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Fishing for Feed or Fishing for Food: Increasing Global Competition for Small Pelagic Forage Fish

At present, small pelagic forage fish species (includes anchovies, herring, mackerel, sardines, etc.) represent the largest landed species group in capture fisheries (27.3 million t or 29.7% of total capture fisheries landings in 2006). They also currently constitute the major species group actively fished and targeted for nonfood uses, including reduction into fishmeal and fish oil for use within compound animal feeds, or for direct animal feeding; the aquaculture sector alone consumed the equivalent of about 23.8 million t of fish (live weight equivalent) or 87% in the form of feed inputs in 2006. This article attempts to make a global analysis of the competition for small pelagic forage fish for direct human consumption and nonfood uses, particularly concerning the important and growing role played by small pelagic forage fish in the diet and food security of the poor and needy, especially within the developing countries of Africa and the Sub-Saharan region.

CAPTURE FISHERIES LANDINGS AND CONTRIBUTION OF SMALL PELAGIC FORAGE FISH

Globally, capture fisheries landings (excluding aquatic plants and mammals) have stabilized at around 92.8 ± 2.1 million t (mean ± SD) since 1994, fluctuating from a high of 95.7 million t in 2000 to a low of 90.5 million t in 2003 (Fig. 1). As in previous years, the Peruvian anchovy (*Engraulis ringens*) was the top landed species at 7.0 million t in 2006 (Table 1), with small pelagic forage fish species representing the largest landed species group at 27.3 million t or 29.7% of total landings in 2006 (1). For the purposes of this article, small pelagic forage fish include finfish species that serve as easy prey for other animals to forage on (including other larger fish, seabirds, marine mammals, and humans) because of their small size and schooling behavior (2). Within this species grouping are included anchovies, herring, mackerel, pilchards, sprat, capelin, sardines, saury, sandlance, and shads.

DISPOSITION OF THE FISHERIES CATCH AND NONFOOD ROLE OF SMALL PELAGIC FORAGE FISH

As in previous years, a major proportion of the total fish catch is destined for nonfood uses (Fig. 1), being either targeted for reduction into fishmeal and fish oil (for use within industrially compounded animal feeds) or fed whole or in wet-processed form (for use in farm-made aquafeeds, in canned pet foods, or as fishing bait) (3–8). Surprisingly, despite the rising population and increasing demand for food fish for direct human consumption, the proportion of the total fish catch destined for nonfood uses has remained relatively constant in overall percentage terms since disposition data were first collected, with nonfood capture fisheries landings averaging 26.7 million t since 1970, increasing from 24.5 million t or 39.0% of the total catch in 1970 to 33.3 million t or 36.2% of the total catch in 2006 (1). However, whereas the proportion of the catch targeted for reduction has been relatively static since the mid-1980s, the proportion of the catch destined for use in farm-made aquafeeds, canned petfoods, and/or as fishing bait has risen considerably, increasing from 0.9 million t in 1970 (3.7% total nonfood use landings) to 13.1 million t in 2006 or 39.5% total nonfood use landings (7).

Moreover, of particular significance is the strong correlation between the estimated nonfood use trend line and the reported landings of small pelagic forage fish (Fig. 1); small pelagic forage fish usually constitute the bulk of the fish targeted for nonfood uses, including reduction and/or direct animal feeding (2, 8–9). In addition to small pelagic forage fish species, it is important to mention here that several demersal fish species are also targeted for reduction, and include blue whiting (2.0 million t landed in 2006; Table 1), hakes, and grenadier (1).

DECLINE IN FOOD FISH SUPPLY FROM CAPTURE FISHERIES AND RISE OF AQUACULTURE

Notwithstanding the above significant nonfood use of the total fish catch, it is not surprising that the per capita supply of food fish for direct human consumption from capture fisheries has not been able to keep pace with population growth. Thus, while total captured food-fish landings have increased at an average annual rate of 1.2% from 37.9 million t in 1970 to 58.7 million t in 2006, per capita food fish supply from capture fisheries (includes captured fish and shellfish) is declining, decreasing by 20.5% from a high of 11.2 kg in 1987 to 8.9 kg in 2006 (1). In marked contrast, food fish supply from aquaculture (farming of aquatic animals and plants) has increased 271% during the same period, increasing from 2.1 kg in 1987 to 7.8 kg in 2006, with the aquaculture share of total food fish intake for human consumption increasing to 47% compared with 53% from capture fisheries in 2006 (S. Vannuccini pers. comm.). If aquaculture food fish supply continues its average annual growth of 8.6% per year, it is expected that fish supply from aquaculture will reach that of capture fisheries by 2010.

Whereas total global per capita food fish supply continues to increase to a new high of 16.7 kg in 2006 (8.9 kg from capture + 7.8 kg from aquaculture), the aquaculture sector is also a major consumer of nonfood fish in terms of feed inputs (10–13). For example, it has been estimated that in 2006 the aquaculture sector consumed the equivalent of 23.8 million t of small pelagic forage fish in the form of feed inputs, including 3.7 million t of fishmeal and 0.83 million t of fish oil within compound aquafeeds (equivalent to 16.6 million t of small pelagic forage fish) and 7.2 million t of low value/trash fish as a direct feed or within farm-made aquafeeds (7, 8). The above usage levels equate to 37.3% of total aquaculture food fish production (19.3 million t out of a total of 51.7 million t in 2006) currently being dependent upon capture fisheries for sourcing feed inputs (7), small pelagic forage fish and fish oil currently being the only commercially viable source of dietary essential omega-3 fatty acids (and in particular eicosapentaenoic acid and docosahexaenoic acid) for carnivorous fish species and crustaceans (14).

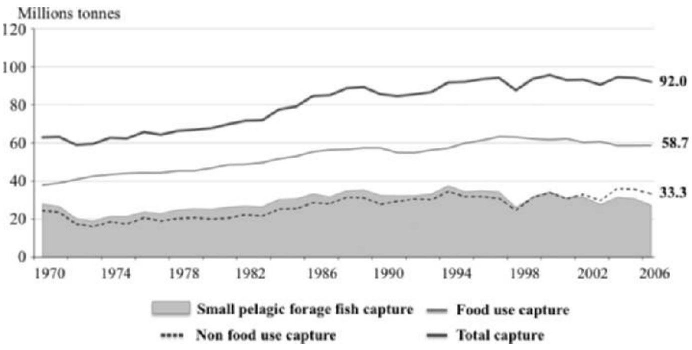


Figure 1. Contribution of small pelagic forage fish to global capture fisheries production and disposition of the fisheries catch (values given in million t) (1).

CONTRIBUTION OF FOOD FISH AND PELAGIC FISH TO HUMAN NUTRITION AND GLOBAL FOOD SUPPLY

Food fish, whether captured or cultured, play an important role in human nutrition, particularly within the diet and food security of the poor and needy as a source of much needed essential dietary nutrients and high quality animal protein (15–17). For example, Figure 2 shows the contribution of fish (includes both fish and shellfish) and pelagic fish to total daily per capita calorie and protein intake by major geographical region and country grouping in 2003 (according to the latest FAO Food Balance Sheets) (18).

Thus, although Africa and the Sub-Saharan region had the lowest average per capita supply of total calories (2436 and 2266 calories d^{-1}), protein (61.1 and 55.1 g d^{-1}), animal protein (12.8 and 11.5 g d^{-1}), and fish (7.6 and 6.9 kg y^{-1}) compared with all other major regions of the world in 2003, food fish contributed 8.1% to 8.6% of total animal calorie intake (the highest of any continent or region) and 17.6% to 18.3% of total animal protein consumption in Africa and the Sub-Saharan region (second only to the Asian region at 21.2%) (Fig. 3), with marine pelagic fish contributing 45.5% to 46.1% and 42.5% to 43.3% of total food fish calorie and protein supply, respectively (the highest of any continent or region) (Fig. 4) (18).

Food fish currently represents a major source of animal protein (contributing more than 25% of the total animal protein supply) for about 339 million people within 19 Sub-Saharan countries or about 51.6% of the total population of Sub-Saharan Africa (Fig. 3).Within this region food fish constituted 20.15% of total animal protein supply (2.09 g $capita^{-1}$ d^{-1}) and represented the second major source of animal protein consumed after milk (2.77 g $capita^{-1}$ d^{-1}). The other major sources of animal proteins are bovine meat (1.84 g $capita^{-1}$ d^{-1}), mutton and goat meat (0.80 g $capita^{-1}$ d^{-1}), other meats (0.78 g $capita^{-1}$ d^{-1}), poultry meat (0.73 g $capita^{-1}$ d^{-1}), edible offals (0.66 g $capita^{-1}$ d^{-1}), eggs (0.38 g $capita^{-1}$ d^{-1}), and pig meat (0.31 g $capita^{-1}$ d^{-1}; calculated from FAO [18]).

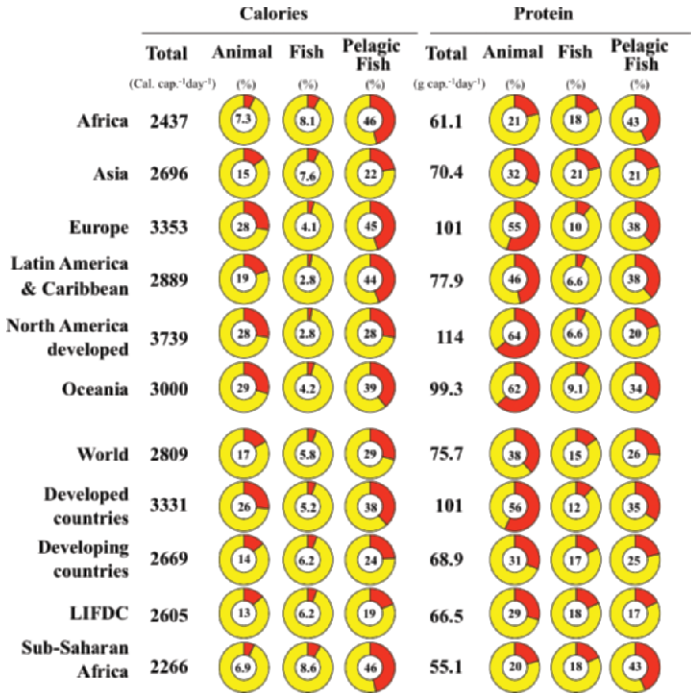


Figure 2. Contribution of fish (includes both fish and shellfish) and pelagic fish to total daily per capita calorie and animal protein intake by major geographical region and country grouping in 2003 according to the latest FAO Food Balance Sheets) (18).

Moreover, in contrast to Asia where total aquaculture production (61.4 million t) exceeded total capture fisheries landings (48.4 million t) in 2006 and contributes to more than half of total food fish supply in this region, aquaculture

Table 1. Top 20 small pelagic forage fish species and demersal fish targeted for food and nonfood uses in 2006 (1).

Common name	Latin name	Quantity fished in 2006 (million t)	Main contributing countries (% of the total)
Peruvian anchovy (=Anchoveta)	*Engraulis ringens*	7.0	Peru, 85%; Chile, 14%; Ecuador, 1%
Atlantic herring	*Clupea harengus*	2.2	Norway, 32%; Iceland, 13%; Canada, 7%
Blue whiting (=Poutassou)	*Micromesistius poutassou*	2.0	Norway, 32%; Russian Federation & Faroe Islands, 16%
Chub mackerel	*Scomber japonicus*	2.0	Japan, 32%; China, 23%; Chile, 18%
Chilean jack mackerel	*Trachurus murphyi*	1.8	Chile, 75%; Peru, 15%; China, 9%
Japanese anchovy	*Engraulis japonicus*	1.7	China, 59%; Japan, 25%; Republic of Korea, 16%
Scads nei	*Decapterus* spp.	1.2	China, 52%; Indonesia, 25%; Philippines, 22%
European pilchard (=Sardine)	*Sardina pilchardus*	0.94	Morocco, 48%; Algeria, 9%; Portugal, 8%;
Sardinellas nei	*Sardinella* spp.	0.73	Philippines, 42%; Thailand, 16%; Nigeria, 10%
California pilchard	*Sardinops caeruleus*	0.63	Mexico, 86%; US, 14%
European sprat	*Sprattus sprattus*	0.59	Denmark, 31%; Sweden, 18%; Poland, 10%
Atlantic mackerel	*Scomber scombrus*	0.56	Norway, 22%; UK, 21%; US, 10%
European anchovy	*Engraulis encrasicolus*	0.53	Turkey, 51%; Italy, 15%; Ghana, 8%
Araucanian herring	*Strangomera bentincki*	0.44	Chile 100%
Round sardinella	*Sardinella aurita*	0.42	Venezuela, 33%; Senegal, 24%; Ghana, 17%
Gulf menhaden	*Brevoortia patronus*	0.41	US, 100%
Silver pomfrets nei	*Pampus* spp.	0.40	China, 100%
Pacific saury	*Cololabis saira*	0.39	Japan, 62%; Russian Federation, 19%; Taiwan, 15%;
Indian oil sardine	*Sardinella longiceps*	0.39	India, 75%; Oman, 9%; Pakistan, 8%
Japanese jack mackerel	*Trachurus japonicus*	0.35	Japan, 47%; China, 45%; Republic of Korea, 6%

Figure 3. Countries in Africa with gray color where food fish contributes more than 25% of the total animal protein supply in 2003 (calculated from the FAO Food Balance Sheets) (18).

Country	%
Ghana	62.2
Sierra Leone	60.8
Gambia	55.3
Seychelles	48.2
Guinea	42.8
Senegal	42.8
Dem. Rep. of Congo (Kinshasa)	41.0
Togo	39.6
Ivory Coast	36.0
Rep. of Congo (Brazzaville)	35.5
Gabon	33.4
Angola	32.3
Cameroon	31.8
Nigeria	28.3
Malawi	27.9
Tanzania	27.1
Liberia	26.7
Cape Verde	26.3
Burundi	25.0

production in the African continent (0.76 million t in 2006) represented only 10.9% of total capture fisheries landings (0.69 million t in 2006) (1). The upshot of this is that food fish derived from both marine and freshwater capture fisheries still plays an essential role as a provider of much needed animal protein and other essential nutrients, Sub-Saharan Africa currently being home to 206 million undernourished people or 24.1% of the world total of 854 million persons (19).

Figure 4 shows the percent contribution of pelagic food fish to total food fish supply according to the latest FAO Balance

36 countries where Pelagic fish contribute over 50 percent of total fish supply ■ :
Algeria (82.9%), Sri Lanka (78.4%), Cape Verde (77.1%), Yemen (76.8%), Albania (76.0%), Maldives (75.8%), Kazakhstan (74.6%), Honduras (74.4%), El Salvador (73.7%), Togo (71.4%), Ukraine (70.7%), Ecuador (69.2%), South Africa (69.1%), Senegal (69.1%), Ghana (68.8%), Romania (66.9%), Haiti (66.2%), Turkey (66.1%), Vanuatu (63.4%), Morocco (63.2%), Panama (62.0%), Sierra Leone (61.1%), Gambia (59.2%), Philippines (58.0%), Malta (58.0%), New Caledonia (57.7%), Tunisia (57.2%), French Polynesia (56.6%), Libya (55.4%), Samoa (54.1%), Seychelles (53.7%), Trinidad & Tobago (51.9%), Guinea (51.9%), Mozambique (51.2%), Nigeria (51.0%), and Grenada (50.8%) (calculated from 18)

Figure 4. Contribution of small pelagic forage fish to total food fish supply in 2003 (values expressed as % total food fish supply, dark gray 50–85%, light gray 25–50%: calculated from FAO [18]).

Table 2. Major traded and processed small pelagic forage fish species in 2006 (1).

Processed traded products	Quantity (million t)	Percentage of total
Frozen Atlantic herring	0.69	15.0
Frozen chub mackerel	0.48	10.4
Frozen jack and horse mackerel	0.43	9.6
Frozen mackerels nei	0.28	6.1
Frozen anchovies	0.25	5.5
Frozen clupeoids nei	0.21	4.7
Frozen Atlantic mackerel	0.20	4.3
Prepared/preserved pilchards	0.19	4.1

Table 3. Top world producing (A) and European exporting (B) countries for internationally traded processed small pelagic forage fish species in 2006 (1).

	Quantity (thousand t)
A. Producing country	
Japan	1206
Norway	529
The Russian Federation	439
Morocco	209
B. Exporting country	
Norway	626
The Netherlands	354
United Kingdom	239
Spain	155
The Russian Federation	144

Sheets (18). Although this figure does include tunas, bonitos, and billfishes (6.5 million t, representing 17.8% of total reported marine pelagic species in 2006) (1), these species play a very minor role in the food supply of the major pelagic fish consumers, particularly within most Sub-Saharan countries (1). At present, pelagic fish contribute more than 50% of total fish supply in more than 36 countries (Fig. 4; calculated from FAO [18]), Of particular note is the important contribution of pelagic fish to total fish supply within the Sub-Saharan African region (Fig. 4).

Consumption of marine small pelagic fish in most Sub-Saharan countries is primarily in the form of locally-caught or imported lower-cost species such as mackerels, herrings, pilchards/sardines, and, to a lesser extent, anchovies (20–22); the fish usually are consumed in fresh, frozen, canned, cured, and/or dried form depending upon country, species, availability, market price, and financial resources of the consumer. However, it is also important to mention here that freshwater fish contributed 33.0% of total food fish supply in Africa, second after marine pelagic fish in 2003, and as such also play an important role in food fish supply within inland regions (18).

COMMERCIALLY TRADED PROCESSED SMALL PELAGIC FORAGE FISH FOR HUMAN CONSUMPTION

Although total reported landings of small pelagic forage fish was 27.2 million t in 2006, only 4.6 million t or 16.9% of processed food-grade small pelagic forage fish products were internationally traded in 2006 (1). Contrary to the notion often expressed that most small pelagic forage fish species targeted for reduction are not suitable for direct human consumption (23), a variety of food-grade processed products are produced from these generally lower value (in marketing terms) fish species (see Table 2 for an example of the major processed traded products in 2006) (1).

Surprisingly, although more than 36.7% of total small pelagic forage fish landings were reported within the South American region (10 million t in 2006), the major country producers of processed small pelagic forage fish products in 2006 were in Europe (45.7% total) and Asia (34.5%). Top producing countries are presented in Table 3A (1). Moreover, Europe accounted for more than 59.43% of total exports (2 422 098 t), with the top European exporting countries shown in Table 3B (1).

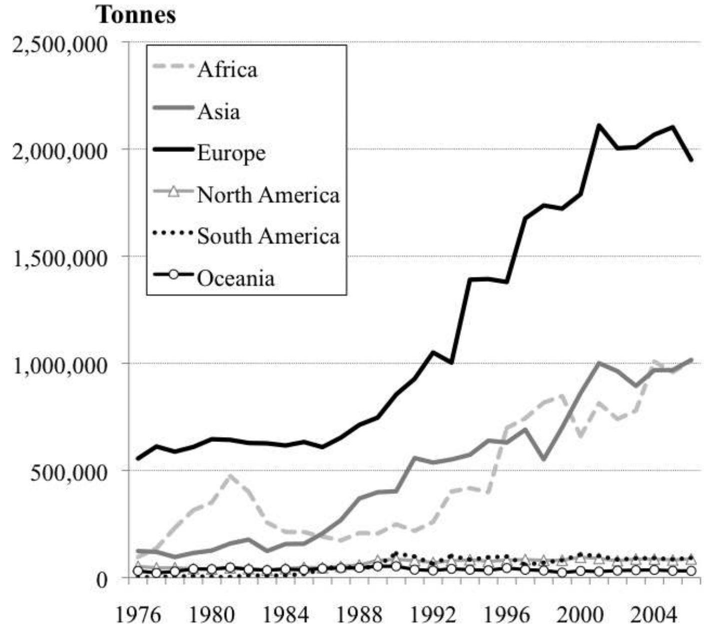
Of particular significance is the marked decrease of total exports of processed food-grade small pelagic fish from Peru (the largest producer of small pelagic fish in the world at more than 5.9 million t in 2006) (24), with exports decreasing after a reaching a high of more than 100 000 t in 1981 to a low of 22 000 t in 2006. In marked contrast, exports from Chile have increased more than sixfold from 37 000 t in 1993 to more than 197 000 t in 2006; the main export markets for frozen Chilean jack mackerel are Nigeria, Peru, and Cuba, and Sri Lanka for canned mackerel (25).

Figure 5 shows the imports of processed small pelagic fish by region, with Europe showing the fastest growth in imports (responsible for more than 45.9% total imports in 2006), followed by Asia (23.9%) and Africa (23.8%). At the country level, the largest single importer of processed food-grade forage fish products in 2006 was Nigeria (372 000 t), with other major importers within the Sub-Saharan region including Ghana (264 000 t), Cote d'Ivoire (103 000 t), and Cameroon (81 000 t) (1). According to FAO, total imports of processed small pelagic fish in Africa was 1.01 million t in 2006, mainly in frozen form (85%), with the main species being mackerels, sardines (included sardinellas and sprats), and herrings.

SMALL PELAGIC FISH USED AS HUMAN FOOD

According to Franz et al. (21) about 70% of Namibian horse mackerel landings were exported to the Democratic Republic of Congo, with the remainder exported to South Africa, Nigeria, Cameroon, Ghana, Angola, Zimbabwe, and Mozambique. Total Namibian landings of small pelagic species in 2006 were reported as 0.32 million t, including 0.31 t of Cape horse mackerel, 4.9 thousand t of whitehead round herring, 2.9 thousand t of chub mackerel, 2.3 thousand t of Southern African pilchard, and 1.1 thousand t of Southern African anchovy (1). In general, horse mackerel are frozen whole at sea and then shipped for export, with the remainder usually used to produce fishmeal and fish oil that are exported to South Africa and Japan. By contrast, the anchovy is generally regarded as being of lower value and as such is usually reduced to fishmeal and fish oil. However, the pilchard is generally regarded as being the most valuable small pelagic species in Namibia, with landed fish usually canned and the processing waste reduced to fishmeal and fish oil; 90% of Namibia's pilchard catch is usually canned and exported to South Africa. Moreover, Franz et al. (21) reported that Namibia's fisheries benefited from duty free access to the European Union.

In marked contrast, the consumption of small pelagic forage fish in Asia and the Pacific, either fresh, frozen, canned, dried, cured or fermented, has had a very long tradition (4, 15, 26–28), and this does not need repeating again here. However, competition for the use of these resources, either as inputs for the preparation of traditional sauces/food preparations or for use as feed inputs for the production of high value aquaculture species, usually results in the product being sold to the person/sector that can afford to pay more; this is usually the farmer producing the cash crop rather than the cash poor and most needy (4, 27). Moreover, because these lower-value fish species are usually consumed by the poorer and most vulnerable



Total small pelagic forage fish imports 2006 (tonnes)	
Total	**4,249,914**
Nigeria	371,971
Russian federation	366,895
Ghana	264,490
Netherlands	231,685
Korea, Rep.	215,705
Japan	190,886
China	182,691
Ukraine	174,936
Denmark	143,973
Germany	138,684
Poland	133,502
Cote d'Ivoire	103,493
Spain	97,474
UK	83,401
Cameroon	81,355
France	76,905
Thailand	75,157
Egypt	67,987

Figure 5. Total imports of traded small pelagic fish and derived food products by region (values given in t) (1).

segments of society, they suffer most when the price of these life-saving commodities increase out of their economic grasp and food basket (16, 17).

In the past, the problem usually associated with the direct utilization of Peruvian anchovy (*E. ringens*) and other small oily pelagic fish species have been related to their rapid deterioration in quality on prolonged storage and the difficulties of processing large volumes of fish during a relatively short period of time (28–30). However, recent advances in fishing methods and fish processing technology (31) are now such that a variety of different food products have been successfully developed from anchovy (*E. ringens*) and other small pelagic fish species. Apart from improvements in fish freezing and chilling methods (28, 32), one of the most important advances in fish processing has been the development of stabilized surimi products (33–37); surimi is stabilized myofibrillar from muscle or, more simply put, mechanically deboned fish flesh that has been washed with water and then stabilized (after dewatering) by blending with cryoprotectants (low molecular weight carbohydrates such as sucrose or sorbitol) to ensure a good shelf life and protein function (gelling, texture) on prolonged storage or freezing (30, 35).

Other food products that have been successfully prepared from Peruvian anchovy (*E. ringens*) and other small oily pelagic fish species include: *i)* frankfurters, fish balls, fish chips, fish nuggets, fish fillets, fish sausages, noodles and ravioli products produced from surimi/minced fish (29, 38, 39); *ii)* canned anchovy marinates (40–43); *iii)* fermented and powdered anchovy seasoning products (44); *iv)* edible quality refined fish oils (45); *v)* anchovy protein hydrolysates and oils (46); *vi)* dried anchovies (47); *vii)* food-grade fish powders and fish protein concentrates (39, 48, 49), *viii)* and menhaden roe (50); *ix)* smoked/cured fish products (28); and *x)* dry salted products, fish biscuits, and extruded fish balls (dried) made from food-grade fishmeal and cereals (39).

Similarly, in a survey undertaken of local fish markets in Metro Manila (the Philippines), small sardines and anchovies are usually brine-salted and dried whole, with larger fish usually split open, cleaned, salted, and then sun dried. The consumption of cured fish (including dried salted fish) is one of the highest in the Southeast Asian region (51). The same author also noted that imported frozen fish (mainly low-cost pelagic fish and cuttlefish) were increasingly being distributed to Metro Manila at relatively lower prices than locally caught species (51).

INCREASING COMPETITION BETWEEN USERS FOR SMALL PELAGIC FORAGE FISH

Market economics and free market access are currently the main drivers that select whether small pelagic forage fish are fished for feed or fished for food. It may be that with improvements in fishing and on-board fish processing techniques the market will take care of itself. For example, in Chile a greater proportion of the Jack mackerel catch is being diverted from fishmeal manufacture to processing as frozen whole fish for export (Table 4), as the production of frozen jack mackerel is much more profitable than producing fishmeal (53). However, this may not always be the case, especially if the market price of fishmeal and/or fish oil price should rise in the future.

In the case of Peru, only 43 000 t or 0.73% of the total anchovy (*E. ringens*) harvest of 5 935 302 t was destined for direct human consumption in 2006 (24); 99.3% of the total anchovy catch was reduced to fishmeal and fish oil almost exclusively for export. Moreover, the proportion of the total fish catch in Peru destined for food use has been relatively small, fluctuating from a low of 7.0% in 2002 to a new high of 16.1% in 2006. In marked contrast to the Peruvian Anchovy (*E. ringens*), all the reported landings of the other two pelagic species in Peru, namely the Chilean jack mackerel (*Trachurus murphyi*; 278 000 t) and chub mackerel (*Scomber japonicus*: 102 000 t) were processed for direct human consumption in 2006 (24).

In addition, it is often stated that there is no cultural tradition for consumption of Anchoveta in Peru (*viz*. Peruvian Anchovy, *E. ringens*) (54), and that it is for this reason that the bulk of the Anchoveta harvest is processed by the industrial fisheries sector for export and foreign cash earnings. However, this is not the case, as the earliest known civilization in the Americas, the "Caral civilization" (a thriving metropolis as Egypt's great pyramids were being built, located in the Supe Valley near the coast of central Peru, that flourished for about 5 centuries starting about 2600 B.C.), relied largely on fish and shellfish, including Anchoveta and sardines, as their main source of protein (55). Sadly, the Caral civilization ended around 1600 B.C. and with it, the "cultural tradition" of consuming fish and shellfish (56).

Although the food fish supply in Peru in 2003 was 20.7 kg caput^{-1} and above the global average of 16.1 kg y^{-1} (3), greatest

Table 4. Fishmeal production by major fish species in Chile from 1995 to 2005 (values are given in thousand t, and inserts for fishmeal production from Jack mackerel [52]).

	Peruvian anchovy	Chub mackerel	Jack mackerel	Sardines	Patagonian grenadier	Others	Fish waste
1995	439	25	956	50	36	1	45
1996	306	34	834	103	70	3	49
1997	392	49	594	99	12	6	72
1998	117	14	260	73	69	3	106
1999	424	26	204	214	58	2	72
2000	387	2	216	153	16	3	81
2001	194	77	302	72	28	4	100
2002	333	69	243	71	15	1	104
2003	183	123	227	60	2	11	99
2004	417	115	233	74	0	17	128
2005	341	53	221	58	2	27	125

consumption occurs in areas and cities near the coast (72% of Peru's 27 million inhabitants live in urban areas along the coast) (39). However, this is not the case in rural inland areas. Moreover, about half of the population in Peru still lives below the national poverty line, with more than half of rural Peruvians considered as being extremely poor (that is, living on less than USD 1 a day) and Indigenous people comprising an estimated 15% of the population and having a poverty rate of 70% (57). However, of the 357 000 t of processed fish products produced in Peru in 2006 for direct human consumption (from a total fish landing of 7 027 000 t), 329 000 t or 92.3% was exported; total Peruvian fisheries exports in the form of fishmeal, fish oil, and food fish exceeded USD 1.76 thousand million in 2006 (24).

The Californian pilchard has also recently entered into another potential conflict of interests in Mexico. With reported landings of more than 545 000 t in 2006 (1), this species was usually targeted by fishermen for reduction into fishmeal, with usually smaller quantities processed for direct human consumption (mainly by canning). However, the recent development and demand by tuna aquaculture fattening operations (the growing of wild caught small-sized tuna to larger-size tuna within offshore cages for subsequent export) along the Pacific Mexican coast for the pilchard catch as feed have resulted in prices paid for product to increase from USD 70 t^{-1} for freshly caught fish to as high as USD 300 t^{-1} for frozen fish from Mazatlan (58–61). Competition for the resource has been such that fishmeal factories along the coast are finding it hard to source product for reduction; Mexico reportedly produced 64 000 t of prepared/preserved pilchards, 80 000 t of fishmeal nei (will also contain product produced from local tuna processing plants; "nei" is a FAO terminology for species not specified), 30 000 t of frozen pilchard, and 27 000 of fish body oils nei in 2006 (1). It has been estimated that the tuna fattening operations in Mexico are currently consuming about 50 000 to 70 000 t of pilchards (this value differs from the 20 000 to 30 000 t estimated by Zertuche-González et al. [61]), with total tuna production in 2006 reported by FAO (1) as 4735 t and valued at USD 43.2 million. Farmed tuna production was the second most valuable aquaculture crop in Mexico after farmed shrimp, with both high value products being almost exclusively produced for export to developed country markets. Similar domestic price increases in forage feed fish for tuna fattening operations have also been reported in Italy and Spain (59, 62).

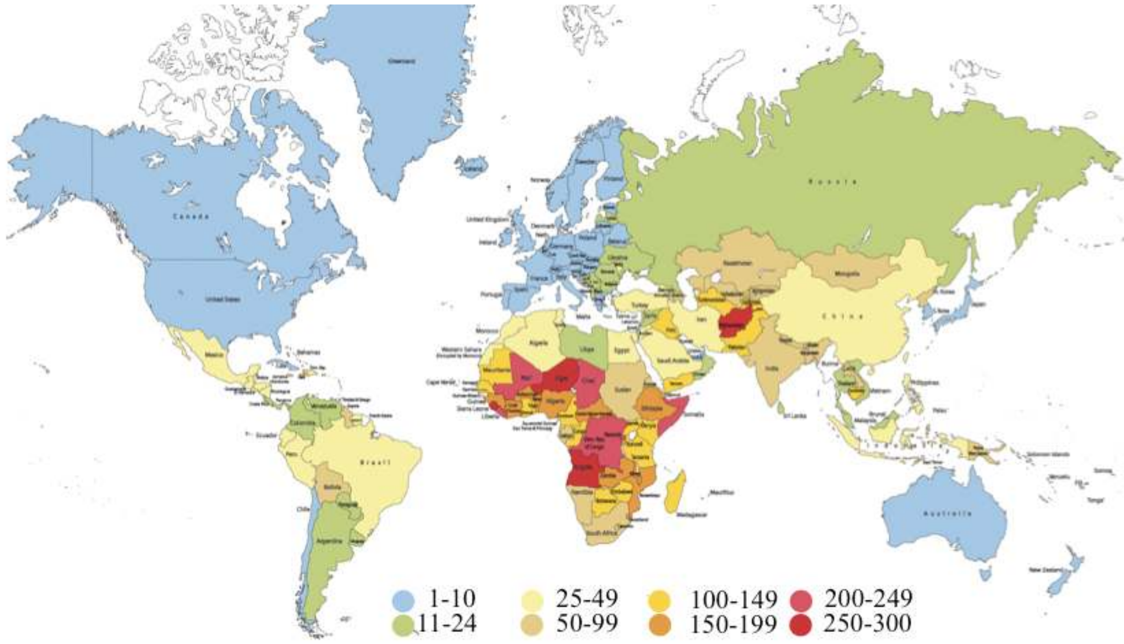
OBSTACLES TO DIRECT HUMAN USE OF SMALL PELAGIC FORAGE FISH

As mentioned previously, the major obstacles to the direct and increased use of small pelagic forage fish for direct human consumption are primarily economic and relate to the current free market access of fisherfolk and industrial fishing companies to exploit this resource for reduction into fishmeal and fish oil and/or animal feeding. Moreover, emphasis by fisheries managers, conservationists, and environmentalists has been placed on the sustainable management of specific fishery resources so as to prevent overexploitation rather than on postharvest management strategies and the end user of the resource. With aquaculture now consuming more than 57% of total global fishmeal production, 87% of total global fish oil production, and 55% of total other nonfood small pelagic forage fish usage in 2006 (7), there is a strong market demand for continuing the market availability, supply, and use of these precious commodities for animal feeding (63, 64). Apart from the willingness of the aquaculture sector to pay higher market prices for these valuable commodities (compared with terrestrial livestock and other potential users), the culture of higher market value carnivorous fish and crustaceans (which are more dependent upon fishery resources as feed inputs) is actively promoted by major aquaculture producers (including China, the world's largest aquaculture producer and user of fishmeal and low value/trash fish [7, 13, 19]) as a means of generating cash income and export revenues (49, 65).

On the basis of the above usage of fishmeal and fish oil, it is perhaps not surprising that for many high value cultured species the consumption of fishery resources (in terms of small pelagic forage fish equivalents) is greater than the quantity of cultured fish produced (8). The long term sustainability and ethics of using these precious fishery resources as feed inputs by the aquaculture sector has been questioned (10, 12) and has generated increased attention on the sector from seafood awareness campaigns to promote a more sustainable seafood supply within developed country markets (66–69).

RESPONSIBLE FISHERIES AND NEED FOR INCREASED LEGISLATIVE CONTROLS

Notwithstanding the critical role played by lower-cost small pelagic forage fish species in total food fish supply and the subsequent nutritional wellbeing of cash-poor people within developing countries (Fig. 2), it may be that the only way to safeguard and promote increased access and usage of this resource for direct human consumption is through the imposition of legislative controls by national/local governments by prohibiting the use of these potentially food-grade small pelagic forage fisheries for animal feeding. This includes reduction to fishmeal and fish oil. Successful examples include the introduction in Peru of legislation establishing that Jack mackerel, Chub mackerel, and sardine should only be exploited for direct human consumption (69). Similarly, legislature in California in the early 1920s introduced legislation prohibiting the processing of fish (in this case the California sardine [=Californian pilchard *Sardinops caeruleus*) for reduction if it was fit for human consumption (70). Moreover, in the case of many African coastal and Island states the small pelagic fish



1-10 : Andorra, Australia, Austria, Belarus, Belgium, Brunei Darussalam, Canada, Chile, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Lithuania, Luxembourg, Malta, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Korea, San Marino, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, UK, USA ;
11-24 : Albania, Antigua & Barbuda, Argentina, Bahamas, Bahrain, Barbados, Venezuela, Bosnia & Herzegovina, Bulgaria, Colombia, Cook Islands, Costa Rica, Dominica, Federated States of Micronesia, Fiji, Grenada, Jamaica, Kuwait, Latvia, Libyia, Malaysia, Mauritius, Oman, Panama, Paraguay, Qatar, Romania, Russian Federation, Saint Kitts and Nevis, Saint Lucia, Saint Vincent & the Grenadines, Serbia & Montenegro, Seychelles, Sri Lanka, Syria, Thailand, The former Yugoslav Republic of Macedonia, Trinidad & Tobago, Ukraine, Uruguay, Viet Nam ;
25-49 : Algeria, Armenia, Belize, Brazil, Cape Verde, China, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Guatemala, Honduras, Indonesia, Iran, Jordan, Lebanon, Maldives, Mexico, Morocco, Nauru, Nicaragua, Niue, Palau, Peru, Philippines, Republic of Moldova, Samoa, Saudi Arabia, Suriname, Tonga, Tunisia, Turkey, Vanuatu ;
50-99 : Azerbaijan, Bangladesh, Bhutan, Bolivia, Comoros, Democratic People's Republic of Korea, Eritrea, Gabon, Guyana, India, Kazakhstan, Kiribati, Kyrgyzstan, Lao People's Democratic Republic, Lesotho, Marshall Islands, Mongolia, Namibia, Nepal, Papua New Guinea, Solomon Islands, South Africa, Sudan, Timor-Leste, Tuvalu, Uzbekistan ;
100-149 : Botswana, Cambodia, Cameroon, Congo, Djibouti, Gambia, Ghana, Haiti, Iraq, Kenya, Madagascar, Mauritania, Myanmar, Pakistan, Sao Tome & Principe, Senegal, Tajikistan, Togo, Turkmenistan, Uganda, United Republic of Tanzania, Yemen, Zimbabwe ;
150-199 : Benin, Burkina Faso, Burundi, Central African Republic, Côte d'Ivoire, Ethiopia, Guinea,Malawi, Mozambique, Nigeria, Swaziland, Zambia ;
200-249 : Chad, Democratic Republic of the Congo, Equatorial Guinea, Guinea-Bissau, Liberia, Mali, Rwanda, Somalia; and
250-299 : Afghanistan, Angola, Niger, Sierra Leone.

Figure 6. Probability of dying (per 1000) for children under 5 years of age (78).

catch is often simply not available for human consumption as it is processed into fishmeal on board or piped or trucked directly to land-based fishmeal processing plants, primarily for export (22, 71). In fact, developed countries imported 80% of total traded fisheries products in 2006 valued at USD 72.6 thousand million, with the largest importers being the European Union, followed by Japan and the United States (1). In fact, on a per capita basis, the highest consumers of fish and seafood in 2003 were Developed Countries at 23.95 kg y^{-1}, followed by Oceania 22.93 kg y^{-1}, North America (developed) 21.56 kg y^{-1}, Europe 20.98 kg y^{-1}, and Asia 17.53 kg y^{-1} (18). In marked contrast, the lowest consumers (on a per capita basis) were Developing Countries at 13.94 kg y^{-1}, followed by Latin America and the Caribbean at 8.54 kg y^{-1}, Africa 7.57 kg y^{-1}, and Sub-Saharan Africa at 6.94 kg y^{-1} (global average: 16.06 kg y^{-1}) (18).

In particular, governments should be encouraged to adhere and adopt into their national legislations the recommendations and guidelines laid down in the FAO Code of Conduct for Responsible Fisheries (72, 73). For example, Article 2.f of the FAO CCRF states one of the major objectives of the Code as being to promote the contribution of fisheries to food security and food quality, giving priority to the nutritional needs of local communities. Article 11.1.9 states that "States should encourage the use of fish for human consumption and promote consumption of fish whenever appropriate." In line with the above declarations and agreements it is thus recommended that *i)* governments within major aquaculture producing countries prohibit and/or severely limit the manufacture of fishmeal/fish oil from potentially food-grade small pelagic forage fish species and the use of potentially food-grade small pelagic forage fish for use as feed inputs for aquaculture and animal feeding, particularly within those countries/regions where small pelagic forage fish are consumed directly by the rural poor; *ii)* government and civil society be made aware through seafood awareness campaigns of the potential that small pelagic forage fisheries have to improve national food security and the nutritional well being and health of the poor and needy, including children; *iii)* the aquaculture sector reduce its reliance upon the use of potentially food-grade fishery resources as feed inputs through the development and increased use of locally available agricultural feed resources, including plant and animal by-products arising from the domestic agriculture sector; and *iv)* the dependency of the commercial and sport/recreation fisheries sector upon the use of potentially food-grade fish bait species be reduced through the promotion and use of artificially prepared fish bait substitutes based on the use of feed-grade fish, agricultural by-products, and other natural feeding attractants.

CONCLUDING REMARKS

In conclusion, it is important to remember that malnutrition is still the number one killer and cause of suffering on earth, causing more deaths than HIV/AIDS, warfare, genocide, terrorism, or any other ailment, particularly within developing countries; 23 children currently die every minute from undernutrition (17, 19). According to the United Nations Development Program, the World Health Organization (WHO), and FAO it is estimated that about one-fifth of the world's population is currently living in extreme poverty (defines as living on less than USD 1 per day), with more than 4 thousand million people earning less than USD 4 per day and the majority living within developing countries. Moreover, with the world population expected to grow by 2.6 million between 2005 and 2050 (a number roughly equal to the total global population in 1950 of 2.5 thousand million) (74), there are growing doubts as to the long term sustainability of many existing agricultural and aquacultural food production systems to meet the increasing global demand for food (75–77). Nowhere is this more critical than within many of the world's developing countries, and in particular within Sub-Saharan Africa; the Sub-Saharan region is the only region of the world where per capita consumption of fish has fallen (aquaculture representing only 3.1% [158 thousand t] of total capture fisheries landings in the region [5.1 million t] in 2006) (1).

Despite the obvious nutritional and health benefits to be gained from the continued access and consumption of fish by the rural poor, sadly little or no information exists concerning the role played by fish in the diet and nutritional food security of the poor and vulnerable, and in particular in the diet of children within low-income food deficit countries (17). As a reminder of the seriousness of the malnutrition problems faced by the Sub-Saharan African region and others, Figure 6 shows probability of dying (per 1000) for children under 5 years of age according to WHO (78). At present, food fish represents a major source of animal protein (contributing more than 25% of the total animal protein supply) for about 1.25 thousand million people within 39 countries worldwide, including 19 Sub-Saharan countries (Fig. 6).

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