Reviews in Fisheries Science

ISSN: 1064-1262 (Print) 1547-6553 (Online) Journal homepage: http://www.tandfonline.com/loi/brfs20

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To cite this article: Albert G. J. Tacon & Marc Metian (2013) Fish Matters: Importance of Aquatic Foods in Human Nutrition and Global Food Supply, Reviews in Fisheries Science, 21:1, 22-38, DOI: 10.1080/10641262.2012.753405

To link to this article: https://doi.org/10.1080/10641262.2012.753405

Published online: 13 Feb 2013.

Reviews in Fisheries Science, 21(1):22–38, 2013

ISSN: 1064-1262 print / 1547-6553 online
DOI: 10.1080/10641262.2012.753405

Fish Matters: Importance of Aquatic Foods in Human Nutrition and Global Food Supply

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In a world where nearly 30% of humanity is suffering from malnutrition and over 70% of the planet is covered with water, aquatic foods represent an essential component of the global food basket to improve the nutrition, health, and well being of all peoples.

It is not by chance that Japan, the country with one of the world's highest reported life expectancies and lowest incidences of obesity and deaths from heart related illnesses, is also one of the world's top consumers of captured and farmed aquatic animal food products and aquatic plants. According to the FAO, in 2009, total captured and farmed aquatic animal food products accounted for 16.6% of the global population's intake of animal protein, providing more than three billion people with almost 20% of their average per capita intake of animal protein, and 4.3 billion people with at least 15% of such protein. This article reviews the nutritional composition of different farmed and captured aquatic food products and compares these with conventional terrestrial meat products. In addition to the superior nutritional profile and benefits of aquatic animal food products, small-sized marine pelagic fish play an important role in the nutrition of the poor as an affordable and much needed source of high quality animal protein and essential amino acids, omega-3 fatty acids, vitamins, minerals, and trace elements. As one of the best aquatic animal foods from a nutritional perspective, the direct consumption of small pelagic fish should be encouraged and promoted, as apposed to the continued targeted use of these species for reduction into fishmeal and fish oil for use in animal feeds.

Keywords aquatic foods, fisheries, aquaculture, nutrient composition, food supply, FAO

MALNUTRITION, HUNGER, AND FOOD RELATED DISEASES: A MAJOR GLOBAL PROBLEM

At present, more than 30% of humanity is suffering from malnutrition and food–related diseases, either in the form of insufficient nutrient intake and undernourishment or in the form of excessive nutrient intake and obesity. The global reach of malnutrition and food insecurity is such that hunger is still the world's number one health risk, killing more people every year than acquired immunodeficiency syndrome (AIDS), malaria, and tuberculosis combined (Tacon et al., 2010a; World Food Programme [WFP], 2012).

The global magnitude and consequences of hunger and malnutrition are profound and long-lasting (Figure 1), with 925 million chronically undernourished people within the developing world and over 6.6 million child deaths every year related to malnutrition (or one child every five seconds). Further, more than two billion people in the world suffer from specific dietary micronutrient deficiencies, including iron, iodine, vitamin A, and zinc; the groups most vulnerable to micronutrient deficiencies being pregnant women, lactating women, and young children within low income countries (WFP, 2012).

Ironically, at the same time as one part of the world is suffering from hunger and undernourishment, there is an equivalent number of people within middle-income and higher-income countries suffering from an epidemic of excess caloric intake and obesity, and consequent increased risk of cardiovascular disease, diabetes, and cancer. According to the World Health Organization (WHO), being overweight and obesity is the fifth leading risk for global deaths, with at least 2.8 million adult deaths resulting from being overweight or obese; 44% of the global

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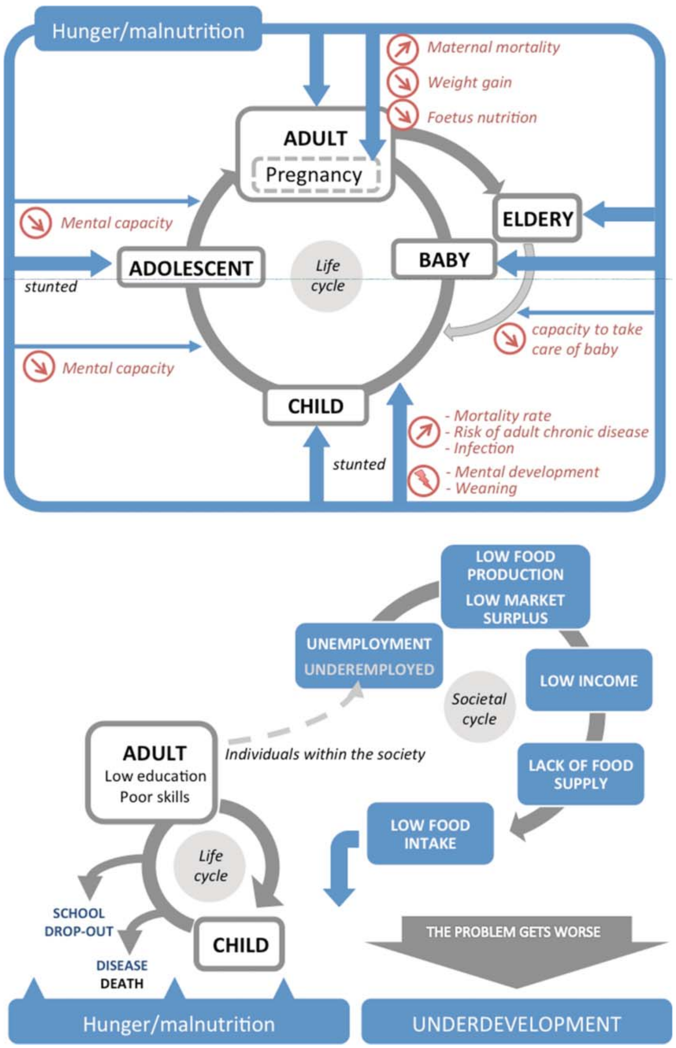


Figure 1 Impact of hunger and malnutrition throughout the life cycle and its impact on society (adapted from FAO, 2004). In the first part of the figure, the arrows starting for the outside border indicate how malnutrition impacts different stages of human life. Arrow down: Reduction; Arrow up: Increase; Lightening: Strong impact (color figure available online).

diabetes burden, 23% of the ischaemic heart disease burden, and between 7% and 41% of certain cancer burdens attributable to being overweight and obesity (WHO, 2012).

Therefore, it follows that diet and nutrient supply are key determinants in the health and well-being of all peoples, whether they be poor in low-income countries or rich in high-income countries. In a world where nutritious food products are in high demand, aquatic food products represent an essential component of the global food basket. This article reviews the role played by aquatic food in human nutrition and global food supply. For the purposes of this article, aquatic food includes all major captured and farmed edible aquatic food products entering the human food chain, including fish, crustaceans, molluscs, and edible aquatic plants or seaweeds.

GLOBAL SUPPLY OF EDIBLE AQUATIC FOODS

Trade in Edible Aquatic Animal Food Products

Aquatic food products have been an integral part of the human diet since mankind started fishing the oceans and producing food through aquaculture. In fact, the global market demand for these nutritious products is so high that more edible aquatic animal food products are internationally traded (26.85–27.45 million tonnes in 2009, excluding aquatic plants; FAO/FISHSTAT, 2012) than all traded beef, pork, and poultry combined (20.38–21.99 million tonnes in 2009; Foreign Agricultural Service/ United States Department of Agriculture [FAS/USDA], 2012).

Valued at over US $94.11 billion in 2009, developed countries currently consume the lion's share of edible seafood imports (77.8% by value in 2009); the top importers include the United States (US $13.68 billion), followed by Japan (US $12.90 billion), Spain (US $5.80 billion), France (US $5.48 billion), Italy (US $4.93 billion), Germany (US $4.22 billion), and China (US $3.62 billion; FAO/FISHSTAT, 2012). In particular, the domestic appetite and demand for aquatic food products within the United States is such that edible fishery products have the largest trade deficit of any imported food product (US $11.47 billion in 2011; National Marine Fisheries/ National Oceanographic and Atmospheric Administration [NMFS/NOAA], 2011), with 86% of all the seafood consumed within the United States currently being imported, half of this coming from aquaculture (NOAA, 2011).

Global Supply of Aquatic Animal Food Products—Whole Live Weight Basis

In terms of global food supply, total edible aquatic animal food production (expressed on a whole live weight basis, and excluding aquatic plants) has increased over threefold from 40.8 million tonnes in 1970 to 128 million tonnes in 2010, with production increasing at an average annual rate of 2.9% since 1970 (FAO 2012b). By comparison, total terrestrial meat production grew from 101 million tonnes in 1970 to 293 million tonnes in 2010, with production increasing at an average annual rate of 2.7% over the same period (FAO/FAOSTAT, 2012); however, marked differences exist between capture fisheries and aquaculture in terms of the growth of the sector, with production from aquaculture growing at an average annual rate of 8.2% per year from 2.57 to 59.9 million tonnes from 1970 to 2010, compared with captured production which only grew at an average rate of 1.5% per year from 38.2 to 68.4 million tonnes from 1970 to 2010 or below the average global population growth rate of 1.6% over the same time period (Stefania Vannuccini, FAO, personal communication; FAO/FISHSTAT, 2002; FAO/FAOSTAT, 2012).

Apart from differences in growth rate, marked differences also exist between capture fisheries and aquaculture in terms of

Table 1 Major captured and farmed aquatic food species in 2010 and estimated position in the aquatic food chain (production data expressed in tonnes; FAO/FISHSTAT, 2012)

	2010	Type[A]	TL
Top captured fish			
Marine fishes nei	10,511,073	MS	🟠
Freshwater fishes nei	5,886,464	FS	🟠
Alaska Pollock (*Theragra chalcogramma*)	2,829,704	MS	🟠
Skipjack tuna (*Katsuwonus pelamis*)	2,523,001	MS	🔴
Largehead hairtail (*Trichiurus lepturus*)	1,343,571	MS	🔴
Yellowfin tuna (*Thunnus albacares*)	1,165,296	MS	🔴
Atlantic cod (*Gadus morhua*)	950,950	MS	🔴
Cyprinids nei	903,829	FS	🟢
Croakers, drums nei (*Sciaenidae*)	772,279	MS	🟠
Threadfin breams nei (*Nemipterus* spp.)	536,647	MS	🟠
Top captured crustaceans			
Natantian decapods nei	763,611	MS	🟢
Akiami paste shrimp (*Acetes japonicas*)	573,613	MS	🟢
Gazami crab (*Portunus trituberculatus*)	385,281	MS	🟢
Northern prawn (*Pandalus borealis*)	360,745	MS	🟢
Marine crabs nei	331,680	MS	🟢
Squillids nei	317,636	MS	🟢
Southern shrimp (*Trachypenaeus curvirostris*)	293,722	MS	🟢
Antarctic krill (*Euphausia superba*)	215,175	MS	🟢
Giant tiger prawn (*Penaeus monodon*)	209,662	MS	🟢
Blue swimming crab (*Portunus pelagicus*)	184,864	MS	🟠
Penaeus shrimps nei (*Penaeus* spp)	166,260	MS	🟢
Top captured molluscs			
Jumbo flying squid (*Dosidicus gigas*)	815,978	MS	🟠
Marine molluscs nei	766,893	MS	🟢
Various squids nei (*Loliginidae, Ommastrephidae*)	603,383	MS	🟠
Cephalopods nei	430,416	MS	🟠
Freshwater molluscs nei	360,335	FS	🟢
Japanese flying squid (*Todarodes pacificus*)	357,590	MS	🟠
Yesso scallop (*Patinopecten yessoensis*)	330,740	MS	🟢
Octopuses, etc. nei	296,034	MS	🟠
American sea scallop (*Placopecten magellanicus*)	274,970	MS	🟢
Cuttlefish, bobtail squids nei	265,256	MS	🟠
Top captured aquatic plants			
Aquatic plants nei	274,066	MS	○
Japanese kelp	73,980	MS	○
Red seaweeds	54,527	MS	○
Gracilaria seaweeds	45,089	MS	○

	2010	Type	TL
Top farmed fish			
Grass carp (*Ctenopharyngodon idellus*)	4,337,114	FS	🟢
Silver carp (*Hypophthalmichthys molitrix*)	4,116,835	FS	🟢
Catla (*Catla catla*)	3,869,984	FS	🟢
Common carp (*Cyprinus carpio*)	3,444,203	FS	🟢
Bighead carp (*Hypophthalmichthys nobilis*)	2,585,963	FS	🟢
Nile tilapia (*Oreochromis niloticus*)	2,538,052	FS	🟢
Crucian carp (*Carassius carassius*)	2,217,799	FS	🟠
Atlantic salmon (*Salmo salar*)	1,425,968	DS	🔴
Pangas catfishes nei (*Pangasius* spp)	1,306,838	FS	🟠
Freshwater fishes nei	1,266,868	FS	🟠
Top farmed crustaceans			
Whiteleg shrimp (*Penaeus vannamei*)	2,720,929	MS	🟢
Giant tiger prawn (*Penaeus monodon*)	781,581	MS	🟢
Red swamp crawfish (*Procambarus clarkii*)	616,232	MS	🟢
Chinese mitten crab (*Eriocheir sinensis*)	593,301	FS	🟢
Oriental river prawn (*Macrobrachium nipponense*)	225,645	FS	🟢
Giant river prawn (*Macrobrachium rosenbergii*)	215,029	FS	🟢
Indo-Pacific swamp crab (*Scylla serrata*)	140,948	MS	🟢
Swimming crabs nei (*Portunidae*)	91,050	MS	🟠
Penaeus shrimps nei (*Penaeus spp*)	88,231	MS	🟢
Kuruma prawn (*Penaeus japonicus*)	56,739	MS	🟢
Fleshy prawn (*Penaeus chinensis*)	45,339	MS	🟢
Top farmed molluscs			
Cupped oysters nei (*Crassostrea* spp)	3,677,691	MS	🟢
Japanese carpet shell (*Ruditapes philippinarum*)	3,604,247	MS	🟢
Scallops nei (*Pectinidae*)	1,408,169	MS	🟢
Sea mussels nei (*Mytilidae*)	891,638	MS	🟢
Constricted tagelus (*Sinonovacula constricta*)	714,434	MS	🟢
Marine molluscs nei	697,500	MS	🟢
Pacific cupped oyster (*Crassostrea gigas*)	662,513	MS	🟢
Blood cockle (*Anadara granosa*)	465,871	MS	🟢
Chilean mussel (*Mytilus chilensis*)	221,522	MS	🟢
Yesso scallop (*Patinopecten yessoensis*)	220,956	MS	🟢
Top farmed aquatic plants			
Japanese kelp (*Laminaria japonica*)	5,146,883	MS	○
Aquatic plants nei	3,125,641	MS	○
Wakame (*Undaria pinnatifida*)	1,537,339	MS	○
Nori nei (*Porphyra* spp)	1,072,350	MS	○
Gracilaria seaweeds (*Gracilaria* spp)	565,366	MS	○
Laver (Nori, *Porphyra tenera*)	564,234	MS	○

[A]Type indicates if it is a freshwater species (FFS), a diadromous species (DFS), or a marine species (FFS).
TL: trophic levels; TL of 1 (plant): ○; TL between 2 and 3: 🟢; TL between 3 and 4: 🟠; TL over 4: 🔴. TL of individual aquatic species taken from FishBase (Froese and Pauly, 2007). n.e.i.: not elsewhere included.

the types of aquatic animal food products being supplied to the market place. For example, whereas over 82% of the edible fish supplied by capture fisheries in 2010 were marine and diadromous fish species (the majority positioned high in the aquatic food chain), over 86% of the fish supplied by aquaculture in 2010 were freshwater fish species (the majority positioned low in the aquatic food chain; Table 1).

Global Supply of Processed Aquatic and Terrestrial Meat Products

At present, aquatic food supply data are usually reported by FAO on a whole live weight basis, and as such this results in an over-estimate of aquatic food supply as no allowance is given to inedible components (depending upon species and national dietary preferences), including the outer calcareous shells of molluscs; the chitinous exoskeleton and "heads" of crustaceans; and the heads, skin, and gastro-intestinal tract of fish. For the purposes of this artile, the average major species group conversion factors used for converting whole live weight aquatic food product data to edible aquatic meat were as follows: fish 1.15 (gutted, head-on), crustaceans 2.80 (tails/meat, peeled), and molluscs 6.0 (meat, without shells; Roberts, 1998).

On the basis of the previously mentioned conversion factors, total estimated global aquatic meat production has increased from over 32.1 million tonnes in 1970 to 91.1 million tonnes in 2010, with production increasing at an average annual rate of 2.7% or the same as the growth rate of terrestrial meat production over the same period; aquatic meat production from aquaculture grew at an average annual rate of 8.5% per year from 1.47 million tonnes to 38.5 million tonnes from 1970 to 2010, compared with capture fisheries production where production only grew at an average rate of 1.2% per year from 30.7 to 52.6 million tonnes from 1970 to 2010 (data excludes miscellaneous invertebrates, amphibians, and reptiles, which represented 0.8 and 1.3% of total edible capture fisheries and aquaculture production in 2010, respectively; FAO/FISHSTAT, 2012). Thus, in terms of aquatic meat production in 2010, aquaculture currently supplies 42.2% of the total global production.

Figure 2 shows the global trends in the production of farmed aquatic and terrestrial meats from 1970 to 2010, and Figure 3 shows the production of the same products in China, the world's largest global producer of farmed terrestrial and aquatic meat (FAO/FAOSTAT, 2012). From the data presented, it can be seen that farmed aquatic meat production has been the fastest growing animal meat producing sector for nearly half a decade and in China, represents the second most produced meat after pork (21.7 millions tonnes vs 51.7 millions tonnes, respectively). The global dominance of China in aquaculture production (producing over 47.8 million tonnes of farmed aquaculture products in 2010 or 60.6% of total global aquaculture production; FAO/FISHSTAT, 2012) has been due to its over 2,000-year history in China and pro-active government policies in promoting aquaculture development within the country (Hishamunda and Subasinghe, 2003).

Global and Regional Per Capita Supply of Aquatic Animal Food Products—Whole Live Weight Basis

In terms of per capita food supply, total aquatic animal food supply (live weight equivalent) has grown from 11.1 kg in 1970 to 18.6 kg in 2010 (total supply growing at an average annual rate of 1.3%) and per capita aquatic meat supply has grown from 8.7 kg in 1970 to 13.2 kg in 2010 (total aquatic meat supply growing at an average annual rate of 1.1%); the same annual growth (1.1%) as the total per capita supply of terrestrial meat, which grew from 27.3 kg in 1970 to 42.5 kg in 2010 (FAO/FAOSTAT, 2012); however, whereas the per capita supply of aquatic meat from capture fisheries has been steadily declining after reaching a high of 9.0 kg in 1986, the per capita supply of farmed aquatic meat has been increasing at an average annual rate of 6.8% since 1970 (Figure 4; FAO/FISHSTAT, 2012). On

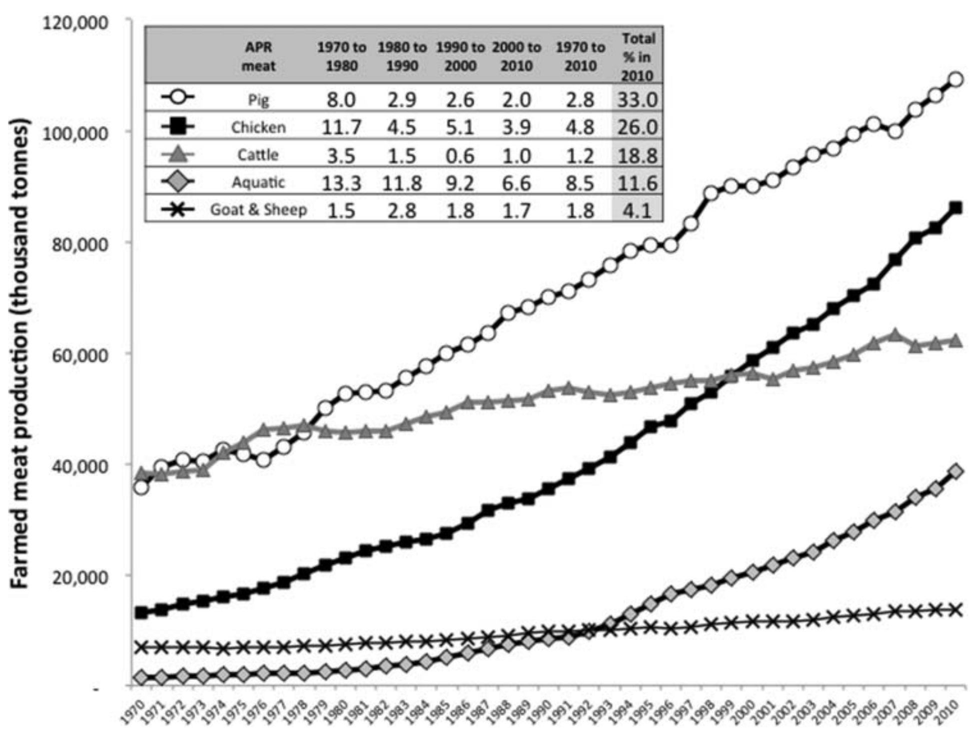


Figure 2 Global production of farmed aquatic and terrestrial meat (FAOSTAT/FISHSTAT, 2012).

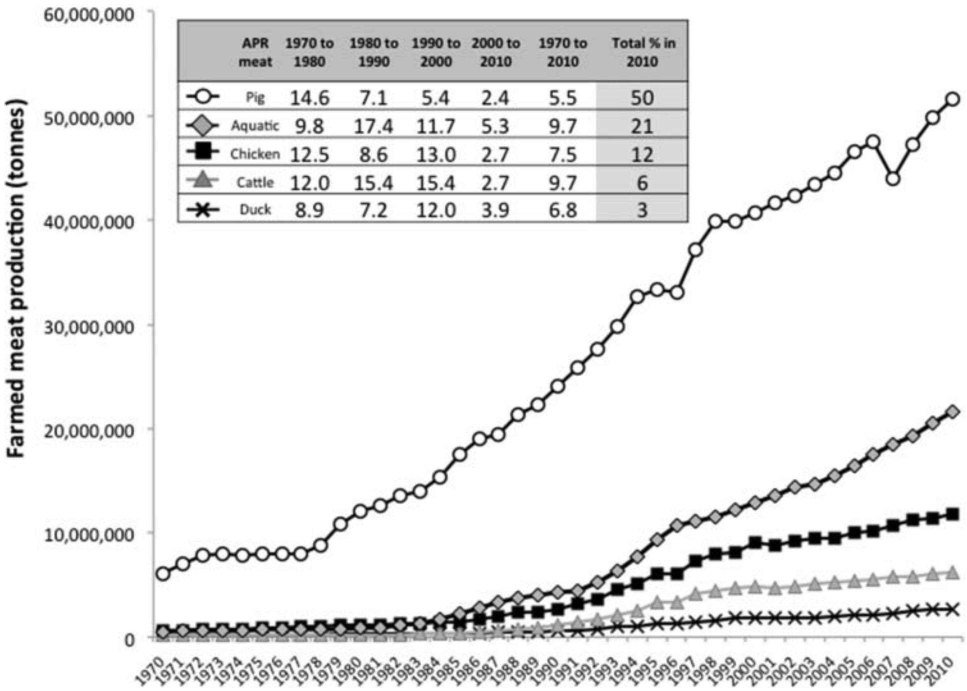


Figure 3 Total production of farmed aquatic and terrestrial meats in China (FAOSTAT/FISHSTAT, 2012).

the basis of these growth trends, it is anticipated that aquaculture's share of global aquatic meat production will increase from its current level of 42% in 2010 to 50% by 2015 and 75% by 2031.

Global Supply of Edible Aquatic Plants—Whole Live Weight Basis

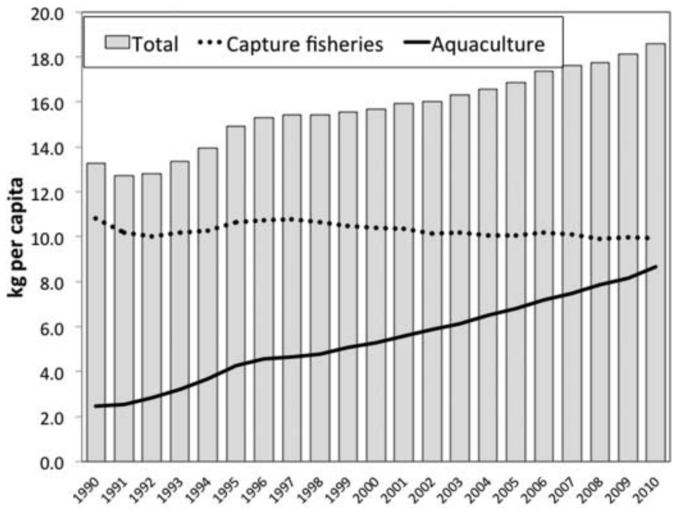
Apart from aquatic animal foods, it is also relevant to mention the important role played by edible aquatic plants or seaweeds in global food supply, particularly within many Asian countries (including China, Japan, and Korea) where the production and consumption of edible aquatic plants has had a long tradition (Fleurence et al., 2012; MacArtain et al., 2007; McHugh, 2003). Aquaculture currently supplies over 95.5% of the total global production of aquatic plants, with production exceeding 19 million tonnes in 2010, compared with a total production of 0.88 million tonnes from capture fisheries (Table 1; FAO/FAOSTAT, 2012). In terms of the contribution of edible aquatic plants to global food supply, it is estimated that about half of total global aquaculture production or about 9 million tonnes (live weight equivalent) is currently destined for direct human consumption, with the remainder used for the extraction of phycocolloids or for use as a dried feed ingredient within farm animal feeds, including aquaculture feeds (Tacon et al, 2009).

CONTRIBUTION OF AQUATIC FOODS TO ANIMAL PROTEIN SUPPLY

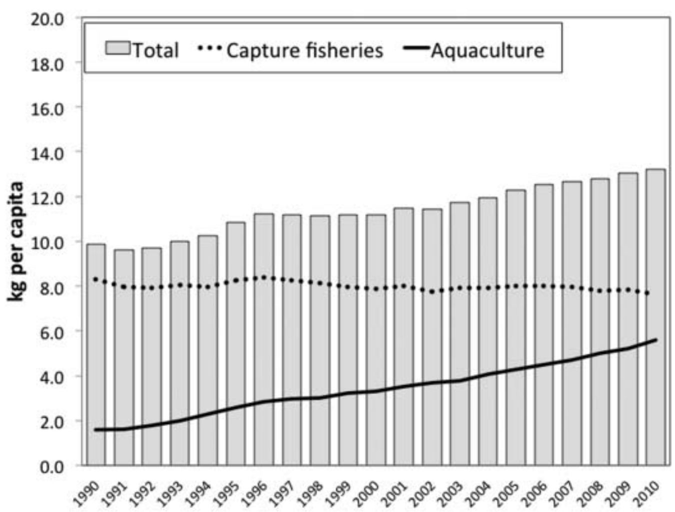
At a global level in 2009, aquatic animal food products accounted for 16.6% of the total supply of animal protein and 6.5% of all plant and animal protein consumed, with aquatic animal food products providing more than three billion people with almost 20% of their average per capita intake of animal protein, and 4.3 billion people with at least 15% of such protein (FAO, 2012a). Despite these generalizations, marked differences exist within and between countries and geographic regions in terms of the consumption of aquatic products and their subsequent contribution to the overall dietary nutrient intake and nutritional wellbeing and health of individual consumers.

Thus, despite the fact that the African region has the lowest per capita supply of aquatic animal food products of any region (9.50 kg/year, with the bulk of this supply coming from capture fisheries; Figure 5), aquatic food products represent over 18.5% of total animal protein supply within the region, and only second to the Asian region at 22.6% in 2009 (FAO Food Balance Sheets, FAO/FAOSTAT, 2012; Figure 6). Moreover, 18 sub-Saharan countries derive the bulk of their very limited animal protein supply from aquatic animal food products, including: Sierra Leone (64.8% total animal protein supply), Gambia (56.6%), Comoros (55.6%), Ghana (54.5%), Cameroon (49.3%), Congo Republic (48.0%), Sao Tome and Principe (46.4%), Equatorial Guinea (42.8%), Nigeria (41.1%), Congo DPR (39.6%), Senegal (38.6%), Mozambique (37.6%), Benin (35.7%), Guinea (33.3%), Guinea (33.3%), Uganda (33.3%), Cote d'Ivoire (31.8%), and Malawi (27.1%; FAO/FISHSTAT, 2012).

Similarly, in Asia (where the bulk of aquatic food products are derived from the rapidly growing aquaculture sector), aquatic animal food products represent the major source of animal protein in more than 14 countries within the region, including the

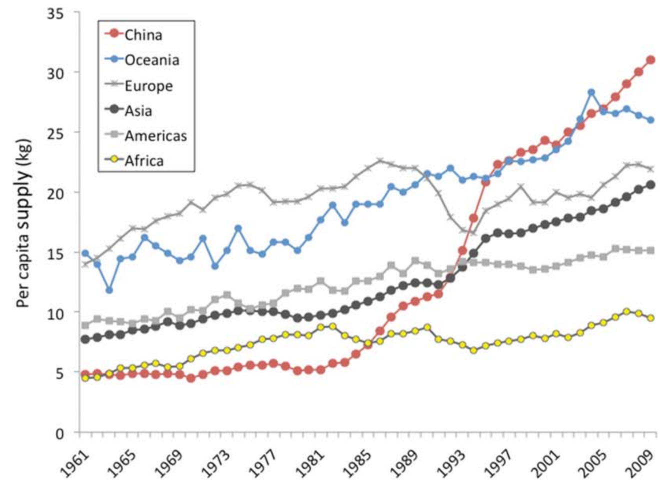


A. Total aquatic animal food supply

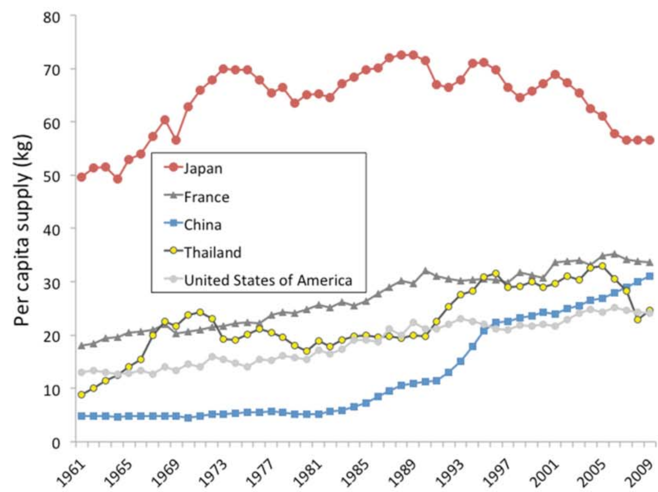


B. Aquatic processed meat supply

Figure 4 Global per capita supply of aquatic animal food products. Data are expressed on a whole live weight (A) and processed aquatic meat basis (B) (compiled from FAO/FISHSTAT, 2012).



A. Regions + China



B. Selected countries

Figure 5 Per capita supply of total aquatic animal food (whole live weight basis). Regional and within selected countries (FAO/FISHSTAT, 2012; color figure available online).

Maldives (70.5%), Cambodia (59.0%), Bangladesh (56.5%), Indonesia (53.7%), Sri Lanka (52.6%), Myanmar (45.4%), Philippines (42.6%), Korea Rep. (41.2%), Malaysia (39.1%), Lao PDR (37.9%), Japan (37.2%), Vietnam (35.3%), Thailand (32.0%), and Korea DPR (26.1%; FAO, 2012a).

Thus, it is not by chance that Japan, the country with the highest reported life expectancy and with one of the world's lowest incidences of obesity and deaths from heart related illnesses, is also one of the world's top consumers of aquatic animal products and farmed aquatic plants (FAO/FAOSTAT, 2012; Yamori, 2009). It is also important to mention that food supply in Japan differs markedly from that of other major western industrialized countries such as the USA (where obesity and deaths related to heart related illnesses are currently major causes for concern) in several important nutritional aspects, including (but not limited to):

- Total calories (kcal/capita/day): Japan 2,723 < USA 3,688 (+35.3%).
- Total animal protein (g/capita/day): Japan 50.6 < USA 72.3 (+42.9%).
- Total animal fat (g/capita/day): Japan 34.2 < USA 69.0 (+101.7%).
- Total terrestrial meat (kg/capita/year): Japan 45.9 < USA 120.2 (+161.9%).
- Total aquatic animal foods (kg/capita/year): Japan 56.6 > USA 24.1 (−57.4%).
- Total aquatic animal protein (g/capita/day): Japan 20.8 > USA 5.6 (−271.4%).
- Total aquatic animal fat (g/capita/day): Japan 6.8 > USA 1.5 (−353.3%).
- Total aquatic plants (kg/capita/year): Japan 1.6 > USA 0 (FAO/FAOSTAT, 2012).

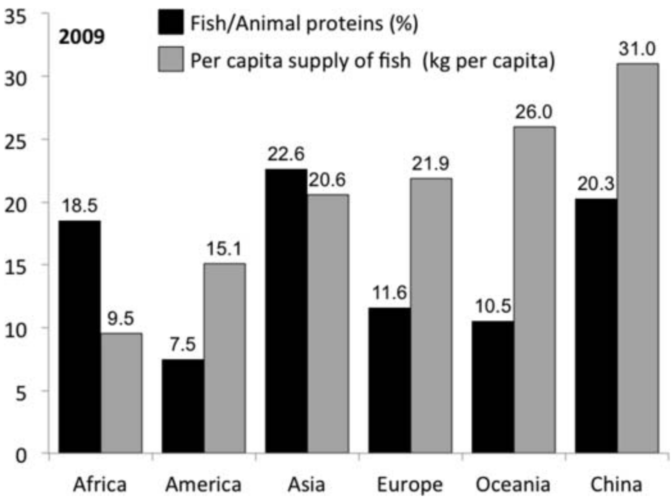


Figure 6 Per capita supply of animal food products on regional basis (expressed as kg/capita/year) and as a percentage of total animal protein supply (FAO/FAOSTAT, 2012).

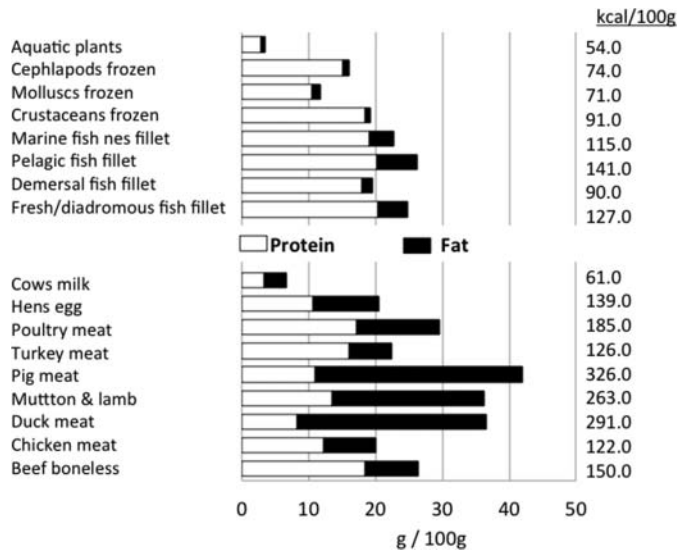


Figure 7 Composition retail weight as purchased in 100 grams of different foods. Protein and fat are represented with bars (g/100g) and calories in right column (kcal/100g; compiled from FAO, 2001).

The observed country differences in aquatic animal food consumption reflect the market availability and cost of aquatic food products compared with terrestrial food products within individual countries and the disposable income of consumers; small-sized fish products representing one of the least expensive sources of high quality animal protein and essential nutrients in sub-Saharan Africa and the Asian region, with lower trophic level freshwater fish species and small pelagic marine forage fish species generally having a lower market cost (and consequently more affordable to the poorer segments of the community) than the higher trophic level predatory marine fish and mollusc species (Dey et al., 2005; FAO, 2003; Hossain et al., 2008; Tacon and Metian, 2009; Tacon et al., 2010b).

NUTRITIONAL COMPOSITION OF AQUATIC FOODS

In terms of nutrient composition (Table 2A–D), aquatic animal food products represent one of the world's most healthy and nutritious food sources (Figure 7). Thus, compared with terrestrial farmed meat products, aquatic animal foods (whether captured or cultured) generally have the following nutritional and health attributes:

- Aquatic animal foods have a higher protein content on an edible fresh weight basis (mean 17.3%) than most terrestrial meats (mean 13.8%), despite having a higher moisture content than most terrestrial meats (Table 2A–D).
- Aquatic animal food proteins are highly digestible and have a high biological value, as evident by their excellent essential amino acid (EAA) profile, the latter closely approximating to the recommended human dietary EAA requirement pattern (WHO, 2007). In particular, aquatic animal proteins are rich dietary sources of methionine (5.9% total EAA in mollusc proteins, 6.1% total EAA in crustacean proteins, 6.4% total EAA in fish proteins, and 5.7% total EAA in terrestrial meat proteins) and lysine (18.2% total EAA in mollusc proteins, 19.1% total EAA in crustacean proteins, 19.6% total EAA in fish proteins, and 19.0% total EAA in terrestrial meat proteins (values calculated from Table 2A–D). Since these EAA are usually limiting within most edible plant proteins consumed by humans, aquatic food products constitute a perfect addition to the typical plant-based diets consumed by the rural poor.
- Aquatic animal foods are generally leaner on an edible fresh weight basis (average of fat = 2.7%) compared with terrestrial meats (average of fat = 16.6%; Figure 7), have a lower saturated fat content (average of 0.16% in crustaceans, 0.32% in molluscs, 1.19% in fish, and 4.97% in terrestrial meats; Table 2A–D), have a lower calorific density (average of 101.3 kcal/100g) than terrestrial meats (average of 209 kcal/100g; Figure 7).
- Aquatic animal food products contain the highest concentration of long-chain omega-3 [(n-3)] polyunsaturated fatty acids of any foodstuffs (Sargent and Tacon, 1999), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA; average of EPA/DHA are respectively 130 and 84 mg per 100g of crustaceans, 149/162 mg per 100g of mollusc, 279/467 mg per 100g of fish, and 2/8 mg/per 100g of terrestrial meat; Table 2A–D). Highest levels of EPA/DHA were reported within small pelagic fish species (average of EPA/DHA = 778/966 mg/100g, including Atlantic mackerel, Pacific herring, Atlantic herring, and European anchovy), and farmed and wild salmonid fish (average of EPA/DHA of 482 and 841 mg/100g, respectively, including Atlantic salmon, Chinook salmon, Coho salmon, Sockeye salmon and rainbow trout; Tables 2C,D). Of particular note is the fact that despite the higher observed fat content of farmed salmonid fish species compared to their wild counterparts, total levels of EPA/DHA within the edible flesh were similar in both wild and farmed animals (Table 2C). This was not

Table 2A Nutrient composition in 100 grams of edible portion of different terrestrial animal food products (compiled from USDA/ARS, 2011)

Nutrient per 100g	Pork			Beef					Chicken						
	Bacon (cured, raw)	Backribs (fresh, raw)	Ground (fresh, raw)	Bottom sirloin tri-tip roast (trimmed, raw)	Brisket, flathalf (trimmed, raw)	Chuck short ribs (trimmed, raw)	Flank steak (trimmed, raw)	Rib-eye steak (trimmed, raw)	Back meat (raw)	Breast meat (raw)	Drum stick (raw)	Lamb Foreshank, (trimmed,[A] raw)	Turkey Roast, light & dark meat(raw)	Eggs Hens (whole fresh)	Milk Dairy (whole, no add.)
Water, g	40.20	63.47	61.06	70.08	69.89	64.76	70.73	63.02	75.31	75.79	72.46	67.01	70.40	76.15	88.13
Energy, kcal	458	224	263	165	165	227	155	228	137	114	159	201	120	143	61
Protein (N x 6.25), g	11.60	19.07	16.88	20.64	20.32	17.87	21.22	19.26	19.56	21.23	17.59	18.91	17.60	12.56	3.15
Total lipid (fat), g	45.04	16.33	21.19	8.55	9.29	17.28	7.17	16.71	5.92	2.59	9.29	13.38	2.20	9.51	3.27
Amino acids															
Tryptophan, g	0.097	0.221	0.214	0.136	0.229	0.291	0.139	0.215	0.228	0.267	0.190	0.221	0.200	0.167	0.040
Threonine, g	0.454	0.818	0.771	0.825	0.894	1.136	0.848	0.908	0.826	0.952	0.812	0.810	0.782	0.556	0.134
Isoleucine, g	0.544	0.880	0.790	0.939	0.864	1.098	0.965	0.897	1.033	1.042	0.815	0.913	0.915	0.671	0.163
Leucine, g	0.903	1.530	1.354	1.642	1.634	2.076	1.688	1.660	1.467	1.757	1.460	1.471	1.402	1.086	0.299
Lysine, g	0.962	1.654	1.518	1.745	1.777	2.257	1.793	1.845	1.661	2.042	1.611	1.670	1.657	0.912	0.264
Methionine, g	0.258	0.510	0.447	0.538	0.577	0.733	0.553	0.521	0.541	0.552	0.488	0.485	0.509	0.380	0.083
Cystine, g	0.129	0.210	0.215	0.266	0.213	0.271	0.274	0.196	0.250	0.222	0.201	0.226	0.183	0.272	0.019
Phenylalanine, g	0.460	0.773	0.674	0.815	0.773	0.982	0.838	0.772	0.776	0.857	0.690	0.770	0.698	0.680	0.163
Tyrosine, g	0.363	0.737	0.588	0.658	0.701	0.890	0.676	0.718	0.660	0.765	0.643	0.636	0.695	0.499	0.159
Valine, g	0.617	0.940	0.916	1.024	0.918	1.167	1.053	0.963	0.970	1.099	0.838	1.021	0.934	0.858	0.206
Arginine, g	0.751	1.198	1.049	1.335	1.338	1.699	1.372	1.311	1.180	1.436	1.230	1.124	1.227	0.820	0.090
Histidine, g	0.436	0.756	0.674	0.659	0.658	0.836	0.677	0.722	0.607	0.791	0.513	0.599	0.549	0.309	0.095
Alanine, g	0.742	1.065	0.983	1.255	1.159	1.472	1.290	1.194	1.067	1.239	1.065	1.138	1.089	0.735	0.107
Aspartic acid, g	1.091	1.739	1.566	1.880	1.822	2.315	1.933	1.876	1.743	1.997	1.699	1.665	1.708	1.329	0.270
Glutamic acid, g	1.707	2.840	2.642	3.099	3.213	4.082	3.185	3.149	2.929	3.145	2.823	2.745	2.870	1.673	0.708
Glycine, g	0.814	0.840	0.802	1.257	0.927	1.178	1.292	0.948	0.961	0.940	0.914	0.924	0.872	0.432	0.062
Proline, g	0.636	0.752	0.678	0.984	0.835	1.061	1.012	0.864	0.804	0.675	0.756	0.793	0.731	0.512	0.311
Serine, g	0.441	0.776	0.697	0.813	0.780	0.991	0.836	0.793	0.673	0.810	0.729	0.703	0.782	0.971	0.190
Total amino acids	11.41	18.24	16.58	19.87	19.31	24.54	20.42	19.55	18.38	20.59	17.48	17.91	17.80	12.86	3.36
Lipids															
Saturated fatty acids, g	14.993	5.783	7.870	3.140	3.592	7.738	2.978	7.363	1.520	0.567	2.450	5.830	0.730	3.126	1.865
Monounsaturated fatty acids, g	20.047	6.861	9.440	4.246	4.586	8.716	2.924	7.880	1.840	0.763	3.720	5.490	0.470	3.658	0.812
Polyunsaturated fatty acids, g	4.821	2.676	1.910	0.394	0.691	1.297	0.277	0.794	1.470	0.399	1.980	1.060	0.640	1.911	0.195
20:5 n-3 (EPA), mg	0	0	ND	0	1	0	0	0	20	2	3	ND	0	0	0
22:6 n-3 (DHA), mg	0	2	ND	0	0	0	0	0	60	3	7	ND	20	58	0
Cholesterol, mg	68	69	72	66	67	78	65	68	81	64	92	72	53	372	10

(Continued on next page)

Table 2A Nutrient composition in 100 grams of edible portion of different terrestrial animal food products (compiled from USDA/ARS, 2011) *(Continued)*

Nutrient per 100g	Pork			Beef					Chicken			Lamb	Turkey	Eggs	Milk
	Bacon (cured, raw)	Backribs (fresh, raw)	Ground (fresh, raw)	Bottom sirloin tri-tip roast (trimmed, raw)	Brisket, flathalf (trimmed, raw)	Chuck short ribs (trimmed, raw)	Flank steak (trimmed, raw)	Rib-eye steak (trimmed, raw)	Back meat (raw)	Breast meat (raw)	Drum stick (raw)	Foreshank, (trimmed,[A] raw)	Roast, light & dark meat(raw)	Hens (whole fresh)	Dairy (whole, no add.)
Minerals															
Calcium (Ca), mg	6.00	31.00	14.00	25.00	13.00	14.00	25.00	8.00	17.00	5.00	10.00	11.00	1.00	56.00	113.0
Iron (Fe), mg	0.48	0.76	0.88	1.49	2.00	2.76	1.55	1.81	1.04	0.37	0.63	1.67	2.10	1.75	0.03
Magnesium (Mg), mg	12	16	19	21	22	21	22	20	22	26	20	22	20	12	10
Phosphorus (P), mg	188	154	175	189	210	180	195	137	151	210	166	170	158	198	84
Potassium (K), mg	208	247	287	317	344	269	328	246	204	370	223	214	360	138	132
Sodium (Na), mg	833	87	56	52	80	71	54	52	82	116	104	72	678	142	43
Zinc (Zn), mg	1.17	2.54	2.20	3.58	4.98	10.23	3.70	4.96	1.85	0.58	1.92	5.22	1.91	1.29	0.37
Copper (Cu), mg	0.07	0.09	0.05	0.07	0.07	0.10	0.07	0.07	0.06	0.03	0.06	0.10	0.09	0.07	0.03
Manganese (Mn), mg	0.02	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.02	0.02	0.02	0.02	0.02	0.03	0.00
Selenium (Se), μg	20.2	30.7	24.6	23.1	23.1	31.9	23.9	24.2	13.5	32.0	19.4	19.9	26.5	30.7	3.7
Vitamins															
Vitamin C, mg	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0
Thiamin, mg	0.28	0.46	0.73	0.06	0.08	0.09	0.07	0.10	0.07	0.06	0.08	0.10	0.04	0.04	0.05
Riboflavin, mg	0.11	0.31	0.24	0.10	0.15	0.25	0.10	0.24	0.16	0.10	0.17	0.19	0.12	0.46	0.17
Niacin, mg	3.83	6.78	4.34	6.09	6.02	3.50	6.26	4.78	6.67	10.43	4.84	5.47	4.40	0.08	0.09
Pantothenic acid, mg	0.52	0.82	0.67	0.59	0.69	0.79	0.61	*ND*	1.22	1.43	1.03	0.69	0.73	1.53	0.37
Vitamin B-6, mg	0.21	0.42	0.38	0.56	0.59	0.31	0.58	0.41	0.33	0.75	0.33	0.15	0.38	0.17	0.04
Folate, μg	2	0	5	11	3	6	11	3	9	4	3	19	7	47	5
Choline, mg	46.6	65.5	*ND*	86.2	59.9	61.3	88.6	ND	ND	73.4	52.8	ND	ND	293.8	14.3
Vitamin B-12, μg	0.69	0.56	0.70	1.06	1.76	3.09	1.09	1.73	0.36	0.20	0.55	2.34	0.35	0.89	0.45
Vitamin A, IU	37	22	7	0	12	15	0	15	99	30	46	0	0	540	162
Vitamin E, mg	0.27	0.24	ND	0.32	0.14	0.14	0.31	0.00	0.22	0.19	0.19	0.25	ND	1.05	0.07
Vitamin D, IU	63	42	ND	0	4	4	ND	6	ND	5	2	ND	ND	82	2
Vitamin K, μg	0.00	0.00	ND	1.30	1.50	1.50	1.20	1.50	2.40	0.20	2.50	ND	ND	0.30	0.30

ND: Not determined.

All products considered are raw for the analyses. Beef products trimmed to 0" fat, all grades (except chuck short ribs); boneless chicken are broilers or fryers and chicken drum stick include meat and skin, raw. Turkey: Roast, boneless, light and dark meat, raw. Dairy: Milk, whole, 3.25% milk fat, without added vitamin A and D. Lamb is domestic, separable lean and fat, trimmed to 1/4" fat, choiced.

Table 2B Nutrient Composition in 100 grams of edible portion of different crustaceans and molluscs (compiled from USDA/ARS, 2011)

					Molluscs								
	Crustaceans				Bivalves						Cephalopods		
Nutrient per 100g	Cr1	Cr2	Cr3	Cr4	Bi1	Bi2	Bi3	Bi4	Bi5	Bi6	Cp1	Cp2	Cp3
Water, g	79.18	79.02	80.95	83.01	78.98	80.58	82.06	86.20	89.04	82.53	80.56	78.55	80.25
Energy, kcal	86	87	77	71	86	86	81	59	51	69	79	92	82
Protein (N x 6.25), g	17.41	18.06	16.52	13.61	14.67	11.90	9.45	5.22	5.71	12.06	16.24	15.58	14.91
Total lipid (fat), g	0.97	1.08	0.75	1.01	0.96	2.24	2.30	1.55	1.71	0.49	0.70	1.38	1.04
Amino acids													
Tryptophan, g	0.242	0.251	0.215	0.155	0.205	0.133	0.106	0.059	0.069	0.102	0.182	0.174	0.167
Threonine, g	0.705	0.731	0.654	0.540	0.700	0.512	0.407	0.225	0.230	0.369	0.699	0.670	0.642
Isoleucine, g	0.844	0.875	0.723	0.627	0.693	0.518	0.411	0.227	0.229	0.406	0.707	0.678	0.649
Leucine, g	1.381	1.433	1.197	1.165	1.200	0.838	0.665	0.368	0.358	0.720	1.143	1.096	1.049
Lysine, g	1.515	1.572	1.240	1.297	1.123	0.889	0.706	0.390	0.381	0.739	1.213	1.164	1.114
Methionine, g	0.490	0.508	0.413	0.397	0.423	0.268	0.213	0.118	0.129	0.286	0.366	0.351	0.336
Cystine, g	0.195	0.202	0.181	0.162	0.175	0.156	0.124	0.069	0.055	0.120	0.213	0.204	0.196
Phenylalanine, g	0.735	0.763	0.680	0.593	0.560	0.426	0.339	0.187	0.207	0.351	0.582	0.558	0.534
Tyrosine, g	0.579	0.601	0.586	0.515	0.597	0.381	0.302	0.167	0.202	0.296	0.520	0.498	0.477
Valine, g	0.819	0.849	0.741	0.637	0.743	0.520	0.413	0.228	0.262	0.379	0.709	0.680	0.651
Arginine, g	1.521	1.577	1.524	1.342	1.210	0.868	0.689	0.381	0.372	0.646	1.185	1.136	1.088
Histidine, g	0.354	0.367	0.413	0.300	0.300	0.228	0.181	0.100	0.110	0.185	0.312	0.299	0.286
Alanine, g	0.986	1.023	0.878	0.842	0.885	0.720	0.572	0.316	0.271	0.536	0.982	0.942	0.902
Aspartic acid, g	1.799	1.866	1.602	1.517	1.608	1.148	0.912	0.504	0.491	0.923	1.567	1.503	1.438
Glutamic acid, g	2.969	3.080	2.437	2.390	2.248	1.618	1.285	0.711	0.675	1.404	2.208	2.118	2.027
Glycine, g	1.050	1.089	1.102	0.801	0.640	0.744	0.591	0.327	0.275	1.034	1.016	0.974	0.933
Proline, g	0.574	0.595	0.741	0.626	0.500	0.486	0.386	0.213	0.225	0.286	0.662	0.635	0.608
Serine, g	0.685	0.711	0.637	0.555	0.690	0.533	0.423	0.234	0.225	0.360	0.727	0.698	0.668
Total amino acids	17.44	18.09	15.96	14.46	14.50	10.99	8.73	4.82	4.77	9.14	14.99	14.38	13.77
Lipids													
Saturated fatty acids, g	0.132	0.222	0.181	0.115	0.187	0.425	0.510	0.443	0.474	0.128	0.118	0.358	0.227
Monounsaturated fatty acids, g	0.167	0.192	0.220	0.080	0.120	0.507	0.358	0.152	0.253	0.048	0.081	0.107	0.162
Polyunsaturated fatty acids, g	0.317	0.387	0.296	0.130	0.192	0.606	0.894	0.591	0.528	0.130	0.134	0.524	0.239
20:5 n-3 (EPA), mg	219	170	102	30	43	188	438	188	177	42	39	146	76
22:6 n-3 (DHA), mg	88	150	68	31	64	253	250	203	136	61	66	342	81
Cholesterol, mg	59	78	127	126	30	28	50	25	40	24	112	233	48
Minerals													
Calcium (Ca), mg	46.00	89.00	84.00	54.00	39.00	26.00	8.00	44.00	59.00	6.00	90.00	32.00	53.00
Iron (Fe), mg	0.37	0.74	0.26	0.21	1.62	3.95	5.11	5.78	4.61	0.38	6.02	0.68	5.30
Magnesium (Mg), mg	45	34	38	22	19	34	22	33	18	22	30	33	30
Phosphorus (P), mg	182	229	161	244	198	197	162	93	97	334	387	221	186
Potassium (K), mg	354	329	200	113	46	320	168	124	156	205	354	246	350
Sodium (Na), mg	295	293	423	566	601	286	106	178	85	392	372	44	230
Zinc (Zn), mg	4.27	3.54	3.53	0.97	0.51	1.60	16.62	37.92	39.30	0.91	1.73	1.53	1.68
Copper (Cu), mg	0.67	0.67	1.35	0.18	0.05	0.09	1.58	0.74	2.86	0.02	0.59	1.89	0.44
Manganese (Mn), mg	0.08	0.15	0.06	0.03	0.09	3.40	0.64	0.39	0.30	0.02	0.11	0.04	0.03
Selenium (Se), μg	37.1	37.4	63.6	29.6	30.6	44.8	77.0	63.7	19.7	12.8	44.8	44.8	44.8
Vitamins													
Vitamin C, mg	3.5	3.0	0.0	0.0	0.0	8.0	8.0	4.7	0.0	0.0	5.3	4.7	5.0
Thiamin, mg	0.05	0.08	0.02	0.02	0.02	0.16	0.07	0.11	0.02	0.01	0.01	0.02	0.03
Riboflavin, mg	0.17	0.04	0.01	0.02	0.04	0.21	0.23	0.07	0.09	0.02	0.91	0.41	0.04
Niacin, mg	3.14	2.70	1.59	1.78	0.35	1.60	2.01	1.27	0.93	0.70	1.22	2.18	2.10
Pantothenic acid, mg	0.35	0.35	1.45	0.31	0.15	0.50	0.50	0.16	0.22	0.22	0.50	0.50	0.50
Vitamin B-6, mg	0.15	0.15	0.10	0.16	0.01	0.05	0.05	0.06	0.03	0.07	0.15	0.06	0.36
Folate, μg	44	44	10	19	5	42	10	18	7	16	16	5	16
Choline, mg	ND	ND	70.3	80.9	65.0	65.0	ND	ND	65.0	65.0	ND	65.0	65.0
Vitamin B-12, μg	9.00	9.00	1.25	1.11	11.28	12.00	16.00	16.20	8.75	1.41	3.00	1.30	20.00
Vitamin A, IU	90	5	4	180	300	160	270	25	44	3	375	33	150
Vitamin E, mg	ND	ND	0.87	1.32	0.68	0.55	ND	ND	0.85	0.00	ND	1.20	1.20
Vitamin D, IU	ND	ND	1	2	1	0	ND	ND	1	1	ND	0	0
Vitamin K, μg	ND	ND	ND	0.30	0.20	0.10	ND	ND	1.00	0.00	ND	0.00	0.10

ND: Not determined.

All the fish/crustacean/mollusc are raw. Cr1: Dungeness crab (*Cancer magister*); Cr2: Crustacean: Blue crab (*Callinectes sapidus*); Cr3: Crustacean: Northern lobster (*Homarus americanus*); Cr4: Crustacean: Shrimp mixed species (*Penaeidae and Pandalidae*); Bi1: Clam mixed species (*Lamellibranchia*); Bi2: Blue mussel (*Mytilus edulis*); Bi3: Pacific oyster (*Crassostrea gigas*); Bi4: Eastern oyster farmed (*Crassostrea virginica*); Bi5: Eastern oyster wild (*Crassostrea virginica*); Bi6: Scallop mixed species (*Pectinidae*); Cp1: Cuttlefish mixed species (*Sepiidae*); Cp2: Squid mixed species (*Loligoidae and Ommastrephidae*); Cp3: Common octopus (*Octopus vulgaris*).

Table 2C Nutrient composition in 100 grams of edible portion of different freshwater and diadromous fish species (compiled from USDA/ARS, 2011)

					Diadromous fish												
	Freshwater fish				Salmonids										Miscellaneous		
Nutrient per 100g	Carp	Tilap	CatF1	CatF2	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	Misc1	Misc2	Misc3
Water, g	76.31	78.08	80.36	79.06	68.50	64.89	71.64	70.47	72.66	73.15	75.52	75.38	71.42	71.87	68.26	79.22	70.85
Energy, kcal	127	96	95	119	142	208	179	160	146	142	127	120	148	119	184	97	148
Protein (N x 6.25), g	17.83	20.08	16.38	15.23	19.84	20.42	19.93	21.27	21.62	21.31	20.50	20.14	20.77	20.48	18.44	17.73	20.53
Total lipid (fat), g	5.60	1.70	2.82	5.94	6.34	13.42	10.43	7.67	5.93	5.61	4.40	3.77	6.61	3.46	11.66	2.33	6.73
Amino acids																	
Tryptophan, g	0.200	0.210	0.183	0.182	0.222	0.209	0.225	0.238	0.242	0.270	0.221	0.226	0.233	0.229	0.207	0.199	0.230
Threonine, g	0.782	0.950	0.718	0.688	0.870	0.860	0.879	0.932	0.948	1.004	1.066	0.883	0.911	0.898	0.809	0.777	0.900
Isoleucine, g	0.822	0.930	0.755	0.678	0.914	0.968	0.924	0.980	0.996	1.025	0.954	0.928	0.957	0.944	0.850	0.817	0.946
Leucine, g	1.449	1.603	1.331	1.153	1.613	1.615	1.630	1.729	1.757	1.759	1.562	1.637	1.688	1.664	1.499	1.441	1.669
Lysine, g	1.638	1.810	1.504	1.386	1.822	1.870	1.842	1.953	1.985	2.072	1.759	1.849	1.907	1.881	1.694	1.628	1.886
Methionine, g	0.528	0.593	0.485	0.445	0.587	0.626	0.594	0.629	0.640	0.691	0.577	0.596	0.615	0.606	0.546	0.525	0.608
Cystine, g	0.191	0.220	0.176	0.162	0.213	0.219	0.215	0.228	0.232	0.237	0.159	0.216	0.223	0.220	0.198	0.190	0.220
Phenylalanine, g	0.696	0.810	0.639	0.607	0.775	0.845	0.783	0.830	0.844	0.874	0.845	0.786	0.811	0.799	0.720	0.692	0.802
Tyrosine, g	0.602	0.680	0.553	0.506	0.670	0.759	0.677	0.718	0.730	0.971	0.742	0.680	0.701	0.691	0.623	0.599	0.693
Valine, g	0.919	0.970	0.844	0.738	1.022	1.107	1.033	1.096	1.114	1.176	1.100	1.037	1.070	1.055	0.950	0.914	1.058
Arginine, g	1.067	1.277	0.980	0.951	1.187	1.221	1.200	1.273	1.294	1.381	1.287	1.205	1.243	1.225	1.104	1.061	1.229
Histidine, g	0.525	0.470	0.482	0.334	0.584	0.549	0.590	0.626	0.636	0.572	0.543	0.593	0.611	0.603	0.543	0.522	0.604
Alanine, g	1.078	1.220	0.991	0.860	1.200	1.271	1.213	1.286	1.307	1.327	1.308	1.218	1.256	1.239	1.115	1.072	1.242
Aspartic acid, g	1.826	2.297	1.677	1.487	2.032	2.025	2.054	2.178	2.214	2.180	2.575	2.062	2.127	2.097	1.889	1.816	2.102
Glutamic acid, g	2.662	3.213	2.445	2.164	2.962	2.830	2.994	3.175	3.227	3.140	2.903	3.006	3.100	3.057	2.753	2.647	3.065
Glycine, g	0.856	1.043	0.786	0.769	0.952	0.960	0.963	1.021	1.038	1.025	1.263	0.967	0.997	0.983	0.885	0.851	0.986
Proline, g	0.631	0.757	0.579	0.566	0.702	0.721	0.709	0.752	0.764	0.788	0.867	0.712	0.734	0.724	0.652	0.627	0.726
Serine, g	0.728	0.813	0.668	0.577	0.809	0.896	0.818	0.868	0.882	0.853	0.905	0.822	0.847	0.836	0.753	0.723	0.838
Total amino acids	17.20	19.87	15.80	14.25	19.14	19.55	19.34	20.51	20.85	21.35	20.64	19.42	20.03	19.75	17.79	17.10	19.80
Lipids																	
Saturated fatty acids, g	1.083	0.585	0.722	1.310	0.981	3.050	3.100	1.816	1.260	1.182	0.810	0.840	1.149	0.722	2.358	0.507	1.660
Monounsaturated fatty acids, g	2.328	0.498	0.844	2.573	2.103	3.770	4.399	3.330	2.134	1.863	1.348	1.541	3.254	1.129	7.190	0.660	2.580
Polyunsaturated fatty acids, g	1.431	0.363	0.865	1.119	2.539	3.886	2.799	1.861	1.992	1.945	0.811	0.898	1.499	1.237	0.947	0.784	1.840
20:5 n-3 (EPA), mg	238	5	130	17	321	862	1008	385	429	348	182	233	202	167	84	169	ND
22:6 n-3 (DHA), mg	114	86	234	57	1115	1104	944	821	656	681	333	394	528	420	63	585	ND
Cholesterol, mg	66	50	58	55	55	55	50	51	45	53	46	74	58	59	126	80	52
Minerals																	
Calcium (Ca), mg	41.00	10.00	14.00	8.00	12.00	9.00	26.00	12.00	36.00	10.00	7.00	11.00	43.00	67.00	20.00	15.00	51.00
Iron (Fe), mg	1.24	0.56	0.30	0.23	0.80	0.34	0.25	0.34	0.56	0.42	0.38	0.55	1.50	0.70	0.50	0.84	0.32
Magnesium (Mg), mg	29	27	23	19	29	27	95	31	31	30	27	22	22	31	20	40	30
Phosphorus (P), mg	415	170	209	204	200	240	289	292	262	266	261	283	245	271	216	198	162
Potassium (K), mg	333	302	358	302	490	363	394	450	423	343	366	429	361	481	272	256	292
Sodium (Na), mg	49	52	43	98	44	59	47	47	46	112	75	50	52	31	51	69	72
Zinc (Zn), mg	1.48	0.33	0.51	0.48	0.64	0.36	0.44	0.43	0.41	0.42	0.39	0.47	0.66	1.08	1.62	0.40	0.82
Copper (Cu), mg	0.06	0.08	0.03	0.03	0.25	0.05	0.04	0.05	0.05	0.06	0.06	0.06	0.19	0.11	0.02	0.03	0.03
Manganese (Mn), mg	0.04	0.04	0.03	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.85	0.16	0.04	0.02	0.02
Selenium (Se), μg	12.6	41.8	12.6	8.2	36.5	24.0	36.5	12.6	36.5	30.6	31.4	36.5	12.6	12.6	6.5	36.5	12.6
Vitamins																	
Vitamin C, mg	1.6	0.0	0.7	0.0	0.0	3.9	4.0	1.1	1.0	0.0	0.0	0.0	0.5	2.4	1.8	0.0	0.0
Thiamin, mg	0.12	0.04	0.21	0.02	0.23	0.21	0.05	0.09	0.11	0.18	0.08	0.08	0.35	0.12	0.15	0.10	0.01
Riboflavin, mg	0.06	0.06	0.07	0.08	0.38	0.16	0.11	0.11	0.14	0.12	0.11	0.18	0.33	0.11	0.04	0.03	0.05
Niacin, mg	1.64	3.90	1.91	2.11	7.86	8.67	8.42	6.81	7.23	8.14	8.00	7.00	4.50	5.38	3.50	2.10	6.44
Pantothenic acid, mg	0.75	0.49	0.77	0.67	1.66	1.55	0.75	1.14	0.82	1.15	1.03	0.75	1.94	0.93	0.24	0.75	0.75
Vitamin B-6, mg	0.19	0.16	0.12	0.15	0.82	0.64	0.40	0.66	0.55	0.61	0.61	0.40	0.20	0.41	0.07	0.30	0.42
Folate, μg	15	24	10	10	25	26	30	13	9	8	4	4	13	12	15	9	16
Choline, mg	65.0	42.5	ND	65.0	ND	78.5	ND	ND	109.4	94.6	94.6	ND	65.0	ND	65.0	ND	ND
Vitamin B-12, μg	1.53	1.58	2.23	2.88	3.18	3.23	1.30	2.67	4.17	5.95	4.15	3.00	7.79	4.45	3.00	3.82	3.40
Vitamin A, IU	30	0	50	1	40	50	453	188	135	193	117	99	57	62	3477	90	100
Vitamin E, mg	0.63	0.40	ND	0.81	ND	3.55	1.22	ND	0.73	0.95	0.40	1.09	0.20	ND	3.40	ND	ND
Vitamin D, IU	988	124	500	9	ND	ND	ND	ND	361	441	435	ND	155	ND	932	ND	ND
Vitamin K, μg	0.10	1.40	ND	2.10	ND	0.50	ND	ND	0.10	0.10	0.40	ND	0.10	ND	0.00	ND	ND

ND: Not determined.

Origins (aquaculture or capture fisheries) when available in the data are precised. Carp: Common carp (*Cyprinus carpio*); Tilap: Tilapia (*Oreochromis spp*); CatF1: Channel catfish (*Ictalurus punctatus,* wild), CatF2: Channel catfish (*Ictalurus punctatus,* farmed), S1: Atlantic salmon (*Salmo salar,* wild); S2: Atlantic salmon (*Salmo salar,* farmed); S3: Chinook salmon (*Oncorhynchus tshawytscha*); S4: Coho salmon (*Oncorhynchus kisutch,* farmed); S5: Coho salmon (*Oncorhynchus kisutch*, wild); S6: Sockeye salmon (*Oncorhynchus nerka*); S7: Pink salmon (*Oncorhynchus gorbuscha*); S8: Chum salmon (*Oncorhynchus keta*); S8: Rainbow trout (*Salmo gairdneri,* farmed); S9: Rainbow trout (*Salmo gairdneri,* wild); Misc1:Eel Mixed species (*Anguilla spp.*); Misc2:Striped bass (*Morone saxatilis*); Milkfish (*Chanos chanos*).

Table 2D Nutrient composition in 100 grams of edible portion of different marine fish species (compiled from USDA/ARS, 2011)

	Pelagic fish										Miscellaneous marine fish							
	Small pelagic fish				Large pelagic fish													
Nutrient per 100g	SPF1	SPF2	SPF3	SPF4	LPF1	LPF2	LPF3	LPF4	LPF5	LPF6	Misc1	Misc2	Misc3	Misc4	Misc5	Misc6	Misc7	Misc8
Water, g	73.37	72.05	71.52	63.55	71.67	68.09	70.58	74.03	77.55	73.38	81.22	84.63	79.22	83.38	80.34	77.01	78.27	76.87
Energy, kcal	131	158	195	205	139	144	103	109	85	144	82	70	92	74	91	117	97	100
Protein (N x 6.25), g	20.35	17.96	16.39	18.60	19.29	23.33	22.00	24.40	18.50	19.66	17.81	12.41	19.38	16.32	18.56	19.35	18.43	20.51
Total lipid (fat), g	4.84	9.04	13.88	13.89	6.30	4.90	1.01	0.49	0.70	6.65	0.67	1.93	1.02	0.45	1.33	3.79	2.00	1.34
Amino acids																		
Tryptophan, g	0.228	0.201	0.184	0.208	0.216	0.261	0.246	0.262	0.207	0.222	0.199	0.161	0.217	0.212	0.233	0.217	0.206	0.230
Threonine, g	0.892	0.787	0.719	0.815	0.846	1.023	0.964	1.025	0.811	0.868	0.781	0.585	0.849	0.829	0.912	0.848	0.808	0.899
Isoleucine, g	0.938	0.828	0.755	0.857	0.889	1.075	1.014	1.077	0.852	0.912	0.821	0.614	0.893	0.871	0.959	0.892	0.849	0.945
Leucine, g	1.654	1.460	1.332	1.512	1.568	1.896	1.788	1.900	1.504	1.609	1.447	1.087	1.575	1.537	1.692	1.573	1.498	1.667
Lysine, g	1.869	1.650	1.506	1.708	1.771	2.142	2.020	2.147	1.699	1.818	1.635	1.270	1.779	1.736	1.911	1.777	1.693	1.883
Methionine, g	0.602	0.532	0.485	0.551	0.571	0.690	0.651	0.692	0.548	0.586	0.527	0.455	0.574	0.560	0.616	0.573	0.546	0.607
Cystine, g	0.218	0.193	0.176	0.199	0.207	0.250	0.236	0.251	0.198	0.212	0.191	0.149	0.208	0.203	0.223	0.207	0.198	0.220
Phenylalanine, g	0.794	0.701	0.640	0.726	0.753	0.911	0.859	0.913	0.722	0.773	0.695	0.508	0.756	0.738	0.813	0.755	0.720	0.801
Tyrosine, g	0.687	0.606	0.553	0.628	0.651	0.787	0.743	0.789	0.625	0.668	0.601	0.479	0.654	0.638	0.703	0.653	0.622	0.692
Valine, g	1.048	0.925	0.845	0.958	0.994	1.202	1.133	1.204	0.953	1.020	0.917	0.651	0.998	0.974	1.072	0.997	0.950	1.056
Arginine, g	1.217	1.075	0.981	1.113	1.154	1.396	1.316	1.399	1.107	1.185	1.066	0.895	1.159	1.131	1.245	1.158	1.103	1.227
Histidine, g	0.599	0.529	0.483	0.548	0.568	0.687	0.648	0.688	0.545	0.583	0.524	0.304	0.570	0.557	0.613	0.570	0.543	0.604
Alanine, g	1.231	1.086	0.991	1.125	1.167	1.411	1.331	1.414	1.119	1.198	1.077	0.771	1.172	1.143	1.259	1.170	1.115	1.240
Aspartic acid, g	2.084	1.839	1.679	1.905	1.975	2.388	2.253	2.394	1.894	2.028	1.823	1.382	1.984	1.936	2.131	1.981	1.887	2.100
Glutamic acid, g	3.038	2.681	2.447	2.777	2.879	3.482	3.284	3.489	2.762	2.956	2.658	2.127	2.892	2.822	3.107	2.889	2.751	3.061
Glycine, g	0.977	0.862	0.787	0.893	0.926	1.120	1.056	1.122	0.888	0.950	0.855	0.640	0.930	0.908	0.999	0.929	0.885	0.984
Proline, g	0.720	0.635	0.580	0.658	0.682	0.825	0.778	0.827	0.654	0.700	0.630	0.487	0.685	0.669	0.736	0.684	0.652	0.725
Serine, g	0.830	0.733	0.669	0.759	0.787	0.952	0.898	0.954	0.755	0.808	0.726	0.579	0.791	0.771	0.849	0.789	0.752	0.837
Total amino acids	19.63	17.32	15.81	17.94	18.60	22.50	21.22	22.55	17.84	19.10	17.17	13.14	18.69	18.24	20.07	18.66	17.78	19.78
Lipids																		
Saturated fatty acids, g	1.282	2.040	3.257	3.257	1.828	1.257	0.328	0.172	0.188	1.602	0.131	0.441	0.233	0.091	0.292	1.116	0.511	0.285
Monounsaturated fatty acids, g	1.182	3.736	6.872	5.456	1.530	1.600	0.190	0.116	0.121	2.971	0.094	0.535	0.202	0.061	0.471	1.078	0.424	0.251
Polyunsaturated fatty acids, g	1.637	2.133	2.423	3.350	1.739	1.433	0.315	0.147	0.165	1.147	0.231	0.374	0.321	0.166	0.290	0.715	0.743	0.459
20:5 n-3 (EPA), mg	538	709	969	898	329	283	71	12	20	107	64	137	27	42	66	217	161	51
22:6 n-3 (DHA), mg	911	862	689	1401	1012	890	185	88	88	647	120	108	220	89	128	108	434	260
Cholesterol, mg	60	60	77	70	76	38	47	39	73	66	43	45	37	54	49	49	41	37

(Continued on next page)

Table 2D Nutrient composition in 100 grams of edible portion of different marine fish species (compiled from USDA/ARS, 2011) *(Continued)*

	Pelagic fish																	
	Small pelagic fish				Large pelagic fish						Miscellaneous marine fish							
Nutrient per 100g	SPF1	SPF2	SPF3	SPF4	LPF1	LPF2	LPF3	LPF4	LPF5	LPF6	Misc1	Misc2	Misc3	Misc4	Misc5	Misc6	Misc7	Misc8
Minerals																		
Calcium (Ca), mg	147.0	57.0	83.0	12.0	11.0	8.0	29.0	4.0	15.0	5.0	16.0	21.0	27.0	11.0	7.0	41.0	10.0	32.0
Iron (Fe), mg	3.25	1.10	1.12	1.63	0.44	1.02	1.25	0.77	1.13	0.38	0.38	0.18	0.89	0.17	0.16	1.02	0.29	0.18
Magnesium (Mg), mg	41	32	32	76	33	50	34	35	30	29	32	18	31	21	23	29	41	32
Phosphorus (P), mg	174	236	228	217	205	254	222	278	143	255	203	252	162	227	236	221	194	198
Potassium (K), mg	383	327	423	314	446	252	407	441	416	418	413	160	483	286	435	357	256	417
Sodium (Na), mg	104	90	74	90	59	39	37	45	88	81	54	296	53	213	68	65	68	64
Zinc (Zn), mg	1.72	0.99	0.53	0.63	0.49	0.60	0.82	0.37	0.46	0.66	0.45	0.32	0.48	0.32	0.36	0.52	0.40	0.36
Copper (Cu), mg	0.21	0.09	0.08	0.07	0.06	0.09	0.09	0.04	0.04	0.04	0.03	0.02	0.02	0.02	0.02	0.05	0.02	0.03
Manganese (Mn), mg	0.07	0.04	0.05	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Selenium (Se), μg	36.5	36.5	36.5	44.1	36.5	36.5	36.5	90.6	36.5	57.4	33.1	26.6	36.5	25.9	45.6	36.5	36.5	38.2
Vitamins																		
Vitamin C, mg	0.0	0.7	0.0	0.4	1.6	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.2	0.0	1.6
Thiamin, mg	0.06	0.09	0.06	0.18	0.13	0.24	0.03	0.12	0.02	0.08	0.08	0.02	0.07	0.02	0.05	0.09	0.11	0.05
Riboflavin, mg	0.26	0.23	0.20	0.31	0.17	0.25	0.10	0.12	0.07	0.05	0.07	0.02	0.01	0.06	0.03	0.08	0.12	0.00
Niacin, mg	14.02	3.22	2.20	9.08	2.30	8.65	15.40	18.48	6.10	7.76	2.06	1.04	0.31	3.36	6.51	5.20	1.60	0.28
Pantothenic acid, mg	0.65	0.65	1.00	0.86	0.75	1.05	0.42	0.28	0.75	0.35	0.15	0.19	0.75	0.40	0.34	0.76	0.75	0.75
Vitamin B-6, mg	0.14	0.30	0.45	0.40	0.40	0.46	0.85	0.93	0.40	0.54	0.25	0.10	0.30	0.28	0.55	0.43	0.40	0.40
Folate, μg	9	10	5	1	1	2	9	2	5	2	7	5	9	12	12	9	5	5
Choline, mg	ND	65.0	ND	65.0	50.5	65.0	ND	65.0	ND	65.0	65.2	65.0	ND	65.0	61.8	70.2	60.8	65.0
Vitamin B-12, μg	0.62	13.67	10.00	8.71	2.40	9.43	1.90	2.08	0.60	1.70	0.91	1.13	0.60	1.83	1.10	0.22	0.30	3.00
Vitamin A, IU	50	93	106	167	130	2183	52	60	180	120	40	33	143	57	67	123	154	106
Vitamin E, mg	0.57	1.07	ND	1.52	0.69	1.00	ND	0.24	ND	2.02	0.64	0.63	ND	0.45	0.00	1.00	0.84	0.96
Vitamin D, IU	ND	167	ND	643	292	227	ND	69	ND	558	36	113	ND	18	190	61	226	408
Vitamin K, μg	0.10	0.10	ND	5.00	0.10	0.00	ND	0.10	ND	0.10	0.10	0.10	ND	0.10	0.00	0.10	0.10	0.10

ND: Not determined.

SPF1: European anchovy (*Engraulis encrasicholus*); SPF2: Atlantic herring (*Clupea harengus harengus*); SPF3: Pacific herring (*Clupea harengus pallasi* Valenciennes); SPF4: Atlantic mackerel (*Scomber scombrus*); LPF1: Spanish mackerel (*Scomber maculatus*); LPF2: Bluefin tuna (*Thunnus thynnus*); LPF3: Skipjack tuna (*Euthynnus pelamis*); LPF4: Yellowfin tuna (*Thunnus albacares*); LPF5: Dolphinfish (*Coryphaena hippurus*); LPF6 : Swordfish (*Xiphias gladius*); Misc1: Atlantic cod (*Gadus morhua*); Misc2: Flatfish (flounder and sole species (*Bothidae* and *Pleuronectidae*); Misc3: Grouper mixed species (*Epinephelus spp*); Misc4: Haddock (*Melanogrammus aeglefinus*); Misc5: Halibut Atlantic and Pacific (*Hippoglossus hippoglussus* and *H. Schmidt*); Misc6: Striped mullet (Mugil cephalus); Misc7: Sea bass mixed species (*Centropristes striata* L. and *Lateolabrax japonicus*); Misc8: Snappers mixed species (*Lutjanidae*).

the case, however, in farmed Channel catfish, where despite their higher fat content, tissue EPA/DHA levels were considerably lower (17/57 mg/100g) than their wild counterparts (130/234 mg/100g; Tables 2). Although not analyzed or presented here, it is important to mention that filter feeding freshwater fish species (such as silver carp *Hypophthalmichthys molitrix* and bighead carp *Hypophthalmichthys nobilis*) are also rich sources of EPA/DHA (Steffens and Wirth, 2005), which they derive from freshwater plankton (Brett et al., 2009). As a general rule, the tissue levels of EPA/DHA within farmed fish and crustacean species are usually derived from the level of fish oil used within their formulated feeds, with higher levels usually reported with feeds containing higher dietary fish oil levels (NRC, 2011; Turchini et al., 2009). In health terms, fish-derived omega-3 [(n-3)] fatty acids EPA and DHA have been shown to have a positive role in infant development (including neuronal, retinal, and immune function), cardiovascular diseases (including reduced incidence of heart disease in adults), cancer, and various mental illnesses (including depression, attention-deficit hyperactivity disorder, and dementia; Riediger et al., 2009; Ruxton et al., 2004; Swanson et al., 2012).

- Aquatic animal food products are a richer source of most essential minerals and trace elements than most terrestrial meats, including:
  - Calcium (average of 68.2 mg/100g in crustaceans, 39.7 mg/100g in molluscs, 26.0 mg/100g in fish, and 13.8 mg/100g in terrestrial meats).
  - Phosphorus (average of 230.5 mg/100g in fish, 208.3 mg/100g in molluscs, 204.0 mg/100g in crustaceans, and 175.6 mg/100g in terrestrial meats).
  - Magnesium (average of 34.7 mg/100g in crustaceans, 33.0 mg/100g in fish, 26.8 mg/100g in molluscs, and 20.2 mg/100g in terrestrial meats).
  - Iron (average of 3.72 mg/100g in molluscs, 0.69 mg/100g in fish, 0.40 mg/100g in crustaceans, and 1.35 mg/100g in terrestrial meats).
  - Potassium (average of 367.6 mg/100g in fish, 249.0 mg/100g in crustaceans, 218.8 mg/100g in molluscs, and 278.2 mg/100g in terrestrial meats).
  - Sodium (average of 394.2 mg/100g in crustaceans, 254.9 mg/100g in molluscs, 73.8 mg/100g in fish, and 179.8 mg/100g in terrestrial meats).
  - Zinc (average of 11.31 mg/100g in molluscs, 3.08 mg/100g in crustaceans, 0.61 mg/100g in fish, and 3.45 mg/100g in terrestrial meats).
  - Copper (average of 0.92 mg/100g in molluscs, 0.72 mg/100g in crustaceans, 0.06 mg/100g in fish, and 0.07 mg/100g in terrestrial meats).
  - Manganese (average of 0.56 mg/100g in molluscs, 0.08 mg/100g in crustaceans, 0.02 mg/100g in fish, and 0.01 mg/100g in terrestrial meats).
  - Selenium (average of 42.6 μg/100g in molluscs, 41.9 μg/100g in crustaceans, 32.5 μg/100g in fish, and 24.1 μg/100g in terrestrial meats; Table 2A–D).

  As with the long-chain omega-3 fatty acids EPA and DHA, higher levels of mineral elements were observed in small pelagic fish species (includes European anchovy, Atlantic and Pacific herring, Atlantic mackerel and Spanish mackerel), compared to other fish species, including calcium (average of 75 mg/100g), iron (average of 1.8 mg/100g), magnesium (average of 45 mg/100g), potassium (average of 362 mg/100g), zinc (average of 0.97 mg/100g), copper (average of 0.11 mg/100g), manganese (0.04 mg/100g), and selenium (mean 38.4 μg/100g; Table 2D). In addition to the mineral elements listed in Table 2A–D, aquatic animal food products are also rich dietary sources of other important essential trace elements that are generally lacking in terrestrial meat products, including iodine (<1 to 700, average of 84.7 μg/100g of 20 fish and shellfish products; Solhelm, 2010; Eckhoff and Maage, 1997), fluorine (Malde et al., 2007; Tóth and Sugár, 1978), and trivalent chromium (Kumpulainen, 1992).

- Aquatic animal food products are a richer source of several key water soluble and fat soluble vitamins than most terrestrial meats (Solhelm, 2010), including:
  - Vitamin A (average of 263.7 IU/100g in fish, 151.0 IU/100g in molluscs, 69.8 IU/100g in crustaceans, and 21.8 IU/100g in terrestrial meats).
  - Vitamin C (average of 4.0 mg/100g in molluscs, 1.6 mg/100g in crustaceans, 0.8 mg/100g in fish, and 0.1 mg/100g in terrestrial meats).
  - Vitamin B12 (average of 10.0 μg/100g in molluscs, 5.1 μg/100g in crustaceans, 3.3 μg/100g in fish, and 1.1 μg/100g in terrestrial meats).
  - Folic acid (average of 29.3 μg/100g in crustaceans, 15.0 μg/100g in molluscs, 10.0 μg/100g in fish, and 6.4 μg/100g in terrestrial meats).
  - Vitamin E (average of 1.1 mg/100g in fish and crustaceans, 0.80 mg/100g in molluscs, and 0.21 mg/100g in terrestrial meats).
  - Vitamin D (average of 44.9 IU/100g in fish, and 15.7 IU/100g in terrestrial meats).
  - Choline (average of 75.6 mg/100g in crustaceans, 68.6 mg/100g in fish, 65.0 mg/100g in molluscs, and 41.1 mg/100g in terrestrial meats; Table 2A–D).

  As with the omega-3 fatty acids and minerals, higher vitamin levels were observed in small pelagic fish species (includes European anchovy, Atlantic and Pacific herring and Atlantic mackerel), compared to other fish species, including riboflavin (average of 0.25 mg/100g), niacin (7.13 mg/100g), vitamin B_{12} (8.25 μg/100g, vitamin A (104 IU/100g), and vitamin D (405 IU/100g; Table 2D).

Last, but not least, edible aquatic plants or seaweeds also play an important role as a valuable source of essential nutrients in global food supply, including:

- Depending upon the species, season, and or culture conditions, edible seaweeds may contain considerable amounts of protein, with the red seaweeds such as *Porphyra* spp. (Nori) usually having the highest levels of protein (up to 47% on a dry weight basis), followed by green seaweeds such as *Enteromorpha lactuca* (former *Ulva*; sea lettuce) with protein levels ranging between 10 to 25%, and lastly by brown seaweeds such as *Laminaria japonica* with the lowest protein levels of between 5 and 12%, on a dry weight basis (Fleurence et al., 2012; MacArtain et al., 2007) According to MacArtain et al. (2007), aspartic acid and glutamic acids constitute a large part of the amino acid make-up of edible seaweed proteins, with these amino acids being highest within brown seaweed proteins. Moreover, edible seaweeds such *Palmaria palmata (*Dillisk/Dulse) and *Enteromorpha* spp. (sea lettuce) are good sources of essential amino acids such as histidine, leucine, isoleucine, methionine and valine, with the levels of isoleucine and threonine in *Palmaria palmata* being similar to the levels found in legumes, and histidine levels is in *Enteromorpha pertusa* being similar to the levels found in egg proteins (Fleurence et al., 2012; MacArtain et al., 2007).

- Although the lipid fraction of marine edible seaweeds is usually low (typically ranging between 1.5 and 3.5%, on a dry weight basis), the lipids present are rich in omega-3 polyunsaturated fatty acids, and in particular EPA and to a lesser extent DHA, which are important to human health (Fleurence et al., 2012; MacArtain et al., 2007; Norziah and Ching, 2000).
- Edible seaweeds are a good source of dietary fiber (range 3.4 to 9.8, mean 5.76 g/100g), including insoluble fiber (range 0.5 to 2.3, mean 1.47 g/100g) and soluble fiber (range 2.1 to 7.7, mean 4.31 g/100g fresh weight basis; MacArtain et al. 2007). The main component of the fiber component in marine seaweeds are xylans, alginates, carageenans and/or agar (Fleurence et al., 2012).
- Edible seaweeds are a rich dietary source of biologically available minerals and trace elements (compared with most other terrestrial plant food sources), including (mg/100g wet weight): iodine 1.3 to 97.9, mean 24.43 mg/100g; iron 3.9 to 45.6, mean 14.61 mg/100g; zinc 0.3 to 1.7, mean 0.96 mg/100g; copper 0.1 to 0.8, mean 0.27 mg/100g; magnesium 78.7 to 573.8, mean 277.45 mg/100g; potassium 62.4 to 2,013.2, mean 787.5 mg/100g; and calcium 30 to 575.0, mean 229.7 mg/100g wet weight (MacArtain et al., 2007).
- Edible seaweeds are a rich source of many water-soluble and fat soluble vitamins, including vitamin C (range 8.17 to 184.7, mean 97.25 mg/100 dry weight), vitamin E (range 0.36 to 17.4, mean 7.76 mg/100g dry weight), vitamin B_{12} (range 1.64 to 78.7, mean 20.576 g/100g wet weight), thiamin (range 0.14 to 5.04, mean 1.65 mg/100g dry weight), riboflavin (range 0.14 to 11.70, mean 2.89 mg/100g dry weight), niacin (range 0 to 100, mean 55.31 mg/100g dry weight), pyridoxine (range 0.01 to 6.41, mean 2.23 mg/100g dry weight), inositol (range 0.01 to 6.41, mean 1.66 mg/100g dry weight), folic acid (range 0 to 45.6, mean 10.85 mg/100g dry weight; MacArtain et al., 2007).
- Lastly, edible seaweeds may contain a variety of different species specific bioactive chemicals with potential pharmaceutical and health enhancing properties, including bromophenols, phytosterols, photosynthetic pigments, and immune enhancing polysaccharides (Holdt and Kraan, 2011; MacArtain et al., 2007; Michikawa et al., 2012; Norziah and Ching, 2000; Yang et al., 2010).

CONCLUDING REMARKS

On the basis of the nutritional analysis provided, it is clear that aquatic food products represent one of the world's most nutritious and healthy food sources. Moreover, according to the FAO/WHO Joint Expert Consultation on the risks and benefits of fish consumption, there is convincing evidence that:

- Fish consumption reduces the risk of death from coronary heart disease and that fish consumption by women reduces the risk of sub-optimal neurodevelopment in their offspring.
- Fish consumption may reduce the risk of multiple other adverse health outcomes, including ischaemic stroke, non-fatal coronary heart disease events, congestive heart failure, atrial fibrillation, cognitive decline, depression, anxiety and inflammatory diseases.
- Fish consumption may provide a greater nutritional impact than the sum of the health benefits of the individual nutrients consumed separately (FAO/WHO, 2011).

Finally, it is important to mention that small pelagic fish species represent one of the best aquatic animal foods from a nutritional perspective (Table 2). As such, the continued targeted use of these lower-value fish (from a marketing perspective) for reduction into fishmeal and fish oil for animal feed should be minimized, and their direct use as human food should be encouraged and promoted for the benefit of the rural poor and needy (Kawarazuka and Béné, 2011; Tacon and Metian, 2009).

ACKNOWLEDGMENTS

Marc Metian is a Nippon Foundation Senior Nereus Fellow and his research is partially supported by the Nereus Program.

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