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Fish consumption behavior and rates in native and non-native people in Saudi Arabia

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Abstract

Fish are a healthy source of protein and nutrients, but contaminants in fish may provide health risks. Determining the risk from contaminants in fish requires site-specific information on consumption patterns. We examine consumption rates for resident and expatriates in the Jeddah region of Saudi Arabia, by species of fish and fishing location. For Saudis, 3.7 % of males and 4.3 % of females do not eat fish; for expatriates, the percent not eating fish is 6.6 % and 6.1 % respectively. Most people eat fish at home (over 90 %), and many eat fish at restaurants (65 % and 48 %, respectively for Saudis and expatriates). Fish eaten at home comes from local fish markets, followed by supermarkets. Saudis included fish in their diets at an average of 1.4±1.2 meals/week at home and 0.8±0.7 meals/week at restaurants, while expats ate 2.0±1.7 meals/week at home and 1.1±1.1 meals/week in restaurants. Overall, Saudis ate 2.2 fish meals/week, while expats ate 3.1 meals/week. Grouper (*Epinephelus* and *Cephalopholis*) were eaten by 72% and 60% respectively. *Plectropomus pessuliferus* was the second favorite for both groups and *Hipposcarus harid* and *Lethrinus lentjan* were in 3rd and 4th place in terms of consumption. Average meal size was 68 g for Saudis and 128 g for expatriates. These data can be used by health professionals, risk assessors, and environmental regulators to examine potential risk from contaminants in fish, and to compare consumption rates with other sites.

Keywords

Fishing; Fish consumption; Saudi Arabia; Meal/week; Meal size

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1. Introduction

Fishing, and fish/shellfish consumption are important aspects of culture in many places in the world, particularly for coastal communities, as well as being a method of obtaining protein (Toth and Brown, 1997; IOM, 2006; Burger and Gochfeld, 2011). High fishing rates occur in many different cultures, including both rural and urban areas (Burger et al., 2001a,b; Bienenfeld et al., 2003), and in other regions of the world, particularly in Asia (Burger et al., 2003; Lu et al., 2008; Hsiao et al., 2011). Well over half of the world's population resides within 100 km of oceans, making it important to understand the factors that affect the health and safety of marine fish as a food source. Seafood consumption is generally increasing in many parts of the World, particularly for coastal communities (NOAA, 2004). In many places, fish and shellfish are the only readily available sources of protein that people can self-harvest, often throughout the year.

Fish provide high-quality protein, vitamins, and other nutrients that are essential to human health; regular fish consumption is widely promoted as part of a healthy diet (Sidhu, 2003; Verbeke and Vackier, 2005; Sioen et al., 2008, Sun, 2008). There is growing evidence that fish consumption reduces the risk of cardiovascular disease and has beneficial effects on fetal development during pregnancy (Olsen and Secher, 2002; Patterson, 2002; Olsen et al., 2006). Fish consumption is associated with low blood cholesterol (Anderson and Wiener, 1995), positive pregnancy outcomes, and better child cognitive test performances (Oken et al., 2008). Fish (and fish oil) contain omega-3 (n-3) fatty acids that reduce cholesterol levels and the incidence of heart disease, blood pressure, stroke, and pre-term delivery (Kris-Etherton et al., 2002; Daviglus et al., 2002; Patterson, 2002; Mozaffarian and Rimm, 2006; Virtanen et al., 2008; Mozaffarian, 2009; Ramel et al., 2010).

Yet people are faced with deciding whether the benefits of eating fish outweigh the risks from contaminants. Consumption of fish, shellfish and other seafood is the primary source of exposure to contaminants (IOM, 2006), especially methylmercury and PCBs (NRC, 2000, Rice et al., 2000; Stern et al., 2004). Determining the effect of contaminants on humans and eco-receptors requires site-specific information on contaminant levels and consumption patterns (Burger et al., 1992; 1999, 2001a,b; NRC, 2000; IOM, 2006). Risk is a function of exposure and toxicity, and thus information must be available on both (Burger and Gochfeld, 2006).

Persistent contaminants, such as mercury, polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and other halogenated aromatic compounds, are among the environmental contaminants that remain from mining, manufacturing, military, transportation and agricultural activities. Some of the compounds are produced deliberately for commerce; others are unwanted byproducts or breakdown products. Although many of these compounds (PCBs, OCPs) have restricted use, or are banned in many countries, they remain as legacy waste that can accumulate in soils, sediment, water, and biota, including seafood. Many contaminants (e.g. metals, chlorinated hydrocarbons) can remain unchanged in the environment for decades, or longer, and others can be modified to daughter products that are also toxic and persistent (e.g. PCBs or other organics). Many of these chemicals

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bioaccumulate in organisms and can bioamplify as they move up the food chain, reaching concentrations that have deleterious effects on organisms and the predators that eat them (Downs et al., 1998).

The objective of this paper is to examine the consumption rates of native and non-native (expatriate) residents in the Jeddah coastal region of Saudi Arabia. Because of oil development in the region, there is a massive influx of expatriates (Feidi, 1998). Hence, it was important to understand whether consumption patterns differ for native versus non-native residents. While our overall goal was to determine whether people are at risk from consuming fish from markets or from fish collected from the coastal waters surrounding Jeddah, the first step was to examine consumption rates, and we do so in this paper.

York and Gossard (2004) reported that after controlling for other factors, fish consumption rates in the Middle East and Africa were not significantly different from those in the West (defined to include the Americas, Europe, Australia, and New Zealand), and the effect of economic development on fish consumption tends to be the same for all non-Asian nations. In the Arab region, Feidi (1998) noted that fish consumption rates were highest in coastal states where fish is relatively abundant and human population is low; fish formed a major part of the national diet. However, the consumption rates were lower in inland Arab states as a result of low production levels, high human populations, and limited fish importation capability due to hard currency shortages. However, such studies are not available for Saudi Arabia at the regional level. The present study provides information on consumption for Saudi Arabians and expatriates living in the Jeddah region. Overall, the present study was part of study consisting of four parts: 1) fish consumption survey, 2) collection and contaminant analysis of popularly eaten fish, 3) risk evaluations and risk assessments, and 4) recommendations for fish consumption advisories and management of any potential risk to people from seafood in the coastal Jeddah area. Only fish consumption pattern will be examined in this paper.

2. Methods

Fish consumption was determined by interviewing people in a variety of locations about fishing, fish consumption, and attitudes about fishing. After developing a consumption questionnaire, we conducted a pilot study by interviewing 50 people, and modifying the questionnaire accordingly. Some questions pertaining to weight, income were subsequently dropped because of cultural sensitivity.

2.1. Study area and population

The present study was conducted in coastal city of Jeddah (Fig. 1), which is the largest urban center on the western seaboard of the Kingdom of Saudi Arabia. It is the second largest city in the Kingdom, after the capital Riyadh in the central mainland. The main urban area of Jeddah sprawls over a low-lying coastal plain that is bounded by the central Red Sea to the west and a chain of hills to the east (El-Shafie, 2009). The urban space has physically expanded 1000-fold to 176,500 ha from six decades ago (Abdulaal, 2012). From a small seaport and fishing settlement of about 30,000 people in the late 1940s, the Jeddah population has grown 10-fold at the start of 1970s, 100-fold by late 2000s, and may reach

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5.6 million by 2029 (Basaham et al., 2009; Abdulaal, 2012). This rapid population growth has been attributed to increased local migrations, higher influx of migrant workers and pilgrims, increased birth rate, and decreased mortality rate, all coinciding with the recent boom in the oil-based national economy (Aljoufie et al., 2012).

2.2 Protocol for interviews

Data were taken opportunistically by intercepting people to interview at fishing sites, markets, restaurants, malls, and schools (N = 1000). Interviews were conducted in both English and Arabic, by experienced interviewers (both male and female) who were bilingual. The questionnaire solicited responses on individual and household fish consumption rates, fish choices and preferences, purchasing behavior, methods of fish preparation, and other attitudes toward fishing and fish consumption. Table 1 lists the names of the fish commonly reported eaten by the study population, along with their English and Saudi names.

2.3. Protocol for determining consumption rates and significant differences

The average fish consumption rate per household was estimated as follows:

$$W_{ij}=c_i w_{ij} f_{ij}$$

where W_{ij} is the annual consumption of species i by household j (kg/day), c_i is a factor indicating the portion of weight actually eaten for species i, w_{ij} is the mean wet weight of species i consumed by household j per meal (kg/meal), and f_{ij} is the frequency of consumption of species i by household j (in meals/day after conversion from different time basis given by respondents).

The mean per capita consumption (P_{ij}) of species i for household j, with adjustment by age and gender class, was calculated as follows:

$$P_{ij}=\frac{W_{ij}}{\sum_{k=1}^{m} \alpha_k A_{jk}}$$

where W_{ij} is as derived by the first equation, A_{jk} is the number of persons for age-gender (age class for males, and for females) class k in household j, α_k is a correction factor for the age-gender class k, and m is the number of age-gender classes. The factor c_i was assumed to be 0.8 for all species and α_k was based on the values in Kronen et al. (2006), but with a slight modification of the age and gender classes.

All statistical calculations, inferential hypothesis testing, and graphic presentations were performed on the IBM SPSS 19 and Microsoft Excel software.

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3. Results

3.1. Demographics

Subjects ranged in age from < 2 years old (4 % of sample) to over 60 years (1 % of sample). Overall, 53 % were male, 84 % were Saudis (16 % were expatriates), and 41 % were between 20 and 40 years (the primary reproductive age) (Total N = 1000). However, the 10–20 year olds are either in the reproductive phase, or soon will be. 62 % were in the 10–40 year old age group, of which 47 % were female. Thus, 284 were women of child-bearing age. 4.3 % of the females were pregnant at the time of the survey (3.9 % for Saudis; 6.4 % for Expatriates). Of expatriates, about 79% were from nearby countries (Middle East/North Africa), 13% from Asia, 6% from Africa, and 2% from Europe/North America. While the median residency of Saudi Arabians was 21–25 years, for expatriates it was < 5 years (which relates to total exposure time). The mean Saudi household had 5.4 ± 2.7 members, while the mean expatriate household had 5.2 ± 2.5 members, which as rather similar.

3.2. Fishing and purchasing behavior

For Saudi households, 3.7 % of males and 4.3 % of females do not eat fish: for expatriates, the percent not eating fish was 6.6 % and 6.1 % respectively. Most people eat fish at home (92 % Saudis, 97 % expats), and many eat fish at restaurants (65 % and 48 %, respectively). The criteria people used in deciding which fish to purcahse were similar for Saudis and expats. Both mentioned that quality was the primary consideration when purchasing fish (about 70 % of respondents), followed by freshness (40–45 % of respondents), and then price (20–22 %). Other reasons included source, taste, convenience, and fishing ground (local or not).

Most households obtained their fish from fish markets or supermarkets (Table 2). 23 % of Saudi households, and 18 % of expats had members that engaged in recreational fishing, and they all ate their fish. Most (over 80 %) fishing was by hook and line, although some people used spears, traps, or gill nets (about 18–25 %).

3.3. Fish consumption

Saudis included fish in their diets an average of 1.4±1.2/week at home and 0.8±0.7 meals/week at restaurants, while expats ate 2.0±1.7 meals/week at home and 1.1±1.1 meals/week in restaurants. Thus, Saudis were eating 2.2 meals/week, while expats were eating 3.1 meals/week. Meal frequency differed somewhat for Saudis and expatriates. However, in general there was remarkable concordance in the percent of people eating the seven most common species of fish for the two groups (Kendall tau correlation = .90, p=0.0014, Table 3). For both groups “Hamour” or Grouper (including both *Epinephelus* and *Cephalopholis*) were preferred fish, eaten by 72% and 60% respectively. *Plectropomus pessuliferus* was the second favorite for both groups and *Hipposcarus harid* and *Lethrinus lentjan* were in 3rd and 4th place in terms of percentage of respondents saying they ate those species.

However, expatriates ate either larger portions and/or more frequent meals. The average of the mean meal sizes was 68 g for Saudis and 128 g for expatriates. Likewise the average meal size for the 90th percentile 172 g vs 212 g. Thus for Saudis the risk from the

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contaminants in fish is somewhat lower than for the expatriates because of average meal size. The most striking difference in fish consumption, however, was for two species that were unpopular with both groups. *Plectropomus areolatus* was eaten by 1% of Saudis and 2% of expatriates, but the meal size was 60 g for Saudis vs 329 g reported for expatriates. This is a very large quantity to be reported as a mean for any fish. Moreover, no Saudis reported eating *Chanos chanos*, which was eaten by 3% of expatriates with a 250 g average meal size.

Consumption rates (g/day) for the population overall are shown in Table 4. Since both frequency of meals and meal size varied between Saudis and expatriates, we examined them separately (Tables 5, 6). As is clear, there are not only ethnic differences, but differences in preferences for particular fish species.

4. Discussion

4.1. Methodological issues

Self-reported fish consumption is the usual method of determining exposure, and Jaarvinen et al. (1993) found that dietary recall data are reproducible and acceptable. Consumption histories have been validated by other methods, including biomarkers (levels of contaminants in tissues). Mercury concentration in hair reflect fish intake. A study of hair from 13 countries showed that mercury levels increased with increasing fish consumption (Airey, 1983). Both fish consumption by recall, and mercury intake, are positively associated with mercury levels in hair (Johnsson et al., 2004; Schoeman et al., 2010; Freire et al., 2010), including in pregnant women (Xue et al., 2007). There is also a significant correlation between mercury levels in blood and mercury intake by fish consumption (Knobeloch et al., 2003, 2006). Similarly, there is a significant correlation between fish consumption and biomarkers of inorganic mercury (Passos et al., 2007). There are far more studies on different tissue components for mercury than for other contaminants. Further, dioxins, PCBs and methylmercury in human tissues reflect fish consumption rates (Turunen et al., 2010). In general, increasing fish consumption (as determined by surveys and interviews) results in increasing biomarker values. Thus, fish consumption results in exposure to these contaminants.

On the contrary, there are some studies that suggest that the correlation (although significant) is not high. For example, Lucas et al., (2008) estimated that the overall correlation between EPA+DHA estimated from dietary recall of fish consumption by type and measured RBC EPA+DHA was only 0.37. Similarly, Mozzafarian et al. (2011) estimated that the correlation between toenail Hg and either fish consumption or self-reported fish intake was only 0.39. In general, fish consumption studies (recall) provide approximate actual consumption as indicated by biomarkers of exposure, although determining intake from a small number of consumption days (e.g. 24 hr recall, 2−3 day recall) over-estimates the upper percentiles of exposure (Jarvinen et al. 1993, Tran et al., 2004). It should also be noted, however, that under-reporting dietary intake seems to be more common in women than men, and in less well-educated populations (Klesges et al., 1995). Both of these factors might increase the risk to at-risk populations (e.g. women of child-bearing age). Since then, however, considerable attention devoted to the approaches

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and questions asked on consumption recall studies have no doubt contributed to more realistic reports (EPA, 1998, 2001, 2008), including the use of fish models to estimate size of fish meals (Burger et al., 1999).

There is considerable discussion about whether preparation or cooking practices affect the contaminants absorbed by the body. Since PCBs are stored in fat tissue, removing fat from fish (sometimes along the abdomen) reduces exposure to PCBs (ATSDR, 2000). Baking, frying, broiling, boiling, and microwaving fish all resulted in reducing the concentration of ΣDDT and PCBs in fish tissue, but not mercury (Wilson et al., 1998). Accordingly, consumption information for different cooking methods was obtained in this study. For the top ten fish species consumed in the Jeddah study, 68.9 % were fried, 28.1 % were grilled, 7.4 % were boiled, and 12 % were baked in the oven.

4.2. Preferences for different fish

It is not surprising that people prefer some species of fish over others. However, most studies of fish consumption do not examine consumption patterns by fish species, or do so for only one or a very few species of fish. In this study, we examined preferences for 13 of the most commonly consumed fish from the Jeddah region. The groupers, however, contained many species because they are not generally distinguished by the local population. Overall consumption, however, varied greatly among these fish (and grouper group). Groupers were preferred, followed by trout, and emperor fish. Thereafter, preferences dropped markedly.

The clear preferences for a very few kinds (or types) of fish suggest that attention should be directed to both the advantages and disadvantages of consuming these fish in terms of contaminants, availability (e.g. are they being fished out), omega-3s, and other positive health benefits. Further, the use of these fish reflects mainly quality, freshness, and to a lesser degree, price, according to the respondents. Clearly, quality is a subjective effect of consumer belief (Olsen, 1999), but is one that managers must take into account. Presumably, freshness is linked to sensory cues about the degree of fish deterioration or spoilage. It should be noted, however, that consumer judgment of freshness may not be indicative of overall quality (Juhl and Poulsen, 2000).

4.3. Ethnic differences

Where consumption information or biomarkers of exposure are not available, risk assessors usually use default values derived from the US EPA (Strauss, 2004). While this is the best practice given the lack of exposure information, the resultant risk assessment are weakened by the great deal of variability in fish consumption (and thus exposure) patterns. We examined consumption patterns to have site-specific data on consumption rates for different species of fish, which allows for determinations of risk from specific fish species. In general, consumption varies from region to region of a country (Imm et al., 2007), and even within a given region or area. Fish consumption varies markedly as a function of ethnicity, age, income, and a range of other factors (Garcia-Closas et al., 1993; Connelly et al., 1996; Buck et al., 2000; Burger et al., 2001a,b; Burger and Gochfeld, 2011; Gochfeld and Burger, 2011; Nahab et al., 2011), especially in societies where cultural mores are changing (Burger et al.,

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2003). Average consumption rates of specific ethnic groups may be many times higher than for the general population, particularly for tribal, low-income, or subsistence populations (Judd et al., 2004). Further, fish consumption patterns vary with perceptions about personal weight, health, and income (Trondsen et al., 2004). The present study provided site-specific data on fish consumption, which could be used for risk assessment studies.

Saudi Arabia is unusual in that there is a rather sedentary Saudi population along the coast that is consuming fish, and has done so for 20 + years. There is also a population of expatriates that have come to work in the oil-related industries. This influx of labor creates a second group of fish consumers that have much lower residencies (less than 5 years), are likely to be larger bodied, and may have very different preferences for fish, and for particular fish species. Unfortunately, due to cultural sensitivities, we were unable to obtain information on income and education, but it is likely that the incomes (and educational level) of expatriates were higher than the overall coastal Saudi population sampled.

The Saudi traditional diet, rich in fiber and low in fat and cholesterol, has been increasingly westernized by the influx of expatriate labor as a result of the oil-based economic boom in the Kingdom (Kumosani et al., 2011). The shift was due to a change in eating habits and lack of knowledge, rather than a limitation to the traditional Saudi diet. A strategic plan for a consumption advisory program requires site-specific data on current diet, and we provide this information for fish consumption.

4.4. Management implications

The possible risk from contaminants in fish consumed by people is of great public health concern, as well as an environmental justice issue in some places (EPA, 1994, 2002, 2009a; Burger and Gochfeld, 2011). Governments can respond to the risk from contaminants in fish by source reduction, physical barriers to either the movement of pollutants or people wishing to fish, or by changing human behavior. In the latter case, responsibility for pollution is shifted from governmental agencies to individual people. In most cases, governmental agencies and organizations respond to contaminants in food by issuing guidelines or consumption advisories (FAO, 2003; EC, 2008; EPA, 2009b; USFDA, 2001, 2003). The objective of the present paper was to provide site-specific information on fish consumption that can be used by health professionals, governmental agencies, and public policy makers to examine potential risk from contaminants in the fish that they eat. While the government solicited this information through funding, it was less willing to issue consumption advisories. Partly, information on consumption (and on contaminants in fish) has not been available to the government, nor have these agencies considered issuing advisories. The information is under consideration by the government, which is well aware of its responsibility for the health of its citizens. This information can also be used by fisheries regulators to understand preferences for particular fish species, and by economists to consider in food economics.

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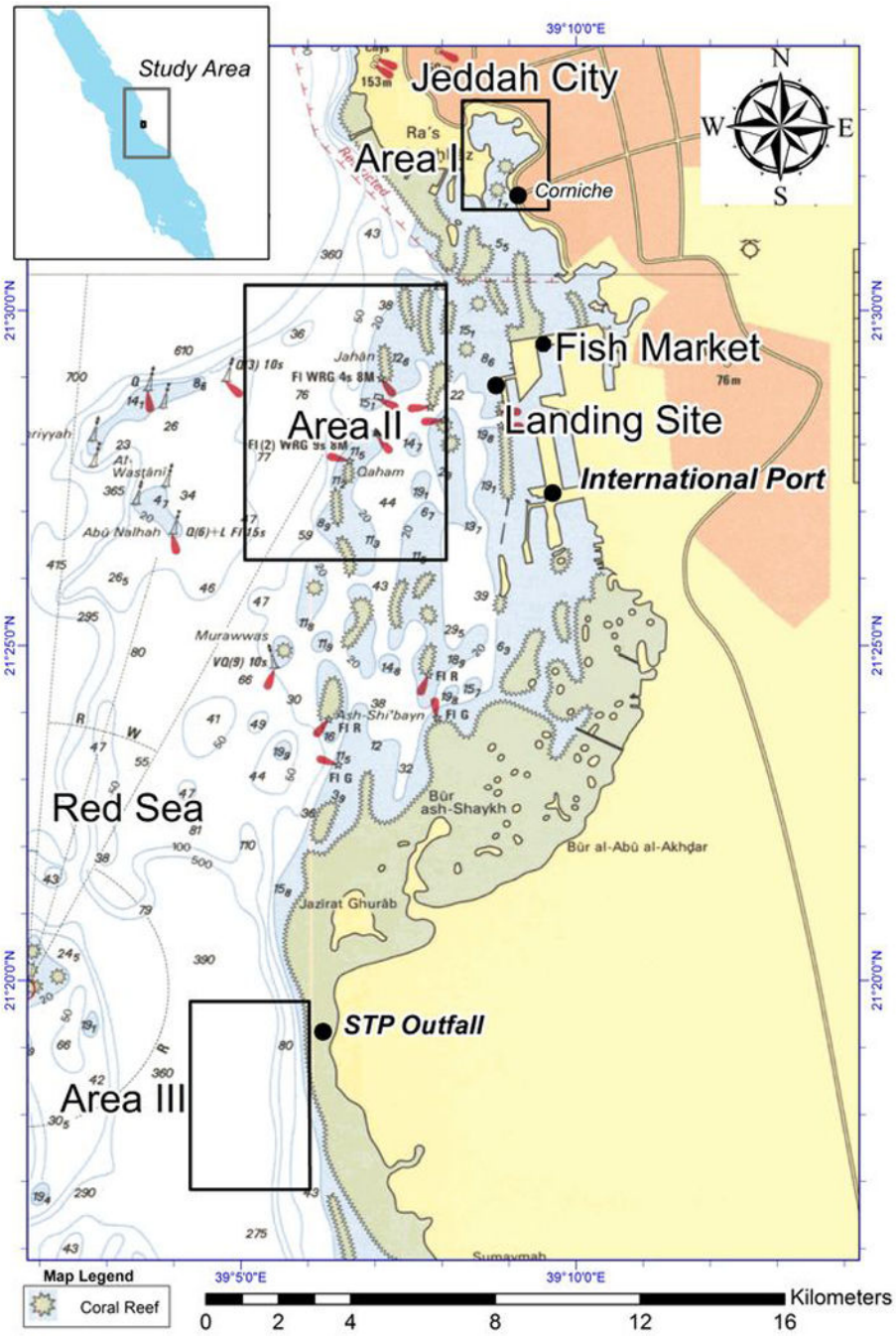

Figure 1.
Map of the Jeddah region where fish consumption was examined.

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Table 1

List of examined fish species for metal and organic contaminants in edible tissues.

Scientific Name	Common English	Local Name
Apharius rutilans	Sole	Mosa, Faris
Cephalopholis argus	Grouper	Hamour
Carangoides bajad	Orange-spotted trevally	Bayad
Chanos chanos	Milkfish	Salmani
Ephinephelus tauvina	Grouper	Hamour
Hipposcarus harid	Parrotfish	Harid
Lutjanus bohar	Red snapper	Bohar
Lethrinus lentjan	Emperor	Shaoor, Krseit, Sheiry
Mugil cephalus	Mullet	Arabi, Bori
Plectropomus areolatus	Squaretail grouper	Tarathi
Plectropomus pessuliferus	Coral trout (grouper)	Najil
Siganus rivulatus	Rivulated rabbitfish	Sijan, Safi
Variola louti	Moontail seabass (grouper)	Louit, Shareef, Shrefi

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Table 2

Frequency and amount of fish purchased by Saudi and expatriate households.

Source	SAUDIS				EXPATS			
	%	Range	Mean ± SD	Median	%	Range	Mean ± SD	Median
Frequency (times per week)								
Fishing Market	60	0.1–7	0.9 ± 0.7	1.0	54	0.3–7	1.4 ± 1.5	1.0
Supermarket	34	0.3–6	1.0 ± 0.7	1.0	30	0.3–4	1.6 ± 0.9	1.0
Landing Site	3	0.3–3	1.2 ± 0.8	1.0	2	1–5	2.8 ± 2.1	2.5
Others	6	0.1–3	0.8 ± 0.7	0.5	3	0.3–2	1.1 ± 0.6	1.0
Amount (kg per week)								
Fishing Market	59	0.5–60	5.6 ± 5.1	5.0	54	0.5–25	4.9 ± 3.6	4.0
Supermarket	34	1–20	3.5 ± 2.3	3.0	30	0.5–14	3.3 ± 3.0	2.0
Landing Site	3	1.5–10	3.6 ± 2.0	3.0	2	1–3	2.5 ± 1.0	3.0
Others	6	1–30	5.5 ± 5.6	4.0	3	2–15	5.8 ± 5.3	4.0

% indicates percentage of group, SD–standard deviation, Range = Minimum–Maximum.

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Table 3

Meal frequency of fish consumption of Saudis and expatriates by fish species. SD = standard deviation.

Species	Local Name	SAUDIS					EXPATS				
		%	Frequency, meals/wk				%	Frequency, meals/wk			
			Mean	SD	Min	Max		Mean	SD	Min	Max
Cephalopholis / Epinephelus spp.	Hamour*	72.2	0.8	1.1	0.25	7	60.0	1.3	1.0	0.25	7
Plectropomus pessuliferus	Najil	58.4	0.7	1.0	0.04	5	34.2	1.2	1.1	0.25	7
Hipposcarus spp.	Harid	37.5	0.9	1.0	0.25	11	13.7	1.0	0.7	0.25	3
Lethrinus spp.	Shaoor, Krseit	28.5	0.8	1.2	0.25	7	31.1	1.7	1.6	0.25	7
Siganus rivulatus	Sijan, Safi	16.3	1.2	1.4	0.25	7	12.1	1.5	1.3	0.25	6
Penaeus semisulcatus	Shrimp	10.8	0.7	1.2	0.25	3	13.7	1.7	1.4	0.5	7
Carangoides bajad	Bayad	6.3	1.1	1.2	0.13	7	2.6	1.9	1.2	0.25	3
Scomberomorus commerson	Derak, Kanaad	4.7	0.7	1.4	0.25	3	4.7	2.1	2.0	0.25	7
Variola louti	Louti, Shrefi	2.5	0.8	1.2	0.25	4	3.2	1.3	0.5	1	2
Mugil cephalus	Arabi, Bori	1.4	1.8	1.3	0.25	4	11.6	1.3	0.7	0.25	3
Aphareus rutilans	Faris	1.3	0.6	1.1	0.25	2	0	–	–	–	–
Plectropomus areolatus	Tarathi	1.1	0.4	1.0	0.5	2	2.1	1.3	0.6	1	2
Oreochromis niloticus	Bolti, Tilapia	0.5	2	1.4	1	4	11.6	1.2	0.6	0.25	2.5
Portunus pelagicus	Kub kub, Abu magas	0.4	0.4	0.8	0.25	1	1.6	1.3	0.7	0.75	2
Lutjanus bohar	Bohar	0.1	–	1.0	1	1	0	–	–	–	–
Chanos chanos	Salmani	0	–	–	–	–	3.2	1.7	1.2	1	4
Others (20 species combined)		3.4	2.7	1.5	0.25	25	6.8	1.5	1.2	0.25	7

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* Collective term for grouper species of the genera Epinephelus and Cephalopholis. Frequencies given in monthly rate were converted to weekly basis by assuming 1 month = 4 weeks. % indicates the proportion of group that eat the fish species.

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Table 4

Distribution of per capita fish consumption (g/day) for all respondents eating each kind of fish (% indicates how many people ate that species). The values given are only for those people reporting eating a particular fish. P75 = the 75th percentile of consumption.

Species	%	Mean	Median	SD	Min	Max	P75	P90	P95
Hamour*	69.7	80	44	106	2.9	952.4	95	190	254
Plectropomus pessuliferus	53.5	69	40	91	1.3	914.3	85	157	237
Hipposcarus spp.	32.6	58	36	79	2.9	914.3	69	129	190
Lethrinus spp.	28.8	91	48	121	1.3	761.9	108	226	357
Siganus rivulatus	15.9	78	43	117	1.9	1185.2	95	203	255
Carangoides bajad	5.6	58	39	56	2.6	228.6	82	156	193
Mugil cephalus	3.2	83	57	93	6.5	381.0	107	245	348
Variola louti	2.8	80	50	93	7.9	397.5	95	201	369
Plectropomus areolatus	1.3	143	38	340	5.7	1269.8	95	808	---
Aphareus rutilans	0.9	59	48	68	2.3	228.6	68	68	---
Chanos chanos	0.6	250	63	331	5.7	714.3	655	655	---
Lutjanus bohar	0.1	38	38	---	38.1	38.1	38	38	38

*General term for grouper species of the genera Epinephelus and Cephalopholis. % indicates frequency of consumption relative to total of surveyed households (n=975).

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Table 5

Distribution of per capita fish consumption (g/day) for all Saudi Arabian respondents eating each kind of fish. (% indicates how many people ate that species. The values given are only for those people reporting eating a particular fish. P75 = the 75th percentile of consumption).

Species	%	Mean	Median	SD	Min	Max	P75	P90	P95
Hamour*	72.1	76	42	102	3	952	85	185	239
Plectropomus pessuliferus	58.2	65	39	79	3	635	85	152	229
Hipposcarus spp.	37.2	57	34	80	3	914	67	127	190
Lethrinus spp.	28.3	84	43	110	2	593	95	211	350
Siganus rivulatus	16.8	76	42	122	4	1185	95	198	255
Carangoides bajad	6.4	57	35	57	3	229	82	173	197
Mugil cephalus	1.1	99	50	118	7	327	185	---	---
Variola louti	2.7	81	48	102	13	398	87	295	390
Plectropomus areolatus	1.1	60	50	34	19	114	95	---	---
Aphareus rutilans	1.1	59	48	68	2	229	68	---	---
Chanos chanos	0.0	---	---	---	---	---	---	---	---
Lutjanus bohar	0.1	38	38	---	38	38	38	38	38

*General term for grouper species of the genera *Epinephelus* and *Cephalopholis*. % indicates frequency of consumption relative to total of surveyed households (n=785).

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Table 6

Distribution of per capita fish consumption (g/day) for all expatriate respondents eating each kind of fish. % indicates how many people ate that species. The values given are ONLY for those people reporting eating a particular fish. P75 = the 75th percentile of consumption.

Species	%	Mean	Median	SD	Min	Max	P75	P90	P95
Hamour*	60.0	103	57	123	3	714	143	229	343
Plectropomus pessuliferus	34.2	95	41	150	1	914	114	253	423
Hipposcarus spp.	13.7	67	43	63	8	274	88	170	239
Lethrinus spp.	31.1	121	71	154	1	762	163	229	593
Siganus rivulatus	12.1	89	57	81	2	286	169	223	274
Carangoides bajad	2.6	73	76	49	10	143	114	---	---
Mugil cephalus	3.2	77	59	84	7	381	109	166	350
Variola louti	3.2	77	84	51	8	143	121	---	---
Plectropomus Areolatus	2.1	329	21	627	6	1270	958	---	---
Aphareus rutilans	0.0	---	---	---	---	---	---	---	---
Chanos chanos	3.2	250	63	331	6	714	655	---	---
Lutjanus bohar	0.0	---	---	---	---	---	---	---	---

*General term for grouper species of the genera *Epinephelus* and *Cephalopholis*. % indicates frequency of consumption relative to total of surveyed households (n=190).

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