

## FISH TO 2020: SUPPLY AND DEMAND IN CHANGING GLOBAL MARKETS<sup>1</sup>

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### Abstract

The structure of global supply and demand for fish has changed dramatically over the past few decades. Traditional marine fisheries increased and reached its peak in the 1990s, while aquaculture has expanded rapidly since the 1970s, making it one of the fastest growing sectors in all of agriculture. Fish has also become widely traded internationally. A large part of the rising trade, production, and consumption has taken place in the developing world. These developments highlight the need for and complexities of making projections for future trends in production and consumption. The International Food Policy Research Institute (IFPRI) and WorldFish Center have recently collaborated on a landmark study applying state-of-the-art-modeling techniques to analyze the outlook for global fish markets over the next 20 years. Model simulations suggest world fish demand will outpace supply growth, resulting in higher fish prices. (In contrast, other food commodity prices will decline in real terms). The share of fish supply that is globally traded will continue to rise; meanwhile growth in production and consumption will increasingly take place in developing countries. The implications of these changes are profound with respect to resource allocation to and within fisheries, as well as the design of strategies and options for improving outcomes for the poor and the environment.

### 1. Introduction

The significance of fisheries resources as an agricultural commodity and vital source of animal protein that addresses the issue of food and nutrition security in developing countries have become more evident in the recent decades as fish became an important global commodity, and demand for fish continue to grow (World Bank 2004; Kura et al. 2004). Trends in capture fisheries and aquaculture production is being observed and analyzed for decades in order to understand the changes in the supply of fisheries that influences the demand of these resources from the urban rich to the rural poor. The changing patterns in fisheries production is alarming because of its continuous depletion of wild stock, an observation made not only in poor developing countries but also even in developed ones. In US for example, government officials, scientists, business leaders and fishers pointed to overfished and depleted fish stocks in its waters along with severe habitat degradation (Pew Oceans Commission 2003). Moreover, even corrected China's fisheries statistics that provide best estimates of biophysical potential do not give an encouraging scenario on global catch (Watson and Pauly 2001). The Fisheries Department of Food and Agriculture Organization repeatedly gave forewarning on the threatened and depleted stocks of wild fish worldwide thru its bi-annual publication of the State of the

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World Fisheries and Aquaculture (FAO 1995, 1998 and 2000). Yet the alarming trends on the decline of fisheries production continue in spite of all these forewarnings.

Fisheries resources behavior and development impinges on the socioeconomic and political arena in both developed and developing world. The birth and boom of aquaculture industry in developing countries during early 1980s till 1990s presented as the savior and liberator of catching wild fish and more importantly, a new source of food fish for the poor (FAO 1995; Williams 1996). Until now, the problems from the biological to the economic aspect in this industry still arise. Moreover, health effects to humans from genetically modified organisms are still an on-going debate (Pew Initiative on Food and Biotechnology 2003). In addition, feed demand for aquaculture that utilizes wild-caught fish put more pressure on the wild fisheries (Tuominen and Esmark 2003). A number of studies have illustrated the negative effect of aquaculture industries ranging from escape of cultured fish to the wild population to water pollution due to effluent coming from artificial feeds. Naylor et al (2000) argued that though aquaculture provides significant contributions to fish supply, it has its own environmental tradeoffs. Business people in the industry and policymakers defended aquaculture as an environmentally sustainable means of contributing to the dwindling wild fish supplies.

The pros and cons of aquaculture production, wild fish harvest and fish consumption from the economics, politics and biological environment has been in discussion particularly its economic and social tradeoff. This paper intends to provide a summary of broad economic analysis on the rapid changes in fisheries over the past two decades and the future scenario of capture and aquaculture supply and demand till 2020.

## **2. The Status of Fisheries Resources and Employment Opportunities**

The fisheries sector have revolutionize since the late 1980s through the decline of traditional marine capture fisheries, particularly in developed countries; the growing roles of developing countries and aquaculture, which are interlinked and; the rising role of China in the fisheries world.

### **2.1. Fish supply**

Global fisheries production has reached 130.4 million mt with 94.8 million mt coming from capture fisheries and 35.6 million mt from aquaculture in 2000. These figures are currently the highest in records and have significant impacts on food and nutrition security as it provides more than 15% of total animal protein supplies (FAO 2002). Figure 1 presents the trends in fish production from 1970 to 2000. Total global fish production has doubled since 1970 with most of the growth provided by the introduction of aquaculture during the mid-1980s.

Aquaculture gave over 70% by weight of the total growth in food fish production from 1985 to 2000. It has been steadily rising from only 7% in 1973 to 12% in 1985 to over 30% by 1997. On the other hand, trend in capture fisheries show substantial increase through the late 1980s but has slowed down since then. FAO's State of World Fisheries and Aquaculture (2000) reported that majority of world capture fish stocks have been fully or over-exploited hence the stagnated if not declining production.

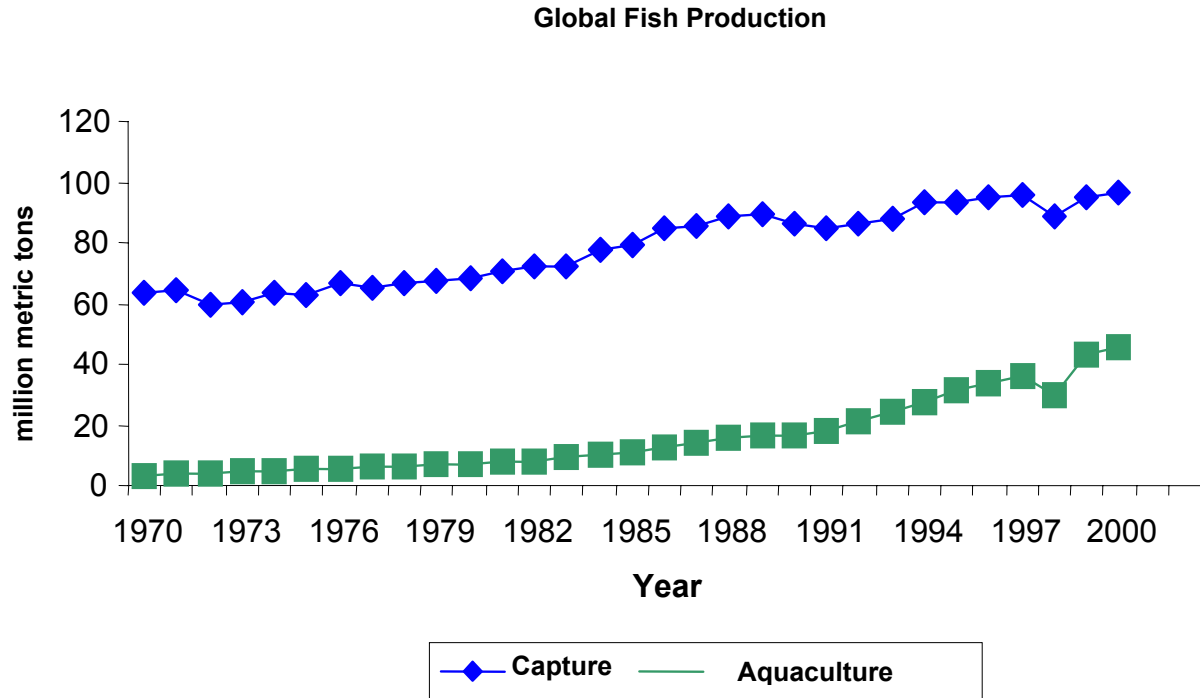


Figure 1. Trends in global fish production, 1970-2000. Source: FAO 2002

### Capture Fisheries

During the 1970s until 1990s, a steady if not rapid growth in capture fisheries was observed, starting with 44.5 million mt in 1973 to 94.8 million mt in 2000. Over 90% of the rise in capture fisheries came from marine resources. Growth in this fisheries resource was mainly due to expansion of fishing fleet capacity, technological innovation and increase in investment that led to the full exploitation of fish stocks. Surprisingly, developed world fish production declined to about 3.6 million mt while developing world production grew to an average annual rate of 3.4% showing the overall shift of production from developed to the developing countries (Figure 2).

### Aquaculture

Aquaculture is more of a developing-country farming activity. In 1973, developing countries produced 58% of the world's total aquaculture products and have expanded to 89% in 1997 (Figure 3). The rate of growth corresponds to 13.3% per year in developing countries against 2.7% in developed countries since 1985. Among the regions, Asia accounts for 87% of world aquaculture production by weight and China alone provides 68% share, a rise from 32% in 1973.

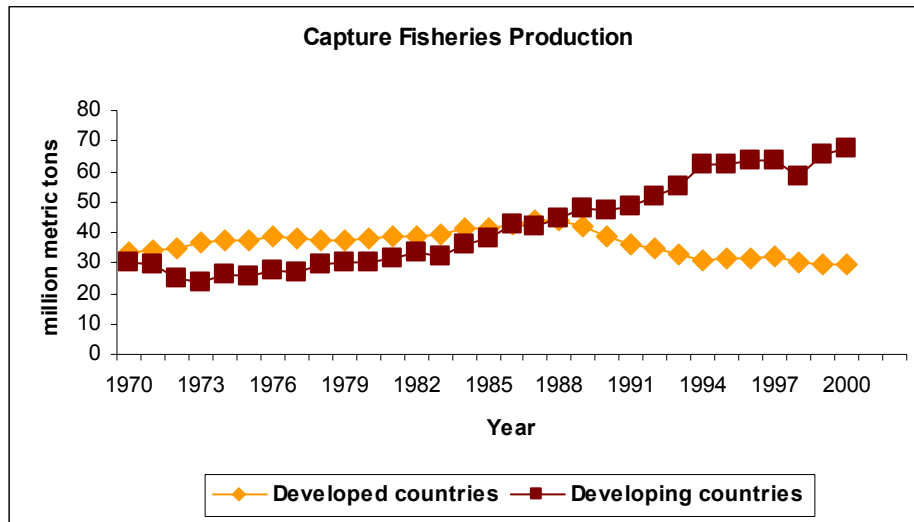


Figure 2. Capture fisheries production from developed and developing countries, 1970-2000. Source: FAO 2002

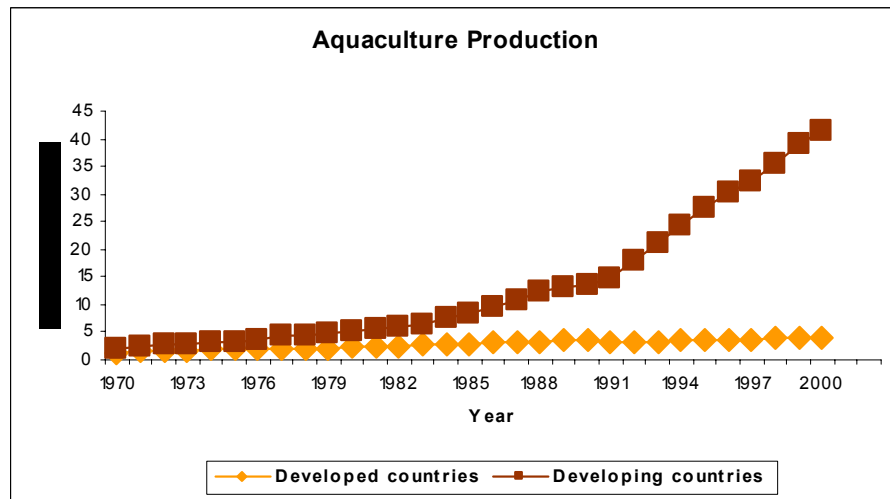


Figure 3. Aquaculture production from developed and developing countries, 1970-2000. Source: FAO 2002

**2.2. Fish demand**

World consumption of fish as food has doubled since 1973 with 90% contributed by the developing countries. FAO (1999) reported that growth in fish consumption as food in richer countries has diminished while consumption in poorer countries has grown rapidly particularly that of freshwater fish in East Asia. Utilization of crustaceans and non-cephalopod mollusks such as oysters and clams has increased significantly. This was also matched with an equally rapid growth in aquaculture production though not exclusively within Asia.

### Total Food Fish

The amount of food fish consumed has increased from 45 million mt in 1973 to over 90 million mt in 1997 worldwide with world per capita food fish consumption rising from 11.6 to 15.7 kg/year during the same years. The rise in food fish consumption has primarily been a developing-country phenomenon where China dominated aggregate consumption (over 36% global consumption in 1997 compared to only 11% in 1973). Developing-country fish consumption has risen from 45% in 1973 to 70% in 1997, mainly due to rapid growth in these regions.

On the other hand, levels of per capita fish consumption have hardly increased in Sub-Saharan Africa over the past 30 years; in fact, it has declined significantly since the mid-1980s. Aggregate consumption levels have also declined since 1985 in the developed world as a consequence of dramatically lower per capita consumption in the former Eastern Bloc countries.

### **2.3. Food Fish Consumption**

#### Commodity groups

According to FAO's commodity group *freshwater and diadromous fishes* had most rapid increase in consumption over the past several years. Consumption of both types of fish expanded in recent years, largely because of the rapid growth in Asian freshwater aquaculture and the marine net pen farming salmon. Aggregate consumption of freshwater and diadromous fish rose from 1.3 million mt in 1981 to 13.2 million mt in 1997 with per capita consumption increasing nearly tenfold in China.

Global consumption of *demersal fish* has remained at the same absolute level since the 1990s, while the growing population has caused per capita consumption to decline. This is partly due to the decline in Atlantic cod and Alaskan pollock fisheries, and from low-farmed production of demersal species. Global per capita consumption of *pelagic fish and unspecified marine fish* has remained relatively constant with aggregate consumption growing slowly. Consumption of marine finfish species has been limited by relative difficulty of aquaculture production combined with already high levels of exploitation in capture fisheries.

Consumption of *farmed and wild caught marine shrimp* has increased rapidly over the past several decades resulting to global per capita consumption nearly tripled since 1970. This trend was also observed in per capita consumption of *non-cephalopods mollusks* – mostly shellfish such as oysters and clams. The rise in consumption of shellfish has centered in Asia, where growing aquaculture production of mollusks, especially China, led to an incredible 13-fold increase in per capita consumption from 1981 to 1997. Aggregate cephalopod consumption, mostly consisting of squid, has more than doubled in 30 years, but per capita levels have remained fairly low – 0.4 kg/year on a global basis in 1997.

#### Trends by Market-Based Category

This section outlines historical consumption trends based on fisheries commodity aggregates devised according to market-based criteria (elaborate discussion is provided in the book by Delgado et al. 2003). Global per capita consumption of market-based fisheries commodities is led by low-value food fish at 7.5 kg/year in 1997, followed by high-value finfish consumption at

4.4kg/year, mollusks at 2.4 kg/year and crustaceans at 1.2 kg/year. Consumption levels of total food fish are highest in China, Southeast Asia, and the developed world.

Largest absolute increase in consumption was observed in *low-value fish* during the past several decades, as the poor in Asia have added diversity to their diets through increased consumption of farmed freshwater fish. Global aggregate consumption of low-value food fish rose from 18 million mt in 1973 to 43 million mt in 1997, driven mostly by Chinese consumption rising from 4 to 20 million mt as per capita consumption grew at an average annual rate of 9.2% during 1985-97. The developing world is a large net importer of low-value food fish, receiving approximately 2.3 million mt in imports from the developed world during 1997.

*High-value finfish* is the only category of fish that has decrease in overall per capita consumption since 1973. Declines in Japan and the former Soviet Union have offset increases in Asia, the United States, and elsewhere. Levels of annual per capita consumption in Japan at 33 kg, European Union at 15 kg and the United States at 13 kg still dwarf the levels in developing countries of only 2 kg. Developed countries are by far the largest consumers of high-value finfish accounting for 73% in global consumption in 1997. However this has decreased from 86% in 1973, a phenomenon driven largely by growth in Chinese and Southeast Asian consumption.

*Mollusks* consumption boomed in China with 14.5% growth in per capita consumption from 1985 to 1997. This has dwarfed the comparatively modest growth of 2.1% of the developing world. Europe and Japan are major importers of mollusks, with combined net imports of 1 million mt in 1997, while Latin America and China are fairly large exporters.

In Asia, specifically, China, India and Southeast Asia, have robust growth in *crustacean* consumption. The per capita consumption of crustaceans by developed world (2.0 kg per annum) is still two times bigger than developing world. Latin America and Southeast Asia are large exporters of crustaceans while the farmed production of shrimp in Ecuador, Indonesia, Thailand and Viet Nam has provided a major source of export revenue for these countries.

### Price Trends

Fresh and frozen fish have shown a long-term increase in their real prices since the Second World War unlike the behavior of red meat prices where half of their value on world markets was lost between the early 1980s and the late 1990s (Delgado et al 1999). Exception was observed in canned finfish products, which is less favored in the consumption baskets of developed countries since the early 1970s. Other exceptions are the specific cases of shrimp and salmon, where rapid entry of aquaculture has lowered prices for these luxury goods, even as it has greatly broadened the market for these goods.

Fisheries commodities show nominal and real export unit values over time where real export unit values declined during 1977-85, though this decline generally reversed or slowed during 1985-97. Export unit values for salmon, shrimp and freshwater fish have seen real declines from 1985 to 1997, a phenomenon that can probably be attributed to the rapid growth of aquaculture production of these commodities. Meanwhile, real export unit values for tuna and cod have risen.

Crustaceans have by far the largest export unit value, while low-value food fish have the lowest. Real export unit values declined for all categories of food fish commodities from 1977 to 1985 but increased from 1985 to 1997. High-value finfish unit values increased the most during this time span (42%), reflecting increased demand and stagnant production in this category. During 1985-97, combined production of high-value finfish grew only 9%, the slowest growth of all market-based fisheries commodities. The reported values are global averages; naturally variation exists across regions and commodities.

#### **2.4. Trends in Fishers and Fisheries**

In 1970s, there are 13 million people engaged in fishing and aquaculture as their source of income and food. This represents 1.5% of the people who are economically active in the agriculture sector. In 1980s, nearly 17 million people are engaged in fishing and aquaculture, accounting for 1.6% of the 1 billion people economically active in the agriculture sector. Trends of increasing mechanization and advancing technology in agriculture make it more attractive to work in agriculture than fisheries, especially in highly populated developing countries. In 1990s, a growth of 15% in the number of people economically active in agriculture was observed accounting to 1.2 billion people. Out of this 1.2 billion, 28.5 million was accounted by fishers and fish farmers showing an increase of 72% compared to 1980s and provided an increase of 2.3% of agriculture sector's economically active population. The expansion in aquaculture largely explains the growth in numbers of fish farmers. In 2000, 2.6% of 1.3 billion people who are economically active in agriculture worldwide represent fishers and aquaculture workers; this has grown compared to 2.3% in 1990. Out of this 35 million people, fishers have been expanding at an average rate of 2.2% per annum since 1990 and about 7% per annum in aquaculture (FAO 2002). Growth in employment in fish farming and aquaculture workers are found in Asia, particularly China. Greater economic opportunities derived from commercial aquaculture production have triggered the involvement of more people in fish farming and aquaculture-related activities.

On a regional distribution, 84% of the fishers come from Asia followed by Africa at 7%, Europe, South America, North and Central America at about 2% each and Oceania at 0.2%. These are fishers working full-time or part-time, directly working in fishing and fish farming. Most of the fishers and aquaculture workers are concentrated in China (9 million), India (6 million), Vietnam, Indonesia, Bangladesh and Philippines (4 million taken together). Artisanal fisheries still dominates in Africa although local commercial fisheries are gradually developing. Because of the widespread extension of national fisheries jurisdiction to 200 miles, a decrease in employment opportunities offered by long-range fleets operating in distant marine fisheries was felt in European countries. Nevertheless, the number of European fishers increased in absolute numbers between 1980 and 1990, probably due to the emerging aquaculture industry (FAO 2002).

### **3. Projections to 2020**

#### **3.1. Brief description of Projections Model**

IFPRI's IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) Model developed and maintained by a team of researchers led by Mark W. Rosegrant,

was used for projection purposes. IMPACT is specified as a set of country or regional submodels within each of which supply, demand and prices for agricultural commodities are determined. IMPACT version of July 2002 covers 36 countries and regions (according to virtually all of world food production and consumption), 6 fish and 22 nonfish commodities, including all cereals, soybeans, roots and tubers, four meats, milk, eggs, oils, oilcakes, meals, sweeteners, fruits and vegetables.

Forecasts of changes in relative prices from 1997 to 2020 are the principal insights offered by supply and demand models such as IMPACT. Changes that are forecast are devoid of inflation and can be shown as percentage changes over the entire period relative to an actual base level in 1997. They provide insights on the net effect of thousands of simultaneous assumptions and parameters, adjusting over time to demographic changes, income growth, and technological changes and to changes in relative prices themselves (substitution effect in both production and consumption).

The fisheries components of IMPACT follow the same general approach as the rest of the world. This version of the Model includes four categories of food fish, namely, high-value finfish (such as salmon and tuna), low-value food fish (such as herring and carp), crustaceans (such as shrimp and crabs), and mollusks (such as clams and squid); all are disaggregated into wild-caught and farm raised. It also includes two animal feed items made from fish: fishmeal and fish oil. A complete description of this Model is given in the book "Fish to 2020: Supply and Demand in Changing Global Markets" by Delgado, et al 2003.

### **3.2. Projections and Implications Under Different Scenarios**

Six scenarios were described based on IMPACT projection. These are:

1. Baseline – judged to be the most plausible set of assumptions
2. Faster aquaculture expansion – production growth trends, excluding supply response to price change, for all four aquaculture output aggregate commodities are increased by 50% relative to the baseline scenario
3. Lower China production – Chinese capture fisheries production is reduced by 4.6 million metric ton in base year 1996-98 based on Watson and Pauly (2001). Consumption is reduced an identical amount to maintain balance. Reductions are spread proportionately among fish commodities. Income demand elasticities, production growth trends, and feed conversion ratios are adjusted downward, consistent with the view that actually growth in production and consumption over the past two decades was slower than reported.
4. Fishmeal and fish oil efficiency – feed conversion efficiency for fishmeal and fish oil improves at twice the rate of specified in the baseline scenario.
5. Slower aquaculture expansion – production growth trends, excluding supply response to price change, for all aquaculture commodities is decreased by 50% relative to the baseline scenario.
6. Ecological response - -1% annual growth trends in production, excluding supply response to price change, for all capture fisheries commodities, including fishmeal and fish oil.



### 3.3. Aggregate and Per Capita Consumption and Net Trade Baseline Scenario

Aggregate consumption trends largely reflects production trends in terms of composition and region except that annual rates of growth of consumption in developing countries exceed rates of growth of production by 0.2% per annum through 2020 (0.3 % excluding China), suggesting net exports of food fish from developing to developed countries. Aggregate consumption of both high- and low-value food fish is projected to continue to increase in the developing world at 2.3% and 1.6%, respectively, whereas it is static in the developed world (Figure 4). The rates hardly change even if China is excluded suggesting that this is a widespread structural phenomenon driven by population growth, urbanization and income growth.

Per capita consumption is projected to grow throughout the developing world under the baseline scenario while developed country consumption remains virtually unchanged. The most rapid growth (in %) continues to be in China, where per capita consumption is projected to grow at an average annual rate of 1.3% to 2020. Mollusk and crustacean consumption per capita are projected to grow most rapidly on a global level at 1% and 0.7% per annum respectively while per capita consumption of high-value finfish actually declines by 0.2% per year. Projections showed that aggregate consumption would rise rapidly in Sub-Saharan Africa as a consequence of the region's rapid population growth rates however per capita consumption is projected to remain unchanged.

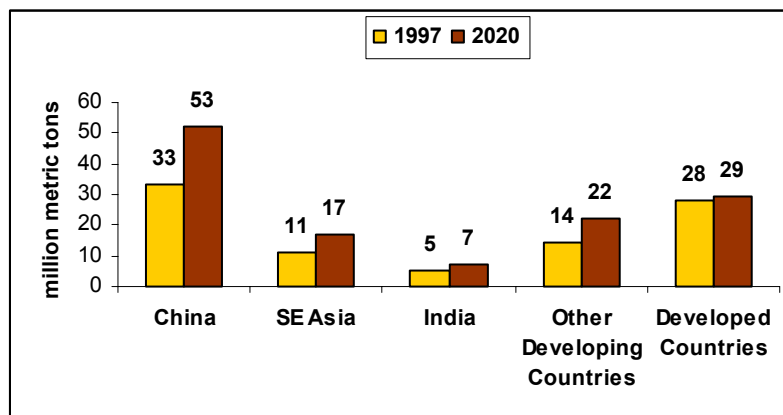


Figure 4. Food fish demand, 1997 and projected 2020, using baseline scenario

Developing countries became significant net exporters at 4 million mt by late 1990s. China, India and Latin America are projected to continue net exports in absolute terms to 2020 under the baseline scenario at 0.5, 0.4 and 3 million metric tons, respectively. Among developing regions, only Latin America's net exports are projected to represent a significant share of total production through 2020 at 35%. Other developing regions show that demand continues to surpass growing supply while net exports of food fish were more than 11% of food fish production in developing countries, excluding China, in the late 1990s, they are projected to be less than 5% in 2020.

#### Alternative Scenarios

Results of the different scenarios in terms of projected per capita food fish consumption in 2020 are presented in Figure 5. The ecological collapse scenario would have the effect of cutting world capture food fish production by more than half through 2020 if price factors did not play a

part. Still projected global per capita consumption in 2020 under this scenario only decline to 14.2 kg/capita/year from 17.1 kg/capita/year baseline level whereas FAO (1999) reported a figure of 15.7 kg/capita/year for 1997. Sharp price increases under this scenario are responsible for the absence of a larger per capita decline in food fish consumption because they slow the decline of production growth in capture fisheries, induce increased aquaculture output and also reduce demand pressure.

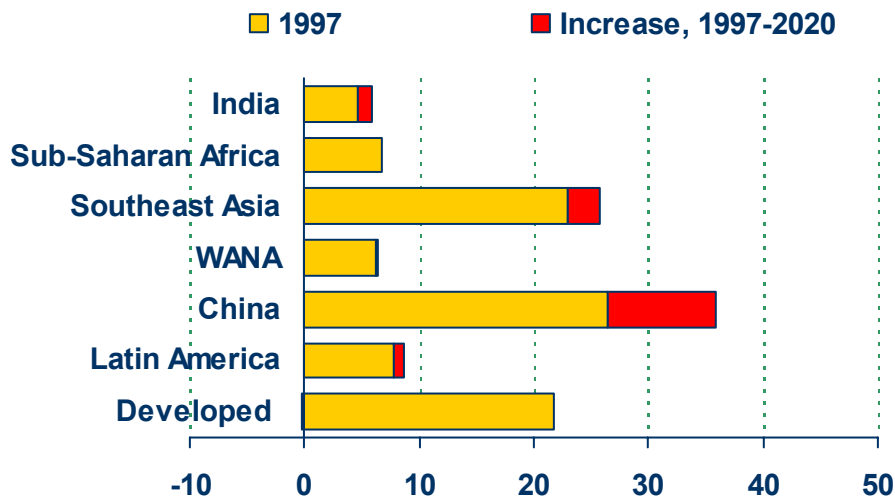


Figure 5. Per capita demand for fish products in 1997-2020 using baseline scenario.

Lower China production scenario leads to a 1 kg/capita/year decrease in global projected food fish consumption in 2020 but this is mostly result from its effect on estimated Chinese consumption. Controversy over China's fish production levels matters in terms of Chinese consumption and global production trends, though surprisingly, it has little effect on consumption or production outside China or world prices for fish.

The most plausible scenario with strongest effects on outcome is faster aquaculture expansion, which modifies IMPACT's conservative assumptions about the rates of technological change and other exogenous factors affecting aquaculture production. A 50% increase in exogenous rate of change in aquaculture production, modeled primarily to be sensitive to prices, leads to an increase in forecast per capita global consumption of food fish in 2020 of 1.9 kg/capita/year, an increase comparable to the absolute magnitude of the declines forecast under the ecological collapse scenario. Investing in technological change in aquaculture production is still critical to growing aggregated fisheries output in the future, particularly in the developing world.

### 3.4. Production

#### Baseline Scenario

Global food production is projected to total 130 million mt in 2020, equivalent to an annual rate of increase of 1.5% from 1997 onwards (Table 1). Of the 37 million mt increase in global food fish production, over 2/3 comes from aquaculture, which is projected to represent 41% of global food fish production in 2020 (up from 31% in 1997). Aquaculture growth trends projected to 2020 are almost twice as high as those for capture food fish in most of the world (Figure 6).

Table 1. Share of world fish production (%) using baseline scenario

	1973	1997	2020
China	10	36	41
Other Developing Countries	33	37	38
Japan	17	6	4
EU 15	13	6	5
All Developed Countries	56	27	21

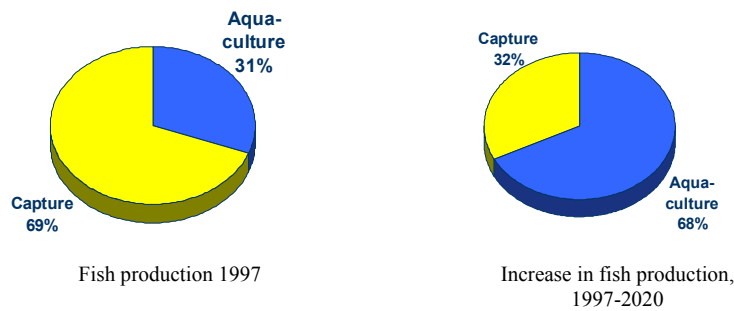


Figure 6. Share of aquaculture in fish production, 1997 and increase from 1997-2020 using baseline scenario.

Three main points highlight food fish production in 2020 based on baseline scenario. First, the share of developing country production rises from 73% in 1997 to 79% in 2020 and China is responsible for about 5 of the 6% point increase. This projection is consistent with trends observed in the past 30 years, including China’s expansion into distant-water fisheries previously occupied by fleets from developed countries. Second, the share of aquaculture worldwide, including China, is projected to increase from 31 to 41% in 2020. China’s share of food fish production from aquaculture increases from 58 to 66%, the production share from aquaculture for other developing countries increases from 17 to 27%, a larger relative change. Third, the share of low-value fish in total food fish is remarkably stable, at about 48%. Although production share of low-value food fish from wild fisheries declines, the production share of low-value food fish from aquaculture rises sufficiently by 2020 to compensate this.

### Alternative Scenarios

Results from the modeling for total food fish under the various scenarios showed that assumptions about technological change or increased investment in aquaculture are shown to be crucial, with a difference of about 25 million mt between faster and slower aquaculture expansion scenarios. The vast majority of this difference is in low-value food fish and mollusks represented a combined 91% of aquaculture production by weight in 1997.

The scenario with a more rapid improvement in feed conversion efficiency of fishmeal results in a 1 million mt (13%) decline in fishmeal production relative to baseline due to price effects – a significant result in terms of fishing pressure on reduction stocks. Greater efficiency of aquaculture production has a negligible effect on total food fish production but larger relative effect on the production of high-value finfish and crustaceans. In the extreme pessimistic ecological collapse scenario, total food fish production declines by only 17%, with greater production declines mitigated by production responses to major output price increases in both capture fisheries and aquaculture.

## **4. Conclusions from IMPACT Model on world food fish production**

Baseline scenario gives that global food fish production will increase slightly faster than global population through 2020. Per capita consumption is projected to rise, and real fish prices are also expected to rise between 4 and 16% depending on commodity. Livestock product prices are expected to decline by 3%. Low-value food fish continues to account for a fairly constant share of total food fish through 2020 (48%) while aquaculture's share of aggregate finfish production increases from 31 to 41%.

Developing countries will continue to dominate world fisheries production at 79% of world food production in 2020, an increase from 73% in 1997. It should be noted that developing countries excluding China just manage to preserve 38% global share of production under baseline scenario.

Global increases in consumption of food fish will predominantly take place in developing countries where population is growing and higher income allow purchase of high-value fisheries items for the first time by many people.

Technological progress in manufacture or use of fishmeal and fish oil will make these stuff progressively more expensive compared to plant derived substitute in the feeding of livestock and non-carnivorous fish. It is to be anticipated that these commodities will eventually exit from the rations of animals other than carnivorous fish, and that fishmeal prices will become progressively delinked from vegetable feed alternatives, such as soymeal.

Sensitivity analysis suggests that the key outcome for the future of fish price, including the price of low-value food fish to poor consumers, is the successful development and extension of sustainable aquaculture. The latter will keep fish prices lower under other production scenarios. A focus on food security in poor countries would suggest concentrating on low-value food fish aquaculture in developing countries. However, the uniform result across scenarios of rising relative prices for high-value fisheries items such as crustaceans and mollusks also suggests

importance for poverty alleviation of finding way to keep poor fishers involved in these key sectors. Finally, several scenarios suggest significant increases in the relative prices of fishmeal. Aquaculture technology investments targeted to low-value fish in developing countries will help ensure that the poor continue to benefit from fisheries development.

IMPACT projections confirm the growing importance of fisheries for food and natural resource policies in both developing and developed countries. They also show the extent to which the effect of relative price changes is likely to change the outlook for these issues when compared with straight-line and other simple projections.

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