1990. Exposure factors handbook. U.S. Environ. Protection. Agency, Office Health Environ. Assessment, Washington, D.C., EPA-600/8/3a/043.