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On the Multiple Uses of Forage Fish: From Ecosystems to Markets

A report to the Pew Institute for Ocean Science, University of Miami, Rosenstiel
School of Marine & Atmospheric Science, Miami, FL

Fisheries Centre, University of British Columbia, Canada

On the Multiple Uses of Forage Fish: From Ecosystems to Markets

edited by
Jackie Alder and Daniel Pauly

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CHAPTER 2

HUMAN CONSUMPTION OF FORAGE FISH²

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ABSTRACT

A brief review of the human consumption of forage fishes is given, with emphasis on traditional use of fermented small pelagic fishes and the importance of these fish to food security. This contrasts with the notion, disseminated by some actors in fisheries and aquaculture, that the ‘reduction’ of such fishes to fishmeal and fish oil has no impact or only a positive impact on human food security. Current regional patterns of small pelagic consumption are reviewed, which suggest that agricultural uses of forage fish compete directly with human consumption in some areas of the world. This has resulted, overall, in a declining human consumption of relatively cheap pelagic fish and, in richer countries, in increased consumption of pricey seafood, some of it farmed and fed meals and oils derived from small fish, particularly small pelagics.

HISTORICAL INTRODUCTION

Many of the small, pelagic fishes described as ‘forage fish’ in other parts of this document have a long history as human food fishes. This is well documented; for example, over 2000 years ago, small pelagic fish were very popular around the Mediterranean basin (Gamer, 1987). Thus, many of the amphora recovered from sunken Roman vessels did not contain wine, as is generally assumed, but *garum*, a fish ‘sauce’ derived from fermented small pelagic fishes, similar to Vietnamese *noc mam*, or Thai *nam pla*, about which more is found below. *Garum* was a mainstay of the Roman diet, and the manufacture and consumption of *garum* has survived from the Roman Empire to the present, at least in a few villages of southern Italy.

In northwestern Europe, a transition from freshwater to marine fishes occurred at the end of the first millennium, possibly due to urban population growth and the concomitant overexploitation of freshwater species (Barrett *et al.*, 2004; Pauly, 2004). The ascent of Christianity intensified the demand for fish, the only permitted animal protein during an interminable Lent period, and on other religious occasions. Fish preservation required huge quantities of salt at specific times, and salt monopolies (and the blackmail of fishers that they allowed) were extremely profitable, as we also know from other parts of the world (Butcher, 1996, 2004). Such a salt monopoly was established in the high Middle Ages by an alliance of mainly German cities, the Hanseatic League, which derived its immense wealth – embodied in superb buildings we now can admire in Hamburg or Lübeck – ultimately from the Norwegian, North Sea and Baltic herring fisheries (Sarhage and Lundbeck, 1992).

The Hanseatic League monopoly was followed by Dutch supremacy, whose herring fisheries, in the 17th century, allowed the Low Countries, for a while, to delay the emergence of Britain’s unchallenged naval power – all this thanks to the lowly herring. In fact, as documented by Cushing (1988), much of the northwestern European politics and warfare can be explained, at least partly, by their erstwhile dominance of fishing grounds for lucrative small pelagic fishes. This conflict over small pelagic fish was similar in other parts of the world, with colonial authorities deriving a sizeable part of their income from the salt monopolies they imposed on fishers in India (hence Ghandi’s early activism on direct access to salt) or Indonesia (Butcher 1996, 2004).

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Indeed, it is in Southeast Asia that we currently find the tightest coupling of a strong dependence of both rural and urban population on small pelagic fishes and sophisticated method for their cost-effective preservation, i.e., fermentation (Ruddle and Ishige, 2005). This yields the highly nutritious *noc mam*, or *nam pla* alluded to above, along with their equivalent in other countries, for example *patis* in the Philippines (Ruddle, 1986, Pauly, 1996).

These products, along with their equivalents in other regions of the world, attest to the deep historical embeddedness of small pelagic fishes in the diet of people, and expose as convenient untruth the notion of some western fisheries managers and aquaculture advocates that the small fish used for 'reduction' to fishmeal and fish oil are not palatable to people.

FORAGE FISH CONSUMED BY HUMANS

The species of small to medium pelagic fish that are eaten vary between geographic regions and reflect historical and current taste preferences. While some medium pelagic fish such as mackerels are also consumed by humans, small pelagics such as sardines and herrings make up the bulk of fish consumed by humans and the focus of this chapter. Indeed some small species of fish that are only recently being exploited are fished both for human consumption and fishmeal (e.g. Blue whiting).

Small pelagic fish are relatively easy to preserve (see above). Also, these fish, due to their schooling habits, are easy to catch using small mesh nets with low operating costs. This is especially true for the fuel cost, which is much lower than for other fisheries such as line and trawl (Tyedmers *et al.*, 2005, and Chapter 1). Consequently, the fish are often much cheaper and more accessible than demersal fish. In countries where the demand for animal protein (or for cheap protein) is not met domestically, imports of small pelagics such as herrings, sardines and mackerel are often used to meet that demand, e.g., in Ghana, Togo or Nigeria (Alder and Sumaila, 2005). Similarly, in the Caribbean, Oceania and Latin America, imports of small pelagic fish as frozen or canned product are common (PFA, 2006).

Table 1 shows that almost all the small fish currently dominating reduction fisheries are (or were) eaten by people. This applies even to the Peruvian anchoveta and associated small fishes which were consumed by humans, until the development of the reduction fisheries in Peru in 1953 (Chapter 1). The increased demand for small pelagic fish for the fishmeal plants resulted in a decline in human consumption of these fish.

Table 1. Major forage fish species and human consumption

Fish	Human consumption	Reference
Peruvian anchoveta	Primarily canned for human consumption;	www.oceansalive.org
Capelin	Roe is used for human consumption; some is frozen for specific markets in Japan and Europe, market is increasing; 100,000 t of 633,000 t landed in 2004/05 was sold for human consumption;	Nortrade (2006)
Japanese pilchard	Approximately 33% of landings are destined for human consumption, primarily in Japan where it was consumed for centuries;	Chapter 1
Chilean jack mackerel	Historically used for human consumption as frozen or canned product sold in Latin America, Africa and Oceania but recently used in fishmeal;	Chapter 1
South American pilchard	Fresh, frozen and canned product is sold for human consumption in Latin America, North America and Europe;	FIS (2006)
Gulf and Atlantic menhaden	None is consumed directly; some is sold as a food oil/emulsifier;	Huss <i>et al.</i> (2003)
Sandeels	A small amount is sold for human consumption;	Nortrade, (2006)
European sprat	Small market for canning and smoking in Europe;	ICES (2005)
Norway pout	No human consumption;	Huss <i>et al.</i> (2003)
Northern blue whiting	Small market for human consumption due to processing problems not palatability; some of the landings are used in the production of surimi;	Min of Ag, Fish and Food (1980); Anon. (2004)
Round sardinella	Frozen exports to Africa, Asia & Eastern Europe for human consumption;	PFA (2005)
Atlantic horse mackerel	Historically targeted for reduction but in the 1970s some landings were used for human consumption and recently larger fish are targeted for consumption but much of it is exported to Eastern Europe and Asia;	ICES (2005)
Herring	Historically as fresh, salted or canned product for human consumption, but until recently increasing trend for its use in fishmeal, recently trend reversed with Nortrade processing 75% of its landings for human consumption in 2004/05 up from 32% in 2000/01;	Nortrade (2006)
Chub mackerel	Fresh or canned fish consumed in California and Mexico;	Anon. (2000)
Japanese anchovy	Consumed as fresh and salted products;	Zhang (2002)
European anchovy	Consumed as fresh, dried, smoked, canned or frozen product.	Eurostat (2005)

In Europe, prior to World War II, herring was also destined for human consumption (see above). However, now at least 50% of herring landings are destined for reduction (see Chapter 3), even though the European Union prohibits the processing of Atlantic herring for fishmeal by its member countries (Huss *et al.*, 2003). This is possible because Norway and Iceland are not part of the EU and not bound by the EU decision regarding herring for human consumption.

In the following, we present an analysis of the conflicting uses of small pelagic fishes, based on a database described below.

METHODS

The tonnage of small pelagic fish that are consumed by humans was estimated based on food consumption, catch and landing statistics, and the imports and exports of large pelagic fish such as tunas and billfish. Initially, two different FAO databases were used, the FAO 'food balance sheets' (FAO, 2006) and the Fisheries Commodities Production and Trade database, which covers the years 1976-2003 (FAO, 2003). The food balance sheet dataset provided information on the amount of 'pelagics' (including large fish such as tunas, billfish and swordfish) consumed annually by humans. To adjust consumption to only forage fish as described in Chapters 1 (i.e., to many of the species listed in Table 1), the net balance of large pelagic fish (i.e., catch + imports - exports - re-exports) was subtracted from total pelagic fish consumption.

Initial attempts were made to estimate consumption this way after converting the commodities to live weight equivalents on a country level, then region level. However, the estimates were not reliable, even including several cases with negative consumption values, due to discrepancies in the databases. Thus, the estimates of human consumption were based on the food balance sheets described above, adjusted for regional estimates of large pelagic from the *Sea Around Us* Project landings database (Watson *et al.*, 2004). For this, it was assumed that most landings of tuna were eventually consumed within the regions where they were caught, with the exception of Oceania where a considerable portion of the catch is caught by distant water fleets. Here, it was assumed that 75% of the landings were exported to the other regions (25% to North America, Europe and Asia respectively) since each region has a significant distant water fleet (e.g., US, France, Japan, Korea and Taiwan) in Oceania.

RESULTS

Global landing trends

Forage fish as a proportion of global marine landings and all pelagic landings fluctuated considerably between 1961 and 2002 (Figure 1). However, there was an increase in the late 1980s, which appears to be reversing since the late 1990s. The percentage of forage fish catch that is consumed as food directly has fluctuated between 10 and 20% of global landings since 1961. Much of the variation is a reflection of the environmentally induced variation in landings of small pelagic fish.

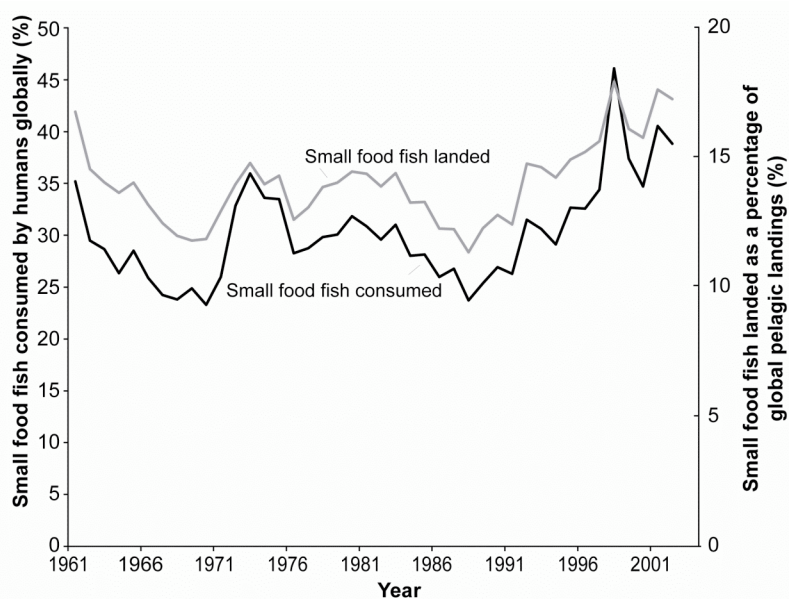


Figure 1. Forage fish consumed by humans as a percentage of global landings (left axis) and as a percentage of global pelagic landings (right axis). (FAO, 2006; *Sea Around Us* Project, 2006).

Regional landing trends

There is considerable variation between continents on consumption trends of forage fish consumed by humans as a percentage of all pelagic fish consumed as food (Figure 2). In Africa, the percentage of small pelagic fish that are consumed by humans has remained constant since the early 1960s, when many African countries became independent. In Europe, there was a decline during the same period; this lasted until the early 1990s, increasing since. For Asia, North and Central America, and particularly in South America and Oceania, the percentage of forage fish consumption has declined. In Latin America, the decline commenced in the mid-1970s, coinciding with a major decline in the small pelagic fisheries along the west coast of South America.

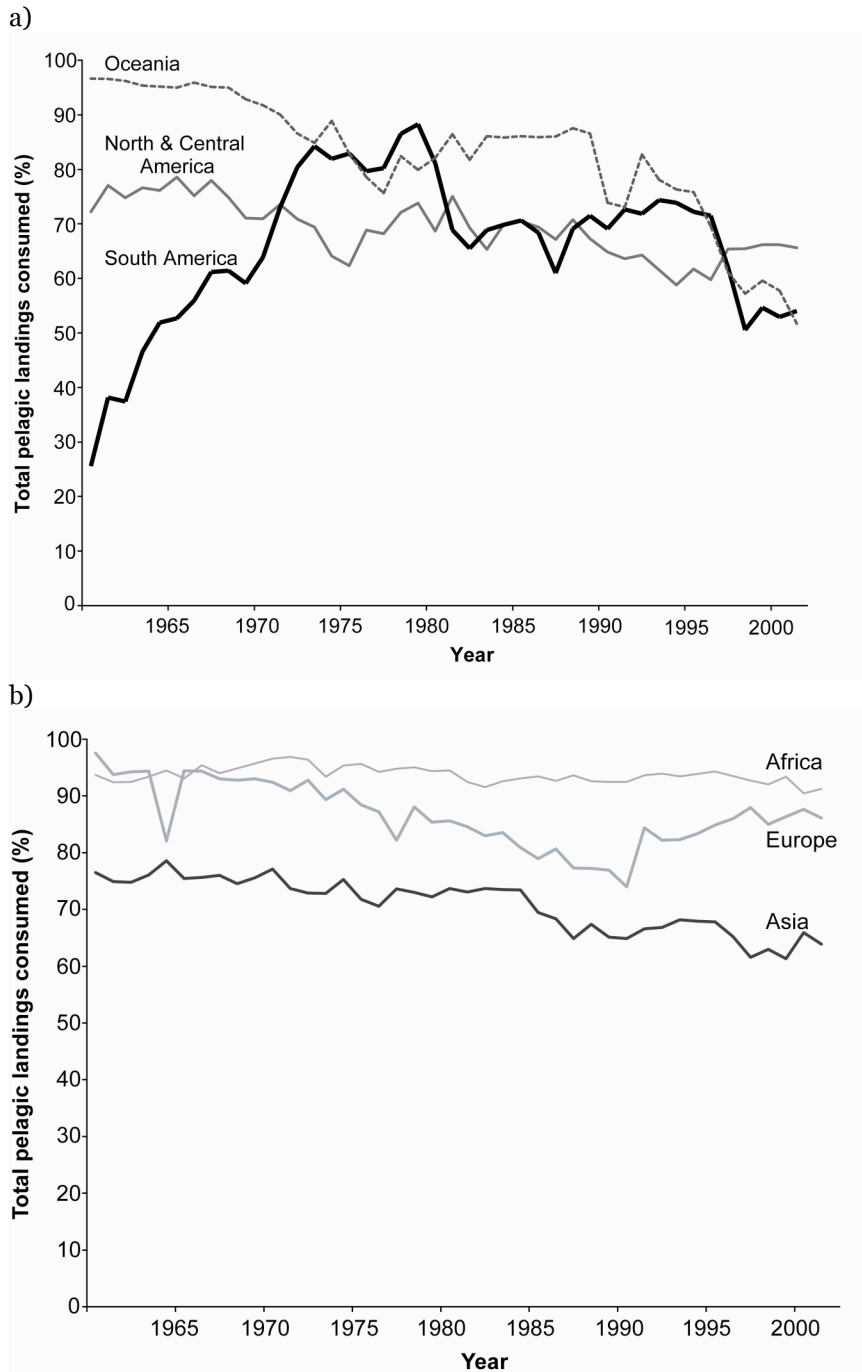


Figure 2a and b. Trends in forage fish as a percentage of total pelagic consumption on a regional basis, adjusted for the high volume of large pelagic fish caught by distant water fleets from North America, Europe and Asia. (FAOSTAT, 2005; *Sea Around Us* Project, 2006).

In Oceania, the tonnage of forage fish consumed by humans is small relative to the commercial landing, and also in comparison to fish consumed in Asia and Africa (Figure 3). Also, Africa and Europe increased their share of forage fish consumption, while the consumption in Asia, North America and South America declined since the 1990s.

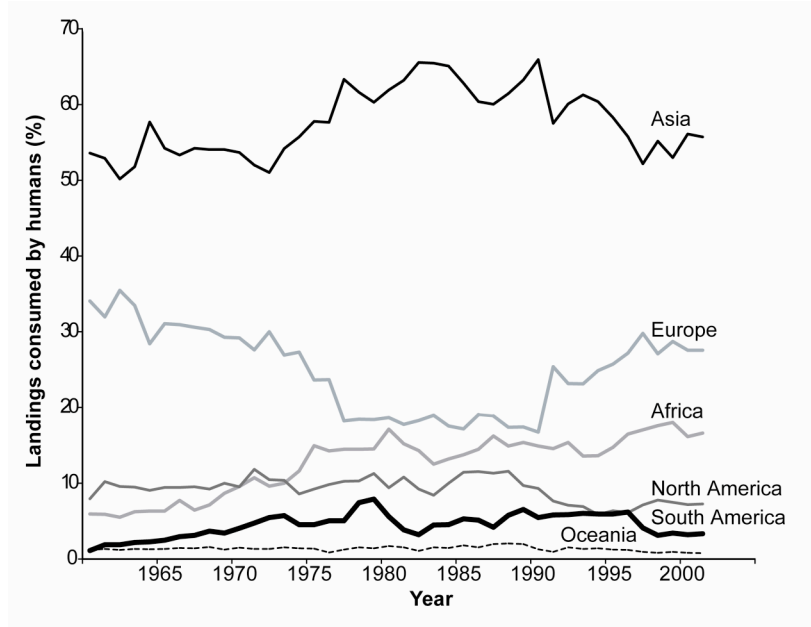


Figure 3. Trends in regional forage fish consumption as a percentage of global forage fish consumption from 1961 to 2002. (FAO, 2006; *Sea Around Us* Project, 2006).

Consumption of forage fish as a proportion of small and medium pelagic landings varies across continents (Figures 4 and 5). Africa's consumption of forage fish increased from 1960 to the early 1990s and now fluctuates around 80% of total small and medium pelagic landings in the area. In Europe and Asia, consumption has been increasing since the mid 1960s, while in Latin America this declined since the mid 1970s.

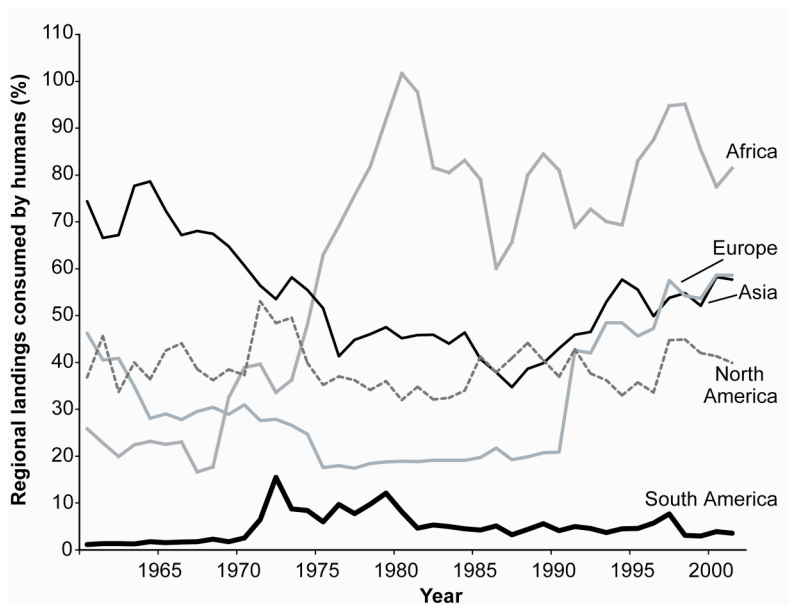


Figure 4. Landings of forage fish as a percentage of regional forage fish landings (adjusted for distant water fleets in Oceania) from 1961 to 2002. Consumption of forage fish in Oceania was combined with Asia due to the relatively small amounts that are consumed in the region. Values greater than 100% indicate that landings were supplemented with imports to meet the demand for low-value food fish. (FAO, 2006; *Sea Around Us* Project, 2006).

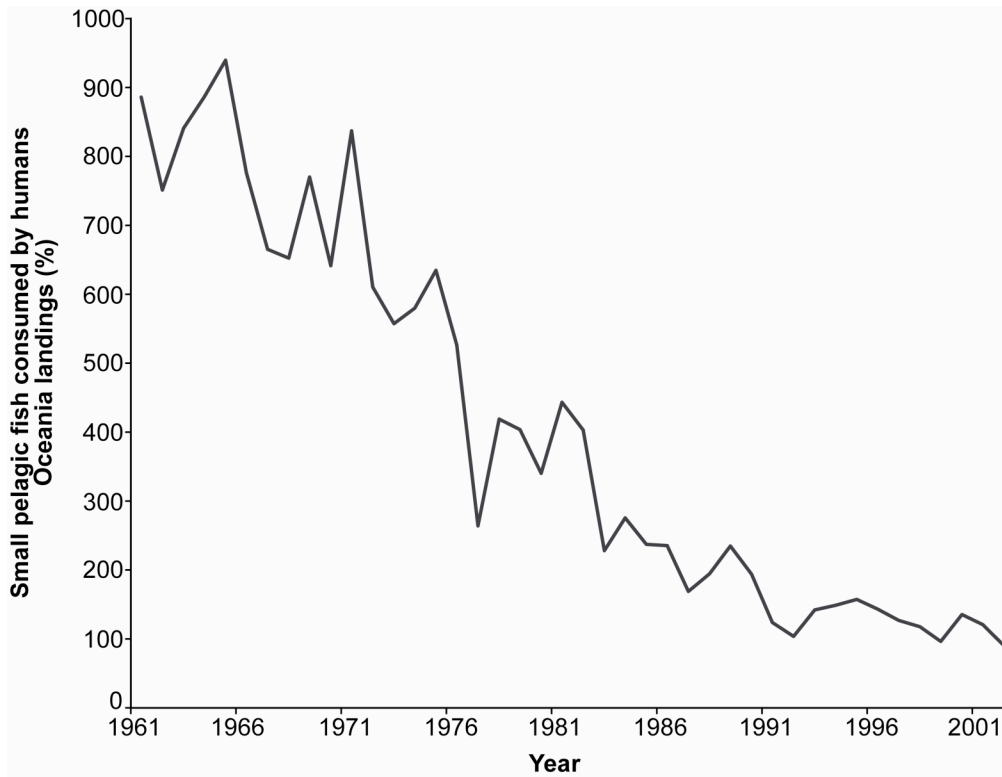
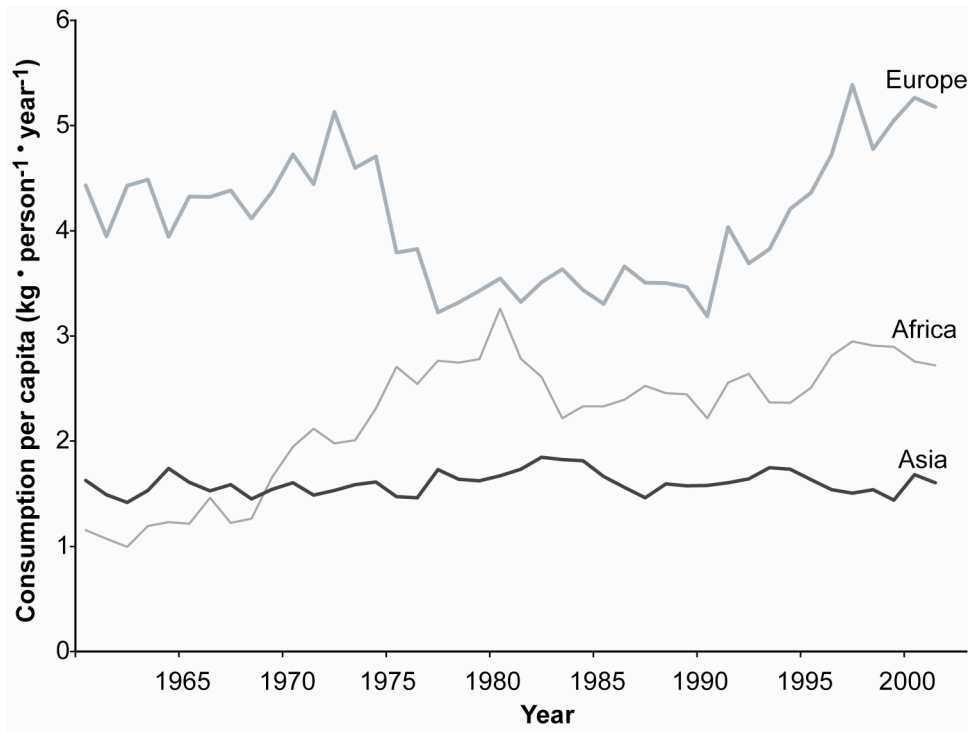


Figure 5. Landings of forage fish as a percentage of total small pelagic fish landings in Oceania from 1961 to 2002. Note that percentage can be greater than 100 due to extremely low landings of small fish and large imports of processed small fish, such as tinned mackerel (FAO, 2006; *Sea Around Us* Project, 2006).

Per capita consumption trends

The trend in per capita consumption of forage fish since 1961 varies with each continent (Figure 6). In Africa and Oceania, where these fish play an important role in food security, per capita consumption declined since the mid-1980s in Oceania, and late 1990s in Africa. There has been an overall decline in per capita consumption in South America since the late 1970s. In Asia, where these fish are also important for food security, per capita consumption has remained steady. In Europe, per capita consumption increased since the late 1980s (Figure 7), while in North and Central America, it has declined.

a)



b)

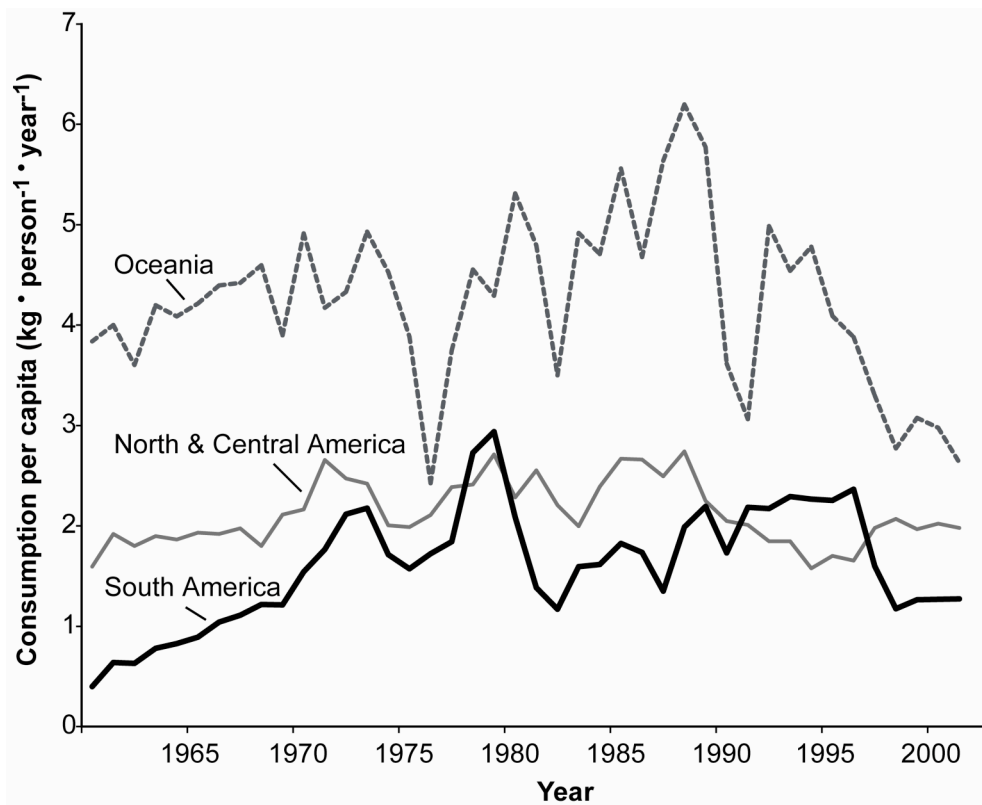


Figure 6a and b. Per capita consumption of small fish 1961 to 2002 (FAO, 2005).

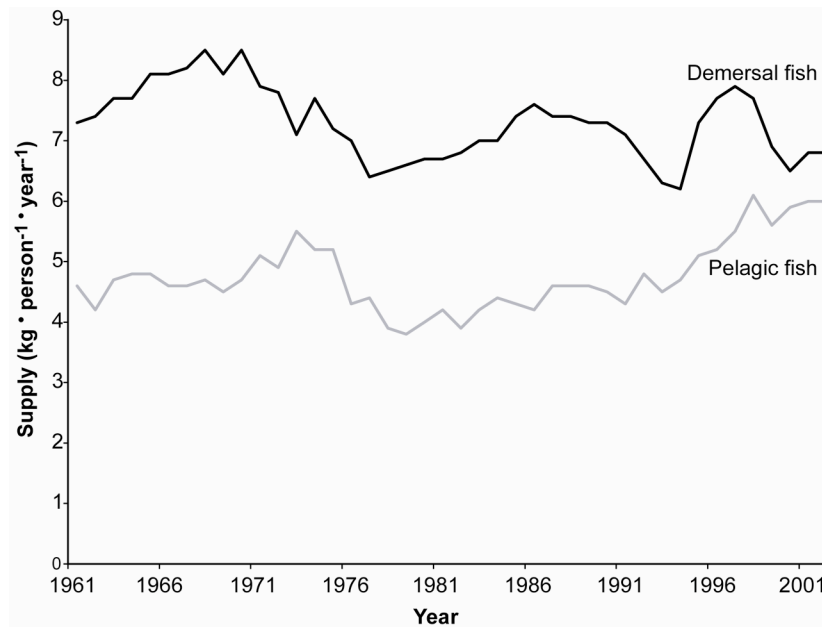


Figure 7. Annual supply of demersal and pelagic fish in Europe since 1961 (FAOSTAT, 2005).

DISCUSSION

A recent study by Delgado *et al.* (2003) examined trends in “low value food fish”, defined as a mixture of unspecified marine fish, freshwater fish and pelagic marine fish. Although this definition makes direct comparisons with this study difficult, some of their results are worth noting. Low-value food fish as a proportion of total fish consumed by humans dropped from 76% in 1973 to 65% in 1997. However, if China is excluded (which is justified by the unreliability of their statistics; see Watson and Pauly, 2001), the decline is much less: 77% in 1973 to 72% in 1997. Globally low-valued food fish increased from 41% to 47% of food fish consumed for the same time period (Delgado *et al.*, 2003). The study, however, noted that the rise in consumption was due in part to the poor in Asia (especially China) increasing their consumption of farmed freshwater fish (Delgado *et al.*, 2003). These authors also concluded that net imports of low-value food fish to the developing world totalled 2.3 million t in 1997.

Nevertheless, more recently, there has been a steady increase in the percentage of marine landings (total and as a percentage of small pelagic) that are consumed by people (Figure 1), although this differs between continents, both for volume and per capita consumption (Figures 2, 3, 4, 5 and 6).

Small pelagic fish populations are highly sensitive to oceanographic variability (Bakun, 1996) and, therefore, landings can vary significantly from one year to the next. However, this has limited impact on worldwide consumption patterns, except when the events are extreme, as in the case of the El Niño events of 1972-1973, 1983, and in the 1990s.

Indeed, Figure 2 in Chapter 1 shows the decline of small pelagic landings in Peru in the early 1970s. As a consequence of a strong El Niño, consumption changed, but not in proportion to the decline (Figure 1, this chapter). There are a number of reasons for this, beyond prices, which account for the spatial differences and fluctuations in human consumption of small pelagic food fish. They are:

- *Increasing wealth* in some countries, resulting in a switch to higher valued fish such as cods and haddock, and large pelagics such as tuna and billfish;
- *Substitution* of small pelagic fish when there is limited availability of demersal and large pelagic fish;
- *Increasing competition* for small pelagic fish for fishmeal and for human consumption, driving the price of these pelagic fish up and making it difficult for poorer countries to purchase the fish; and
- Soybean price fluctuations, due to soybean being used as a substitute for fishmeal in some industries.

We address in the following each of these four factors.

Increasing wealth: It has been noted that for countries such as China, where incomes are rising in major urban areas, there has been an increase in the demand for higher valued fish, including demersal species such as 'red fish' as well as for the larger, higher valued tunas and swordfish (FAO, 2005). The increased consumption of large pelagic fish in China may in part account for the decline in the Chinese share of small pelagic fish consumption in Asia, especially since China has recently expanded its distant water fleet with tuna as one of its target species (Pang and Pauly, 2001). A recent study of fish supply and demand to 2020 noted that developing countries still have great latitude for increasing demand for low-value food fish, but suggested that 'upgrading' is occurring in the wealthier segments of the developing world. Some of this will be realized via high valued farmed fish, further fuelling the demand for fish for feed/reduction to fishmeal (Delgado *et al.*, 2003).

In North America, consumption of low-value food fish is low compared to Asia and Africa (Figures 1, 3 and 5). Increasing wealth among North Americans may account for declining consumption of these low value food fish. Paradoxically, the increasing awareness of the health benefits of eating fish has not increased the consumption of healthy small pelagics, but of high-end products, notably farmed salmon, which are fed fishmeal and oil derived from small pelagics. As a result, overall seafood consumption rates in North America have shown a slight increase since the mid-1980s (Delgado *et al.*, 2003).

Substitution: Replacement of small pelagic fish for high-valued demersal fish such as cod and haddock occurs in Europe, where consumption of small pelagic fish declined from 1961 to the late 1980s, with a subsequent increase since then (Figures 1, 3, 4, 5, and 6). This may be explained by the supply of higher-valued demersal fish declining, and small pelagics meeting the overall increasing demand for fish (Figure 7). The expansion of fish species such as salmon, once considered high-value, has resulted in a lowering of market prices, thus enabling consumers to substitute affordably priced farmed salmon for cheap, small fish (Asche and Tveterås, 2005).

Increasing competition and price: Asche and Bjørndal (1999) suggested that demand for food fish is price-elastic, and that real price rises will cut into fish consumption on average in developing countries. Also, they suggest that the cut into consumption would be stronger for lower-income groups. Delgado *et al.* (2003), in their modeling of fish supply and demand to 2020, noted that a cross-price elasticity of 0.3 implies a 1% rise in poultry prices. This, other things being equal, implies a 0.3 % rise in fish demand. This appears to hold for small pelagic food fish especially in Oceania, Asia, Africa and South America.

In Asia, more than 50% of small pelagic low-value food fish landed are consumed, but the percentage of these fish that are consumed has declined recently (Figures 1 and 3). While the amount of fish consumed is high, on a per capita basis, it is less than for many other areas such as Oceania and Africa (Figure 6). The overall trend is a decline in the consumption of these fish (Figures 1 and 3), despite an overall increasing consumption of the percentage of landings (Figure 4) and a constant per capita consumption rate (Figure 6). Some of this decline in consumption may be due to a shift to higher value species, as a result of increasing wealth in some segments of the population, as discussed above. Some of this decline may also be due to diverting some fish such as bycatch and fish suitable for human consumption to the aquaculture sector (Kelleher, 2005).

The impact of changes in demand for small pelagic fish for reduction or human consumption is well-illustrated by Africa. There, incomes have not increased, and small pelagic fish are an important food source, highly sensitive to price changes. The consumption of small pelagic fish as a percentage of the total pelagics landed in Africa has fluctuated little since the 1990s (Figure 1), but is increasing as a percentage of the global human consumption of small pelagic fish (Figure 3). More recently, Africa has increased its global share of these low-value food fish from less than 10% in 1961 to almost 20% in 2000. The percentage of small pelagics landings in Africa that are consumed increased from 1961 (25%) to the early 1980s, then declined until the late 1980s. It now fluctuates around 80% of total African landings. However, the overall trend in per capita consumption of small pelagics, while fluctuating, is positive over time (Figure 6). These fluctuations in consumption are, in part, a reflection of changes in price and supply on the world market, with the increases or decreases of the landings of Peru and Chile having the strongest impact on world supplies and prices.

In South America, consumption of small pelagic food fish as a percentage of total pelagic landings increased rapidly until the early 1970s, coinciding with the increased landings of small pelagic fish in the region (Figures 1 and 4). It then declined significantly in the 1970s, in the aftermath of the first collapse of the anchoveta fishery. Since then, consumption has fluctuated with an overall declining trend. Similarly, since the late 1970s, there has been an overall decline in South America's consumption of global landings of small pelagic food fish (Figure 3). Per capita consumption of these low-value food fish in South America follows the same increasing trend until the 1970s and early 1980s, with a subsequent decline, accelerating in the last five years (Figure 6).

In South America, especially Chile, salmon aquaculture is expanding. As a result, and given that catches of small pelagics and hence fishmeal/oil production in Chile and Peru have not increased, exports from the region have remained roughly constant, while 'internal' consumption increased (in the aquaculture sector). Concern was raised in the region over food security issues since many of the species, such as mackerels, used for fishmeal are also consumed by local residents (Table 1). In Peru, the government has restricted industrial fisheries (most of it destined for fishmeal) from fishing for some small pelagic species and in certain areas to ensure there is an affordable supply of fish for human consumption (FIS, 2003).

Historically, the supply and demand of small fish for human consumption was a simple model of fishers catching the fish, processing and preserving the products and selling the fish to local consumers or buyers for export to other countries. However, with the expansion of reduction plants in the 1960s, this model became more complex, with fish destined for human consumption competing with several other consumers of fishmeal and fish oil, such as intensive animal producers, especially for pigs and poultry, aquaculture producers, especially for fish oil, the pharmaceutical industry and, more recently, the pet food industry. There is general agreement that there is no scope for increasing the exploitation rates of these small pelagic stocks. Rather, there are limits to the potential expansion of intensive animal production, including aquaculture, which compete with human consumption.

Soymeal can be used as a substitute for fishmeal in intensive animal production, especially in the pig and poultry sectors (Chapter 4). Indeed, in 1996/97, fishmeal accounted for 4% of the world's protein meals supply, while soymeal accounted for 53% (Asche and Tveterås, 2005). Soymeal can also substitute for fishmeal in aquaculture, although the fish cultured do not achieve the same high growth rates (Durand, 1998). Fishmeal is also a small part of a large protein meal market and a close substitute for soymeal. Therefore, it is the total supply and demand for protein meals that determine price (Asche and Tveterås, 2005). If the total demand for protein meals increases, the price for protein meals will increase, including the price of fishmeal. This will also increase the likelihood of small pelagic fish destined for human consumption being diverted to the reduction sector. This was the case in Peru in 2003, as described previously.

CONCLUSION

Forage fish have been and still are consumed by humans as part of a larger suite of fish that were historically consumed, and humans are finding new ways to process and make palatable small fish that were previously shunned or undiscovered by consumers. There are some areas in the world where consumption of these fish is increasing, especially in the developing world, where traditional stocks are depleted as well as other sources of protein being too expensive or difficult to buy. In other areas of the world, especially in developed countries, consumption is declining as consumers substitute these fish for more affordable farmed fish. This is only possible because the small pelagics that are used as feed are extremely cheap on the world market. Changes in consumption patterns vary, but the underlying main driver of change in the last 20 years or more has been the price of forage fish, which risks the food security of people relying on cheap fish protein. The future of balancing food security and the development of an aquaculture sector relies on a number of factors, all controlled by global events such as the price of soy beans, technological developments in the aquafeed industry, climate change and world oil prices.

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