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Food Matters: Fish, Income, and Food Supply—A Comparative Analysis

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ABSTRACT

Human health and socio-economic development are intimately tied to food access and food security. In a world capable of producing sufficient food to meet the entire dietary nutrient needs of all its people, income plays a determinant role in dictating who has access to food or not, with under-nutrition and malnutrition still negatively affecting the health and well-being of many of the world's poorest nations. This article attempts to compare the role played by fish and fishery products (whether derived from wild capture fisheries or aquaculture) in the diet of the world's poorest and richest nations. The data show that fish and fishery products play an essential role in human nutrition, constituting the major source of dietary animal protein consumed within the Asian region and within many lower income countries within the African region.

KEYWORDS

Fish; health; nutrition; aquaculture; food security

Why food matters

Hunger and food insecurity remain amongst the most devastating problems facing the world's poor and disadvantaged, and continue to dominate the health and socio-economic development of the world's poorest nations and peoples (FAO, IFAD & WFP, 2015; NRC, 2006; Tacon, 2001). This is perhaps not surprising bearing in mind that 12.7 percent of the world's population live at or below the international poverty line of $1.90 a day (896 million in 2012; World Bank, 2016a) and the growing income inequality within nations, which obscures the true economic reality and hardship of the low-income segment of the population (UNDP, 2015). Sadly, despite the fact that we live in world which produces sufficient food to meet all the dietary nutrient needs of all of its people to live a healthy and active life, this is not the case for those people without the monitory resources or government support to purchase or obtain sufficient food to meet their daily needs. This remains a continuing travesty and violation of the recognized fundamental human right to adequate food and nutrition, and freedom from hunger and malnutrition (Escueta, 2014; Sundaram et al., 2015).

According to the latest estimates from FAO more than 795 million people had chronically inadequate levels of dietary energy intake during 2014–2016 (FAO, IFAD and WFP, 2015). Micronutrient deficiencies or "hidden hunger" is however much more widespread than hunger (which generally only refers to insufficient caloric intake). According to the latest estimates, about 1.6 billion people suffer from anemia and iron deficiency, about 2 billion people suffer from iodine deficiency (including about 285 million school-age children), 190 million pre-school children and 19.1 million pregnant women suffer from vitamin A deficiency, while at the same time more than 1.5 billion people are overweight with half a billion obese, exposing them to greater risk of cardiovascular problems and other diet-related, noncommunicable diseases (Sundaram et al., 2015). The above three nutrients however represent only a small fraction of the 40 or more essential dietary nutrients required by humans to live a healthy and active life (FAO/WHO, 2011; USDA, 2016; WHO, 2003).

Previous articles by the authors have shown the important role played by fish and fishery products[1] as a source of essential dietary nutrients in human nutrition and global food supply (Tacon, 2001; Tacon and Metian, 2009a, 2013). This article attempts to compare the role played by fish and fishery products (whether derived from wild capture fisheries or aquaculture) in the diet of the world's poorest and richest

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[1]Fish and fishery products includes all captured and farmed aquatic food produce, including marine and freshwater fish, crustaceans, molluscs, amphibians, reptiles, miscellaneous invertebrate animals, and aquatic plants or seaweeds.

nations using data from the latest FAO food balance sheets (FAO, 2016a), and also provides guidance on suggested dietary changes for the improved health and well-being.

Why fish matters

Fish and seafood products represent a important component of the human diet, providing about 3.1 billion people with almost 20 percent of their average daily animal protein intake (FAO, 2015, 2016c), and providing the only readily available dietary source of long-chain omega-3 polyunsaturated fatty acids for direct human consumption (including eicosapentaenoic acid or EPA and docosahexaenoic acid or DHA; Joordens et al., 2014; Sargent and Tacon, 1999).

Although wild caught fish and gathered benthic aquatic food products have been an integral part of the human diet of coastal and riverine communities since mankind first roamed earth, increasing fishing pressure and market demand for these highly nutritious aquatic food products (Golden et al., 2016) has been however such that per capita food fish supply from capture fisheries landings has not been able to keep pace with population growth since the mid-eighties (Pauly and Zeller, 2016), with reported total fisheries landings stagnating at between 90 and 95 million tonnes (whole live weight basis) since the mid-eighties (FAO, 2016a; Figure 1). According to the FAO total capture fisheries landings in 2014 supplied 94.6 million tonnes of aquatic products, including 78.3 million tonnes of finfish (82.8% total), 7.7 million tonnes of molluscs (8.1%), 6.9 million tonnes of crustaceans (7.3%), 1.2 million tonnes of aquatic plants (1.3%), 0.64 million tonnes of miscellaneous invertebrate aquatic animals (0.7%), and 3 thousand tonnes of amphibians and reptiles (0.003%), of which only 72.5 million tonnes or about 77.6% of total captured fish and shellfish production in 2014 was destined for direct human consumption (FAO, 2016a; Figure 1).

In marked contrast to capture fisheries, aquaculture (the farming of aquatic animals and plants) continues to be the fastest growing food sector globally, with the sector growing at an average annual rate of 8 percent per year over the past 30 years, reaching a new high of 101.1 million tonnes in 2014 (surpassing that of total capture fisheries landings; Figure 1), including 49.9 million tonnes of finfish (49.3% total), 27.3 million tonnes of aquatic plants (27.0%), 16.2 million tonnes of molluscs (16.0%), 6.9 million tonnes of crustaceans (6.8%), 0.4 million tonnes of miscellaneous invertebrate aquatic animals (0.4%), and 0.48 million tonnes of amphibians and reptiles (0.5%; FAO, 2016a).

An important aspect often neglected is the parallel trends of total capture fisheries landings and global aquaculture production with non-food uses and the consumable part of the resources, respectively (Stefania Vannuccini, FAO, personal communication; FAO, 2016a). Figure 1 highlights how these values are intimately connected. Although the latest FAO country food balance sheets (FAO, 2016b) do not currently distinguish

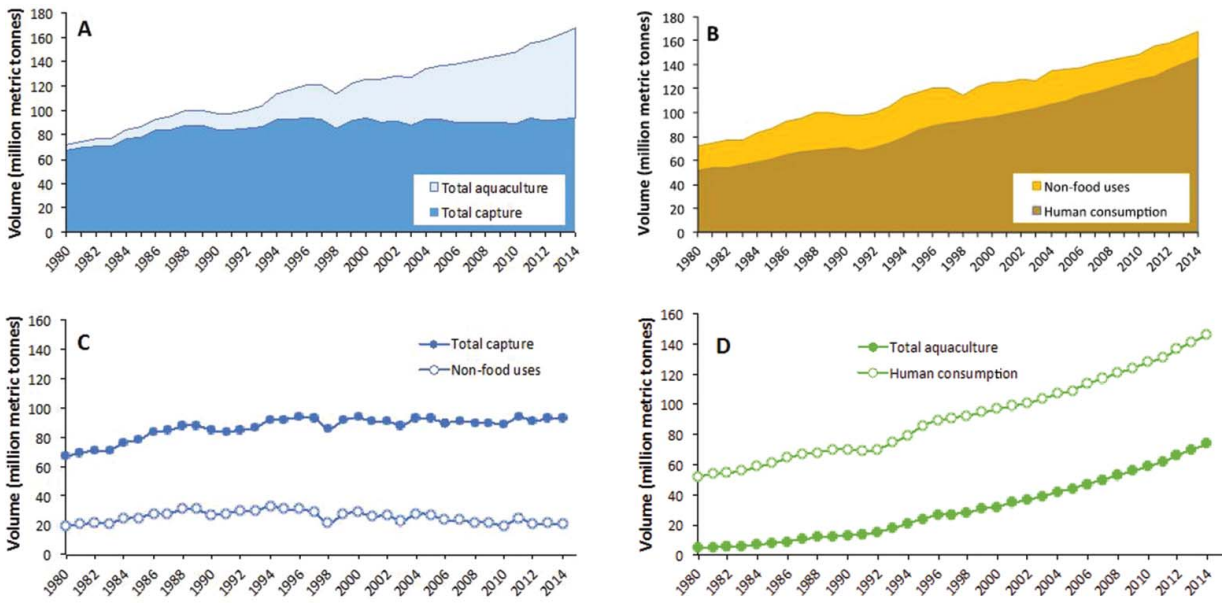

Figure 1. World fish and fishery products: (A) Global production from capture fisheries and aquaculture; (B) Global production represent by food and nonfood disposition; (C) Trends of capture fisheries landings with non-food uses of the global production; and (D) Trends of Aquaculture production with Human food uses of the global production (Stefania Vannuccini, FAO, personal communication; FAO, 2016a).

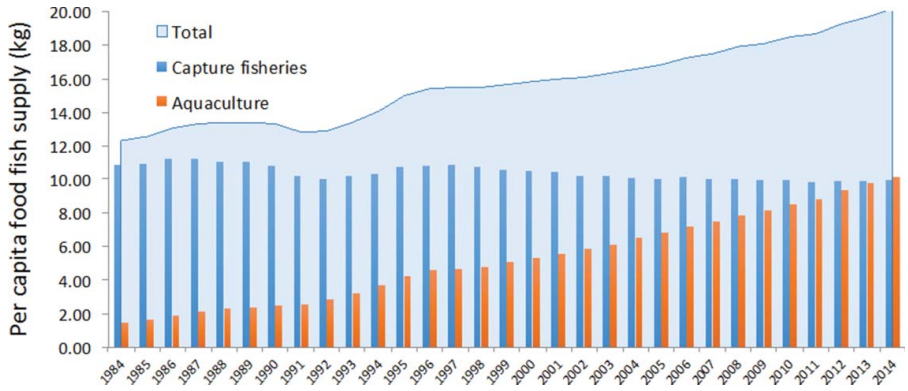

Figure 2. Trends of average per cap supply for fish issued from capture fisheries and aquaculture Stefania Vannuccini, FAO, personal communication; FAO, 2016a; 2016d).

between capture fisheries and aquaculture in terms of aquatic food supply at the country level, the increasing role played by farmed aquatic food products toward global fish and seafood supply is clearly evident (Figure 2). Despite the lack of separation between capture fisheries and aquaculture within the current FAO food balance sheets, some important observations can nevertheless be made concerning the role played by aquatic food and aquatic feed products in food supply, depending upon the per capita gross national income (GNI) of the country and its geographic location.

For the purposes of this analysis, countries have been divided into four major economic groupings according to their GNI (Table 1), namely low-income economies with a GNI per capita (calculated using the World Bank Atlas method) of $1,025 or less in 2015, lower middle-income economies with a GNI per capita between $1,026 and $4,035, upper middle-income economies with a GNI per capita between $4,036 and $12,475, and high-income economies with a GNI per capita of $12,476 or more (World Bank, 2016b).

Fish production by gross national income groupings

Table 2 shows the contribution of capture fisheries and aquaculture to total fish production within the four major country economic groupings, and these included 80 high-income economies, 55 upper middle-income economies, 52 lower middle-income economies, and 31 low-income economies. For ease of analysis, the data has been presented as total aquaculture production or total capture fisheries landings, and includes finfish, crustaceans, molluscs, amphibians and reptiles, miscellaneous invertebrate animals, and aquatic plants. Figure 2 then provides more specific details related to freshwater finfish, marine finfish, and diadromous finfish. All values are presented on a whole live weight equivalent basis.

From the data shown in Tables 1 and 2 and Figures 3 and 4 some general observations can be made:

- African countries currently dominate the low-income economic grouping, with 27 of the total 31 low-income countries listed.
- Land-locked countries represented 14 of the 31 listed low-income countries.
- Although capture fisheries landed more finfish (77.9 million tonnes) than aquaculture (49.9 million tonnes) in 2014, capture fisheries landings have not increased above 2000 levels (78.7 million tonnes), whereas finfish production from aquaculture has doubled over the same period.
- At a global level, 86.5% of captured finfish landings were marine and diadromous fish species in 2014 (67.4 million tonnes), compared with only 14.5% for aquaculture (2.4 million tonnes).
- At a global level, 85.5% of finfish produced through aquaculture were freshwater fish species in 2014 (42.6 million tonnes), compared with 13.5% from capture fisheries (10.5 million tonnes).
- Capture fisheries finfish landings within lower middle income countries have consistently increased since 1984 whereas finfish landings within high-income and upper-middle income countries have declined by 35.5% and 17.3% since 1984 and 2000, respectively. This decrease has been primarily due to over-fishing within these countries.
- As with capture fisheries, aquaculture finfish production within high-income countries is currently dominated by the production of higher-value (in marketing terms) marine and diadromous fish species (Tacon et al., 2010; 3.6 million tonnes or 90.8% of fish production within these countries in 2014).
- In contrast to other regions, capture finfish landings within low-income countries are currently dominated by freshwater fish species (1.7 million tonnes or 64.3% of fish production within these countries

Table 1. Economic classification according to per capita Gross National Income in 2015 (World Bank, 2016b).

High-income economies (GNI > $12,476)			Upper-middle income economies ($4,036 < GNI < $12,475)		Lower-middle income economies $1,026 < GNI < $4,035		Low-income economies (GNI < $1,025)
Andora*	Guam	Seychelles	Albania	Macedonia FYR*	Armenia	Pakistan	Afghanistan*
Antigua & Barbuda	Hong Kong SAR	Singapore	Algeria	Malaysia	Bangladesh	Papua New Guinea	Benin
Argentina	Hungary*	Sint Maarten (Dutch)	American Samoa	Maldives	Bhutan*	Philippines	Burkina Faso*
Aruba	Iceland	Slovak Republic*	Angola	Marshall Islands	Bolivia*	Samoa	Burundi*
Australia	Ireland	Slovenia	Azerbaijan*	Mauritius	Cabo Verde	São Tomé & Principe	Central African Republic*
Austria*	Isle of Man	Spain	Belarus*	Mexico	Cambodia	Soloman Islands	Chad*
Bahamas, The	Israel	St. Kitts & Nevis	Belize	Montenegro	Cameroon	Sri Lanka	Comoros
Bahrain	Italy	St. Martin (French part)	Bosnia & Herzegovina	Namibia	Congo Rep	Sudan	Congo, Dem. Rep.
Barbados	Japan	Sweden	Botswana*	Palau	Côte d'Ivoire	Swaziland*	Eritrea
Belgium	Korea, Republic	Switzerland*	Brazil	Panama	Djibouti	Syrian Arab Republic	Ethiopia*
Bermuda	Kuwait	Taiwan, China	Bulgaria	Paraguay*	Egypt	Tajikistan*	Gambia,The
British Virgin Islands	Latvia	Trinidad & Tobago	China	Peru	El Salvador	Timor Leste	Guinea
Brunei Darussalam	Liechtenstein*	Turks & Caicos Islands	Colombia	Romania	Ghana	Tonga	Guinea-Bissau
Canada	Lithuania	United Arab Emirates	Costa Rica	Russian Federation	Guatemala	Tunisia	Haiti
Cayman Islands	Luxembourg*	United Kingdom	Cuba	Serbia*	Honduras	Ukraine	Korea, DPR
Channel Islands	Macao SAR, China	United States	Dominica	South Africa	India	Uzbekistan*	Liberia
Chile	Malta	Uruguay	Dominican Republic	St. Lucia	Indonesia	Vanatu	Madagascar
Croatia	Monaco	Virgin Islands (U.S.)	Ecuador	St. Vincent/ Grenadines	Kenya	Vietnam	Malawi*
Curacao	Nauru		Equatorial Guinea	Suriname	Kiribati	West Bank and Gaza	Mali*
Cyprus	Netherlands		Fiji	Thailand	Kosovo*	Yemen, Rep.	Mozambique
Czech Republic*	New Caledonia		Gabon	Turkey	Kyrgyz Republic*	Zambia*	Nepal*
Denmark	New Zealand		Georgia	Turkmenistan*	Lao DPR*		Niger*
Estonia	Northern Mariana Island		Grenada	Tuvalu	Lesotho*		Rwanda*
Faroe Islands	Norway		Guyana	Venezuela RB	Mauritania		Senegal
Finland	Oman		Iran, Islamic Republic		Micronesia Fed. States		Sierra Leone
France	Poland		Iraq		Moldova*		Somalia
French Polynesia	Portugal		Jamaica		Mongolia*		South Sudan*
Germany	Puerto Rico		Jordan		Morocco		Tanzania
Gibraltar	Qatar		Kazakhstan*		Myanmar		Togo
Greece	San Marino*		Lebanon		Nicaragua		Uganda*
Greenland	Saudi Arabia		Libya		Nigeria		Zimbabwe*

*Land-locked countries

in 2014). This is perhaps not surprising since 14 of the 31 listed low-income countries are land-locked countries, including 12 countries within the African continent.

Table 3 shows the top twenty countries in terms of reported landings from capture fisheries and farmed production from aquaculture, including the growth of the different sectors. From the data presented the following observations can be made:

- China and Indonesia had the highest total reported production from aquaculture (58.8 and 14.4 million tonnes) and from capture fisheries landings (17.4 and 6.5 million tonnes) in 2014, respectively.
- Total aquaculture production in 2014 exceeded total landings from capture fisheries in China (by 239%), Indonesia (by 121%), India (by 3%), Vietnam (by 17%), Bangladesh (by 26%), and Egypt (by 235%).
- Total capture fisheries landings in 2014 exceeded total production from aquaculture in the USA (by 1086%), the Russian Federation (by 2544%), Myanmar (by 325%), Japan (by 268%), Peru (by 2900%), Chile (by 110%), and Norway (by 84%).
- With the exception of the lower-middle income economies (Myanmar, Indonesia, Vietnam, and Bangladesh), total capture fisheries landings have declined in most upper-middle and high-income countries, primarily due to over-fishing.
- In marked contrast to other major aquaculture producing countries, aquaculture production within Japan and the USA has not been able to surpass 2000 levels. This decrease is believed to

Table 2. Contribution of capture fisheries and aquaculture to fish production by major economic grouping (values given in Million tonnes; FAO, 2016a).

	Grouping	Year	Total production	Aquatic plants	Molluscs	Crustaceans	Finfish
Capture fisheries	Global	2014	94.16	1.18	3.54	3.35	77.93
		2000	94.18	1.21	2.91	3.34	78.73
		1984	67.02	0.87	0.82	1.17	58.38
	Low-income	2014	2.67	< 0.01	0.02	0.05	2.60
		2000	1.84	< 0.01	< 0.01	< 0.01	1.77
		1984	1.92	< 0.01	< 0.01	0.03	1.89
	Lower-middle	2014	29.39	0.07	1.23	1.79	26.23
		2000	19.07	0.12	0.82	1.11	16.95
		1984	10.52	0.02	0.46	0.55	9.48
	Upper-middle	2014	35.21	0.30	3.54	3.35	27.55
		2000	40.31	0.29	2.91	3.34	33.32
		1984	15.75	0.08	0.82	1.17	13.60
	High-income	2014	26.94	0.81	2.84	1.60	21.58
		2000	33.02	0.80	3.83	1.51	26.75
		1984	38.87	0.77	3.28	1.21	33.46
Aquaculture	Global	2014	101.00	27.17	16.16	6.91	49.86
		2000	41.67	9.25	9.76	1.69	20.81
		1984	9.89	3.24	2.21	0.21	4.19
	Low-income	2014	0.72	0.46	0.06	0.05	0.19
		2000	0.50	0.40	0.06	< 0.01	0.03
		1984	0.70	0.67	0.02	< 0.01	< 0.01
	Lower-middle	2014	30.13	11.67	3.03	1.85	16.28
		2000	5.84	0.94	0.07	0.49	4.34
		1984	1.67	0.20	0.04	0.09	1.33
	Upper-middle	2014	62.50	13.57	13.77	4.94	29.36
		2000	30.02	6.96	7.84	1.16	13.95
		1984	4.16	1.39	0.71	0.07	1.99
	High-income	2014	7.66	1.46	2.02	0.11	4.03
		2000	5.31	0.95	1.78	0.04	2.49
		1984	3.36	0.98	1.45	0.04	0.86

have been due to the increased market availability of more competitively priced imported seafood and aquaculture produce within these countries.

- Total capture fisheries landings were three times higher within the listed land-locked countries (1,281,091 tonnes) than aquaculture production (408,364 tonnes) in 2014, with the top capture fisheries and aquaculture producer in 2014 being Uganda at 461,196 tonnes and 111,023 tonnes, respectively (FAO, 2016a).

Role of fish in the national food balance sheets of fish and fishery products

According to the latest FAO national food balance sheets of fish and fishery products (preliminary data only being available for 2013; FAO, 2016c), the following observations can be made regarding the role of fish and fishery products at a regional and national country level:

- At a global and regional level, per capita fish supply was 19.7 kg globally and lowest within the Latin America and Caribbean region and African region at 10.0 kg and 9.9 kg, respectively. By contrast, per capita fish supply was highest within most small island states and Oceania at 24.8 kg, followed by the Asian region at 23.1 kg, Europe at 21.9 kg and North America at 21.7 kg.
- As expected, land-locked countries had the lowest per capita fish supply of only 6.5 kg (mean of 40 countries listed in Table 1), with fish contributing 9.1% of total animal protein supply.
- Similarly, by economic country grouping the low-income countries had the lowest per capita fish supply of 7.9 kg (mean of 31 countries), followed by lower-middle income countries at 16.5 kg (mean of 51 countries), upper-middle income countries at 18.7 kg (mean of 55 countries) and high-income countries at 30.3 kg (mean 69 countries.
- The reverse was however true in terms with the contribution of fish to total animal protein supply, with the highest being reported for low-income countries at 21.6%, followed by lower-middle income countries at 20.7%, high-income countries at 15.1%, and upper-middle income countries at 13.4%.
- Figure 5 shows nevertheless that these opposite trends of average values for per capita fish supply and for fish contribution to total animal protein supply are true although within each economic country grouping, there is a large variability as it can been seen with large standard deviations and the box-plot analyses. However, median values

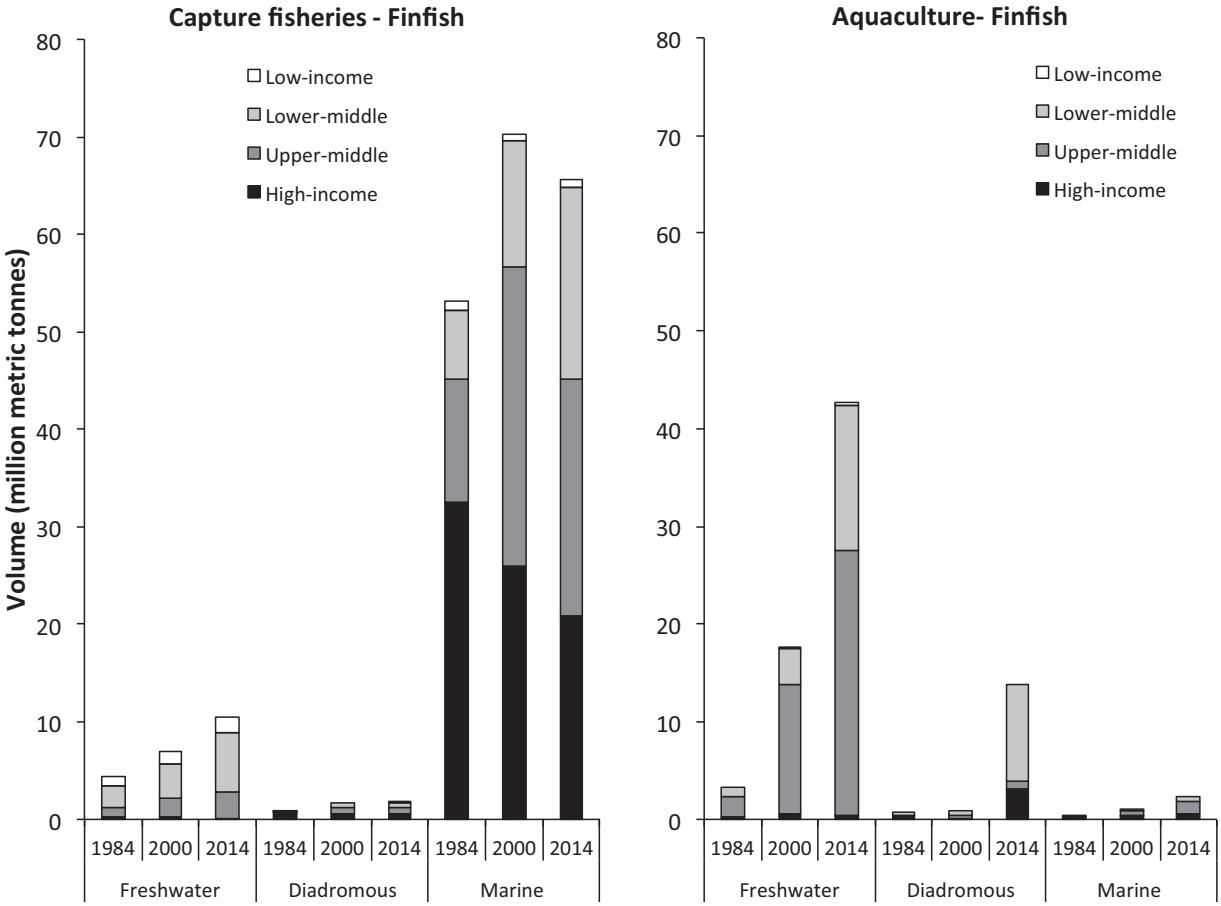

Figure 3. Finfish production by 4 Gross National Income groupings (low, lower-middle, upper-middle, and higher income) for 1984, 2000, and 2014 from capture fisheries and aquaculture (FAO, 2016; World Bank, 2016b).

roughly confirm the 2 following preliminary statements "high income lower per cap supply – higher contribution of fish to total animal protein supply" and "Low-income – higher per cap supply – lower contribution of fish to total animal protein supply."

- Table 4 shows the top 10 countries in terms of per capita fish supply (kg) and contribution of fish to total animal protein supply (%) in 2013. Mainly countries within upper-middle income group and high-income group are in this per capita fish supply

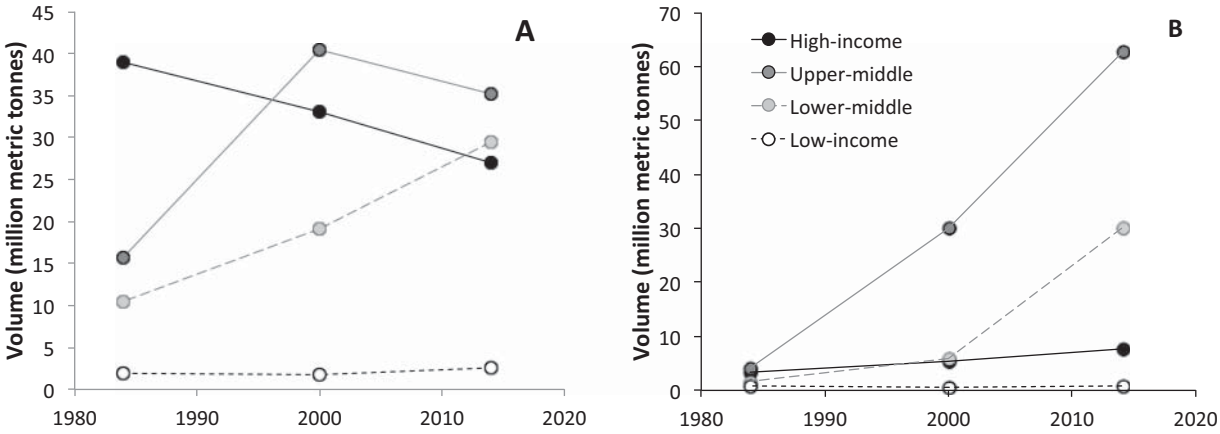

Figure 4. Global fisheries and aquaculture production by 4 Gross National Income groupings (low, lower-middle, upper-middle and higher income) for 1984, 2000, and 2014. (A) Global production from capture fisheries; (B) Global production from aquaculture (FAO, 2016; World Bank, 2016b).

Table 3. Top twenty countries in terms of capture fisheries landings and aquaculture in 2014 (values given in million tonnes; FAO, 2016a).

Capture Fisheries	GNI Grouping	2014	2000	1984	APR	Aquaculture	GNI Grouping	2014	2000	1984	APR
China	Upper-middle	17.35	14.82	3.94	0.5	China	Upper-middle	58.80	28.46	28.46	5.3
Indonesia	Lower-middle	6.51	4.16	1.98	1.3	Indonesia	Lower-middle	14.37	0.99	0.99	21.0
USA	High-income	4.98	4.76	4.72	0.1	India	Lower-middle	4.88	1.94	1.94	6.8
India	Lower-middle	4.72	3.73	2.30	0.7	Viet Nam	Lower-middle	3.41	0.51	0.51	14.5
Russian Fed	Upper-middle	4.23	4.03	–	0.1	Philippines	Upper-middle	2.34	1.10	1.10	5.5
Myanmar	Lower-middle	4.08	1.09	0.61	4.0	Bangladesh	Lower-middle	1.96	0.66	0.66	8.1
Japan	High-income	3.75	5.19	11.59	−0.9	Korea Rep.	High-income	1.57	0.67	0.67	6.8
Peru	Upper-middle	3.60	10.61	3.32	−3.1	Norway	High-income	1.33	0.49	0.49	7.4
Viet Nam	Lower-middle	2.92	1.63	0.66	1.7	Chile	High-income	1.23	0.42	0.42	7.9
Chile	High-income	2.59	4.55	4.66	−1.6	Egypt	Lower-middle	1.14	0.34	0.34	9.0
Norway	High-income	2.45	2.89	2.58	−0.5	Japan	High-income	1.02	1.29	1.29	−1.7
Philippines	Lower-middle	2.35	1.90	1.60	0.6	Myanmar	Lower-middle	0.96	0.10	0.10	17.7
Thailand	Upper-middle	1.77	3.00	2.03	−1.5	Thailand	Upper-middle	0.93	0.74	0.74	1.7
Korea Rep.	High-income	1.74	1.84	2.23	−0.2	Brazil	Upper-middle	0.56	0.17	0.17	8.8
Bangladesh	Lower-middle	1.59	1.00	0.63	1.4	Malaysia	Upper-middle	0.52	0.17	0.17	8.4
Mexico	Upper-middle	1.53	1.35	1.13	0.4	Korea DPR	Low-income	0.51	0.47	0.47	0.6
Malaysia	Upper-middle	1.47	1.29	0.74	0.4	USA	High-income	0.42	0.46	0.46	−0.5
Morocco	Lower-middle	1.37	0.91	0.47	1.2	Ecuador	Upper-middle	0.37	0.06	0.06	13.7
Spain	High-income	1.11	1.07	1.19	0.1	Taiwan	High-income	0.34	0.26	0.26	2.0
Iceland	High-income	1.09	2.00	1.55	−1.8	Iran	Upper-middle	0.32	0.04	0.04	15.9

APR = Average Percentage Rate. GNI = Gross National Income. Each grouping has a color code for visual purpose. High-income grouping = blue, upper-middle income grouping = green, lower-middle income grouping = orange, and low-income grouping = red.

list (8 out of 10) whereas countries within Lower-middle income and Low-income groups are more listed in the Top 10 contribution of fish to total animal protein supply.

- Maldives population has a great access to fish and fisheries products with a per cap supply of 157.8 kg.
- Fish represented 16.8% of total animal protein supply at the global level in 2013, with the contribution being highest within the Asian region at 22.9% and the African region at 18.1%, and lowest within the Latin America & the Caribbean region at 6.7%, followed by the North American region at 7.5%, Oceania at 10.4% and Europe at 11.4%.
- Of particular note is the fact that despite the low per capita consumption of fish within the African region, fish represents the main source of animal protein and other essential nutrients within many low-income and lower-middle income African countries, including Sierra Leone 65.0%, Ghana 49.8%, São Tomé & Principe 48.8%, Senegal 42.5%, Comoros 41.3%, Mozambique 38.7%, Nigeria 38.2%, Congo Democratic Republic 37.8%, Togo 36.9%, Congo Republic 36.7%, Côte d'Ivoire 34.7%, Cameroon 33.8%, Uganda 31.7%, Burundi 28.1%, Guinea 26.8%, Benin 24.6%, Malawi 24.4%, Egypt 24.0%, Rwanda 22.6%, and Morocco 22.2% (FAO, 2016c).
- By contrast, despite the high per capita supply of fish within most European and North American higher-income countries (includes Belgium 25.1 kg, Canada 22.6 kg, Denmark 23.2 kg, France 33.5 kg, Greece 19.3 kg, Ireland 22.0 kg, Israel 23.2 kg, Italy 25.5 kg, Luxembourg 33.9 kg, Netherlands 22.3 kg, Sweden 30.7 kg, UK 20.8 kg and USA 21.5 kg), fish represents a minor source of animal protein in these countries (including Belgium 11.2%, Canada 10.4, Denmark 12.7%, France 13.1%, Greece 8.9%, Ireland 8.0%, Israel 8.5%, Italy 11.9%, Luxembourg 11.5%, Netherlands 9.8%, Sweden 11.7%, UK 9.5%, and USA 7.3%; FAO, 2016c).
- Fish consumption was generally highest within the Asian region (major countries including Myanmar 60.7 kg, Malaysia 54.0 kg, Korea Rep. 53.5 kg, Japan 48.9 kg, Brunei Darussalam 47.0 kg, Cambodia 41.4 kg, China 37.9 kg, Vietnam 34.8 kg, Indonesia 31.8 kg, Philippines 30.2 kg, Sri Lanka 30.1kg, Bangladesh 21.2 kg, Lao DPR 19.8 kg), with fish also generally representing the major source of animal

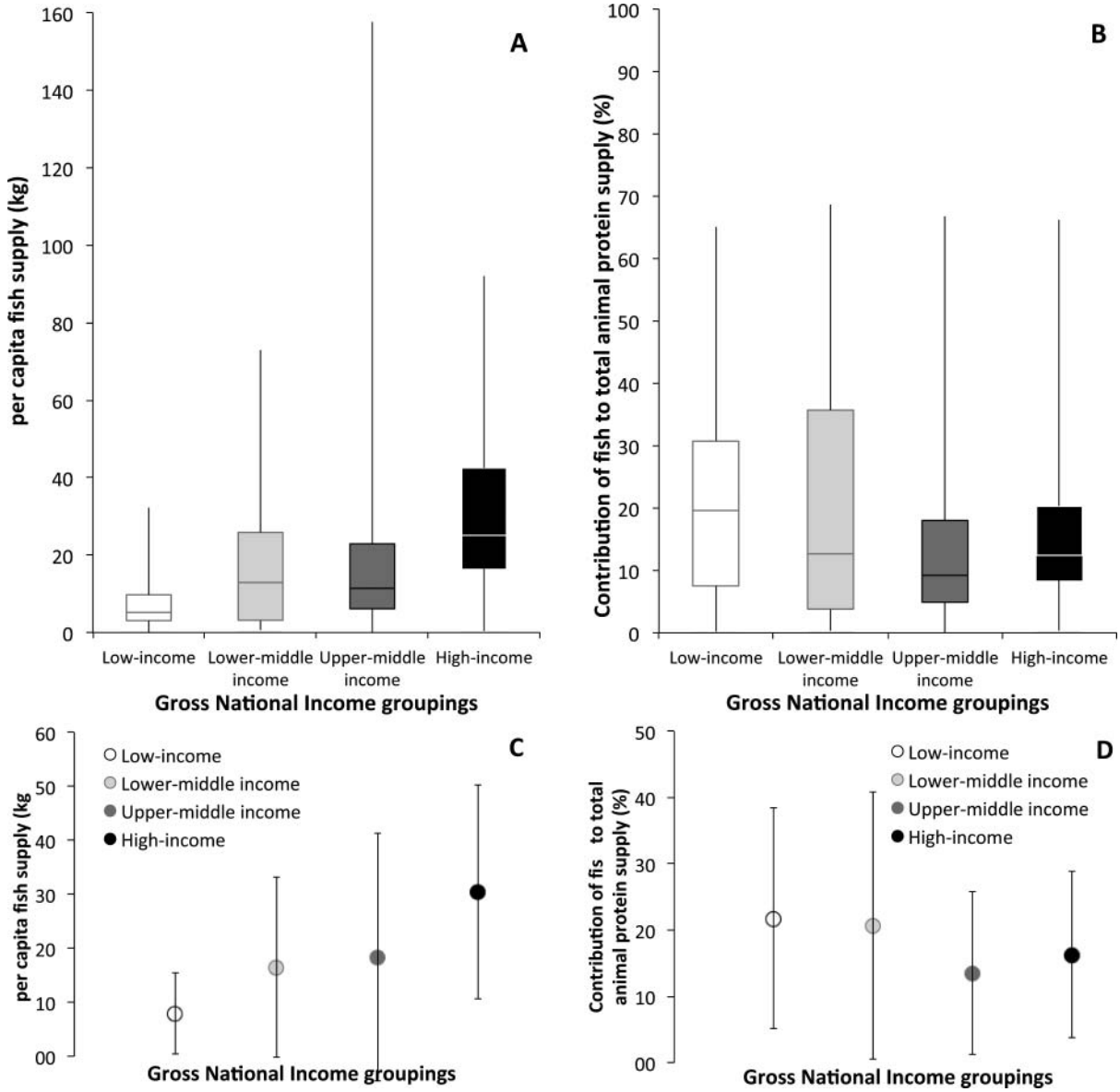

Figure 5. Fish consumption by 4 Gross National Income groupings (low, lower-middle, upper-middle and higher income) (FAO, 2016; World Bank, 2016b). (A) Boxplots analyses (median values with 1st and 3rd quartiles and range) for per capita fish supply (kg). (B) Boxplots analyses (median values with 1st and 3rd quartiles and range) for contribution of fish to total animal protein supply (%). (C) Average values of per capita fish supply (kg; mean ± standard deviation). (D) Average values of contribution of fish to total animal protein supply (%; mean ± standard deviation).

protein consumed (including Cambodia 68.6%, Bangladesh 56.3%, Indonesia 55.2%, Sri Lanka 54.2%, Lao DPR 40.5%, Korea Rep./Malaysia 37.7%, Japan 36.3%, Philippines 36.0%, Vietnam 29.0%, China 22.4%, Brunei Darussalam 20.5%).

- The top fish consumers (in terms of per capita fish supply) within the European region included Iceland 92.0 kg, Portugal 53.8 kg, Norway 52.1 kg, Lithuania 43.9 kg, Spain 42.4 kg and Finland 36.4 kg, France 33.5 kg, and Sweden 30.7 kg, with fish playing an important to total animal protein supply in Iceland 27.8%, Norway 22.2%, Portugal 20.2%, Lithuania 22.5% and Spain 19.8%, and to a lesser extent Finland 14.2%, France 13.1%, Sweden 11.7%; FAO, 2016c).
- Apart from the African region, the lowest fish consumers (in terms of per capita fish supply) were within the Latin America and Caribbean region, and included Guatemala 1.3 kg, Bolivia 2.2 kg, Paraguay 3.7 kg, Honduras 4.0 kg, Haiti/Nicaragua 4.8 kg, Cuba 5.5 kg, Colombia 6.5 kg, Uruguay 7.5 kg, Venezuela RB 7.8 kg, Ecuador 8.2 kg, Dominican Republic 8.1 kg, Brazil/Belize 9.7 kg, and to a lesser extent Costa Rica 12.9 kg, Panama

Table 4. Top 10 countries in terms of for per capita fish supply (kg) and contribution of fish to total animal protein supply (%) in 2013.

Per capita fish supply (kg)			Contribution of fish to total animal protein supply (%)		
	GNI Grouping	2013		GNI Grouping	2013
Maldives	Upper-middle income	157.8	Cambodia	Lower-middle income	68.6
Iceland	High-income	92.0	Marshall Islands	Upper-middle income	66.8
Faroe Islands	High-income	87.3	British Virgin Islands	High-income	66.2
Greenland	High-income	86.9	Sierra Leone	Low-income	65.0
Kiribati	Lower-middle income	72.9	Kiribati	Lower-middle income	62,5
Hong Kong SAR	High-income	65.5	Solomon Islands	Lower-middle income	59,2
Myanmar	Lower-middle income	60.7	Gambia	Low-income	57,4
Seychelles	High-income	58.7	Bangladesh	Lower-middle income	56,3
Palau	Upper-middle income	57.6	Indonesia	Lower-middle income	55,2
Macao SAR, China	High-income	54.6	Sri Lanka	Lower-middle income	54,2

GNI = Gross National Income. Each grouping has a color code for visual purpose. High-income grouping = blue, upper-middle income grouping = green, lower-middle income grouping = orange, and low-income grouping = red.

13.0 kg, Chile 13.2 kg, Suriname 16.5 kg, Peru 22.0 kg kg, and Guyana 31.1 kg.

Role of fish and other food products in total food supply

On the basis of the latest complete nutritional data set for the FAO Food Balance Sheets (for 2013; FAO, 2016d) the role of fish and other major food items in total food supply is summarized at the global and regional level in Table 5 and nationally within key countries in Table 6.

From the data presented, the following observations can be made:

- At the global level fish and seafood products constitute the third major source of dietary protein consumed by humans after cereals and milk, representing 6.4% of total protein supply (19.8% of total animal protein supply), 1.4% of total fat supply, and 1.2% of total calorie supply.
- Within the Asian region, fish and seafood products were the third major source of dietary protein consumed after cereals and vegetables, representing 7.5% of total protein supply (21.9% of total animal protein supply), 1.7% of total fat supply, and 1.3% of total calorie supply.
- Within the African region, fish and seafood products were the fifth major source of dietary protein consumed after cereals, pulses, milk and starchy roots, representing 4.5% of total protein supply (19.3% of total animal protein supply), 1.3% of total fat supply, and 0.76% of total calorie supply.
- Within the European region, fish and seafood products were the fifth major source of dietary protein consumed after cereals, milk, pig meat, and poultry meat, representing 6.4% of total protein supply (11.3% of total animal protein supply), 1.6% of total fat supply, and 1.4% of total calorie supply.
- Within the South American region, fish and seafood products were the seventh major source of dietary protein consumed after cereals, bovine meat, poultry meat, milk, pulses, and pig meat, representing 3.3% of total protein supply (6.0% of total animal protein supply), 0.6% of total fat supply, and 0.6% of total calorie supply.
- Within the North American region, fish and seafood products were the sixth major source of dietary protein consumed after cereals, milk, poultry meat, bovine meat, and pig meat, representing 4.7% of total protein supply (7.5% of total animal protein supply), 0.8% of total fat supply, and 1.0% of total calorie supply.
- Within the Oceania region, fish and seafood products were the fifth major source of dietary protein consumed after cereals, milk, poultry meat, and bovine meat, representing 6.7% of total protein supply (10.2% of total animal protein supply), 1.2% of total fat supply, and 1.4% of total calorie supply.
- Within Low-income Food Deficit Countries (LIFDCs), fish and seafood products were the sixth major source of dietary protein consumed after cereals, milk, pulses, vegetables, and starchy roots, representing 3.5% of total protein supply (17.1% of total animal protein supply), 0.9% of total fat supply, and 0.5% of total calorie supply.
- Within Malawi fish and seafood products were the fifth major source of dietary protein consumed after cereals, pulses, starchy roots, and oilcrops, representing 3.4% of total protein supply (28.0% of total

Table 5. Top dietary protein and fat sources by geographic region according to the FAO Food Balance Sheets in 2013 (FAO, 2016d).

	World		Africa		Asia		Europe		South America		North America
Calories (kcal/d)	2884		2624		2779		3367		3027		3663
Protein (g/d)	81.23		69.1		77.57		102.06		86.09		109.13
	Cereals	31.8	Cereals	33.76	Cereals	33.22	Cereals	30.10	Cereals	23.34	Cereals	23.96
	Milk	8.22	Pulses	7.20	Vegetables	6.40	Milk	19.05	Bovine meat	12.62	Milk	21.02
	Fish & seafood	5.22	Milk	4.30	Fish & seafood	5.84	Pig meat	9.60	Poultry meat	12.13	Poultry meat	17.46
	Poultry meat	5.16	Starchy roots	4.12	Milk	5.83	Poultry meat	8.89	Milk	11.63	Bovine meat	12.17
	Vegetables	4.91	Fish & seafood	3.10	Pulses	4.74	Fish & seafood	6.55	Pulses	6.45	Pig meat	7.29
	Pig meat	4.65	Oilcrops	2.87	Pig meat	4.73	Bovine meat	5.77	Pig meat	3.15	Fish & seafood	5.14
	Pulses	4.23	Bovine meat	2.52	Oilcrops	3.35	Eggs	3.96	Fish & seafood	2.82	Eggs	4.23
	Bovine meat	3.54	Poultry meat	2.40	Poultry meat	3.27	Vegetables	3.59	Eggs	2.53	Vegetables	3.17
	Oilcrops	2.87	Vegetables	2.23	Eggs	2.92	Starchy roots	3.49	Starchy roots	2.32	Oilcrops	2.92
	Starchy roots	2.27	Fruit	1.23	Bovine meat	1.67	Pulses	1.54	Oilcrops	1.99	Starchy roots	2.47
Fat (g/d)	82.76		54.46		72.66		128.96		101.27		160.10
	Vegetable oils	30.69	Vegetable oils	23.55	Vegetable oils	24.34	Vegetable oils	48.14	Vegetable oils	41.70	Vegetable oils	76.43
	Pig meat	11.58	Cereals	8.28	Pig meat	13.91	Animal fats	18.47	Milk	11.76	Milk	21.12
	Milk	7.47	Oilcrops	5.02	Cereals	5.78	Milk	17.86	Poultry meat	11.27	Poultry meat	12.93
	Animal fats	6.82	Milk	4.08	Animal fats	5.48	Pig fat	16.09	Bovine meat	10.18	Animal fats	12.68
	Cereals	5.83	Bovine meat	2.39	Oilcrops	4.83	Poultry meat	4.98	Pig meat	6.93	Pig meat	9.88
	Oilcrops	4.46	Animal fat	1.86	Milk	4.80	Cereals	4.25	Animal fats	6.37	Oilcrops	5.76
	Poultry meat	4.07	Poultry meat	1.51	Poultry meat	2.87	Bovine meat	4.10	Cereals	3.31	Bovine meat	5.26
	Bovine meat	2.71	Pig meat	1.32	Eggs	2.67	Eggs	3.52	Oilcrops	3.19	Eggs	3.87
	Eggs	2.53	Mutton & goat	1.04	Bovine meat	1.60	Tree nuts	2.23	Eggs	2.23	Cereals	3.60
	Fish & seafood	1.18	Tree nuts	0.87	Fish & seafood	1.21	Oilcrops	2.13	Fruits	0.89	Fish & seafood	1.35
			Fish & seafood	0.71			Fish & seafood	2.01	Fish & seafood	0.65		

Major food groups listed within the FAO Food Balance Sheets: Cereals (includes wheat, rice (paddy), barley, maize, rye, oats, millet, sorghum, other cereals); Oilcrops (primary, includes soybeans, groundnuts, sunflower seed, rapeseed & mustard seed, cotton seed, coconuts (including copra), sesame seed, palm kernels, olives, other oilcrops); Pulses (includes beans, peas, other pulses); Vegetable oils (secondary, includes soybean oil, groundnut oil, sunflower-seed oil, rape & mustard oil, cottonseed oil, palm kernel oil, palm oil, copra oil, sesame-seed oil, olive oil, rice bran oil, maize germ oil, other oilcrops); Starchy roots (includes potatoes, sweet potatoes, cassava, yams, other roots); Sugar crops (includes sugar cane, sugar beet); Sugar & sweeteners (includes non-centrifugal, sugar (raw equivalent), honey, other sweetners); Tree nuts (includes cashew nuts, chestnuts, almonds, pistachio, walnuts); Vegetables (includes tomatoes, onions, other vegetables); Fruit (includes oranges, mandarins, lemons, limes, grapefruit, other citrus, bananas, plantains, apples, pineapples, dates, grapes, other fruit); Animal meat (bovine meat, mutton & goat meat, pig meat, poultry meat, other meat); Offals (includes edible offals); Milk (excluding butter, includes cow milk, sheep milk, goat milk); Eggs (includes hen eggs, other eggs); Animal fats (includes butter ghee, cream, raw animal fats, fish body oil, fish liver oil); Fish and seafood (includes freshwater fish, diadromous fish, marine fish, pelagic fish, other marine fish, crustaceans, cephlapods, other molluscs, other aquatic animals);

Table 6. Top dietary protein and fat sources by selected region and countries according to the FAO Food Balance Sheets in 2013 (FAO, 2016d).

	Oceania		China		USA		Japan		Indonesia		India
Calories (kcal/d)	3216		3108		3682		2726		2777		2459
Protein (g/d)	101.58		98.04		109.6		87.73		62.18		60.25
Cereals	21.73	Cereals	33.59	Cereals	23.7	Cereals	22.26	Cereals	35.39	Cereals	32.33
Milk	17.01	Vegetables	12.80	Milk	21.94	Fish & seafood	17.50	Fish & seafood	9.33	Milk	8.17
Poultry meat	14.86	Pig meat	11.62	Poultry meat	17.94	Oilcrops	8.39	Oilcrops	3.80	Pulses	8.07
Bovine meat	11.45	Fish & seafood	8.39	Bovine meat	12.28	Milk	7.19	Poultry meat	2.53	Vegetables	3.26
Fish & seafood	6.77	Oilcrops	5.91	Pig meat	7.41	Poultry meat	6.95	Vegetables	1.60	Fish & seafood	1.53
Pig meat	5.35	Eggs	5.85	Fish & seafood	5.08	Eggs	6.02	Eggs	1.54	Oilcrops	1.24
Mutton/goat meat	3.56	Poultry meat	4.45	Eggs	4.27	Pig meat	5.60	Milk	1.32	Starchy roots	1.14
Vegetables	3.28	Milk	3.12	Vegetables	3.15	Vegetables	3.77	Starchy roots	1.12	Fruits	0.85
Starchy roots	2.61	Starchy roots	2.63	Oilcrops	2.81	Bovine meat	3.59	Bovine meat	0.96	Spices	0.82
Eggs	2.48	Bovine meat	1.96	Starchy roots	2.40	Animal fats	3.10	Pig meat	0.91	Eggs	0.76
Fat (g/d)	141.06		95.87		161.54		86.6		57.0		52.25
Vegetable oils	53.12	Pig meat	35.27	Vegetable oils	77.80	Vegetable oils	40.94	Vegetable oils	27.64	Vegetable oils	23.47
Animal fats	17.67	Vegetable oils	20.37	Milk	22.15	Pig fat	7.66	Oilcrops	9.34	Animal fats	7.99
Milk	17.39	Oilcrops	6.35	Poultry meat	13.28	Fish & seafood	5.93	Cereals	6.91	Cereals	5.69
Poultry meat	11.88	Cereals	5.91	Pig meat	10.01	Milk	5.77	Pig meat	2.81	Milk	5.65
Pig meat	9.08	Eggs	5.35	Oilcrops	5.70	Eggs	5.34	Fish & seafood	1.89	Oilcrops	3.83
Oilcrops	5.17	Poultry meat	5.04	Bovine meat	5.26	Oilcrops	4.93	Poultry meat	1.66	Pulses	1.16
Bovine meat	5.05	Animal fats	4.28	Eggs	3.92	Poultry meat	3.83	Eggs	1.41	Eggs	0.69
Treenuts	3.84	Milk	3.25	Cereals	3.63	Cereals	3.32	Bovine meat	1.10	Spices	0.68
Cereals	2.97	Bovine meat	2.25	Treenuts	2.96	Animal fats	3.10	Animal fat	1.02	Treenuts	0.55
Eggs	2.28	Vegetables	2.06	Fish & seafood	1.35	Bovine meats	1.54	Milk	0.70	Vegetables	0.48
Fish & seafood	1.64	Fish & seafood	1.43							Fruit	0.45
										Poultry meat	0.41
										Fish & seafood	0.31

	LIFDC[1]		Malawi		Uganda		Nigeria		Egypt
Calories (kcal/d)	2445		2367		2130		2700		3522
Protein (g/d)	60.82		64.55		52.68		63.76		103.24
Cereals	31.77	Cereals	34.37	Cereals	14.37	Cereals	30.24	Cereals	60.14
Pulses	7.65	Pulses	8.44	Pulses	14.29	Pulses	7.02	Fish & seafood	6.33
Milk	6.07	Starchy roots	6.65	Fish & seafood	3.73	Starchy roots	6.87	Vegetables	5.77
Vegetables	2.61	Oilcrops	4.77	Starchy roots	3.69	Oilcrops	4.56	Milk	5.66
Starchy roots	2.43	Fish & seafood	2.18	Oilcrops	3.31	Fish & seafood	4.19	Poultry meat	5.04
Fish & seafood	2.11	Pig meat	1.57	Milk	3.16	Vegetables	2.29	Bovine meat	4.83
Oilcrops	1.78	Fruit	1.29	Fruit	2.64	Treenuts	1.06	Pulses	4.00
Bovine meat	1.08	Bovine meat	0.94	Bovine meat	2.06	Mutton & goat	1.05	Fruit	2.10
Fruits	0.90	Mutton & goat meat	0.87	Vegetables	0.99	Eggs	0.99	Oilcrops	1.87
Poultry meat	0.75	Milk	0.69	Pulses	0.85	Bovine meat	0.93	Eggs	1.35
Fat (g/d)	49.78		41.2		46.58		56.43		63.13
Vegetable oils	22.46	Cereals	12.87	Vegetable oils	22.2	Vegetable oils	30.92	Vegetable oils	17.08
Cereals	6.28	Vegetable oils	8.54	Oilcrops	6.89	Cereals	8.34	Cereals	15.72
Animal fats	5.05	Oilcrops	6.55	Pig meat	3.68	Oilcrops	5.64	Milk	5.92
Milk	4.76	Pig meat	5.97	Milk	3.55	Treenuts	2.40	Animal fats	5.05
Oilcrops	3.95	Animal fats	1.93	Cereals	3.08	Starchy roots	1.27	Oilcrops	4.71
Bovine meat	1.04	Bovine meat	0.91	Bovine meat	1.98	Pig meat	1.07	Poultry meat	3.77
Pulses	0.90	Milk	0.71	Animal fats	0.98	Animal fats	1.04	Bovine meat	3.35
Pig meat	0.60	Pulses	0.66	Fish & seafood	0.86	Bovine meat	0.90	Fish & seafood	1.43
Eggs	0.60	Starchy roots	0.65	Fruit	0.61	Fish & seafood	0.87	Eggs	1.28
Mutton & goat	0.59	Mutton & goat meat	0.56	Starchy roots	0.48	Eggs	0.80	Mutton/goat meat	0.76
Poultry meat	0.48	Fish & seafood	0.49						
Fish & seafood	0.45	Fruit	0.37						

[1]/LIFDCs – Low Income Food Deficit Countries.

animal protein supply), 01.2% of total fat supply, and 0.6% of total calorie supply.

- Within Uganda fish and seafood products were the third major source of dietary protein consumed after cereals and pulses, representing 7.1% of total protein supply (30.1% of total animal protein supply), 1.8% of total fat supply, and 1.1% of total calorie supply.

- Within Nigeria fish and seafood products were the fifth major source of dietary protein consumed after cereals, pulses, starchy roots, and oilcrops, representing 6.6% of total protein supply (42.5% of total animal protein supply), 1.5% of total fat supply, and 1.0% of total calorie supply.
- Within Egypt fish and seafood products were the second major source of dietary protein consumed after cereals, representing 6.1% of total protein supply (24.0% of total animal protein supply), 2.3% of total fat supply, and 1.1% of total calorie supply.
- Within China fish and seafood products were the fourth major source of dietary protein consumed after cereals, vegetables, and pig meat, representing 8.5% of total protein supply (21.2% of total animal protein supply), 1.5% of total fat supply, and 1.6% of total calorie supply.
- Within India fish and seafood products were the fifth major source of dietary protein consumed after cereals, milk, pulses, and vegetables, representing 2.5% of total protein supply (12.8% of total animal protein supply), 0.6% of total fat supply, and 0.4% of total calorie supply.
- Within Indonesia fish and seafood products were the second major source of dietary protein consumed after cereals, representing 15.0% of total protein supply (52.7% of total animal protein supply), 3.3% of total fat supply, and 2.1% of total calorie supply.
- Within Japan fish and seafood products were the second major source of dietary protein consumed after cereals, representing 19.9% of total protein supply (36.1% of total animal protein supply), 6.8% of total fat supply, and 4.8% of total calorie supply.
- Within the USA fish and seafood products were the sixth major source of dietary protein consumed after cereals, milk, poultry meat, bovine meat, and pig meat, representing 4.6% of total protein supply (7.3% of total animal protein supply), 0.8% of total fat supply, and 1.0% of total calorie supply.
- The per capita supply of fish and seafood food products exceeded that of all terrestrial meats (includes bovine meat, mutton and goat meat, pig meat, poultry meat, and other meats) in Japan, Indonesia, India, Nigeria and Uganda.
- The per capita supply of terrestrial animal meat products was lowest in low-income and lower-middle income countries (India 3.69 kg, LIFDCs 7.96 kg, Nigeria 9.2 kg, Malawi 11.25 kg, Indonesia 13.55 kg, Africa 19.01 kg) and highest within high-income countries (USA 115.13 kg, North America 112.72 kg, Oceania 108.49 kg).
- Total dietary energy supply (expressed as kcal/capita/day) was generally lowest within low-income and lower-middle income countries (Uganda 2130 kcal, Malawi 2367, LIFDCs 2445 kcal, India 2459 kcal, Africa 2624 kcal, Nigeria 2700 kcal) and highest within high-income economies (with a few noticeable exceptions such as Japan at 2726 kcal), including the USA 3682 kcal, North America 3663 kcal, Europe 3367 kcal, Oceania 3216 kcal).
- Plant and vegetable produce comprise over 90% of the total dietary energy supply within most low-income and lower-income countries, including Nigeria 96.2%, Malawi 94.1%, Indonesia 93.4%, Africa 91.8%, LIFDCs 91.5%, Uganda 91.4%, Egypt 90.6%, India 90.4%.
- Sugars and sweeteners contribute over 10% of total dietary energy supply in most high-income countries and regions, including the USA 16.3% (63.76 kg per capita supply per annum), North America 15.9% (62.22 kg), Oceania 12.4% (46.34 kg), South America 13.5% (42.14 kg), Europe 11.5% (41.75 kg), and Japan 9.3% (27.08 kg).

Figure 6 shows the general trend of share of consumer expenditures for food among economic grouping using ERS-USDA data for 2014 (ERS-USDA, 2016). Although

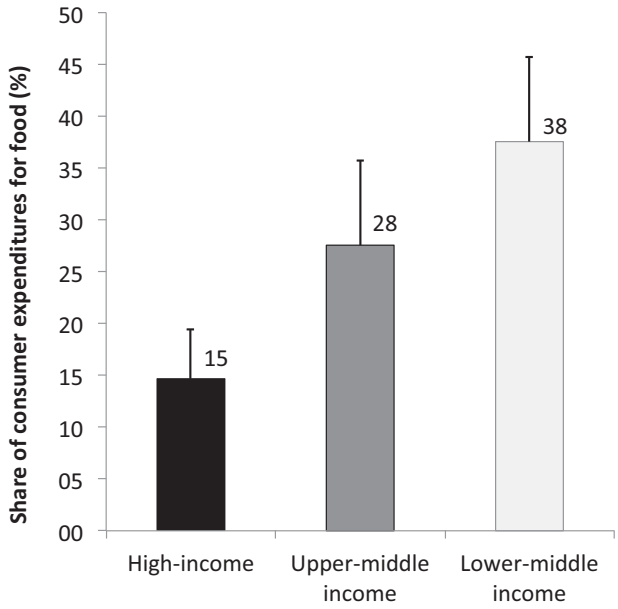

Figure 6. Share of consumer expenditures for food by 4 Gross National Income groupings (low, lower-middle, upper-middle, and higher income) (ERS-USDA, 2016; World Bank, 2016b). Note: Food includes non-alcoholic beverages. Consumer expenditures comprise personal expenditures on goods and services. Consumption expenditures in the domestic market are equal to consumer expenditures by resident households plus direct purchases in the domestic market by non-resident households and minus direct purchases abroad by resident households.

the data we used only used a selection of country and show 3 out of the 4 grouping used throughout the present paper (from high upper-middle and lower-middle incomes country (from the GNI perspectives), it clearly indicates that the "More you earn, relatively less you spend on food." This is consistent with 2002 data presented Gehlhar and Regmi (2005) that showed that the food share of total expenditures declines with income. Nevertheless they showed at the same time that processed food share of food expenditures increased with income. When this statement is connected with previous analyses on the Food balance sheet, fish and shellfish will in general represent a large share of consumer expenditures in low-income countries.

Concluding remarks

The data presented clearly show that fish and seafood produce, whether derived from wild capture fisheries or produced through aquaculture, already plays an important role as a source of dietary protein and other essential dietary nutrients. On a global basis fish and seafood products constitute the third major source of dietary protein consumed by humans after cereals and milk, representing 6.5% of total protein supply or 16.4% of total animal protein supply. It is, however, also apparent that global fish supply through capture fisheries has not been able to keep up with population growth over the past two decades (Figure 1), and that aquaculture is the only real hope to increase production and global market availability in the long-term.

Moreover, it is also clear that fish and seafood plays a greater role in the nutrition of low-income countries within the African continent (primarily derived from capture fisheries) and within the Asian region in general (primarily derived from aquaculture). With increasing income, however, there has also been a significant shift away from the traditional high-fiber staple food based diet to the so-called Western style diet with increased consumption of processed and refined foods, including animal meats, dairy produce, eggs, and refined vegetable oils and sugars (Kagawa, 1978; Willett, 1994).

From a health perspective, it is clear that the excess consumption of these products, in combination with a more sedentary lifestyle, can have a negative effect on human health and an increased risk of coronary heart disease, stroke and diabetes (Cordain et al., 2005; Willett, 1994). As in the case of Japan, however, the high consumption of fish and seafood products in combination with the consumption of meat products in moderation, coupled with a restricted calorie intake (Willcox et al., 2007), can have a beneficial effect on health and longevity (Tacon and Metian, 2013; Yamori et al., 2001).

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