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THE WATER RESOURCES OF LATIN AMERICA AND THE CARIBBEAN: INLAND AND MARINE FISHING AND THE WATER RESOURCE */

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INTRODUCTION

With the emergence of Peru as a major exporter of fish meal in the fifties, for the first time the fisheries of Latin America and the Caribbean became fisheries of more than local significance. The oceans washing the region for a long time remained relatively less exploited than areas in other parts of the world. Recently, however, there has been a large expansion of fishing in the seas around Latin America and the Caribbean by both regional and non-regional fishing fleets, with the annual catch approaching, and in respect of some species exceeding, the maximum sustainable yield.

The expansion of fish production has increased its importance as an economic activity and as a source of employment in coastal, riverine and lake-side areas. In some Latin American and Caribbean countries fisheries contribute significantly to supplies of food and to earnings of foreign exchange. At the same time, industries related to fisheries have undergone considerable development both those processing the catch and those producing boats, nets and other equipment.

The development of fish processing industries has contributed to the aggravation of localized water pollution problems, particularly in the countries of the Pacific coast. These problems, however, are still small in comparison with other water pollution problems existing in the region.

The development of industries related to fisheries have given rise to the emergence of a modern highly mechanized and productive fishing industry alongside the traditional artisanal fishery. The latter has not always been able to benefit from the development of the industry although incorporation of the traditional coastal fisheries has occurred in many Latin American and Caribbean countries.

One of the most important developments during the last decade has been the emergence of aquaculture, including the planting and harvesting of algae, the cultivation of shrimp, and the use of salmon-cage or ocean ranching production methods, as a highly profitable activity and a large foreign exchange earner in several countries. Again, however, there are ecological and environmental problems associated with such activities.

A salient feature of the use of the water resources of Latin America and the Caribbean in last decades has been the emergence of pollution as a significant and alarming problem of many water bodies. Little attention has been paid to the effects of the growing pollution of fresh and coastal waters on fishing. The water quality of the oceanic shelves is still largely unaffected by pollution, but the degradation of inland waters and of some coastal areas is reason for considerable concern, particularly for aquaculture and for fishing for direct human consumption.

This paper evaluates the extent of the challenge posed to water management in Latin America and the Caribbean by the water pollution - fishery industry nexus. No attempt is made at this stage to propose solutions or policy measures, although some successful efforts to reduce the negative impact of pollution on the fisheries are discussed together with efforts to reduce the negative impact of fishery activities on the environment. It is hoped that this paper will contribute to the incorporation of the consideration of the impact of water management decisions on the fisheries of the region.

Part I

THE DEVELOPMENT OF THE FISHING INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN

Chapter 1

FISHERIES IN THE REGIONAL ECONOMY

In the majority of Latin American and Caribbean countries, the value of fisheries production represents only a small fraction of gross domestic product (GDP).[1/] The importance of fishing and its participation in economic activity and employment is usually highly concentrated and localized, and in certain coastal areas it provides, directly or indirectly, the key source of local employment. In Peru, for example, the share of fisheries sector in GDP was 0.8% for country as a whole, in 1987, but in coastal departments of Ancash, Ica and Tumbes, it reached 8.44%, 4.58% and 9.83%, respectively.[2/] The number of people employed in the sector has been estimated for the region as a whole at about 2 million, principally engaged in coastal artisanal fisheries.[3/] The number of full-time fishermen was put at some 500 thousand. Of these at least two thirds and possibly up to 80% can be expected to be full-time artisanal fishermen.[4/] In Chile, for example, of some 65 000 persons estimated to be employed in extractive fishery, 23% are employed in the industrial fishing, and 77% in small-scale fishing.[5/]

The fishing industries of Latin American and Caribbean countries are divided into two very different sectors:

1. Artisanal fisheries are estimated to represent more than 40% in value of the overall fisheries production of the continent and provide a good percentage of its high-quality export commodities. They include subsistence and small-scale fisheries, rely on local fishing traditions, utilize mainly passive methods of fish capture and are characterized by a low level of capital investment. The fishermen are either self-employed or participate in a family, village or co-operative organizations. Fishermen usually do not receive wages, but are paid a proportion of the catch in cash or in kind. Individual catches are small and are consumed in part by the fishermen themselves, their families and communities. Catches centre on relatively highly-prized species which are sold almost entirely on the market for fresh fish for direct consumption. Losses due to spoilage tend to be high since most artisanal fishermen lack access to processing and preservation facilities. Small-scale producers are estimated to account for nearly all fish consumed in Colombia, Central America and the Caribbean islands, almost 90% in Guyana, and for more than half in Brazil and Mexico. According to other sources, artisanal, small-scale fisheries provide more than 90% of the seafood consumed by the local population.

2. The industrial fishery where enterprises are operated on a commercial basis. These enterprises are usually privately owned, capital intensive and their employees receive wages which may be supplemented by a productivity bonus or a small catch share. Industrial fishing fleets use very active and efficient methods of fish capture and supply fish to well established processing and

marketing entities. An important part of their catch is processed and losses due to spoilage tend to be relatively lower than in artisanal fishing. This sector is usually linked with the export market for fishery products through the fish processing industry.[6/]

In 1982/84, fish and seafood accounted for about 8.6% of animal protein consumption in Latin American and Caribbean countries, in comparison with 7.1% in 1961/63 and 7.6% in 1969/71.[7/] Per capita food supply of fish and fishery products in the region is 8.3 kg/year - slightly more than the average for all developing countries, but much below the level of consumption in developed countries (Table 1). The pattern of fish consumption differs considerably within the region, as well as within individual countries. On the whole, the highest level of per capita consumption is found in the Caribbean and the lowest in South America (Table 1). Between 1969-1971 and 1982-1984 fish consumption increased in most countries.[8/]

A. TRADE IN FISHERY PRODUCTS

Latin America and the Caribbean is a net exporter of fish and fishery products in terms of both live weight and value (Tables 1 and 2). In many countries fishing and related industries are important earners of foreign exchange. The fishery trade balance has been particularly large in Chile, Mexico, Ecuador, Peru, and Argentina, in each of these countries it averaged more than US$ 200 million annually during the 1984-1988 period. Only in Bolivia, Colombia and the smaller Caribbean countries is the fishery trade balance usually negative, but even among these countries it has been improving in recent years.

Exports of fishery commodities from Latin American and Caribbean countries reached almost US$ 3.2 billion in 1988.[9/] Average exports for the period 1985 to 1988 were US$ 2.8 billion compared with an average of only US$ 585 million in the period 1970 to 1974 (Table 2). Fishery exports grew at a higher rate than other regional exports during the 1975-1988 period. The share in total world fishery exports has declined, however, from about 18% during 1970-1971, to slightly above 10% during 1987-1988. Chile, Mexico, Ecuador, and Peru are the major exporters of fishery products. The share of fishery commodities exports in total exports of Latin American and Caribbean countries averaged 2.6% over the 1984-1988 period.[10/] The share was highest, averaging more than 10% in Chile, Ecuador, and Peru and in another three countries - Guyana, Honduras, and Uruguay - fish products accounted for more than 5% of total exports.

In terms of value, fresh, frozen, dried, salted, etc. crustaceans and molluscs accounted for over half of total fishery exports, meals, solubles and similar animal feedingstuffs of aquatic animal origin for about 23%, fresh, chilled or frozen fish for almost 20%, and all other fishery commodities (dried, salted or smoked fish, canned fish products and preparations, canned crustaceans and molluscs products and preparations, and oils and fats of aquatic animal origin) for less than 7%.[11/] In terms of tonnage, meals, solubles and similar animal feedingstuffs of aquatic animal origin accounted for over 67% of total fishery exports, fresh, chilled or frozen fish for almost 18%, fresh, frozen, dried, salted, etc. crustaceans and molluscs for over 6%, and other fishery commodities for somewhat over 8%.

Imports of fishery commodities to Latin American and Caribbean countries reached US$ 0.46 billion in 1988. It is relatively low in most countries and has been growing more slowly than in the rest of the world: regional share in total world imports of fishery commodities decreased from about 4.0% during 1970-1971, to 1.3% during 1987-1988. Brazil, Cuba, and Colombia are major regional

Table 1

CATCH AND DESTINATION OF FISH AND FISHERY PRODUCTS, LATIN AMERICA AND THE CARIBBEAN AND THE REST OF THE WORLD, 1984-1986
(Thousands of tons of live weight)

	World	Developed countries	Developing countries						
			All developing countries	Latin America and the Caribbean				Other developing countries
				Central America	Caribbean	South America	Total	
Thousands of tons of live weight per year								
Total catch	**87 170**	**42 853**	**44 317**	**1 446**	**297**	**12 048**	**13 791**	**30 526**
External trade:								
• imports	13 204	10 319	2 886	21	197	170	388	2 497
• exports	13 658	9 164	4 495	95	46	921	1 062	3 433
Food/non-food use:								
• non-food uses	26 625	13 524	13 101	516	43	9 232	9 791	3 310
• food supply	60 339	30 641	29 699	859	405	2 097	3 361	26 338
Kilograms per capita per year								
Total catch	**18.0**	**35.4**	**12.2**	**13.8**	**9.5**	**45.0**	**34.2**	**9.4**
External trade:								
• imports	2.7	8.5	0.8	0.2	6.3	0.6	1.0	0.8
• exports	2.8	7.6	1.2	0.9	1.5	3.4	2.6	1.1
Food/non-food use:								
• non-food uses	5.5	11.2	3.6	4.9	1.4	34.5	24.2	1.0
• food supply	12.4	25.3	8.1	8.2	12.9	7.8	8.3	8.1

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities. Volume 67. 1988, Rome, 1990, pp. 303-306.

Note: Catch, trade and supply data refer to fish, crustaceans and molluscs, including all aquatic organisms except whale and seaweeds. In view of possible distortions in each of the component of the commodity balances, as well as in coefficients used to convert product weight to live weight equivalent, per caput consumption data should be regarded as giving only an order of magnitude indication of consumption levels. Due to the same reasons, figures don't add up.

Table 2

LATIN AMERICA AND THE CARIBBEAN:
AVERAGE ANNUAL EXPORTS OF FISHERY COMMODITIES, SELECTED COUNTRIES
(Millions of US dollars)

Country	1970-1974		1975-1979		1980-1984		1985-1988	
	Millions	(%)	Millions	(%)	Millions	(%)	Millions	(%)
Argentina	15.2	2.6	101.3	8.5	159.8	7.6	224.6	8.0
Brazil	33.2	5.7	82.6	6.9	153.4	7.3	173.8	6.2
Chile	35.2	6.0	132.6	11.1	374.9	17.8	598.7	21.2
Colombia	8.7	1.5	20.8	1.7	31.6	1.5	46.7	1.7
Costa Rica	2.5	0.4	6.6	0.6	10.7	0.5	32.9	1.2
Cuba	29.8	5.1	84.4	7.1	117.6	5.6	140.4	5.0
Ecuador	17.5	3.0	69.1	5.8	208.8	9.9	393.7	14.0
French Guiana	2.7	0.5	3.1	0.3	21.7	1.0	26.9	1.0
Honduras	3.1	0.5	15.7	1.3	28.6	1.4	45.6	1.6
Mexico	98.6	16.9	295.6	24.9	479.0	22.8	461.1	16.4
Panama	16.4	2.8	42.0	3.5	65.7	3.1	103.6	3.7
Peru	273.8	46.8	235.8	19.8	259.6	12.3	298.0	10.6
Uruguay	0.7	0.1	15.5	1.3	50.8	2.4	66.5	2.4
Venezuela	13.3	2.3	16.8	1.4	35.5	1.7	91.8	3.3
Other countries	34.4	5.9	67.4	5.7	107.3	5.1	115.6	4.1
Region	585.2	100.0	1 189.5	100.0	2 104.9	100.0	2 820.2	100.0
including:								
- Central America	140.4	24.0	401.0	33.7	636.8	30.3	689.7	24.5
- Caribbean	37.1	6.3	95.6	8.0	142.3	6.8	184.7	6.6
- South America	407.7	69.7	692.9	58.3	1 325.9	63.0	1 945.8	69.0
World	4 401.7	-	9 946.4	-	15 858.6	-	25 220.9	-
- Region's share	-	13.3	-	12.0	-	13.3	-	11.2

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities, Rome, various years.

importers of fishery products. As a result of depleted local marine supply and traditional reliance of fish as a source of food, coupled with the impact of tourism on the consumption of high value species, fishery imports are particularly important for many Caribbean countries.

B. THE EVOLUTION OF CATCHES

The total world nominal catch of fish, crustaceans, molluscs, and other aquatic organisms has increased almost five times since 1950 and reached 98 million tons in 1988.[12] After a period of rapid growth at an average annual rate of almost 6% during the fifties and sixties, world catch declined in the early seventies, largely as a result of a dramatic collapse of the *Peruvian anchovy* fishery, which was by far the largest in the world during the sixties and early seventies. On the whole, world total catch increased at an average annual rate of 0.9% during the 1970-1979 period. The rates of growth improved markedly during the eighties averaging 3.9% a year.

Most of the world catch comes from the oceans, although the share of marine fishing areas has declined from around 90% of the total catch in the seventies to just over 86% in the last two years.

1. Catches in marine fishing areas

a) Catches in Latin America and the Caribbean

The fishing industry of Latin America and the Caribbean first came into prominence with the rapid expansion of the fisheries of Peru in the sixties. Prior to the explosive growth of the capture of the *Peruvian anchovy*, the fisheries of the region had largely been directed to the production of fish for internal, if not solely coastal and even subsistence, consumption. The regional marine catch registered high growth rates in the sixties and peaked in 1970 when it exceeded 15 million tons accounting for almost 26% of total world marine catch (Figure 1 and Table 3). As a result of the collapse of the *Peruvian anchovy* fishery and the effects of the El Niño event coupled with the sudden rise in fuel costs in 1973, fish production fell to 5 million tons in 1973 equivalent to only 9% of the total world catch. Since 1973, the regional catch has registered an average growth rate of 6.4%, as the fishing industries of other countries have expanded. This growth was uneven, however, with production falling in 1975, 1977, 1980, 1983, and 1987. The share of marine fishing areas in the total regional catch decreased from 98.1% during 1970-1974 to 96.4% during 1985-1988.

In 1987-1988, the regional fish catch in marine areas averaged 14.5 million tons, almost one fifth of the total world catch. Chile and Peru, each with over 35% of the regional catch, are the main producing countries and are among the six top-ranking fishing nations in the world in terms of the volume of their catches. These countries are endowed with some of the world's most productive fishing grounds, mainly due to the effects of the Humboldt current.

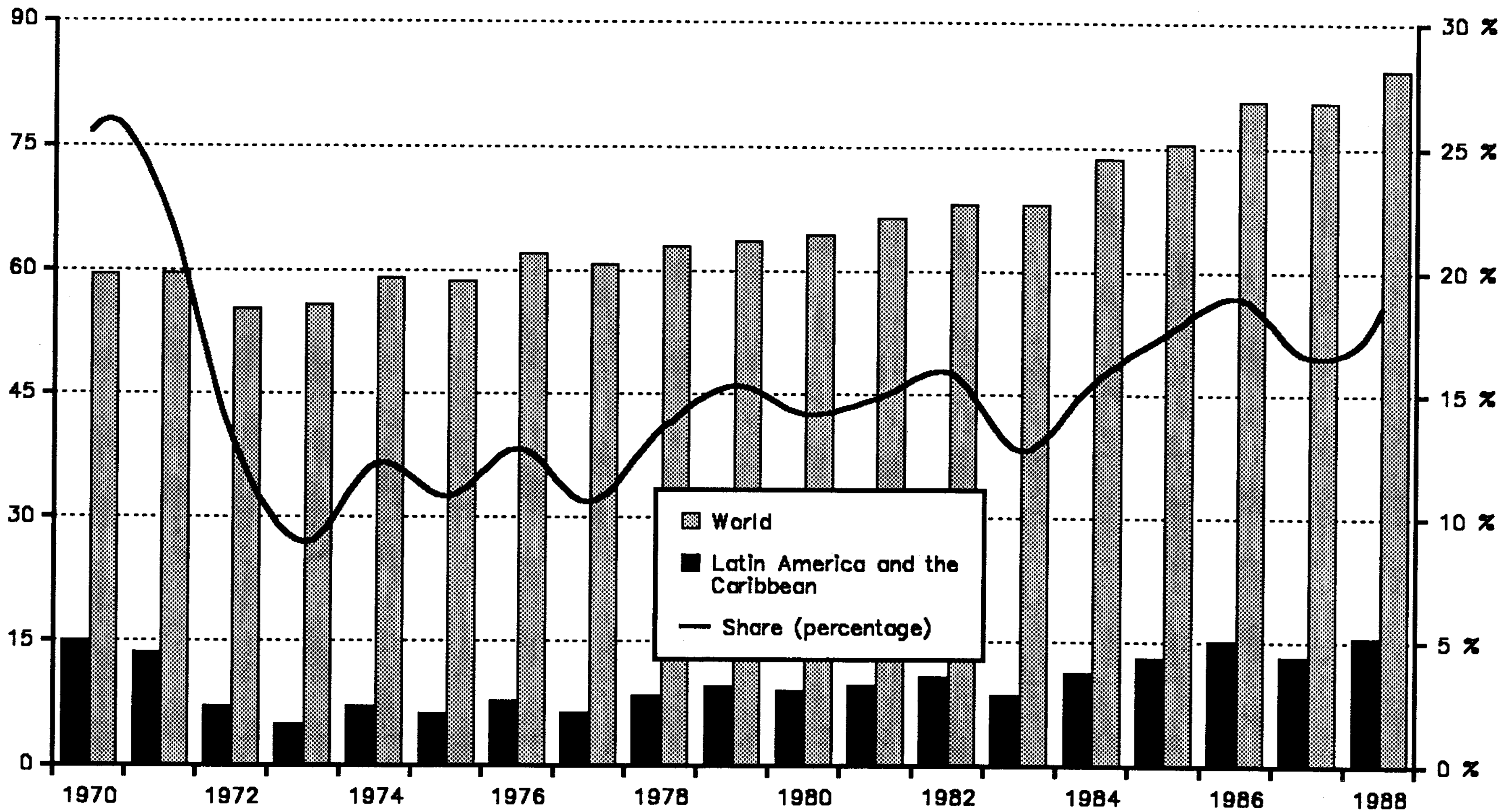
The marine catch of Chile has steadily increased since the late seventies reaching a peak of almost 5.6 million tons in 1986 and slightly decreasing thereafter. The growth in the catch averaged an impressive 11.5% between 1970/74 and 1985/88. In the case of Peru, production peaked in 1970 at 12.5 million tons and abruptly fell to 2.3 million tons by 1973. The Peruvian catch has not recovered its 1970 level and has registered a negative growth rate, -1.9%, between 1970/74 and 1985/88. The Chilean and Peruvian catches are confined mainly to a few pelagic species (anchovies, jurel, mackerel and sardines) which are harvested by the industrial and semi-industrial fleet and are used almost entirely for the production of fish meal. Other countries with significant fish catches include Argentina, Brazil, Ecuador, and Mexico. Sixteen countries of the region have experienced growth rates in their marine fish catch of over 5% a year between 1970/74 and 1985/88.

The bulk of the marine fish catch of Latin American and Caribbean countries, about 99%, comes from marine areas adjacent to the region. Some 72% is caught in FAO's Southeast Pacific marine fishing area, more than 14% from the Eastern Central Pacific marine fishing area, 8% from the Southwest Atlantic marine fishing area, and 5% from the Western Central Atlantic marine fishing area (see Figure 2).[13/] Other marine areas where regional fleets fish include the Northwest Atlantic, the Eastern Central Atlantic, the Southeast Atlantic, the Antarctic Atlantic, and the Western Indian Ocean (see Annex 1).

b) Catches in marine areas adjacent to the region

The seas surrounding Latin America and the Caribbean are divided by FAO into four major fishing areas - the Western Central Atlantic, the Southwest Atlantic, the Eastern Central Pacific, and Southeast Pacific (see Figures 2 and 3). Their combined area is 106 375 000 km², including 4 507 000 km² or 4.2% of waters less than 200 meters deep, the denominated Neritic Zone, where

Figure 1
WORLD NOMINAL CATCHES IN MARINE FISHING AREAS
(millions of tons)



Source: FAO.

Figure 2

LATIN AMERICA AND THE CARIBBEAN: PRINCIPAL FISHING ZONES

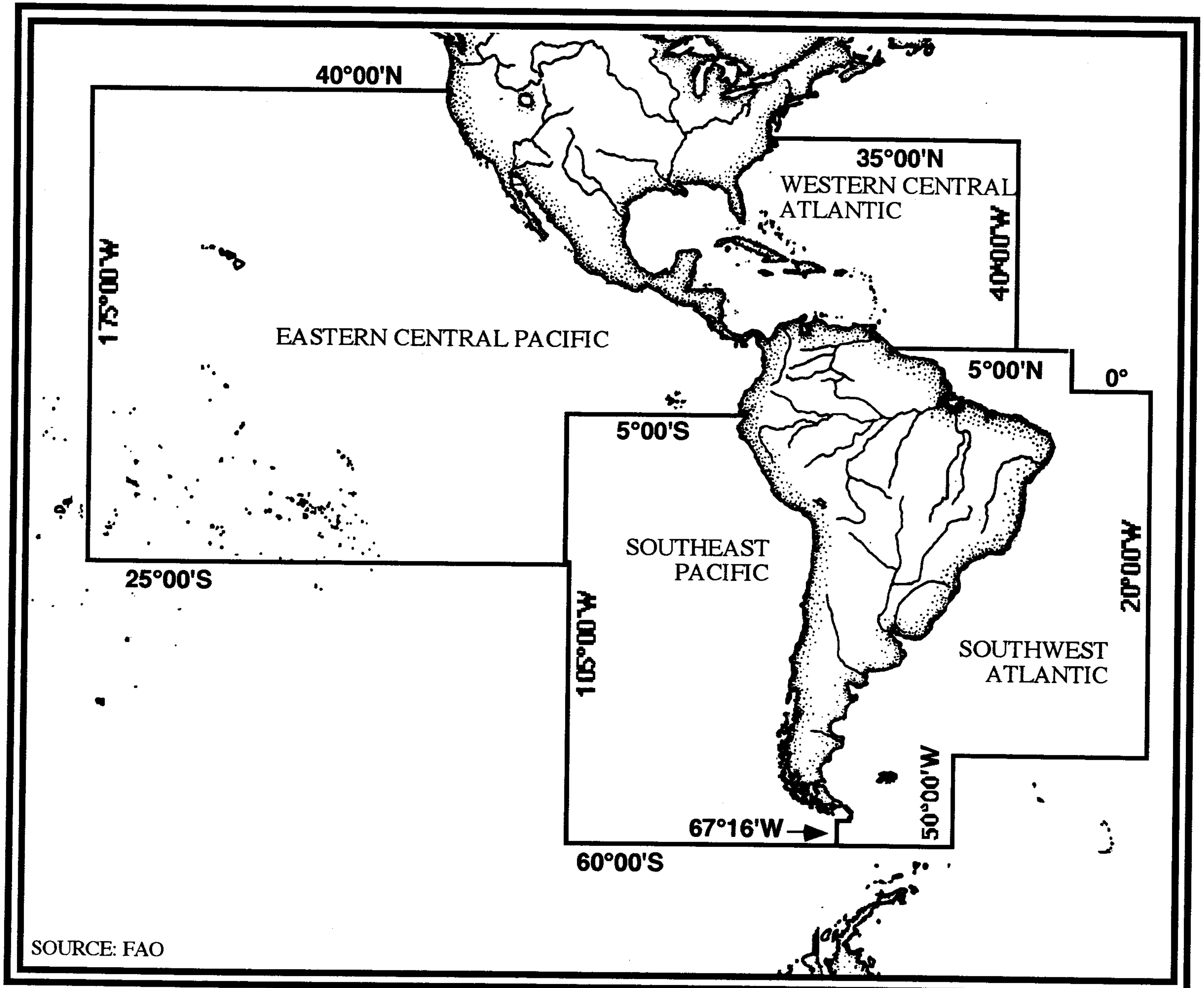
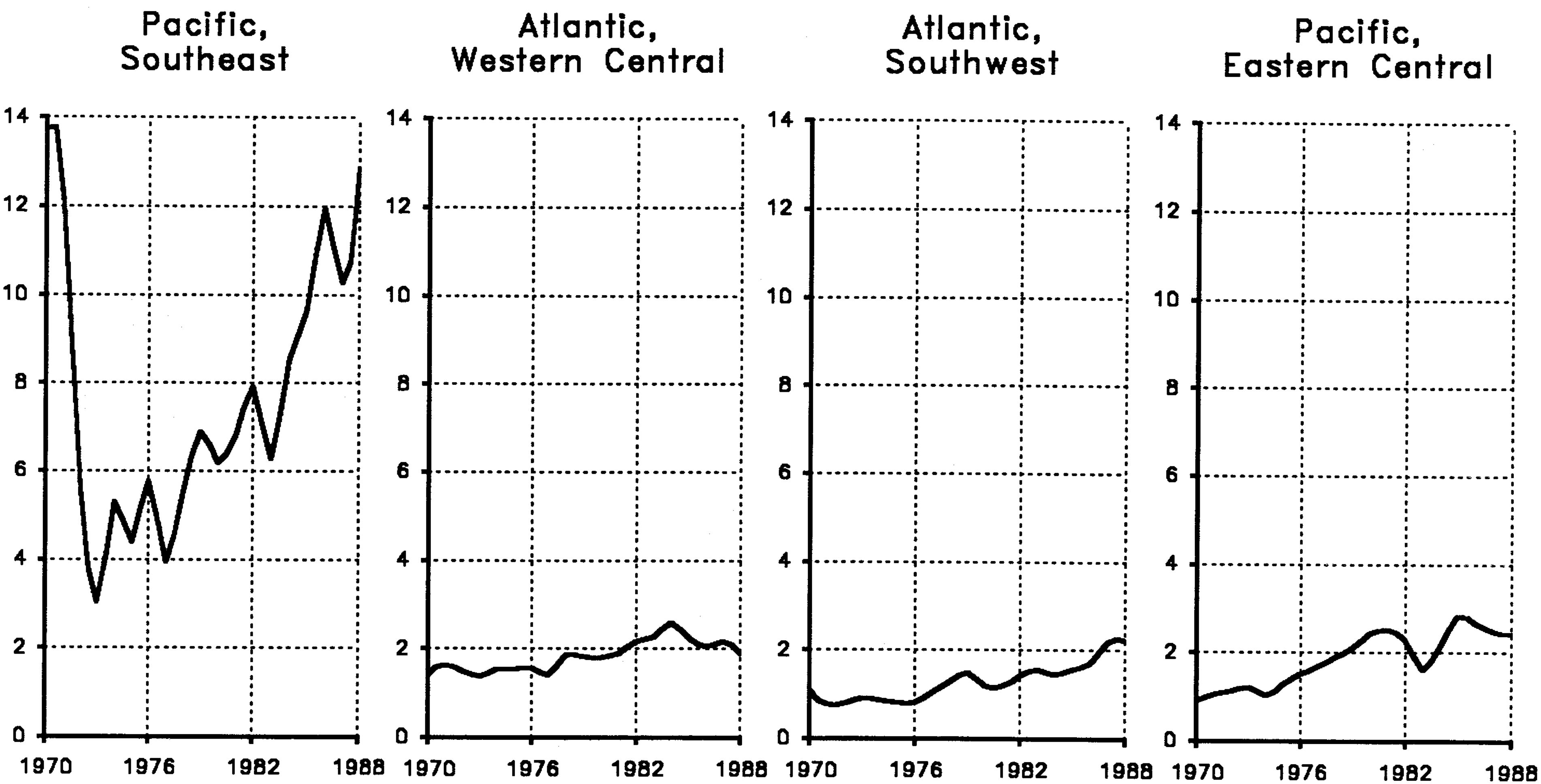


Figure 3
WORLD NOMINAL CATCHES IN SELECTED MARINE FISHING AREAS
(millions of tons)



Source: FAO. Note: Only those marine fishing areas adjacent to Latin America and the Caribbean are included in this figure.

Table 3

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL NOMINAL CATCHES OF FISH, CRUSTACEANS, MOLLUSCS, ETC., ALL FISHING AREAS AND MARINE FISHING AREAS, SELECTED COUNTRIES
(Thousands of tons)

Country	All fishing areas				Marine fishing areas			
	1970-1974		1985-1988		1970-1974		1985-1988	
	1 000 mt	(%)	1 000 mt	(%)	1 000 mt	(%)	1 000 mt	(%)
Argentina	234.0	2.4	469.1	3.1	227.0	2.3	460.7	3.2
Brazil	626.8	6.4	778.8	5.2	524.5	5.4	557.1	3.9
Chile	1 056.5	10.7	5 100.2	34.2	1 056.5	10.9	5 099.3	35.4
Cuba	137.2	1.4	227.7	1.5	136.2	1.4	211.0	1.5
Ecuador	126.9	1.3	884.9	5.9	126.9	1.3	883.5	6.1
Mexico	405.1	4.1	1 328.3	8.9	394.0	4.1	1 182.4	8.2
Panama	74.0	0.7	181.7	1.2	74.0	0.8	181.1	1.3
Peru	6 852.5	69.5	5 242.7	35.1	6 848.8	70.8	5 208.6	36.2
Venezuela	145.1	1.5	288.0	1.9	138.3	1.4	264.5	1.8
Other countries	206.9	2.1	421.4	2.8	149.9	1.5	344.1	2.4
Region	9 865.0	100.0	14 922.9	100.0	9 676.1	100.0	14 392.3	100.0
including:								
- Central America	520.1	5.3	1 575.4	10.6	506.1	5.2	1 425.5	9.9
- Caribbean	183.6	1.9	306.3	2.1	181.8	1.9	286.1	2.0
- South America, Pacific	8 035.9	81.5	11 227.7	75.2	8 032.2	83.0	11 191.4	77.8
- South America, other	1 125.4	11.4	1 813.4	12.2	956.0	9.9	1 489.3	10.3
World	64 447.1	-	92 567.2	-	57 925.3	-	80 411.1	-
- Region's share	-	15.3	-	16.1	-	16.7	-	17.9

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years.

the greatest variety and range of aquatic organisms is usually found. These four areas account for almost 30% of the total ocean area and provide about 22% of the world marine catch (Table 4). Following the collapse of the *Peruvian anchovy* fishery production in these areas decreased from 17.2 million tons in 1970 to 6.6 million tons in 1973. Since 1973-1974 growth has averaged 7.5% per year. The catch obtained in the Southeast Pacific area is the largest accounting for more than 63% of the combined catch in recent years. The combined sustainable yield, according to FAO, of these fishing areas is currently estimated to range between 11.7 to 22.3 million tons per year, including from 3.2 to 5.1 million tons in the Western Central Atlantic fishing area, from 2.6 to 3.9 in the Southwest Atlantic, from 2.2 to 3.0 in the Eastern Central Pacific, and from 3.7 to 10.3 in the Southeast Pacific.[14/] Inter-American Development Bank's estimates of fisheries potential of the sea coast of the American continent are provided in Table 5.

The evolution of catches in marine fishing areas adjacent to Latin America and the Caribbean during the 1970-1988 period is briefly discussed below:

1. Western Central Atlantic. Annual nominal catches of fish, crustaceans, and molluscs averaged 2.0 million tons during the 1987-1988 period. The level of production has been relatively stable during the period in question with an average annual growth rate of only 1.7%.[15/] USA with more than 60% of total catch is the main producing country. Other countries with significant production are Cuba, Mexico, and Venezuela.

Table 4

NOMINAL CATCHES OF FISH, CRUSTACEANS, MOLLUSCS, ETC.
IN MARINE FISHING AREAS ADJACENT TO LATIN AMERICA AND THE CARIBBEAN
(Thousands of tons)

Marine fishing areas	Nominal catches (thousands of tons)			
	1970-1974	1975-1979	1980-1984	1985-1988
Atlantic, Western Central	1 491.3	1 646.3	2 149.6	2 089.1
Atlantic, Southwest	889.0	1 093.8	1 358.5	1 914.2
Pacific, Eastern Central	1 066.7	1 693.4	2 203.1	2 599.9
Pacific, Southeast	7 947.7	5 315.6	7 151.1	11 188.7
Total	11 394.7	9 749.2	12 862.3	17 791.8

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years.

Table 5

LATIN AMERICA AND THE CARIBBEAN: POTENTIAL SEA FISHERIES CATCH
(Thousands of tons per year)

Marine fishing areas	Pelagics a/		Demersals b/		Crustaceans		Total	
	Thousand ton/year	(%)	Thousand ton/year	(%)	Thousand ton/year	(%)	Thousand ton/year	(%)
Atlantic, Western Central	4 550	19.3	4 000	62.5	275	54.0	8 825	29.0
Atlantic, Southwest	2 500	10.6	1 000	15.6	109	21.4	3 609	11.8
Pacific, Eastern Central	4 500	19.1	1 400	21.9	80	15.7	5 980	19.6
Pacific, Southeast	12 000	51.0	n/a	n/a	45	8.8	12 045	39.5
Total	23 550	100.0	6 400	100.0	509	100.0	30 459	100.0

Source: Inter-American Development Bank (IDB), Economic and social progress in Latin America. Natural resource. 1983 report, Washington, D.C., p. 80.

n/a - not available;
a/ - pelagic species are those that live in surface waters and lead a migratory life to obtain food;
b - demersal or benthic species are those that live on the bottom of the continental shelf in stable ecological niches.

2. Southwest Atlantic. Annual nominal catches of fish, crustaceans, and molluscs averaged 2.2 million tons during the 1987-1988 period. The level of production has been relatively stable during the period in question with an average annual growth rate of 5.2%. Argentina and Brazil are the main producing countries. Other countries with significant production are Japan, Poland, and USA.

3. Eastern Central Pacific. Annual nominal catches of fish, crustaceans, and molluscs averaged 2.5 million tons during the 1987-1988 period. The level of production has been relatively stable during the period in question with an average annual growth rate of 5.6%. Ecuador and Mexico are the main producing countries. Other countries with significant production are Japan, Panama, and USA.

4. Southeast Pacific. Annual nominal catches of fish, crustaceans, and molluscs averaged 11.6 million tons during the 1987-1988 period. Production fell abruptly from 13.8 million tons in 1970 to less than 3.1 million tons in 1973 as a result of the collapse of the *Peruvian anchovy* fishery and the effects of the El Niño event. Since 1973-1974 growth averaged 7.6% per annum. Chile and Peru are the main producing countries. As far as other countries are concerned, the share of USSR has been noticeable since 1979.

Information on catches by individual fish species in marine fishing areas adjacent to Latin America and the Caribbean is provided in Annex 2.

2. Catches in inland waters

Commercial fishing in inland waters in Latin America and the Caribbean is much smaller than sea and ocean fisheries, but the catch has increased in recent years. The proportion of the total fish catch taken from inland waters has nearly doubled from about 1.9% of total catch in the early seventies to 3.6% at present. In comparison for the world as a whole the share is about 13%. The region currently accounts for only 4.4% of world inland fish catches (Table 6). The growth rate of inland fishing in the region has averaged 7.6% per annum since 1970; higher both than that of marine catches in the region and of the expansion of catches from inland waters for the world as a whole. In 1987-1988, the total regional inland catch reached 576.4 thousand tons. Inland fishing catches are likely to be somewhat higher than the above figures suggest as much of the catch is not registered. The total freshwater fisheries harvest is used for human consumption and usually includes a large population of highly-valued species (see Annex 2).[16]

The inland fishing is concentrated in a few countries; more than 40% of the catch comes from Brazil, about 28% from Mexico and 10% from Colombia. The Amazon river basin is the traditionally most important area for fresh-water fishing.[17] Bolivia, Brazil, Colombia, and Paraguay obtain more than a quarter of their total commercial catch from inland waters. Costa Rica, Cuba, Honduras, Mexico, Paraguay, Peru, and Uruguay have high rates of growth in production. Almost 75% of the total increase in production since the early seventies has occurred, however, in Brazil and Mexico. A number of countries reported commercial fresh-water fish production for the first time during the seventies or eighties.

Much of the growth in production has resulted from the seeding of streams. In some countries commercial fish are being stocked in hydroelectric dams and irrigation systems.[18] Some 17 thousand tons of fish were harvested from small reservoirs - *acudes* - in the northeast of Brazil in

Table 6

LATIN AMERICA AND THE CARIBBEAN: AVERAGE ANNUAL NOMINAL CATCHES OF FISH, CRUSTACEANS, MOLLUSCS, ETC. IN INLAND WATERS, SELECTED COUNTRIES
(Thousands of tons)

Country	1970-1974		1975-1979		1980-1984		1985-1988	
	1 000 mt	(%)	1 000 mt	(%)	1 000 mt	(%)	1 000 mt	(%)
Argentina	7.0	3.7	13.3	5.2	11.5	3.0	8.5	1.6
Brazil	102.3	54.1	156.8	61.2	201.9	53.1	221.7	41.8
Colombia	49.1	26.0	48.2	18.8	48.6	12.8	54.3	10.2
Cuba	1.0	0.6	2.8	1.1	12.1	3.2	16.7	3.1
Mexico	11.1	5.9	7.1	2.8	51.9	13.6	145.9	27.5
Paraguay	2.4	1.3	3.0	1.2	3.7	1.0	10.1	1.9
Peru	3.7	1.9	10.8	4.2	21.9	5.8	34.1	6.4
Venezuela	6.8	3.6	8.1	3.2	17.1	4.5	23.6	4.4
Other countries	5.5	2.9	6.0	2.3	11.8	3.1	15.7	3.0
Region	188.9	100.0	256.1	100.0	380.5	100.0	530.6	100.0
including:								
- Central America	14.0	7.4	9.6	3.7	54.2	14.2	149.9	28.3
- Caribbean	1.8	1.0	3.7	1.5	15.2	4.0	20.2	3.8
- South America, Pacific	3.7	1.9	10.8	4.2	22.7	6.0	36.4	6.9
- South America, other	169.5	89.7	231.9	90.6	288.4	75.8	324.0	61.1
World	6 521.8	-	7 059.4	-	8 693.5	-	12 156.1	-
- Region's share	-	2.9	-	3.6	-	4.4	-	4.4

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years.

1986. The development of fish farming programmes in reservoirs has also been reported in Cuba, where in 1986 15 thousand tons of fish were harvested from reservoirs, and in Mexico.[19/] On the whole, cultivation in reservoirs is estimated to account for 25% of the total aquaculture production in the region.[20/]

Latin American and Caribbean countries possess a big potential for increasing commercial fishing in inland waters. On the whole, counting only natural lakes, coastal lagoons, and reservoirs of more than 50 hectares, the region has about 10.5 million hectares in which fish production could be carried out. Even without the introduction of induced feeding and substantial environmental changes, it has been estimated that the mere introduction of the fry of appropriate fish species would make it possible to obtain between 525 and 1 050 thousand tons of fish a year.[21/]

The total regional potential harvest from freshwater fisheries is estimated to be as much as 2 million tons per annum, approximately 3.5 times the present level of production.[22/] If catches in inland waters continue to grow at the same growth rate as during the eighties, this potential is likely to be reached by 2004. Reaching this level of production will require that a number of important obstacles, including growing water pollution, competition from alternative water uses, and the lack of nearby markets and improvements in production and transportation facilities be overcome. It will also require more effective management of existing resources.[23/]

3. Aquaculture

Aquaculture, or the farming of aquatic organisms is rapidly increasing worldwide and at present constitutes approximately 12% of the world's fishery production. World aquaculture production reached 14.47 million tons in 1988 and is expected to attain 22 million tons by the turn of the century.[24/] Aquaculture is little developed in most Latin American and Caribbean countries except for the production of crustaceans. The region accounts for less than 2.2% of world aquaculture production - 3.8% of finfish, 1.0% of molluscs, 16.4% of crustaceans, and 0.07% of seaweeds.[25/] Mexico with 133 thousand tons and Brazil with 81 thousand tons are the countries with the most important aquaculture production. Other countries with significant aquaculture development include Cuba, Chile, Ecuador, Panama, and Peru (Table 7).

Commercial aquaculture first gained significant economic importance in Ecuador with the development of shrimp cultivation in the late sixties. By 1985 Ecuador produced about 30 thousand tons, compared with just 9.0 thousand tons in 1980, of cultivated shrimp - almost three fourths of the total regional production or somewhat less than 25% of the world's total. In 1988, Ecuador supplied 70 thousand tons or more than 80% of the region's production. The potential total annual cultured production of shrimp in Ecuador is estimated to be around 120 thousand tons, including production from capture fisheries. It has been reported, however, that Ecuador's output may level out unless hatcheries provide a significant increase in post-larvae.

More recently, shrimp cultivation has been introduced in Brazil, Mexico, and Panama. In Brazil, shrimp farming has been initiated in Macau, state of Rio Grande do Norte. Mexico has a seven-year programme, which aims at a harvest of 61 000 tons by 1994. In Panama, several commercial shrimp farms are located on the Pacific coast, between Panama City and the Azuero Peninsula. It is estimated that farmed production of shrimp in Panama could reach 25-30 thousand tons annually. Shrimp farming is also developing in Colombia, Costa Rica, Cuba, Guatemala and

Table 7

LATIN AMERICA AND THE CARIBBEAN: AQUACULTURE PRODUCTION IN 1985, SELECTED COUNTRIES
(Thousands of tons)

Country	Fish	Molluscs	Crustaceans	Seaweeds	Total	(%)
Brazil	79.8	-	1.2	0.4	81.4	28.7
Chile	1.1	1.5	-	4.9	7.5	2.6
Cuba	15.1	1.1	0.9	-	17.1	6.0
Ecuador	-	-	30.2	-	30.2	10.7
Mexico	86.3	42.7	4.3	-	133.3	47.0
Panama	0.4	-	2.6	-	3.0	1.1
Peru	0.6	3.6	0.6	-	4.8	1.7
Others	3.4	0.4	2.3	-	6.1	2.2
Total	186.7	49.3	42.1	5.3	283.4	100.0

Source: ADCP, data supplied by government, quoted from Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 84.

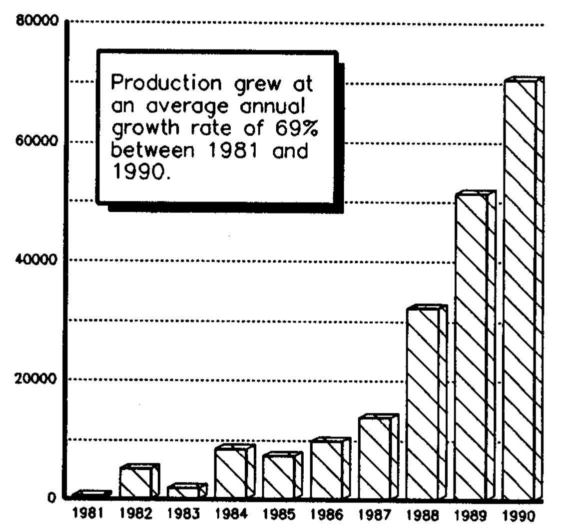
Note: These data are provisional and subject to revision mostly downwards due to the different criteria used by countries in providing information.

Venezuela. On the whole, cultural shrimp is estimated to account for almost half the total shrimp harvest in Latin America and could well exceed 200 thousand tons by the year 2000.

Other important branches of aquaculture are the production of shellfish in Chile, Mexico, and Peru. In 1985 Chile produced 1 000 tons of mussels, Mexico 35 000 tons of oyster, and Peru 3 600 tons of scallops.[26]

Total aquaculture production in Mexico increased from 68 200 tons in 1979 to 185 000 tons in 1989. Fresh water fishes account for about 64% of total production. Crustaceans, whose production has been growing at annual rates exceeding 18%, and fresh water fishes with almost 17%, have been the most dynamic sectors.[27] Mexico aspires to increase its aquaculture production to 800 000 tons in 1992. New aquaculture development is expected to increasingly centre in coastal areas similar to those found in Baja California.[28]

Figure 4
CHILE: AQUACULTURE PRODUCTION, 1981-1990
(tons)



Source: Armada de Chile, Dirección General del Territorio Marítimo y de Marina Mercante, 1991.

Aquaculture has been rapidly developing in Chile during the last decade (see Figure 4). One of the most successful developments in regional aquaculture is salmon-raising in the south of the country. There are some 65 companies engaged in breeding salmon in more than 100 hatcheries centering on the island of Chiloé and the continental zone south of Puerto Montt. A number of salmon species have adapted extremely well to the local climatic conditions. Other positive factors accompanying the growth of salmon rising include the abundance of unpolluted bodies of water and of good-quality fish meal and oil, the principal food for salmon. As a result, the industry has experienced phenomena growth. Salmon production increased from 70 tons in 1980, to 104 tons in 1983, 18 000 tons in 1990, and estimated 30 000 tons in 1991, registering an average annual growth rate of 73% between 1980 and 1991. In 1990, exports of salmon were valued at US$ 111 million and in 1991 they are expected to reach US$ 130 million. Exports from Chile are forecasted to exceed 50 thousand tons by the end of the century.[29] Commercial aquaculture in Chile isn't limited to salmon rising and includes various other species. One of the most recent developments is turbot-raising in the area of Tongoy and other regions which is expected to reach more than 100 tons in 1993 and 1 500 tons several years later.[30]

Aquaculture can be expected to expand in other countries too. In Brazil, for example, a plan has been reported for a major expansion of freshwater fish culture and setting up seven hatcheries to produce over 20 million fingerlings of carp and tilapia. Aquaculture is also attracting increasing attention in Cuba where ten fish hatcheries with a potential annual production of 20 million fingerlings have been established.[31]

Chapter 2

THE FISH PROCESSING INDUSTRY

Many Latin American and Caribbean countries have fish processing industries. In some countries these industries produce mostly for export, while in others their development is related to import-substitution policies and the growth of local demand. Information on regional production by fishery commodities groups is provided in Annex 3.

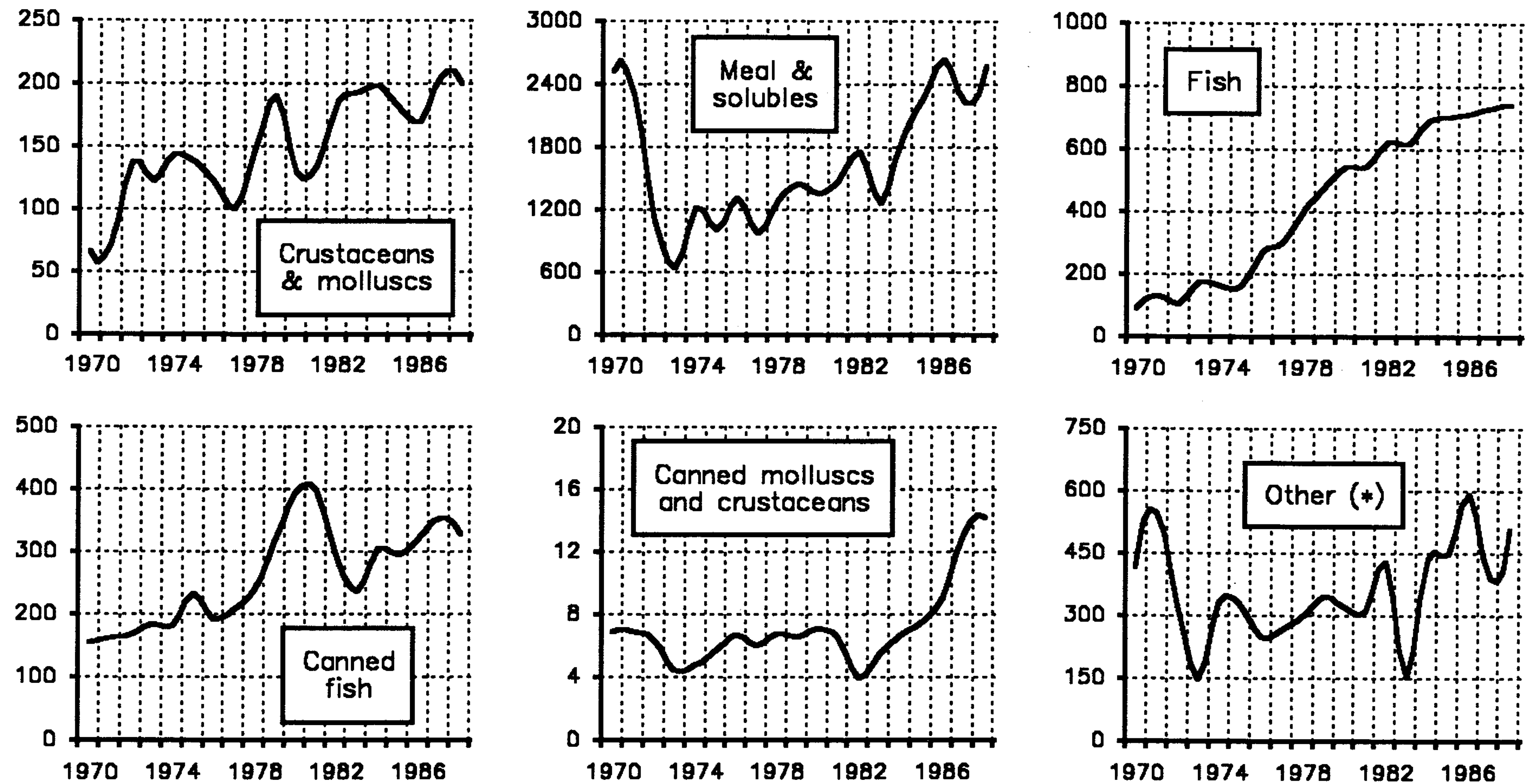
The most important of these industries is the production of fresh and frozen shellfish and of fishmeal for export. The canning industries in contrast are of much lesser significance and the major proportion of the production is for the domestic market.[32/]

i) Shellfish. Latin American and Caribbean countries with an annual production 200 thousand tons account for less than 10% of total world production of shellfish which reached 2.1 million tons in 1988 (see Figure 5). Ecuador (52.5 thousand tons), Mexico (45.9), Argentina (27.0) and Brazil (18.0) are the main producing countries. In Ecuador, the level of production has increased remarkably, although unevenly, since 1970 registering an impressive average annual growth rate of almost 18%. In recent years growth has been particularly strong averaging more than 36% a year during the 1985-1988 period. In Mexico, production peaked in the mid-seventies at about 63 thousand tons, abruptly falling to under 38 thousand tons in 1978 and unevenly recovering since then but still remaining below the peak level. In Argentina, production averaged just over 2 thousand tons during 1970-1977, peaked at over 77 thousand tons in 1979, abruptly fell in 1980 and has registered renewed but uneven growth since then. In Brazil, the level of production has been relatively stable except in 1976-1977 when it abruptly fell to under 10 thousand tons. Total regional production has grown since 1970 at an average annual growth rate of 6.4% slightly above the world average of 6.0%.

The bulk of regional production is exported,[33/] accounting for the major part of the value of regional fishery exports. The processing of crustaceans accounts for over 80% of regional production and molluscs for the remainder. Ecuador accounts for almost one-third of the regional production of crustaceans, Mexico for almost a quarter, and Brazil for about 10 percent. Argentina produces around 60% of molluscs and Chile 23%.[34/]

ii) Fish meals and other animal feeds. Latin America and the Caribbean produced nearly 2.6 million tons of fishmeals in 1988 - more than one-third of the total world production (see Figure 5). Chile and Peru are the main producing countries. In both countries, production has been very erratic. For example, Peruvian production reached nearly 2.3 million tons in 1970 and 1.9 million tons in 1971. Production dropped abruptly, however, to just 0.4 million tons in 1973. From this low point, there has been considerable, but uneven growth with considerable falls in production in a number of years. In Chile, production has increased more steadily in comparison with the pattern in Peru, but production fell in 1972, 1973, 1975 and again in 1987. It is currently estimated that fish meal production will remain little changed in either country for the rest of the century with production of 1.6 million tons in Peru and 1.2 million tons in Chile.[35/] Regional production reached its highest point in 1986 at 2.6 million tons. 1973 was particularly bad year with production falling below 0.7 million tons.

Figure 5
LATIN AMERICA AND THE CARIBBEAN: PRODUCTION OF FISHERY COMMODITIES, 1970–1988
(thousands of tons)



Source: FAO. * — Includes dried, salted or smoked fish, and oils and fats of aquatic animal origin.

The bulk of regional production is exported and it is almost entirely made up of fish meal from oily fish. Chile has about 45% of regional production and Peru about 42%. Chile also produces small amounts of meal from white-fish and other species.

iii) Fresh, chilled and frozen fish. Latin American and Caribbean countries produced 740 thousand tons of fresh, chilled and frozen fish in 1988 slightly more than 5% of total world production (see Figure 5). Brazil, Argentina, Cuba, Chile and Peru are the main producing countries. In all countries the growth of production has occurred relatively recently. Brazil, Argentina and Peru became important producers in the 1970's, Cuba and Chile only since 1980. Regional production grew at an average annual rate of almost 20% during the 1970-1980 period, a rate considerably above the world average. Since 1980 growth has slowed averaging only 4% annually or slightly less than the world average.

Frozen fish (excluding fillets) accounts for about 73% of regional production, frozen fish fillets for almost 18% and fresh or chilled fish fillets for the remaining 9%. Most of the production is exported. Argentina with almost 45% and Brazil with 55% are the largest producers of fresh or chilled fish fillets. Argentina also accounts for almost 60% of production of frozen fish fillets and Uruguay for 18%. In the case of frozen fish, Brazil has 23% of regional production, and Argentina, Chile, Cuba and Mexico, each between 11% and 15%.

iv) Canned fish products and preparations. Latin American and Caribbean countries produce only 328 thousand tons of canned fish products and preparations, approximately 6% of total world production (see Figure 5). The major producers of canned fish products are Brazil, Chile, Mexico, Peru, and Venezuela. The industry has been growing most rapidly in Chile and Peru.[36/] In Chile, the level of production has regularly exceeded 40 thousand tons since 1984. In Peru, production increased from 16.8 thousand tons in 1970 to a peak of about 140 thousand tons during 1980-1981, falling to less than half of this in 1982 and averaging since then slightly more than 50 thousand tons. In Mexico and Brazil, the maximum production levels were reached more than a decade ago and regional production reached its peak - 399 thousand tons - in 1981.

Production is mainly for domestic consumption. Canned herrings, sardines, anchovies, etc. account for almost 70%, canned tunas, bonitos, billfishes, etc. for almost 15% and miscellaneous canned fish products for more than 15%. In Chile, a canned salmon industry has recently been established. Peru accounts for more than a quarter of the regional production of canned herrings, sardines, anchovies, etc., while Mexico produces some 40% of canned tunas, bonitos, billfishes, etc. Chile accounts for over half of the regional production of miscellaneous canned fish products.

v) Canned shellfish. Latin American and Caribbean countries, produce 14 thousand tons of canned shellfish a year, about 3% of total world production (see Figure 5). Chile is the main producing country canning about 70% of the regional total in recent years. Other countries with significant product include Argentina, Mexico and Venezuela. In Chile, production averaged only about 2 thousand tons a year between 197 and 1982. Since 1982, the industry has expanded very rapidly, averaging almost 35% annually. The canning of shellfish has also expanded significantly in Venezuela since 1977. Production declined, however, between 1980 and 1983 to about 800 tons annually, but has recovered averaging since then about 1.6 thousand tons annually. In Argentina, production peaked at 2.2 thousand tons in 1975 and after that year exceeded 1 thousand tons only in 1976, 1987 and 1988.[37/] In Mexico, production decreased from an annual level of over 2 thousand tons in the seventies to under 0.9 thousand tons between 1982 and 1988. In total over the last 20 years, regional production of canned shellfish has grown at an average annual rate of 4.1% or slightly above the world average of 3.0%. There have been considerable fluctuations in production and 1982 was the worst production year. The rates of growth accelerated since 1983 and averaged 24% between 1982 and 1988. Most of the production is exported.

Almost 85% of regional production of canned shellfish products and preparations corresponds to molluscs, almost 10% of world production. The rest is almost entirely crustaceans. Chile cans about 78% of the regional production of molluscs, Argentina - almost 9%, and Venezuela - 6%. Venezuela accounts for 35% of regional production of canned crustaceans, El Salvador for 25%, Chile for 22%, and Mexico for 17%.

vi) Oils and fats. Latin American and Caribbean countries, with a total output of 428 thousand tons, accounted for some 28% of total world production of fish oil and fats in 1988 (see Figure 5). Chile with a production of 188.0 thousand tons and Peru with 203.3 thousands tons are the main producing countries. In Chile, this industry is again of relatively recent origin. Production exceeded 100 000 tons for the first time in 1979 and has only fallen below this in 1983. In 1986 production peaked at over 220 thousand tons. In Peru, the highest level of production, over 410 thousand tons, was achieved in 1971. It dropped to less than 50 thousand tons in 1973. Since then production has fluctuated from 100 to over 200 thousand tons except in 1980, 1981 and 1983 when it fell below 100 thousan tons. The pattern of regional production has been very much influenced by events in Peru. It reached its peak - 483 thousand tons - in 1971. 1973 and 1983 were particularly bad years with production falling below 100 thousand tons. Due to the lower production in Peru, the average annual growth rate in production has only been 1.2%, equal to the world average. The major part of production is consumed within the region.

All regional production corresponds to fish oils and fats other than fish liver oil. This represents about one-quarter of the world production of these commodities.

vii) Dried, salted and smoked fish. Latin American and Caribbean countries with only 78 thousand tons account for less than 1.5% of the total world production of dried, salted and smoked fish (see Figure 5). Argentina, Brazil, Colombia, Peru and Venezuela are the main producing countries. In Brazil, the largest producer, output has decreased since the early seventies from almost 40 thousand tons to just over half this level in recent years. In Peru, production has increased from 6 thousand tons during 1970-1976 to almost 18 thousand tons per year. In Argentina, production exceed 11 thousand tons in 1973 and 1988. In other years it averaged only slightly over 5 thousand tons. In Colombia, production averaged some 3 thousand tons during 1971-1974, over 10 thousand tons during 1975-1982, and about 7 thousand tons during 1983-1988. In Venezuela, production has been relatively more stable slightly increasing from 6.6 thousand tons during the seventies to 7.6 during the eighties. Regional production reached a peak - 81 thousand tons - in 1979. Output has increased at only 0.7% a year which is well below the world average of 3.3%. The major part of production is consumed within the region.

Almost the entire regional production corresponds to dried, salted or in brine fish. Argentina produces fish meal fit for human consumption accounting for 3.6% of world production in 1988. There is some production of smoked fish in Chile, which accounts for over 84% of regional production, and in Brazil. Regional production of smoked fish represents an insignificant part - about 0.02% - of world production.

Part II

THE FISHERY-WATER MANAGEMENT NEXUS

Chapter 1

THE EFFECTS OF FISHING ON THE WATER RESOURCE

The effects of fishing on the aquatic ecosystem are most evident through over-fishing and from water pollution resulting not only from the fish processing industry, but also from fishing itself, and from the development of aquaculture. Additionally, certain fishing operations are sometimes associated with negative physical effects on the environment.

A. OVER-FISHING

Fish populations are renewable, but the maximum annual catch, or the maximum sustainable yield from any given population, that can be harvested, theoretically, under existing environmental conditions continually without depleting the natural breeding stock is limited. Estimates of the maximum potential catch by different types of fishery output have been made for Latin America and the Caribbean (Table 8, see also Table 5). Such estimates are little more than educated guesses, however, and only valid when each stock is exploited at its optimum level. In practice this is seldom the case because fishing effort usually centres on a few valuable species and where several species live together it is not possible to fish each of them optimally.

The removal of large numbers of commercially important species may alter the structure of natural food webs. As a result, the structure of fish stock is likely to suffer considerable changes.[38/] Sustainable yield, particularly of small pelagic species, is subject to abrupt changes due to unpredictable environmental factors (water temperature, currents, pollution, etc.), most of which are beyond human control. These factors help to explain, at least in part, why there exists a high degree of uncertainty in relation to the catch that can be harvested in a given year without running the risk of resource wastage through excessive fishing. On the whole, FAO considers that very few untapped marine resources of conventional species remain anywhere.[39/]

Existing estimates of maximum sustainable yields in fishing areas around Latin America and the Caribbean apparently suggest a notable potential for increased catches (Table 8), however, in order to realize it, apart from technical, financial and other difficulties involved, structural changes in fish output are required, since some species are fully exploited or even depleted while others are unexploited or little exploited. On the whole, of the 280 fish species monitored by the FAO, only 25 are slightly or moderately exploited, whereas at least 42 are already depleted or over-exploited.[40/] There are considerable differences among the marine fishing areas surrounding the region as well as among the different freshwater fisheries (Annex 4).

Table 8

LATIN AMERICA AND THE CARIBBEAN: ESTIMATED POTENTIAL CATCH
(Thousands of tons)

	Estimated potential catch		Average annual catch (1980-1984)	Average annual catch as percentage of estimated potential catch	
	Minimum estimate	Maximum estimate		Minimum estimate a/	Maximum estimate a/
Demersals	2 400	2 900	1 160	48	40
Small pelagics	12 000	16 000	7 680	64	48
Oceanic pelagics	900	1 700	530	59	31
Crustaceans	500	800	470	94	59
Molluscs and cefalapods	600	2 300	670	112	29
TOTAL	16 400	23 700	10 510	64	44

Source: FIR/FI/FAO, quoted from Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 89.

Note: Includes US catches in Central Western Pacific and Central Eastern Atlantic, as well as catches by countries from outside the region.
a/ - minimum/maximum estimates of potential catch.

Marine area by marine area, the situation is estimated to be the following:

- In the Western Central Atlantic marina fishing area many species are already fully exploited or over-fished, and little room remains for further expansion of the fishery.

- The Southwest Atlantic marine fishing area is estimated to posses a notable potential for expansion, the annual catch could reach some 3.3 million tons.

- The Eastern Central Pacific marine fishing area has a potential for an increased catch of between 2.8 and 4 million tons.

- The Southeast Pacific marine fishing area has some potential for increased catch, but there is a high degree of uncertainty in the catch due to the frequency of changes in environmental conditions and the high proportion of small pelagic species in the catch structure.[41/]

- The freshwater fisheries have a notable potential for an increased catch. The potential catch, estimated to be as much as 2 million tons is several times the present level.

Although marine fishing areas surrounding Latin American and Caribbean countries are still less exploited and less characterized by over-fishing than many fishing areas in other parts of the world, over-fishing, particularly by the industrial sector, has already caused considerable economic losses, most notably the losses suffered in Peru in the early seventies. The 10% decline in 1990 of the catch of the fishery industry in Chile has also been attributed to over-fishing.[42/] In Central America, over-fishing of the commercially most important species, including lobster and conch, has been reported in near coastal waters.[43/] Most, if not all, of the penaeid stocks in oceans washing Latin

Am ica and the Caribbean are considered to be exploited beyond their maximum sustainable yield.[44]

The non-industrial sector also shows signs of over-fishing, although on a smaller scale. Some of the clearest cases are the harvesting of "*locos*" (a variety of abalone) in Chile and of shrimp larvae in Ecuador and Peru, and the over-fishing of many coastal species indicated by a decline in the historic levels of catch per unit of effort.[45]

Inland bodies of water also suffer from over-fishing, for example, it has been reported that the Magdalena river fisheries in Colombia have failed to increase their output in recent years due to over-fishing, as well as, pollution.[46] In Brazil, some species have been reported to be locally depleted in the Amazon Basin.[47] In Paraguay, fish life has been reported to be almost extinct in the Ypacarai Lake, near Asunción, due to over-fishing and hunting.[48]

The extent of the damage caused by over-fishing is not always directly visible and can be difficult to measure. For example, between 1980-1989, the fishing sector of Chile grew at a robust 8.8% in terms of the annual value of the catch.[49] This growth, however, was accompanied by over-fishing which affected, *inter alia*, the two most important fishery resources of the country - the South American pilchard (*Sardinops sagax*) and the Chilean jack mackerel (*Trachurus murphyi*). As a result, an important part of the progress was achieved at the expense of future catches and when adjusted for this decline in the capital fish stock, sector growth is much less spectacular (Figure 6).

The effects of excessive fishing in Latin American and Caribbean countries are aggravated by periodical returns of the El Niño phenomenon, by increasing water pollution of coastal and inland bodies of water, as well as by other factors. Some remarks on regulation of fishery activity as well as recent developments in this field are provided in Box 1.

Apart from the impact on the fishing industry itself, and closely related industries processing the catch and the boat building and other equipment industries, the decline in fish populations due to over-fishing also affects the production of *guano* - a natural fertilizer important in Peru. Over-fishing deprives the seabirds who produce the *guano* of food.[50] The population of these birds in Peru suffered an abrupt decline in the early seventies, following the collapse of fish populations, from 6.5 million birds in 1972 to 1.8 million in 1973.[51] *Guano* production decreased from an annual average of 66.2 thousand tons during the 1965-1970 period to only 27.1 thousand tons during the 1971-1986 period.[52]

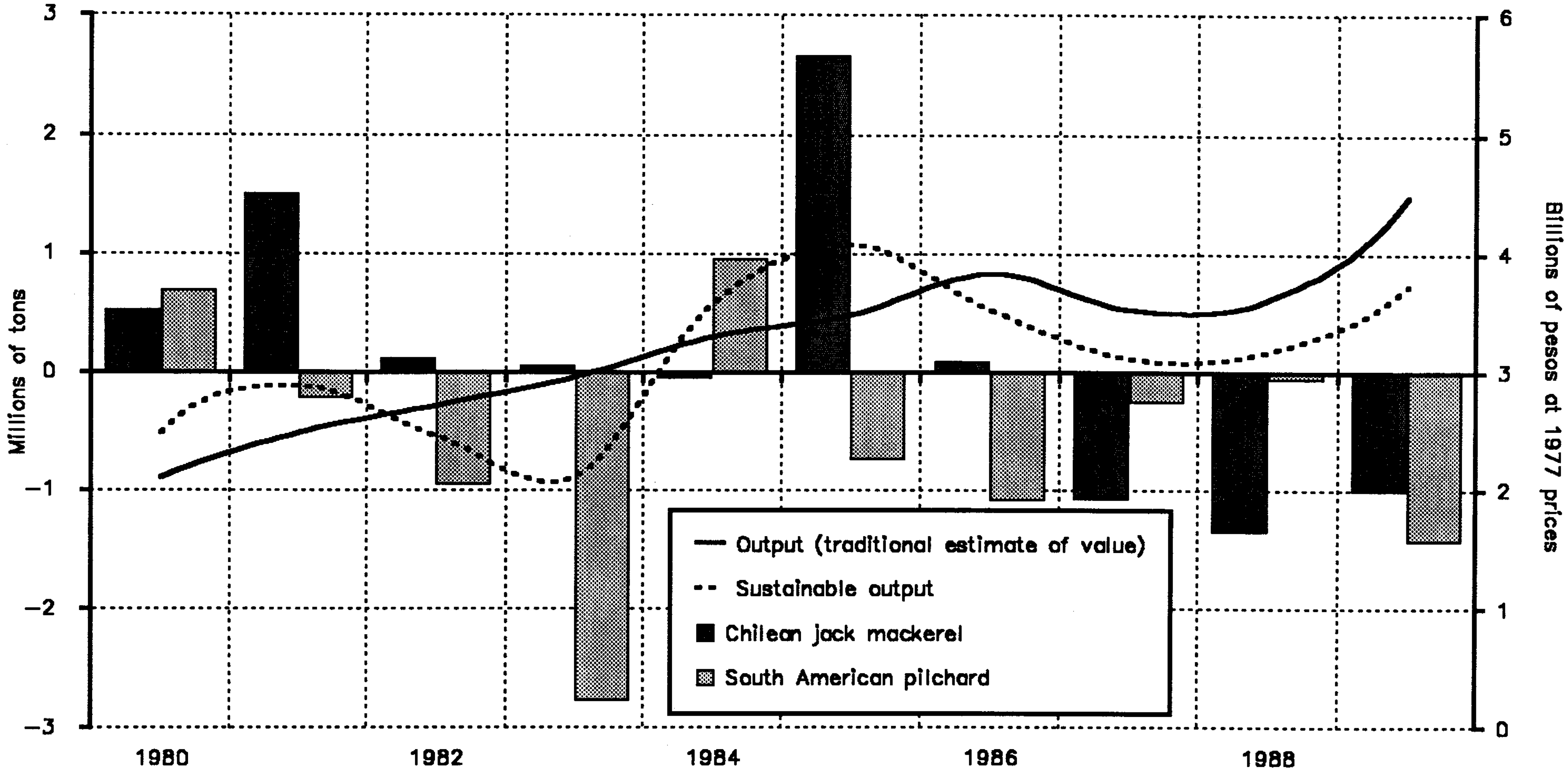
B. WATER POLLUTION

The development of fishing and fish processing has been frequently associated with localized considerable negative impacts on the environment. Their water pollution potential is, however, low, particularly in comparison with other industrial sectors, and is unlikely to increase in the future.

The reasons for this situation, despite the importance of both fishing and fish-processing, include the following:

1. It is widely accepted that the spectacular and sustained increase in fisheries catches is over.[53] Consequently, the fish processing industry, and hence its pollution potential, is unlikely to increase significantly in the future. At present most industries in the region already possess

Figure 6
CHILE: FISHING SECTOR OUTPUT AND VARIATIONS IN BIOMASS OF MACKEREL AND SARDINE



Source: Andrés Gómez-Lobo, Desarrollo sustentable del sector pesquero chileno en los años 80, Encuentro Anual de Economistas de Chile 1990, pp. 29–30; and Banco Central de Chile.

Box 1

MARKET INCENTIVES IN THE REGULATION OF FISHERY ACTIVITY AND THE FISHERIES ACT IN CHILE

Resources without well-defined property rights will tend to be used inefficiently and wastefully, and eventually be over-exploited. In the absence of the right to manage the resource and reap the benefits of good management, users cannot be expected to restrain their demands, protect the resource or invest in it. Consequently, for fishermen, there is no incentive to conserve, manage or enhance the resource and they must depend on governments to do so. To this end many Governments of Latin American and Caribbean countries, as well as in rest of the world, have resorted to close seasons, restrictions on the size of catches, on fishing methods, fishing effort, etc. Experience has shown that such restrictions can, to a certain extent, avoid resource depletion and economic waste but, in their turn, frequently lead to costly inefficiencies since they don't achieve harvest reductions at the minimum cost. In addition, regulations cannot offer incentives to fishermen to increase the efficiency of their operations. On the whole, regulations which result in unnecessary costs waste rather than conserve resources.

A novel approach to protecting the resource consists in the introduction of market forces as a means of harmonizing the needs of the economy and the environment and ensuring resource protection. The aim is to assign well-defined property rights to the catch that the stocks can sustain (the maximum sustainable yield) and let the fishermen, themselves, establish the most efficient and least costly way to harvest it, at the same time providing a strong incentive for resource protection and conservation. The rationale behind this approach is that markets can conserve resources if all their participants bear the full opportunity cost of their actions, that is the value of what must be foregone to undertake the activity in question. This doesn't happen in open access fisheries, where participants bear the capital and labour costs associated with fishing, but don't bear the cost of depleting the fish population with this cost being born by society as a whole. To maximize economic rent, the fisheries depletion cost must be taken into account.

The new Chilean Fisheries Act, put before Parliament in 1990, represents an interesting step in this direction. It provides for two different fishery management systems: one of free access, and the other of restricted access when it has been established that a resource is already fully exploited. In the latter case a system of transferable individual permits would be applied which give the right to a certain proportion of the total permitted annual catch during periods when access is restricted. Three quarters of these permits would be granted on the basis of prior catches and the remaining quarter sold by public tender.

The system of transferable permits/quotas is an efficient method of reducing harvests:

- it allows the government to adjust the overall size of the catch by buying or selling permits; and
- an auction would allocate permits efficiently because the fishermen that can generate the greatest value from each permit would submit the largest bids.

This system makes fishermen pay for the use of fishery capital stock. The distribution of permits is, of course, an income distribution issue and the method by which they are initially allocated has no bearing on the efficiency of the system. Such a system would be efficient as long as the permits are transferable. The method of initial allocation only determines who will receive the economic rent from the fishery.

Market forces may not solve all natural resource management problems and there remains scope for regulatory mechanisms, but individual transferable permits, as contemplated in the Chilean legislation, are likely to ensure better control over the size of individual catches, promote the use of more efficient technologies, prevent over-investment and limit administrative discretion. An alternative, efficient method of reducing harvests is a landing tax, is the tax rate is set appropriately.

Source: Peter H. Pearse, Scarcity of natural resources and the implications for sustainable development, Natural Resources Forum, Volume 15, Nº 1, February 1991, pp. 77-79; Dennis D. Muraoka, Managing the sea urchin fishery: an economic perspective, Natural Resources Forum, Volume 30, Nº 1, Winter 1990, pp. 146-147 and 149-151; and Guillermo Geisse G., Problemas y posibilidades de transformación productiva con conservación ambiental en cuatro sectores de actividad de la economía chilena, Santiago, Chile, December 1990, and Instituto Latinoamericano de Doctrinas y Estudios Sociales (ILADES), Trabajo de asesoría económica al Congreso Nacional, TASC, Nº 1, Santiago, Chile, March 1990, both quoted from United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Sustainable development: changing production patterns, social equity and the environment, LC/G.1648(CONF.80/2)Rev.1, 12 February, 1991, pp. 61-62.

considerable reserve capacity. In Mexico, for example, the level of capacity utilization of fish processing plants averages only 39%.[54] Rather than further expansion of the industry, it is much more probable that technologies permitting better utilization of available catches, mainly through reduction of wastes, will be adopted. The analysis of fish meal production supports this thesis. Efficiency of production, measured in terms of the proportion of meal output to raw material processed, has gradually increased from around 15% of raw material input in the early sixties to values exceeding 26% at present.[55]

2. Distinct from other industries, the introduction of pollution control in fish processing does not necessarily represent a net external cost for the sector. Pollution control frequently leads to increased output and a better quality product. Chilean experience shows that the incorporation of improvements in the technology of fish meal production has not only brought important economic benefits but also reduced polluting emissions.[56]

3. The characteristics of the predominant pollutants emitted by fish processing plants - organic wastes - render them susceptible to biodegradation. The wastes are usually not toxic. In addition, in distinction to other industrial and most municipal wastes, fish industry wastes (except shells) directly serve as food for many birds and fish.

4. The cost of waste treatment, given the characteristics of the wastes, usually is not very high.[57] Detailed estimates are not available, but it is known that the share of environmental protection investments in total net investment in food and beverage industry, the nearest analogue to fish processing for which information is available, is lower than in manufacturing industry as a whole.[58]

5. In the case of aquaculture, prerequisites for its development include uncontaminated water characterized by high dissolved oxygen and low indices of ammonia, heavy metals, pesticides, etc. There is an evident mutual interest among producers themselves to maintain adequate water quality. In addition, nearby population centers and local industries usually generate a far higher volume of wastes.

With some exceptions, the technology employed at fish processing plants in Latin America and the Caribbean has been generally backward and little attention has been paid to effluent treatment and other environmental considerations. In Chile, for example, adequate pollution control technologies only have been adopted by a minority of fish reduction plants and pollution persists particularly in the ports of Iquique and Talcahuano.[59]

1. Fishing

Fishing operations generate a considerable amount of wastes which are usually disposed at sea or in the vicinity of major fishing ports. These wastes include those specifically related to fishing as well as wastes common to all forms of water transport. Water pollution may also result from inadequate fishing methods, especially the use of poisons.

Wastes related to fishing activities at sea include:

- pre-catch losses - fish which die as a result of fishing operation and which are lost and not caught;

- discarded catch-dead - undersized, unsaleable or otherwise undesirable whole fish discarded at the time of capture or shortly afterwards;
- losses due to dressing, handling and processing - loss of fluid content, dumped viscera, heads and other parts;
- losses prior to landing - spoilage and subsequent dumping, use for bait, losses in handling at sea and when landing; and
- unrecorded landings dumped at sea.[60/]

These losses are considerable: according to FAO, worldwide an estimated quantity of between 5 and 16 million tons of fish per year is caught and discarded at sea by trawlers, especially those engaged in shrimping, with perhaps between 20% and 70% being marketable species and sizes, depending on the fishing area. The post-harvest losses, usually resulting from shortage of facilities to preserve fish or lack of technical knowledge, probably amount to about 10% of food fish supplies.[61/]

If the estimate according to which 10% by weight of the world fish catch is lost as a result of poor handling, processing, storage and distribution,[62/] is correct, annual losses in Latin America and the Caribbean could have amounted to some 1.5 million tons in recent years.[63/] The losses, however, are probably greater due to:

- Many smaller fishing boats have no icing facilities. In addition, the bulk of the region's larger boats are considered to be near to or have passed their useful life. Many were bought secondhand from developed countries. In some countries, the fishing fleets are quite old, for example, in Argentina and Peru a large percentage of ships are at least 20 years old.[64/] In Chile, over 44% of the fishing fleet were built between 1945-1964.[65/]
- Port facilities are considered inadequate and require modernization.[66/]
- Some forms of fishing generate considerably more wastes than others. Shrimping, for example, an activity with significant development in several countries of the region, is estimated to produce and dump three tons of accompanying fauna for each ton of shrimps caught.[67/]
- Fish are an exceptionally perishable commodity. The effects of generally warmer climate, characteristic of northern areas of the region, result in a faster deterioration of the catch and, hence, in higher losses.

Another source of pollution from fishing are the discharge of those wastes common to all forms of water transport including sewage, oil, garbage, etc. and other wastes dumped from ships. In the case of fishing vessels marine debris also include discarded nets and other fishing artifacts.[68/]

2. Aquaculture

While aquaculture is little developed in most Latin American and Caribbean countries, a substantial number of heavily financed projects are being implemented in the region and the potential negative impact due to badly planned and uncoordinated development may soon become obvious.[69/]

Any form of large-scale aquaculture exerts influence on the environment, through water pollution, alterations in habitat, in natural food webs and in ecological interactions, visual amenity deterioration and interference with other water uses.[70/] Some effects are nearly always present, while others are usually associated with the introduction or transfer, either as a planned exercise or by accident, of non-indigenous species. The introduction of non-indigenous species represents a special cause for concern since, given the complexity of ecological interactions, it is very difficult, if not impossible, to forecast their impact on the environment. Moreover, once a new species and its associated pests or diseases has been introduced, it is extremely difficult to eradicate them.[71/] Aquaculture production can also result in a reduction in the concentration of dissolved oxygen. This, however, is usually not ecologically significant with the possible exception of low energy costal environments.[72/]

In aquaculture, water pollution results from both the concentration of large numbers of fish or other aquatic organisms in a small space and from the associated material inputs required to maintain them (feed, pesticides, antibiotics, hormones, growth promoters, etc.). Ecological concerns are of particular importance in the case of oligotrophic water bodies which are naturally low in nutrients.[73/] The exact nature of pollution varies according to the type of cultivated organism (carnivores or filter-feeder), the size of production, the techniques applied, the location, the type of culture (with natural feeding or not), and the capacity of the receiving waters. Investigations have shown that the most serious fish farm pollution results from fodder waste and from fish excreta, with wet fodder being particularly polluting.[74/] Water pollution can also be caused by substances, such as heavy metals and plastic additives, released into aquatic environment by some construction materials. For example, plastics are known to contain a wide variety of additives including stabilizers (fatty acid salts), pigments (chromates, cadmium sulphate), antioxidants (for example, hindered phenols), UV absorbers (benzophenones), flame retardants (organophosphates), fungicides and disinfectants, with many of these compounds being toxic to aquatic life.[75/]

Salmonid farming, activity rapidly developing in Latin America and the Caribbean, produces wastes due to uneaten food (the production of 10 thousand tons of salmon is estimated to required between 15 and 20 thousand tons of dry food and about 40 thousand tons of wet food)[76/] and excreta. The form of the bulk of the wastes is organic carbon and nitrogen, but ammonium, urea, bicarbonate, phosphate, and some vitamins, including biotin and B_{12}, therapeutics and pigments are also present. In mollusc cultivation usually no fodder is supplied since molluscs consume phytoplankton. The aquatic environment is affected, however, by large quantities of faeces and pseudo-faeces produced by molluscs.

In both fish and mollusc cultivation, given adequate water movement at the site, the main effects of these activities on the environment come from the accumulation of nutrients on the bottom. This organic deposition is usually much greater than the natural input of these substances into environment. The accumulation of organic wastes has the physical smothering effect of particles and, more importantly, leads to increased oxygen consumption and eventual anoxic - oxygen deficient - conditions in the sediments with associated changes in the macro-benthos and other fauna. In extreme cases this process may result in total elimination of benthic invertebrates and the extension of anoxic conditions into the water column.[77/]

Concern has been expressed in the region on the possible environmental repercussions of aquaculture, as in the recent controversy generated by fears that the pristine waters of lakes - including the lakes of Villarica, Ranco and Llanquihue - in southern Chile and their ecology would be damaged as a result of salmon-raising operations.[78/] Such incidents suggest that investigation of the environmental impact of aquaculture is required.

Some countries, for example Ecuador, have extensive areas of brackish-water aquaculture, and others, including Brazil and Panama, are rapidly expanding such activities. Without adequate soil survey work and measures aimed at minimizing acidity impacts, brackish-water aquaculture development in acid sulfate soil areas is likely to run into major long-term difficulties. This is due to the fact that the areas most promising for intensive cultivation of brackish-water shrimp are frequently susceptible to acidity formation when soils and sediments are disturbed. Research has shown that strong acids, sometimes resulting from natural processes such as oxidation of pyrite,[79/] can kill brackish-water fish by overwhelming the natural buffering provided by dissolved bicarbonate. Crustaceans, including shrimp, have especially low acid tolerance.[80/]

Under certain circumstances, aquaculture activities may also have beneficia effects on the environment and increase the production potential of fisheries. For example, in the areas of dense bivalve culture, the development of polyculture systems, which provides nutrients to extensive shellfish farming, could be considered a possible beneficial side effect on a properly managed system combining intensive and extensive operations.[81/]

3. The fish processing industry

Effluent from the fishing industry is an important source of contamination of coastal waters near large fish-processing and fish-meal factories. Apart from processing wastes, fish plants also use large volumes of water for cleaning the fish and plant equipment, for the conveyance of fish from the hold to the point of processing and for the transport of waste material, etc. Fishing industry effluent usually contains suspended solids, nutrients, including nitrogen and phosphorus compounds, mineral oil and grease, organic carbon, dissolved trace refractory organics, colloidal solids, turbidity and phenols.[82/] The canning, preserving, processing of fish industries are characterized by a relatively high specific annual flow rate of water, 800 m^3 of water per employee, a population equivalent of 31 persons per employee, and an annual BOD pollution load of 243 (minimum), 419 (mean), and 500 (maximum) kilograms per employee,[83/] although higher and lower figures also occur depending upon the technology and equipment actually employed.

The main effects observed after discharge of wastes and water from fish processing industries can be summarized as follows:[84/]

- Fish processing industries are important sources of organic wastes. These wastes are degraded by birds, fish, crab, other marine species, and bacteria. As the loading of wastes becomes larger and larger, bacteria will become responsible for more and more of the degradation of dissolved organic matter. Films of bacteria will cover more and more of the surfaces with slime-forming bacteria in tread-formed algea-like colonies covering most surfaces when exposure is extreme. Since bacteria consume dissolved oxygen, eventually oxygen consumption will exceed the rate of supply. As oxygen depletion starts in the sediment, the "normal" bacteria are replaced by a group that utilize sulphate as an electron receptor and form free sulphur as a by-product of degradation of organic material. The signs of this process are easy visible as sediment surface turns white or yellow-white. As a result of disappearance of dissolved oxygen and anaerobic processes which take over the degradation of the organic wastes, marine organisms including fish and crustaceans, can no longer survive in the area. Other groups of bacteria will develop including those which reduce sulphate to foal-smelling sulphide and anaerobic bacteria which reduce iron in the sediment and release sediment stored nutrients.

- Wastes discharged by fish processing industries are rich in nutrients. Nutrients are also released from anaerobic sediments. Nutrients accelerate the growth of phytoplankton and the process of eutrophication. In addition, a part of the phytoplankton species are toxic. These problems are discussed in detail in Chapter 2.

- Processing of some fish species generates large quantities of oil and greases. Since even a very thin film of oil can easily be seen, its discharge into aquatic environment is objectionable on aesthetic grounds. Grease alone or in combination with suspended solids can form a surface scum. These problems are common along the Pacific coast of South America where industries process anchovetas and other species from the east pacific upwelling zone. Films of oil and grease can also harm birds and negatively affect the recreational use of coastal areas.

- Wastes discharged by fish processing industries can contain suspended solids. Suspended solids floating on the surface can form blankets of scum which are objectionable on aesthetic grounds and reduce the amount of oxygen that can enter the water from the air and the penetration of sunlight. A thick scum blanket provides a breeding ground for flies and other insects constituting a public health hazard. Solids in suspension can also create the odour problems, reduce transparency and change the colour of the water, affect bottom dwelling organisms, etc. (discussed Chapter 2).

- Fish processing industries frequently release water of high temperature (discussed in Chapter 2).

- Wastes discharged by fish processing industries can contain bacteria (discussed in Chapter 2).

In some cases, at discharge points of fish processing plant effluents the receiving water abounds with fish feeding on the effluent.[85/] This effect has been termed "bio-enhancement". It should not be used, however, as a sign that discharges of fish-processing wastes are beneficial for the environment, since:

- the so-called scavenger species are most likely to benefit from the discharges;
- increases in the population of a given species can lead to increases in diseases among fish;[86/] and
- the rate of natural eutrophication is likely to accelerate.

Water pollution caused by the fish processing industry is seasonal and it is characterized by discontinuous operating periods (see Annex 5, Uruguay).

The fish processing industries, particularly fish meal production, are also important sources of air pollution. At least one case has been reported where gaseous emissions from fish processing plants in Peru caused pollution of marine waters with negative effects on fauna.[87/] Air pollution is an issue of considerable concern for the population of affected areas and in some cases interferes with the development of recreation and tourism.

Examples of the pollution caused by the industry in the region, include estimates that more than 41 tons of fishing industry wastes are dumped into coastal waters of the northern zone of Chile daily.[88] Fishing industry effluents have reportedly caused water pollution problems in the area of Talcahuano and Coronel, near Concepción, with the El Morro canal being the principal affected area.[89] Other affected areas in Chile include the Bay of Iquique,[90] and other coastal areas in the north, around Arica, Iquique and the Bahía Inglesa.[91] In Mexico, the fish processing industry is reported to be affecting some coastal areas in the state of Yucatán.[92] In Peru, fishing industry effluents affect coastal waters adjacent to the ports of Ilo, Pisco and Supe, as well as in the bays of Callao and Chimbote.[93] In the bay of Chimbote and nearby beaches fauna that had been characteristic of the zone has been reported to no longer exist because of the discharge of 13 500 000 m^3 of refrigerating water annually by the fishing industry. The decomposition of organic products originating from fishing industry residues has been observed in the ports of Pisco, Supe and Tambo de Mora.[94]

Data regarding volume and characteristics of effluents, receiving water bodies and their conditions, existing methods of waste treatment and disposal, etc. are usually lacking or insufficient. As the fishing industry is supply-oriented, mainly due to the perishable nature of the raw product and the particularities of its conveyance system, processing plants tend to be located in or in the vicinity of major fishing ports (Annexes 5 and 6). Pollution tends to be particularly acute when factories are located on the shores of bays characterized by low in/out flow currents.

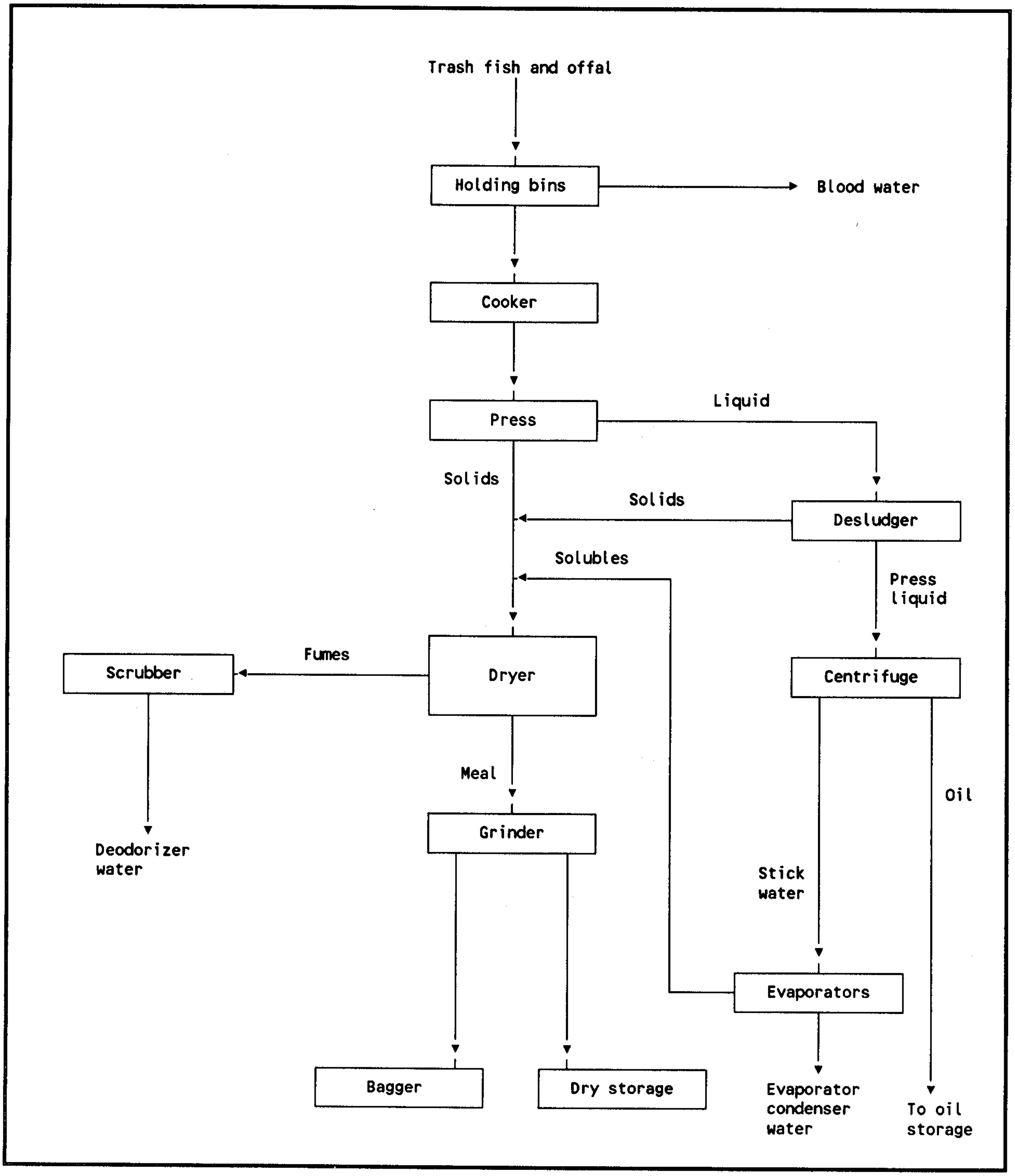
Production of fishery commodities in Latin America and the Caribbean averaged 2.3 million tons during the 1984-1988 period. Of this total, meals and oils account for almost 68%, fresh, chilled and frozen fish for about 18%, and all other products (dried, salted or smoked fish, canned fish, crustaceans, and molluscs) for less than 15%.[95] This pattern of production and available information on effluent characteristics in different branches of the fish processing industry would suggest that the fish meal and oil industries represent a point of particular concern. Insufficient data hamper any quantitative evaluation of the contribution of each industry to overall water pollution caused by fish processing; however, some idea of the extent of their potential contribution can be gained from the characteristics of the production processes:

i) <u>Fish meal</u> is produced from the trash fish, the inedible portions of fish, the offal, from groundfish plants, solids recovered by screening of process waste waters of a fish filleting and/or canning plants, as well as from industrial or scrap fish, and sometimes even higher-quality species, especially caught for this purpose. It is estimated that, on average, for each ton of fish used as raw material 237 kilograms of fish meal are produced, although higher and lower figures also occur depending upon the technology and equipment actually employed. In larger plants output tends to be higher ranging from 260 to 270 kilograms.[96] There are considerable technological differences between countries, for example, it has reported that in Chile, whose fish meal industry is characterized by higher technological level, average efficiency indices are close to those cited above, whereas in Peru, for each ton of raw material only about 170 kilograms of fish meal are produced.[97] If it is assumed that the production of 237 kilograms of fish meal per ton of raw material is representative of the regional industry, the wastes generated in the production process are likely to amount to approximately 7.7 million tons annually in Latin America and the Caribbean as a whole.[98]

A simplified process flow diagram of fish meal production and sources of waste waters are shown in Figure 7. Raw material is conveyed in a wet condition to the fish meal plant and is stored in pits and holding bins.[99] During storage a viscous substance, called bloodwater, begins to ooze from the pile. Some plants discharge bloodwater as waste while others process it in the continuous

Figure 7

PROCESS FLOW DIAGRAM OF FISH MEAL PRODUCTION AND SOURCES OF WASTE WATERS



Source: United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, p. 5.

cooker. Bloodwater usually amounts to some 5% of the reduced capacity of fish and is characterized by a BOD_5 of 30 000 mg/lt.[100/] The next stage of the process is the separation of the solid (press cake) and liquid (press liquid) fractions of the cooked material in a screw press. The press cake is dried, ground and bagged or dry stored as fish meal. Scrubbers or deodourizers are used in some plants to treat gases emitted during the drying operation.[101/] Press liquid which consists of stickwater, fish oil and solids is screened to remove solids. These solids together with the remainder of the press cake are once more introduced into the drier. Oil and stickwater are separated in a centrifuge. Depending upon the raw material used, the average composition of stickwater is: from 89.5% to 91.0% water, from 5% to 8% proteins, 0.5 to 1.0% oils, from 1.5% to 1.8% mineral salts and from 4% to 7% solids.[102/]

Some plants discharge the stickwater as waste while others concentrate it in evaporators and the resultant solids (solubles) are returned to the drier. Stickwater usually amounts to some 60% of the raw material processed or 23% of meal production and is characterized by a BOD_5 of 70 000 mg/lt.[103/] On this basis, the annual production of stickwater is likely to amount to approximately 0.6 million tons in Latin America and the Caribbean.[104/] The effluent of a fish meal plant without treatment facilities for the recovery of bloodwater and stickwater is relatively small in volume but extremely polluting: the BOD and suspended solids of these two components average more than 100 000 mg/l and 10 000 mg/l respectively.

The structure of water use by a typical fish reduction plant in northern Chile is given in Table 9. Pollution parameters of effluent discharged by fish meal factories in comparison with other forms of fish processing is given in Table 10. Information on principal fish meal and oil plants in Chile, their treatment technology and discharges is provided in Table 11.

Apart from the production process itself, conveyance of the fish by suction pump-out with cushion water from ships to fish meal plants represents an important source of water pollution. During this process, the mixture of fish and water (1:1) is pumped from the hold to pits and holding bins with the water used being later returned to the sea. This water is contaminated by fish residues and by bloodwater.[105/] The level of contamination tends to increase when the fish is conveyed over longer distances.[106/]

ii) In fish filleting, some fish are eviscerated at the processing plant before filleting, while others are eviscerated at the fishing boat itself after catch. A simplified process flow diagram of groundfish filleting and sources of waste waters are shown in Figure 8. The fish are stored in holding bins usually packed in ice in order to minimize biological degradation.[107/] Some fish are not pretreated prior to filleting. In this case they are flumed - washed down with water - to the filleting tables where fillets are sliced off both sides of the fish. In some cases, this usually refers to redfish, the scales are removed from fish before they are filleted. The offal is flumed from the filleting tables and is usually processed into fish meal or fish oil. It represents approximately 70% of the weight of the fish.

The offal is not always used for further processing but is sometimes dumped into nearby bodies of water or on solid waste dumps. In Chile, for example, the canning plants in Coquimbo, Iquique and Talcahuano are associated with the fish meal industry and their fish wastes are processed into fish meal. On the other hand, some mollusc canning plants and the majority of refrigeration plants, usually dump fish processing wastes into nearby bodies of water or on solid waste dumps.[108/]

Table 9

STRUCTURE OF WATER USE IN FISH REDUCTION
(A typical plant in Northern Chile)

Purpose	Typical water use, m^3/day	
	Minimum	Maximum
Cushion water (suction pump-out)	600	900
Clean-up of plant and equipment	3	6
Deodorizer water	3 000	6 000
Condenser water	1 000	4 000
Condensed stickwater	50	240

Source: Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, pp. 25-26.

Table 10

CHILE: POLLUTION PARAMETERS OF EFFLUENT DISCHARGED BY 12 FISH FACTORIES
(Measured in the spring of 1988)

Type of plant	Capacity	Flow (m^3/h)	Temperature	Biochemical oxygen demand a/	Chemical oxygen demand b/	Grease c/
Meal	20 - 400 t/h	50 - 1 800	22 - 64°C	545 - 5 157	954 - 6 528	130 - 3 785
Canning	8 - 200 t/d	0.6 - 200	12 - 18°C	700 - 3 361	1 094 - 4 186	607 - 2 700
Refrigeration	100 - 400 t/m	1 - 45	10 - 18°C	800 - 3 000	1 200 - 3 500	130 - 7 700

Source: Ramon Ahumada and Anny Rudolph, Residuos líquidos de la industria pesquera: alteraciones ambientales y estrategias de eliminación, Ambiente y Desarrollo, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Volume V, Nº 1, April 1989, p. 153.

a/ - mg O_2 per litre;
b/ - mg O_2 per litre;
c/ - mg per litre, in the case of refrigeration plants data represent the maximum value obtained in the decantation pool.

Table 11

CHILE: PRINCIPAL FISH PROCESSING PLANTS

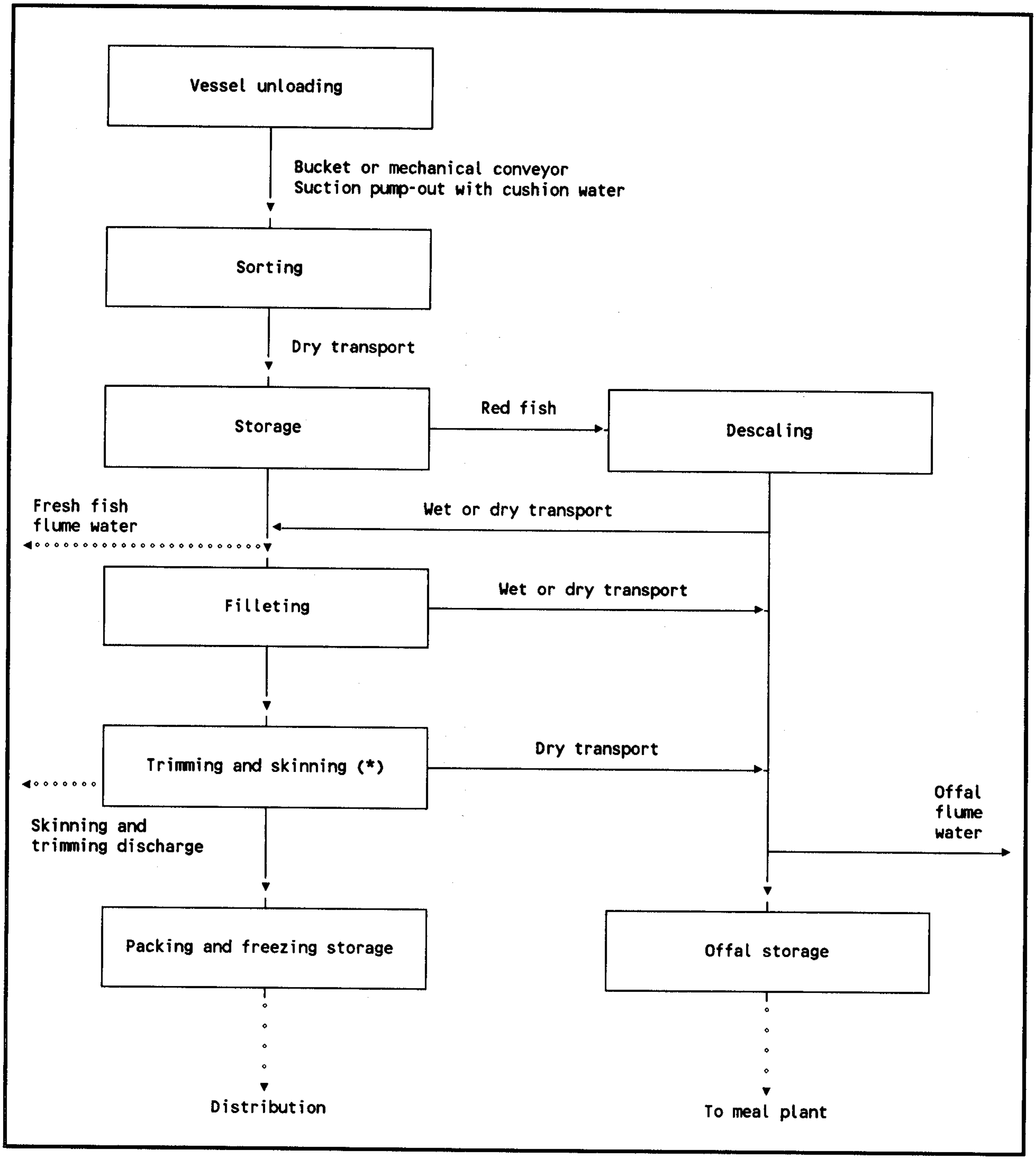
Region	Locality	Industrial process	Production capacity	Treatment technology	Discharge	Recipient water body
I	Arica	Fish meal and oil	397 t/h	Stickwater concentration	-	Beach Los Gringos
	Iquique	Fish meal and oil (canning and refrigeration	618 t/h (meal)	Stickwater concentration	-	Bay of Iquique
II	Tocopilla	Fish meal and oil	25 t/h	Stickwater concentration	-	Tocopilla
	Mejillones	Fish meal and oil	180 t/h	Stickwater concentration	-	Bay of Mejillones
	Antofagasta	Fish meal and oil	15 t/h	Stickwater concentration	-	Bay of Moreno
III	Caldera	Fish meal and oil	25 t/h	Stickwater concentration	-	Bay of Caldera
	Calderilla	Fish meal and oil, canning	120 t/h (meal)	Stickwater concentration	16 800 m³/d	Bay of Calderilla
IV	Coquimbo	Fish meal and oil, canning	35 t/h (meal)	Stickwater concentration	-	La Pampilla
	Coquimbo	Fish meal and oil	25 t/h	Stickwater concentration	-	Beach Changa
V	Quintero	Refrigeration (crustaceans)	36 t/m a/	Without treatment	b/ 183 m³/d	Quintero
	Artificio	Food products (seaweeds)	-	-	1 640 m³/d	River Aconcagua
	San Antonio	Fish meal and oil	30 t/h	-	-	Port of San Antonio
VIII	Tomé	Fish meal and oil, refrigeration	10 t/h (meal)	Stickwater concentration	-	Bay of Concepción
	El Morro	Fish meal and oil, refrigeration and canning	70 t/h (meal)	Stick- and blood-water concentration	-	Bay of Concepción
	Isla Rocuant	Fish meal and oil, canning	185 t/h (meal)	Without treatment	-	Bay of Concepción
	San Vicente	Fish meal and oil, canning	18 t/h (meal)	Stickwater concentration	-	Bay of San Vicente
	San Vicente	Fish meal and oil	112 t/h	Without treatment	-	Bay of San Vicente
	Coronel	Fish meal and oil	10 t/h	-	-	Gulf of Arauco
X	Ancud	Seaweeds processing	3 t/d	Sedimentation	-	Sector of Mutrico
XI	Puerto Chacabuco	Canning and refrigeration	-	-	-	Puerto Chacabuco

Source: Denise Bore R., Francisco Pizarro A. and Nora Cabrera F., Diagnóstico de la contaminación marina en Chile. Anexos, Corporación de Fomento de la Producción (CORFO), Instituto de Fomento Pesquero (IFOP), AP 86/37, February 1986.

a/ - refrigerated;
b/ - including 120 m³/d process water (without solids) and 63 m³/d refrigeration water.

Figure 8

PROCESS FLOW DIAGRAM OF GROUNDFISH FILLETING AND SOURCES OF WASTE WATERS



Source: United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, p. 5.

* - if needed.

Some fish do not require skinning and candling. The skins are removed from fillets of other fish in skinning machines and later the fillets are flumed to candling tables for visual inspection and removal of bones, defective meat, etc. After candling, the fillets are either dipped in a brine or phosphate solution if they are sold fresh, or are frozen separately or in blocks.

Waste waters are produced at practically every stage of fish processing. Large volumes of water are used in the fluming of fish in the different sections of a plant. Salt water is usually used in fluming raw fish and offal. Fresh water is used in skinning machines and in the fluming of cut fillets. The effluent typically contains high dissolved solids, from 17 000 to 36 000 mg/l including salt and have a moderately high BOD and suspended solids content - from 275 to 540 mg/l and from 200 to 500 mg/l, respectively.

iii) Other forms of fish processing (dried, salted or smoked fish, canned fish, crustaceans, and molluscs), because of the generally low level of their production, are much less important sources of water pollution in the region. Some of these industries are artisanal in nature. Effluent characteristics depend upon the technology and equipment employed, but are usually similar to those in fish filleting since some stages of the two processes coincide. Canning, for example, usually involves standard cannery equipment and techniques, such as eviscerating, beheading, sliming, packing, sterilizing and washing,[109/] with the main sources of waste water including unloading operations, holding tanks (if used), general plant clean-up, packing, cooking or retorting, cooling, washing of the cans, etc. The major sources of waste waters in other types of fish processing are summarized in Table 12.

Fish processing industries are also associated with air pollution and solid waste generation problems. The major solid wastes are offal, shells (if lobsters or crabs are processed), and screenings from the waste waters.[110/] Total losses at fish processing plants are usually very high: it is estimated that of each 100 tons of catch, trash fish constitutes 30 tons, spoilage - 15 tons, and loss at fish processing plants - 40 tons).[111/] The problem of fish spoilage is also present at the fish processing plants as a result of limited refrigeration capacities and failures of electric supply. In some countries, most solid wastes, except shells, are frequently used for fish meal production or sometimes as fertilizer. Except in areas characterized by a concentration of fish processing, however, many plants are frequently too remote or too small to be able to take advantage of these possibilities. Where solid wastes are not reused, their dumping, without adequate provisions, in sanitary landfills or in nearby bodies of water may create nuisances and contribute to water and air pollution. In general, in Latin American countries, industrial solid wastes are dumped together with municipal wastes,[112/] and there is no reason to think that fish-processing wastes represent any exception.

Some progress is being made by the fish processing industry in controlling water pollution (Table 13). A pilot project has been reported in Chiloé, Chile on the reuse of fish industry wastes. According to the agreement between Instituto de Fomento Pesquero (IFOP) and fifteen industries of the zone, investigations will include the conversion of fish industry wastes into methane gas, animal fodder and agricultural fertilizers.[113/] Again in Chile, a new fish meal production technology has been reportedly developed which achieves more efficient energy utilization and the almost complete elimination of gaseous emissions. The technology has been adopted, at least partially, by seven plants. Its further adoption, however, is hampered by the relatively high cost, more than US$ 5 million per plant, as the drying and evaporation equipment must be replaced.[114/] Plants using the latest technology reduce water and air pollution.[115/] These technological improvements are not always a direct result of conscious efforts aimed at pollution control but may also stem from the necessity

Table 12

SOURCES OF WASTE WATERS IN SELECTED FISH PROCESSING INDUSTRIES

Industries	Major sources of waste waters
Blue crabs	Waste water flows come from the containers in which the crabs are brought to the plant, from the cooking and cooling operations, from the stations where meat is picked from the claws and bodies, from canning and retorting, and from general plant clean-up operations.
Dungeness, tanner and king crabs	Waste water flows come from the butchering operation, the cooker, from coolers, flumes, from the tables where the meat is separated from the shell, from the inspection station, and from general plant clean-up operations.
Shrimp	Waste water flows come from the washing and blanching operations, from peeling, inspection and sorting, from deveining and retorting (if these operations are undertaken), and from general plant clean-up operations.
Clams	Waste water flows come from the shucking, by several washes, the debellying station, and from general plant clean-up operations. If the clams are canned, waste water also comes from the retorting process.
Salmon	Waste water flows come from the pre-rinse and washing operations, mechanisms used to transfer fish from the boats to the plant, holding bins, the packing of the meat into cans, the retorting, cooling and washing of the cans, and from general plant clean-up operations.
Tuna	Waste water flows come from primary operations, including thawing, precooking, cooling, butchering, cleaning and sorting, canning, and retorting, secondary operations, including odor control apparatus and evaporation procedures, as well as from general plant clean-up operations.
Catfish	Waste water flows come from the tanks used to hold the catfish when they arrive at the plant, from the stations where they are eviscerated, skinned and cleaned, from the packing operations, and from general plant clean-up operations.

Source: United Nations Industrial Development Organization (UNIDO), Environmental assessment and management of the fish processing industry, PPD.15, 12 December 1986, Sectoral Studies Series Nº 28, Sectoral Studies Branch, Studies and Research Division, pp. 21-27.

Table 13

CHILE: APPROXIMATE DATES OF THE INTRODUCTION OF FISH MEAL TECHNOLOGY IMPROVEMENTS

Improvements	Northern Zone	Zone of Talcahuano
Stickwater plants	1960-1976	1975-1985 1970-1978 Tamarugal
Fluming water filtering (unloading)	1970-1978	-
Post stead drying	1960-1970 (partial)	-
Deodourizers/salt water scrubbers	1960-1975	1969-1985
Semi-dry unloading		1976 SOPESA 1978 PISA
Chemical deodourizers	1985	
Steam drying	1985	1987
Flume water recirculation (unloading)	In development	

Source: Ricardo Bravo Lyon, La industria pesquera y el medio ambiente: proceso de producción de harina, p. 269.

to improve the quality of plant output and/or to increase efficiency to compensate for decreased supply and/or increased cost of raw materials. On the whole, however, it is the minority of plants which have adequate treatment facilities.[116/]

C. THE PHYSICAL EFFECTS OF FISHING

Certain fishing operations can have negative physical effects on the environment. These negative effects are usually associated with the towing of demersal gear and inappropriate fishing methods, such as those involving the use of explosives:

- Fishing operations involving the towing of demersal gear (for example, tickler chains strung in front of the net to stir up fish from the bottom, dredges used for clams, oysters and mussels) or hydraulic dredging may have negative physical effects on the sea bed and on the benthic organisms.[117/] Repeated use of this gear on the same bottom is likely to be particularly damaging. The impact of such practices, however, is difficult to assess and little information is available on this subject with respect to Latin America and the Caribbean.

- Some fishing practices, such as driftnetting, can have negative effects on non-target organisms, for example, in the Caribbean, the incidental killing of marine mammals and seas turtles has been reported (shrimp trawling may kill turtles, or the use of gill netting in rivers may kill river dolphins and manatees).[118/]

- Inappropriate fishing methods, including the use of explosives and fish poisoning, also affect fisheries. The use of these methods on the part of artisanal fishermen in eastern areas of Peru has threatened a number of fish species with extinction. The methods employed involve the use of dynamite and *barbasco* - a poison from *Jacquinia armillaris*, an evergreen bush.[119/] The use of explosives to catch fish kills the larval, juvenile and adult fish together with other aquatic organisms of no commercial value and also damages aquatic environment, for example, destroys the coral reefs.[120/] The dynamiting of coral areas, particularly for the export tropical fish aquarium market, has been reported in the Caribbean. This practice is indiscriminately destructive of delicately balanced ecosystems and can result in the permanent loss of valuable breeding grounds.[121/]

- Aquaculture, as well as fish processing industry, development can interfere with the use of bodies of water and nearby areas for tourism and recreation. Similar problems have been reported, for example, in the case of the Villarrica, Ranco, Rupanco and Llanquihue Lakes in Chile. Such interference is rare since aquaculture tends to be located in isolated areas of difficult assess. In addition, the experience of aquaculture development elsewhere shows that aquaculture and tourism can be mutually complementary.[122/] Some conflicts between aquaculture and navigation have also been reported.[123/]

- The land around fish-ponds can become water-logged, although this can be avoided through adequate drainage and ditching.[124/]

D. AQUACULTURE AND WASTE-WATER REUSE

The use of nightsoil and domestic sewage in aquaculture has been practiced in China and in India among other countries for a long time.[125] This practice, however, has been little used in Latin America and the Caribbean.

Aquaculture sewage treatment systems are usually based on constructed ponds, sometimes provided with supplemental aeration to maintain adequate oxygen in the upper layer, seeded with floating aquatic macrophytes (typically *water hyacinth*), a variety of invertebrates, and often with species of fish. Harvested hyacinth can be used as a livestock feed supplement, or may be composted to form a soil amendment. The removal of contaminants achieved in aquaculture systems has been shown to be quite good.[126] Although fish breeding in stabilization ponds at higher than tertiary level has been carried out, it is considered preferable to build specific lagoons for aquaculture into which effluents from stabilization ponds or from irrigation fields are entered, depending upon fish nutrition requirements (Figure 9)[127]

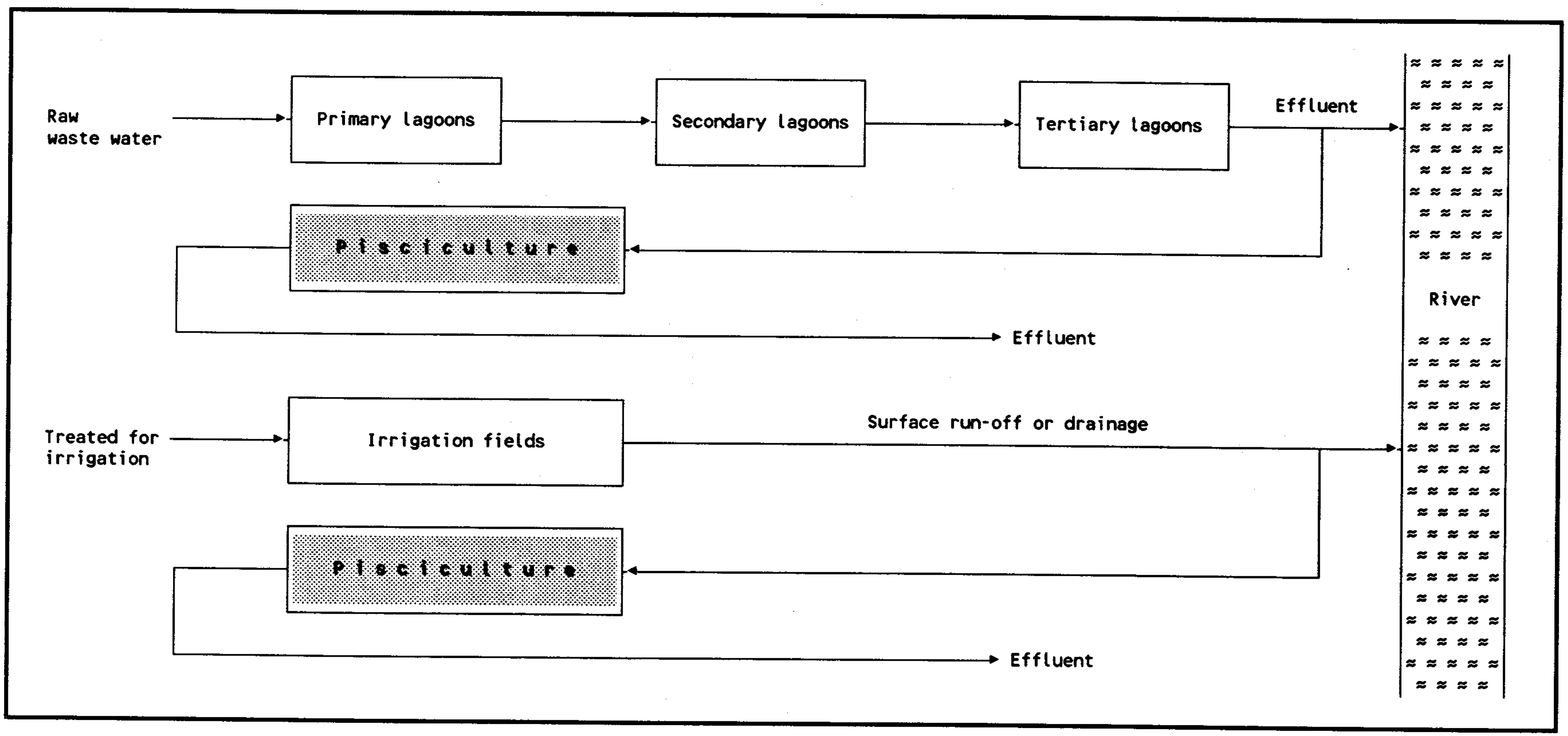
The total volume of wastewater generated in tropical zones of Latin America is estimated at about 240 m^3/sec. This volume of effluent could permit to develop aquaculture on some 70 000 hectares with annual level of production exceeding 500 000 tons. Gross value of production could exceed US$ 400 million and regional annual consumption of fishery products could be increased by 3 kg per capita.[128]

Little information is available on the use of aquaculture for sewage treatment in Latin America and the Caribbean. Some related studies conducted at the San Juan lagoons in Lima, Peru, are briefly described in Box 2.

Fish are used in Latin American and Caribbean countries, as well as in other areas the world, for controlling aquatic plants in reservoirs and irrigation systems. The control is achieved in a number of ways, including direct grazing by fish on aquatic plants, changes in water clarity through increased turbidity as a result of fish rooting in the bottom, or through dislodging rooted plants. In many situations the use of fish has economic and environmental advantages over other methods of weed control (mechanical, chemical, etc.). An integrated approach is also sometimes applied. A variety of fish species are used for weed control, but the widely employed Chinese grass carp (*Ctenopharyngodon idella*) is considered the best herbivorous fish for controlling aquatic plants in temperate and tropical waters.[129]

Figure 9

SCHEMATIC DIAGRAM OF A PISCICULTURE COMPLEX



Source: R. Saenz, Use of wastewater treated in stabilization ponds for irrigation - evaluation of microbiological aspects, Water Quality Bulletin, Volume 12, № 2, April 1987, p. 87.

Box 2

PERU: WASTE-FED AQUACULTURE

Waste-water reuse has been steadily developing in Lima, Peru since the late fifties. Research was centered at the San Juan lagoons and was aimed at the reutilization of treated waste-water for irrigation.

Over recent years, with external support from the World Bank, UNDP and the German Agency for Technical Cooperation (GTZ) aquaculture studies have been incorporated into the over-all scheme and the operation of the lagoons. They have been performed by local research teams at the Universidad Nacional Agraria, the Universidad Nacional Mayor de San Marcos, the Centro de Investigación Instituto Veterinario de Investigaciones Tropicales y de Altura, and the Centro Panamericana de Ingeniería Sanitaria y Ciencias del Ambiente (CEPIS), under the co-ordination of the Servicio de Parques.

The inclusion of aquaculture within the final stages of a treatment scenario was intended to address the problem of accumulation of salts and metals in the roots' cross section, to increase removals of suspended solids and precipitation of dissolved solids, to augment retention times in order to provide enhanced die-offs or removals of potentially pathogenic organisms. In addition, revenues from the sale of aquaculture production could be used to cover the costs of achieving a higher quality waste-water effluent and its adequate disposal.

Aquaculture studies involved *Nile tilapia*, *giant prawn* and *common crab*. Some species were chosen for their reported resistance to high organic contents and low oxygen levels, while others were chosen for their potentially high market value. Both monoculture and polyculture studies were conducted. During these studies pathogenic organisms were monitored both in lagoons and in harvested fish and prawns.

Colour, texture and taste of processed *tilapia*, by both the wet salting and smoking methods, was considered good and competitive with other locally available products. However, a significant population of bacteria was detected in the peritoneal fluid and muscle of raw *tilapia*.

The aim of the next phase of this project will be to determine optimum fish culture operational conditions, including the optimum stocking density, carrying capacity of the ponds, the need for supplemental carbohydrate food with consideration being given to the use of digested animal manure for generation of supplemental protein food. Also more in-depth microbiology studies would be carried out.

Source: On the basis of information in Saul Arlosoroff, Waste-water reuse for irrigation and aquaculture, United Nations, Department of Technical Co-operation for Development, Natural Resources/Water Series Nº 22, Non-conventional water resources use in developing countries, proceedings of the interregional seminar, Willemstad, Curaçao, Netherlands Antilles, 22-28 April 1985, pp. 237-244.

Chapter 2

THE EFFECTS OF OTHER WATER USES ON FISHING

The negative effects of other uses of water on fishing are generally minor in Latin America and the Caribbean. The most serious negative factors are water pollution and flow regulation. Fishing has also been damaged as a result of the degradation of coastal ecosystems, including coral reefs, mangroves and sea-grasses, which provide important habitat for fish reproduction and growth.

A. WATER POLLUTION

The negative effects of certain forms of water pollution on fishing have been known for a long time. Water pollution problems have frequently become the focus of public attention following fish kills. Fishing may be affected by water pollution in various ways: fish may be destroyed directly through oxygen depletion, by specific toxic substances, including agro-toxic chemicals, etc.; sedimentation of suspended matter may damage spawning grounds; changes in temperature and water transparency may affect fish behaviour and abundance.[130/] Contamination by water pollution may also lead to the catch becoming either totally unsalable or unexportable or, at least, to a decline in its price. Finally, fish or their fitness as food may be affected as a result of contamination by pathogenic organisms. Annexes 7-9 provide information on the water quality standards relevant for fishing.[131/]

Of all forms of water pollution, that caused by heavy metals, agro-toxic chemicals and other substances prone to food chain concentration is, perhaps, the most important and represents a cause of particular concern. Fish absorb toxic chemicals directly from the water flowing across their grills as part of their normal respiration. Contaminants are also absorbed from the sediments by bottom-dwelling animals such as tubificid worms, insect larvae, molluscs or crayfish. Heavy metals and many organic micro-pollutants, including polychlorinated biphenyls (PCBs), dioxines and organo-chlorinated pesticides, may be absorbed from the water by phytoplankton and then pass through the food web to fish and other aquatic organisms. These chemicals resist being metabolized and excreted by aquatic animals and if the organism continues to be exposed to chemicals it cannot adequately excrete or detoxify, concentrations can increase to toxic levels or cause carcinogenic, reproductive and/or developmental effects. As many aquatic animals excrete the chemicals in question very slowly or not at all, they tend to build up to higher concentrations at each step in the food web because of the bio-magnification effect.[132/]

Water pollution primarily affects inland and coastal waters. The pollution of coastal waters is of crucial importance since nearly all the marine catch is currently estimated to be taken within 320 kilometers of land, the zone where more than half of the total biological productivity of the oceans is believed to occur.[133/] At the same time, most fish spawn either on the continental shelf or in coastal estuaries.[134/] For example, some 98% of fish caught in the Gulf of Mexico are considered to be estuarine dependent.[135/]

In general, the effects of water pollution on fishing in Latin America and the Caribbean are limited and the major part of the fish catch comes from marine areas still largely free of pollution. Water pollution problems and their impact on fishing can be expected to increase, however, and environmental degradation will become and increasingly serious problem in maintaining fisheries in coastal waters,[136/] as well as inland bodies of water. The information available on water quality in rivers, lakes and other bodies of water in Latin America and the Caribbean would suggest that many do not seem to provide an adequate environment for aquatic life (see Box 3).

Fishing in coastal and inland waters, although small in most countries in comparison with marine fishing, represents a subsistence activity for many people living along the sea coast or near lakes and rivers. Contamination could have a serious impact on this population both through their diet and through the loss of income. Recreation and tourism are also likely to suffer. In addition, where consumers are more and more conscious of the health aspects of food, including seafood, fears of contamination, whether justified or not, are likely to result in considerable market losses for the industry. For example, as a result of the recent cholera epidemic in Peru, countries closed their borders to fish and food products, not only from Peru, but also from other Latin American countries. According to estimates of the Asociación de Exportadores of Peru, losses due to the bans on exports of frozen fish have amounted to US$ 50 million. Other estimates suggested that if the European bans spread, total losses during 1991 could reach between 10% and 20% of Peru's total export earnings, between US$ 300 million and US$ 600 million. Local consumption has also declined causing the loss of some 400 tons of fish at the Lima and Callao terminals, worth about US$ 1 million.[137/] Neighboring countries have also suffered from export bans. Experience has shown that

Box 3

WATER BODIES WHOSE WATER QUALITY IS LIKELY TO BE INADEQUATE FOR FISH

Cause	Water body
Acidity	Río Lerma, Mexico; Lago de Chapala, Mexico; Río Sao Francisco in Petrolandia, Brazil; Reservatorio do Río Descoberto, Brazil.
Dissolved oxygen	Río Atoyac, Mexico; Río Lerma, Mexico; Río Cauca in Juanchito, Colombia.
Faecal coliforms	Río Pixcaya, Guatemala; Río Atoyac, Mexico; Río Lerma, Mexico; Río Paraiba do Sul in Barra Mansa, Brazil; Río Cauca in Juanchito, Colombia; Río Daule, Ecuador; Río San Pedro, Ecuador. On the whole, of the 24 Central and South American rivers monitored by Global Environment Monitoring System (GEMS), 96% had faecal coliform count of at least 100 per 100 ml and 17% of 10 000 or more.

Source: On the basis of (i) water quality data supplied by the Canada Centre for Inland Waters, Burlington, Ontario from the GEMS/Water database, quoted from United Nations Environment Programme (UNEP), Environmental data report, 1989, Prepared for UNEP by the GEMS Monitoring and Assessment Research Centre, London, UK in co-operation with the World Resources Institute, Washington, D.C., UK Department of the Environment, London, Tables 1.26, 1.28 and 1.34; and (ii) Global Environment Monitoring System (GEMS), World Health Organization and United Nations Environment Programme, Global pollution and health. Results of health-related environmental monitoring, 1987, p. 10.

Note: Water quality parameters of these bodies of water have been compared to quality standards for surface water required for fish propagation and wildlife (Annex 7) and water quality standards for aquatic life in freshwater (Annex 8). Water in above water bodies is not necessarily damaging to all forms of aquatic life.

environment-related trade conflicts can also arise over other issues, such as fishing technology. An example is afforded by a recent controversy when the Earth Island Institute and five tuna canning firms accused Mexico of massive dolphin killing (schools of dolphins usually accompany tuna and are killed when they get trapped in fishing nets) and a United States federal court in San Francisco decreed an embargo on Mexican tuna exports.[138]

1. Major sources of water pollution and their effects on fishing

The major sources of water pollution are domestic sewage, effluents from manufacturing industry and mining, the extraction, transport and refining of petroleum, and run-off from agricultural land. It is estimated that at least 85% of ocean pollution in Latin America and the Caribbean is man-induced and results from land-based sources, and that 90% of these pollutants remain in coastal water ecosystems.[139]

a) Domestic sewage

Only some 5% to 10% of the sewerage systems in Latin America and the Caribbean have some degree of treatment and this situation has not changed significantly in the last three decades.[140] At the same time, the urban population with access to sewerage has dramatically increased - from 50.2 million (including 45.7 million without treatment facilities) in 1962, to 142 million (including 128 million without treatment facilities) in 1988.[141] As a result, the input of sewage into the environment in many locations exceeds the natural decomposition and dispersal capacity of the recipient water bodies with subsequent significant degradation of the quality of water.

The discharge of domestic sewage into the aquatic environment without adequate treatment can have negative effects on aquatic organisms:[142]

- Domestic sewage is characterized by a high biochemical oxygen demand (BOD) and chemical oxygen demand (COD). The dumping of such wastes into water bodies can lead to deoxygenation of the water with negative effects on aquatic organisms. In areas where rapid dilution occurs or where dumping takes place in well-mixed waters, deoxygenation of the water column is unlikely, however, to affect aquatic life.

- Domestic sewage is rich in nutrients, including phosphates and nitrates. Its decomposition can release large amounts of these substances into the aquatic environment increasing the rate of natural eutrophication. Although, in theory at least, eutrophication of a water body with low fertility is generally not harmful and may even increase fish production, negative effects (sedimentation of spawning grounds, decreased water transparency, the creation of anoxic conditions, etc.) may arise when the water body is over-fertilized. Even if a body of water is oligotrophic, large inputs of nutrients may actually decrease fish population: (i) usually rapid augmentation of nutrients to oligotrophic lakes cannot be readily utilized by organisms beyond the invertebrate groups at the secondary trophic level; (ii) the accumulation of dead plant materials will decrease oxygen availability; (iii) since cultural eutrophication is at best only under moderate control, any benefit is normally only happenstance; and (iv) large cultural inputs of nutrients may render the environment qualitatively unsuitable for salmonid communities, which over evolutionary time have become adapted to the oligotrophic body of water.[143] Eutrophication affects numerous bodies of water in several Latin American and Caribbean countries.[144]

- Domestic sewage contains large numbers of pathogenic micro-organisms which can be transmitted to humans through fish and molluscs. Filter-feeding molluscs represent a particular concern because they may take up a massive number of fecal organisms even at large distances from the point of discharge and after dilution with water.[145/] There is a serious risk of the transmission of pathogenic organisms to the consumer. The possibility of contamination is increased as molluscs are frequently cultivated in the vicinity of large population centers, areas usually characterized by high biological contamination of nearby bodies of water. The situation is aggravated even more as molluscs are commonly eaten whole, alive and uncooked. Pathogenic micro-organisms, either derived from sewage or naturally present in the aquatic environment, that can be transmitted by seafood include: seafood-borne bacterial diseases - typhoid fever, cholera, botulism, non-cholera vibrios and Beneckea; seafood-borne viral diseases - infectious hepatitis and viral gastro-enteritis; and seafood-borne parasitic diseases - *Pseudoterranova decipiens* and *Anisakis simplex*.[146/] An example of what can occur is afforded by a recent cholera epidemic in Peru. The most affected area was on the coast. The disease was believed to be spread, at least in part, through the eating of raw seafood contaminated by domestic sewage.[147/] The *V. parahaemolyticus*-associated gastro-enteritis as a result of eating contaminated seafood has been reported from Central America.[148/] In Chile, bacteriological contamination of some molluscs has been detected.[149/]

- It has been suggested that the discharge of active substances of terrigenous origin, particularly sewage, may be related to the blooms - so-called "red tides" - of certain planktonic organisms, mainly the *dinoflagellate genera Gonyaulax* and *Gymnodinium*. The possible effects of these blooms include mass mortalities of marine animals and the accumulation of a toxin in molluscan shellfish with the main hazard for public health being paralytic shellfish poisoning.[150/] The negative effects of blooms on fish and other aquatic organisms are basically related with the associated extreme shifts in dissolved oxygen and pH resulting from high concentration of algae in a bloom.[151/] "Red tides" periodically affect coastal areas of Latin America and the Caribbean. During the last six years this phenomenon was detected some 8 times in Chile, particularly in its southern waters. As a result of the blooms, several persons were intoxicated and some deaths were reported.[152/] Fish processing industry has also been affected.[153/] Deaths from bloom-contaminated shellfish have been reported in Guatemala.[154/] Plankton blooms may also have negative effects on aquaculture. For example, the "*marea café*" which affected southern areas of Chile between Llanquihue and Chiloé in 1988, caused damage to salmon aquaculture and similar events resulted in high losses for coastal aquaculture again in 1989 and 1990.[155/]

b. Effluents from manufacturing industry

At the Conference of the Fishing Committee of the Food and Agriculture Organization (FAO) held in 1991, industrial pollution was held to be "endangering the marine environment and the sustainability of marine resources".[156/] It is certainly the case that the growth of industry in Latin American and Caribbean countries has contributed to the pollution of rivers, lakes, groundwater aquifers and coastal waters. Many industrial plants do not have the appropriate technologies and facilities or the necessary economic and human resources to adequately handle and dispose of wastes.[157/] As a result, practically all, but the most toxic, industrial effluent is discharged into the nearest water body without adequate treatment and, in addition, the region is estimated to have a higher share of industries with potentially noxious effluents than the world as a whole.[158/] In total, industry in Latin American countries is estimated to dump some 41 000 tons of hazardous wastes daily.[159]

Depending upon the nature of the industry, the potentially harmful constituents of industrial effluents can include toxic substances, heavy metals, acid-producing compounds, soluble organics causing depletion of dissolved oxygen, substances resistant to biodegradation, trace organics, suspended solids, colour and turbidity, radioactive materials, and nitrogen and phosphorus compounds.[160] Because of the great variety of these wastes, it is not possible to make a general statement as to their possible effects on fish life. The discharge of practically all of them into aquatic environment without adequate treatment can provoke negative effects on aquatic organisms. For example, heavy metals are prone to food chain concentration, consequently, even relatively low concentration of these elements in the aquatic environment will translate into a much higher concentration in fish and molluscs. Some examples of bio-accumulation concentration factors - the ratio of the concentration of the element in fish to that in ambient water - are for arsenic a range from 77 to 4 100, for cadmium from 180 to 730, and for mercury from 530 to 12 300. In the case of macro-invertebrates concentration factors tend to be even higher.[161]

The types of pollution associated with selected individual industrial processes are summarized below:

- The smelting, refining, mining and electroplating industries, the chemical and petrochemical industries, the tanning industry and the pulp and paper industries, etc. are important sources of heavy metals, particularly mercury and cadmium. Concentrations of toxic metals including arsenic, cadmium, lead, mercury and selenium are known to be highest in foodstuffs of marine origin. Heavy metals are toxic to many forms of life, including fish and molluscs. Their toxicity is usually associated with the inhibition of enzyme systems, but at high concentrations a metal may kill by disrupting the respiratory surfaces, for example, the gills.[162]

- Thermal and nuclear electric generating plants, as well as industrial cooling, result in thermal discharges. Cooling water amounts to between 60% and 70% of all industrial water use or 90% when electric power production is included.[163] Thermal discharges can contain trace chemicals, but this is usually a minor problem. Aquatic organisms, particularly those with limited temperature tolerance ranges, may be forced to migrate to other areas and/or be otherwise affected as a result of thermal pollution. Apart from fish, heated effluents can also affect sea-grasses, since their upper lethal limit is only a few degrees above their summer ambient temperature.[164] The negative effects of power plant effluents on sea-grasses have been reported in Guayanilla Bay on the southern coast of Puerto Rico, as well as elsewhere.[165]

- Thermal electric generating plants, internal combustion engines and some industrial processes discharge sulfur dioxide (SO_2) and nitrogen oxides (NO_x) into the atmosphere. The resultant progressive acidification of freshwater lakes and streams by acidic precipitations has severely reduced fish population in a number of developed countries.[166] Some areas of the region, for example parts of Brazil and Chile, have been reported to be affected by acidic precipitations.[167] The damage to fish from acid rain results from a combination of factors, including the mobilization at low water pH of toxic metals such as aluminum, interruption of fish reproductive cycles, and death of food organisms. Crustaceans, including shrimps, have a particularly low acid tolerance.[168]

In Latin America and the Caribbean, many bodies of water in the vicinity of large industrial concentrations are polluted to such a degree that fish life and fishing have been seriously affected. For example, in Argentina fish kills were reported following industrial pollution of the River Negro.[169/] A survey of marine pollution in Brazil revealed that industrial effluents in the areas of Salvador, Recife, Guanabara Bay, Santos and Lagoa dos Patos exerted intense effects on marine fauna, including fish mortality and progressive reduction of shrimp catches.[170/] The discharges, into the River Paraiba, from an integrated iron and steel plant in Volta Redonda, Brazil, have reportedly killed all fish life at distances up to 50 kilometers downstream.[171/] Fish caught in the Santos estuary, São Paulo, Brazil, had mercury counts of up to 4.6 parts per million or some 10 times the permited limit.[172/] The industrial waste from sugar cane distilleries, together with untreated municipal sewage, has seen a reduction in the Capibaribe River's oxygen levels to the point where it can no longer support fish life.[173/] In Chile, increased mercury concentrations have been found in some molluscs caught in the area of the bay of San Vicente.[174/] Chilean exports of certain fish have reportedly been refused in the United States as a result of similar problems.[175/] In Colombia, the disappearance of fish and related problems drew attention to the growing water pollution of Cartagena Bay. Fishing activities within the Bay were banned when it was determined that mercury levels in fish and shellfish captured in waters of the Bay exceeded internationally accepted levels.[176/] In Guatemala, clams contaminated by toxic waste have reportedly resulted in 22 deaths.[177/] In Mexico, the concentrations of nickel in river sediment and marine organisms in the heavily polluted River Coatzacoalcos were reported to be much greater than those normally encountered in areas of human activity. Thirteen polynuclear aromatic hydrocarbons, including the very carcinogenic benzol pyrene and benzol perylene, were found in 19 species of organisms, such as fish, crustaceans and molluscs.[178/] In Venezuela, the Golfo Triste area was subject for several years to metallic mercury discharges from a chloralkaly plant. As a result, the local fish populations show total mercury concentrations per unit body weight at least about one order of magnitude higher than the corresponding values obtained for the Oriente area, which has not received known mercury pollution loads (Table 14).[179/]

Chemical accidents are a further cause of water pollution in Latin America and the Caribbean. Available information suggests that this is a problem of major magnitude. 6 fish kills were reported in Venezuela between 1982 and 1984 as a result of such accidents. Fish kills resulting from chemical spills have also been reported in other countries ranging from Brazil to Santa Lucia.[180/]

c. **Effluent from the mining industry**

Water, usually in very large quantities, is essential in every stage of the mineral industry - mining, concentration and refining. Liquid mine, mill or refining plant effluents may contain toxic elements, particularly metals such as cadmium, chromium, lead, mercury, nickel and zinc, and in some cases chlorides, fluorides, nitrates, arsenic or cyanide, and organic processing reagents such as coagulants, collectors, depressants, dispersants, flocculants and frothers. In addition, mine and mill effluents are frequently acidic (low pH), whereas most fresh-water fish require water in a pH range between 5.0 and 8.5 with fish dying at a pH below 4.0 or above about 9.0.[181/] Fish multiplication and growth can also be seriously affected by sudden variations of the pH level. Acidic water also reacts with heavy metals either in the effluent, in the soil or rock in the banks or bottom of bodies of water and renders the metals soluble with resulting possible toxic pollution. Mining operations frequently increase water turbidity caused by high levels of solids in suspension. Water turbidity interferes with the gill function of both fish and crustaceans, seriously affects larvae of all aquatic

Table 14

VENEZUELA: TOTAL MERCURY CONCENTRATION PER UNIT BODY WEIGHT FOR AQUATIC ORGANISMS CAPTURED IN THE AREAS OF GOLFO TRISTE AND ORIENTE

Species	Golfo Triste		Oriente	
	Number of species analyzed	Range of total mercury concentrations per unit body weight (µg/g/Kg)	Number of species analyzed	Range of total mercury concentrations per unit body weight (µg/g/Kg)
Bagre marinus	2	0.93 - 1.24	1	0.15
Cynoscion virencens	3	6.78 - 0.82	3	0.60 - 0.32
Diapterus rhombeus	20	9.30 - 8.83	5	0.11 - 0.72
Haemulon plumieri	1	8.28	4	0.18 - 0.29
Lutjanus synagris	14	13.86 - 5.70	4	0.21 - 0.31
Priacantus arenatus	2	3.15 - 6.25	8	0.25 - 0.08
Sphyraena picudilla	36	6.14 - 2.70	12	0.27 - 0.68

Source: Chanel Ishizaki and Juan Urich, Mercury contamination of food: a Venezuelan case study, Interciencia, July-August 1985, Volume 10, Nº 4, p. 177.

animals, and causes an avoidance reaction in many fish species. It also leads to decreased light penetration with adverse effect on the food chain in a marine ecosystem.[182/]

Effluents from mining and related activities have affected fish life in many places, particularly in South America. Sluice mining and other activities have killed most life in the Jequitinhonha River of Minas Gerais in Brazil.[183/] Fish contamination by mercury as a result of gold mining in certain areas of the Amazon Basin is discussed in Box 4. In Ecuador, pollution by mercury has been reported in some gold-producing areas, for example the River Amarillo and the risk of contamination of sea products by mercury is considered to be grave.[184/] In Chile, the negative effects of mining industry effluent on aquatic organisms are widely reported (see Box 5).[185/] One extreme case is Chañaral in Northern Chile, where effluents from the Salvador and Potrerillos copper mines have destroyed all aquatic life for up to 15 kilometers off the coast.[186/] In Peru, effluent from the mines of Toquepala and Cuajone is reported to negatively affect fish resources in the Bay of Ite.[187/] Fauna of one of the most important rivers in the Andean region, the Mantaro, has been destroyed by heavy pollution originating from concentrators and foundries located on its banks.[188/] In the Caribbean, the major mining-related threat to fish is considered to come from the dumping of bauxite-mining wastes.[189/]

d. Pollution from the petroleum industry

Pollution occurs in all stages of petroleum production, refining and distribution. It may occur at the points of oil extraction, in exploration, in refining, during industrial operations and in transportation by pipelines and ships. One of the largest sources is the dumping of fuel-oil sludge, the ballasting of tankers and tank cleaning, tanker accidents, and waste oil from the bilges of ships.[190/] Both crude and refined oil can be considered as toxic to most living organisms. Fish, however, frequently escape the toxic effects of massive amounts of petroleum by swimming away to unpolluted areas. The less mobile aquatic organisms suffer more.[191/]

Box 4

BRAZIL: MERCURY POLLUTION FROM GOLD MINING AND FISHING

In the extraction of one gram of gold, a miner will use as much as 2 grams of mercury. In the process of production, about half of the mercury escapes as a vapor, which later is returned to the earth with rain, while the rest, in the form of residue or ash, is usually dumped into rivers. The total volume of mercury dumped in the Amazon Basin has been estimated to be some 100 tons annually. In 1989, experts estimated that up to 132 tons of mercury were entering the Amazon ecosystem each year and moving up the food chain. The Tapajós River alone, a major mining area, is believed to have received some 1 200 tons of mercury since 1958. Near the top of the food chain fish can concentrate the metal in their tissues, sometimes at 100 000 times the levels found in surrounding water.

Fish is a staple of the diet of both the miners and other Brazilians who live in Amazon River communities. Analysis of 34 fish netted downstream of gold-mining operations in the states of Amapá, Pará and Rondônia indicated that in almost half the mercury content exceeded Brazil's maximum permissible limit of 0.5 mg per kilogram of wet fish. Samples of common food fish caught below gold-mining sites on the Madeira River in the state of Rondônia showed average concentrations of 2.7 mg in the *pintado* species and 2.1 mg for *dorado* species.

Source: On the basis of information in James Brooke, Mercury poisoning: the dark side to Brazil's gold rush, International Herald Tribune, Friday, August 3, 1990; Louis Byrne, Mercury poison threat to Brazil, The Times, Wednesday, June 6, 1990; Saving the Yanomani, The Times, January 13, 1990; and Ann Misch, The Amazon: river at risk, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, January-February 1992, Volume 5, Nº 1, pp. 36-37.

Box 5

CHILE: EFFECT OF MINING EFFLUENTS ON AQUATIC ORGANISMS

Investigations carried out in 2° Region, Chile, by the Instituto de Investigaciones Oceanológicas have determined that the majority of fish, invertebrates and sea-weeds present in uncontaminated areas, were absent in areas contaminated by discharges of mining industry. Of ten species of fish under investigation (*Paralabrax humeralis, Chromis crusma, Pimelometopon maculatus, Hemilutjanus macrophthalmus, Medialuna sp., Auchenionchus spp., Paralichthys adpersus, Graus nigra, Oplegnathus insignis, and Labrisomus spp.*) three were classified as rare, four as meager, and three as abundant in uncontaminated areas, whereas none of them was found in contaminated areas.

The situation was similar in the case of invertebrates and sea-weeds. Of eleven species of invertebrates under investigation, including *Concholepas concholepas, Fisurella spp., Collisella ssp., Heliaster helianthus, tetrapygus niger, Loxechinus albus, Pyura praeputialis, Pyura chilensis, Leptograpsus variegatus*, etc., two were classified as meager, five as abundant, and four as very abundant in uncontaminated areas. Only one of them was found in contaminated areas (*Bataeus truncatus*) where it was abundant.

Of three sea-weeds considered (*Macrocystis integrifolia, Lessonia nigrescens*, and *Enteromorpha compressa*), one was classified as meager, one as abundant, and one as very abundant in uncontaminated areas. Only one of them was detected in contaminated areas (*Enteromorpha compressa*) where it was classified as very abundant.

Source: Instituto de Investigaciones Oceanológicas, 1985, quoted from Denise Bore R., Francisco Pizarro A. and Nora Cabrera F., Diagnóstico de la contaminación marina en Chile, Corporación de Fomento de la Producción (CORFO), Instituto de Fomento Pesquero (IFOP), AP 86/37, February 1986, pp. 187-188.

Note: The quantity of different species was calculated for each 100 linear meters of coast up to the depth of 5 meters and was classified according to the following scheme: "rare" - from 1 to 10 per 100 linear meters, "meager" - from 11 to 50, "abundant" - from 51 to 100, and "very abundant" - over 100.

The possible biological effects of petroleum pollution include:

- Lethal toxic effects, where the components of the oil interfere with cellular and subcellular processes in the organism to such an extent that death follows.[192] The components of drilling fluids are also highly toxic to marine life.[193]

- Sublethal effects that disrupt physiological or behavioural activities but do not cause immediate mortality, although death may follow because of interference with feeding and reproductive activities or other abnormal behaviour.

- The up-take of the oil or fractions of it by marine organisms and the initiation of a sequence whereby the pollutants are transferred to other members of the food chain. This process can lead to deleterious physiological effects on the different marine organisms involved as well as to making them unfit for human consumption.

- Direct smothering and suffocation or interference with movements to obtain food or escape from predators as a result of becoming coated with oil.

- Alterations to the chemical and physical properties of the marine habitat which result in changes in the populations of individual species as well as shifts in species composition and diversity.

- Mortalities caused by indiscriminate use of detergents to disperse oil. Plankton and free-swimming larvae are likely to be most sensitive to the presence of emulsifiers.[194]

The marine areas of Latin America and the Caribbean most affected by petroleum pollution are on the Atlantic coast - from Venezuela to latitude 25°N, off Brazil between the states of Maranhão and Rio Grande do Norte, and Pernambuco and São Paulo and on the Pacific coast - off Chile south of latitude 40°S, off Ecuador, Panama, and to a lesser extent off Colombia, Peru and the Central American countries.[195]

Off-shore oil drilling represents another danger to fisheries, in particular the coastal shrimp industry.[196] Oil and gas exploration and exploitation on the continental shelf is considered to be the most important source of marine pollution in the South-West Atlantic, off-shore from the States of Rio de Janeiro and São Paulo in Brazil and off-shore from the San Jorge Gulf in Argentina.[197] Countries with major off-shore oil production are Mexico, Venezuela, Brazil, Trinidad and Tobago, and Peru. Venezuela, Mexico, Brazil, and Colombia also have important off-shore production of natural gas.[198]

Examples of the effects of pollution by petroleum on fishing are numerous. In Ecuador, oil spills have reportedly killed large numbers of freshwater pink dolphins in the Cuyabeno Wildlife Production Reserve near Lago Agrio.[199] In Mexico, water pollution caused by petroleum refining has considerably reduced the former abundant fishery of the Coatzacoalcos River.[200] In Venezuela, oil spills have damaged fauna and fish nets in Maracaibo Lake.[201] In 1986, the area just east of the Caribbean entrance to the Panama Canal was affected by the largest recorded oil spill into coastal habitats in the tropical Americas. Oil covered intertidal mangroves, seagrasses, algae, etc. which died soon after. Extensive mortality of shallow subtidal reef corals and infauna of seagrass beds was also observed. Even 18 months later recovery was reported only for some organisms in areas exposed to the open sea.[202] The discovery of major petroleum deposits in the central part of the Amazon Basin, in the Andean foothills of Bolivia, Ecuador and Peru, has caused a considerable increase in water pollution near the oil extraction sites and transportation of the oil also poses a very serious potential danger to the fishery resources of the Amazon river and its tributaries.[203]

Marine oil pollution seems, however, to be declining, the "amount of oil entering the world's oceans has been cut by 60 per cent since 1981". A further reduction of oil entering the sea can be expected when all ships comply with the 1973 International Convention for the Prevention of Pollution from Ships.[204]

e. Run-off from agricultural land

Run-off from agricultural land usually carries pollutants in dissolved or suspended form, including fertilizers, agro-toxic chemicals (herbicides, pesticides, etc.), suspended solids, salts, etc.

The main components which effect the aquatic environment are:

- Fertilizers, both synthetic and natural, are important sources of nutrients and their accumulation in the aquatic environment, especially in lakes and reservoirs, increases the rate of natural eutrophication. In general, the consumption of fertilizers per hectare of agricultural area is low in Latin America and the Caribbean (11.7 kg/ha (N, P_2O_5,K_2O)) in comparison with developed countries (43.7 kg/ha) and even developing countries taken as a whole (22.3 kg/ha).[205] Fertilizer consumption in some countries or areas considerably exceeds the regional average.

- Agro-toxic chemicals, such as herbicides and pesticides, can be transported to water bodies either by agricultural run-off or may be applied directly to control weeds or vectors of waterborne diseases. These chemicals are toxic both to aquatic life and to humans, are frequently non-degradable or only degrade very slowly in the aquatic environment, and have a tendency to concentrate in the food chain (Table 15). In general, in Latin America and the Caribbean the consumption of toxic chemicals in agriculture is low. Again, there are areas where pesticide consumption is substantially higher and some farmers continue to use chemicals whose consumption is restricted, discontinued or prohibited in countries with more stringent environmental legislation. There are also cases of improper application and misuse of chemicals in agriculture.

- Suspended solids. Siltation and increased turbidity in inland and coastal waters results from massive erosion due to inadequate agricultural practices and destruction of tropical forests. High turbidity is known to reduce light penetration and affects the breathing and digestion systems of fish. Sedimentation in coastal areas can also reduce or even stop growth of corals, important breeding grounds for many fish.[206] Along Costa Rica's Caribbean coast sediments from local rivers have reportedly killed three fourths of the reefs.[207]

Information on effects of agricultural chemicals on fishing is limited in Latin America and the Caribbean. It has been reported, for example, that a variety of shrimp and fish in the Northern Caribbean and Gulf of Mexico showed that DDT was widely distributed. Shellfish and fish contamination in Cartegena Bay has also been associated with pesticide run-off.[208] Pollution by pesticides and fertilizers has reportedly affected shrimps in the Gulf of Honduras.[209] A great

Table 15

CHARACTERISTICS OF PESTICIDES IN THE AQUATIC ENVIRONMENT

Characteristics	Organophosphates	Organochlorides	Carbamates
High toxicity to aquatic fauna	* * *	* *	* *
Solubility	-	*	*
Assimilation and bio-concentration	* * *	*	*
Persistence in aquatic environment	* * *	*	*
Intensive use in zones adjacent to aquatic systems	* * *	* * *	* *

Source: Elia García, "Los pesticidas", Ambiente, Nº 2, 1982, p. 16.

amount of fish killed has been reported in the Windward Islands following intensive application of organochlorine insecticides to banana plantations.[210/] Pesticides in run-off have also been responsible for fish kills in coastal waters of Colombia and Jamaica.[211/] Organochlorine residue concentrations were found in the blubber of sperm whale (*Physeter macrocephalus*) in the Caribbean - ∑DDT 8.30, DDE 5.35, and PCBs 2.35 μg/g wet weight.[212/]

2. Environmentally sensitive fishing areas

The water quality of the oceanic shelves, which account for the bulk of the fish catch, is still largely untouched by human activities in Latin America and the Caribbean. There are, however, many fresh water bodies and coastal areas which suffer water pollution to the extent that fish have either been killed or, at least, rendered unsuitable for human consumption. The non-industrial fishery sector, the bulk of whose catch comes from coastal and inland waters and which concentrates its activities on highly-prized species sold almost exclusively on the market for fresh fish for direct consumption, is the most severely affected by pollution.[213/]

Degradation of inland and coastal waters causes considerable concern due to:

- their importance for fishing;

- the size of the population dependent on fishing in these areas either as a source of income or for protein; and

- their potential for the development of aquaculture (some forms of aquaculture, particularly those centering on fish species that can exist only in oligotrophic water, such as salmonids and coregonids,[214/] may depend on high water quality), although optimal fish production does not necessarily require high water quality.

Examples of the pollution of inland and coastal waters abound. In Guanabara Bay, Brazil, pollution by sewage and industrial effluents has reportedly killed many of its fish and damaged mangroves.[215/] In Chile, pollution of the Biobio River has substantially reduced fish population and high concentrations of toxic substances, including mercury, are found in marine organisms in nearby coastal areas.[216/] In the Damas River, dumping of organic wastes and high bacteriological contamination have reportedly resulted in partial extinction of aquatic life and fish.[217/] In Colombia, high turbidity has negatively affected aquatic life in the Muchindote and El Gusano rivers.[218/] In the Dominican Republic, water pollution has eliminated practically all forms of life in the Ozama and Haina rivers.[219/] In Mexico, water pollution has been reported to have affected fishing in the Alvarado Lagoon in the state of Veracruz,[220/] and the fishing area adjacent to Puerto de Guaymas.[221/] Some unique species of fish are thought to have become extinct, while discoveries of dead fish have become frequent, in the heavily polluted Coatzacoalcos River.[222/] In Panama, diversity of marine fauna has been drastically reduced in the centre of the Bay of Panama, between Punta Paitilla and Casco Viejo, as a result of sewage discharges.[223/]

B. FLOW REGULATION

Dam construction and the canalization of rivers can affect fishing by restricting migration and changing the characteristics of the water environment.[224/] In Latin America and the Caribbean, most river systems remain largely uncontrolled despite the growth in the regulation of streamflows. There are, however, some 1 400 large dams with a total reservoir storage capacity of approximately 650 km^3. The highest number of dams are located in the North Pacific, North-east Brazil and Plate river basins, and the Plate, Pampa and Amazon river basins have the highest reservoir storage capacity.[225/]

The flooding of large tracts of forest, particularly tropical forest, has serious repercussions on the chemical and biological quality of water. Experiences with the Brokopondo Dam in Suriname and Curuá-Una Dam in Brazil demonstrate that the by-products from decomposing, submerged forest can lead to massive fish kills, infestation of aquatic weeds, and other negative effects.[226/] For example, the filling of the Brokopondo dam was followed by the emissions of hydrogen sulphide (H_2S), a soluble and poisonous gas.[227/] Dam projects may also interfere with fish migration and lead to increased siltation.

Dam construction can have beneficial effects on fishing. When a large reservoir is filled, the number of fish is likely to increase (except those fish which are adapted to the riverine environment) as advantage is taken of the expanded environment and as a result of the temporary release of large quantities of nutrients from submerged soil and vegetation. This expansion, however, is likely to be short-lived. On the whole, in terms of fish yield, the total loss of fish throughout the river basin can, in most cases, equal - or even exceed - the temporary gains made when a reservoir is filled.[228/]

C. MAJOR CAUSES OF THE DEGRADATION OF COASTAL ECOSYSTEMS

Coastal waters play an important role in fish production and conservation, and frequently contain areas of high localized productivity. In Latin America and the Caribbean, coastal waters are the site of vital upwelling areas, including some of world significance, as for example off the coasts of Peru.

The most important coastal ecosystems of Latin America and the Caribbean include coral reefs, mangrove swamps and areas of sea grasses, which are discussed below in detail:

- Coral reefs are shallow-water ecosystems growing on a substratum of lime stone and representing an assemblage of numerous types of plants and animals with corals being one of the principal components. Coral reefs are formed by coral polyps as a result of the removal of calcium ions from sea water and their deposition as a limestone (*aragonite*) skeleton. Coral reefs require sun-light, stable high salinities and temperatures of 22°C to 28°C for their optimum development. Their importance is explained by a number of factors: (i) in spite of the low nutrient levels in the surrounding waters, coral reefs have a very high rate of productivity and are characterized by abundant fish life, representing a storehouse of valuable species; (ii) they are important breeding and nursery grounds for many marine organisms; (iii) in many places coral reefs act as a buffer against sea erosion; and (iv) reefs are important for tourism.[229/] Major causes of degradation of coral reefs include silting, storms, over-fishing and tourism (see Table 16). Corals are also affected by bleaching - a phenomenon which occurs when corals expel the algae that reside within their cells, thereby turning snowy white. Coral bleaching is believed to be related to increased ocean temperatures, elevated nutrient levels and other local stresses. Bleaching events were reported, for example, in 1987-1988 and October 1989 in Jamaica. Recently, major coral bleaching has been reported to appear to be beginning in Jamaica, the Cayman Islands, the Florida Keys, Puerto Rico, Bermuda, the Bahamas, and possibly other areas in the Caribbean. Possible consequences of coral bleaching include large scale changes in the food chains and the inability of the ecosystem to adapt to rising sea levels.[230/]

- Mangroves are salt-tolerant trees or shrubs usually found in low-lying tropical coastlines with freshwater drainage. They filter water through the root system and provide a habitat for many marine species, including commercially valuable species of fish, crabs, lobsters, mussels, and oysters.[231/] A square kilometer of mangrove estuary has been estimated to be able to produce a commercial yield of US$ 95 000 per year in fish and shellfish

Table 16

LATIN AMERICA AND THE CARIBBEAN:
MAJOR CAUSES OF DEGRADATION OF COASTAL ECOSYSTEMS

M a n g r o v e s			Sea-grass	Coral Reefs
(Central America)	(South America)	(Wider Caribbean)	(Wider Caribbean)	(Wider Caribbean)
Clear-cutting Firewood Land reclamation: - aquaculture Solar salt	Clear-cutting Firewood Land reclamation: - aquaculture Development: - urban - ports	Clear-cutting Firewood Land reclamation: - agriculture - aquaculture Development: - Urban - Ports Solar salt Pollution: - chemical - domestic - oil Tourism/recreation	Direct destruction - dredge/fill Siltation: - dredge/fill Pollution: - chemical - oil - thermal	Siltation: - dredge/fill - land runoff Destructive fishing Intense localized fishing effort Curio trade Tourism Pollution: - chemical - domestic - nuclear - oil Natural stress: - storms

Source: World Resources Institute and the International Institute for Environment and Development, World resources 1986, Basic Books, Inc., New York, 1986, pp. 148, 151 and 153.

production.[232] The degradation of mangroves is widespread in Latin America and the Caribbean. Major caused of this degradation are listed in Table 16. It is estimated that, on the whole, more than 50% of mangroves in Latin America (60 000 km²) are exploited, reconverted or degraded in some form.[233] In Guatemala, Honduras, and El Salvador, mangroves are harvested for making charcoal and for firewood. As a result, some areas have been degraded or completely destroyed. In Costa Rica, mangroves have been destroyed to provide bark for the tanning industry, practice now outlawed, for salt production, and for coastal development. In Panama, mangroves swamps have been drained, cleared and filled for urban, resort and mariculture development. Around Belize City, mangroves have been reported to be rapidly cleared to make room to the growing city. Mangroves are also threatened by agricultural run-off, for example in El Salvador, Honduras, and Guatemala.[234] Catches of lobsters and conch have been reported to have decreased considerably in some areas of Central America as a result of destruction of mangrove breeding habitats.[235] It is known that mangrove forests and their bordering provinces in tropical and subtropical countries frequently represent most attractive areas for the development of brackish-water aquaculture. This is particularly true of the pond systems in which tidal currents are responsible for water exchange. Large mangrove forests in the countries with extensive areas of brackish-water aquaculture, as in Ecuador, or in which such activities are rapidly expanding, as in Brazil and Panama, appear likely to suffer considerable reduction in their area (see also Chapter I).[236] Extensive mangrove destruction by the shrimp farms has also been reported in Colombia.[237]

- <u>Sea-grasses</u> are salt-tolerant underwater plants widely distributed throughout much of the temperate and tropical coastal environments, particularly in clean, calm and shallow waters. Sea-grasses reduce turbidity, clarify surrounding waters, and provide a habitat, spawning grounds and a source of food for fish.[238] For example, sea-grass beds are estimated to provide 80% of the breeding and nursery grounds for many fish and shellfish in the Caribbean.[239] The importance of sea-grasses for fisheries is also related to their high productivity - it is estimated that sea-grasses can contribute as much as 2 kilograms dry weight per square meter per year, about 0.5 kg/m²/year of epiphytes, and approximately 0.2 kg/m²/year of benthic macro-algae, that is nearly 3 kg/m²/year in total, comparable to or greater than the production of mangrove forests.[240] Major causes of sea-grasses degradation in the Caribbean are listed Table 16.

These three eco-systems, for the world as a whole, are considered to be at greatest risk in the coastal waters off Central America. Overall, coral reefs seem to be the most threatened.[241]

The creation of protected areas is known to be a useful management tool for preserving coastal ecosystems and underwater habitats, particularly as fish breeding grounds and as tourism attractions. Protected areas may include coral reefs, estuaries, coastal and open water areas, small islands, sea-grass beds, etc. The creation and maintainence of protected areas can preserve threatened fish species, provide safe breeding grounds, enhance artisanal fisheries, etc. In Latin America and the Caribbean the highest number of such areas is found in Chile, Brazil and Venezuela, whereas Chile, Ecuador and Brazil have the largest areas under protection (Table 17). To efficiently accomplish their functions marine protected areas should be endowed with adequate funding and staff. A study of 112 protected areas in the Caribbean revealed that 26% had neither budget nor staff and only 25% had both.[242] The situation is unlikely to be much better in the majority of other national marine and coastal protected areas in the rest of the region.

Table 17

LATIN AMERICA AND THE CARIBBEAN:
NATIONAL MARINE AND COASTAL PROTECTED AREAS
(Hectares)

Country	Number	Hectares	Country	Number	Hectares
Argentina	1	63 000	Guyana	0	0
Barbados	1	2 500	Haiti	0	0
Bolivia	NA	NA	Honduras	1	350 000
Brazil	15	1 843 996	Jamaica	0	0
Chile	28	10 760 496	Mexico	7	623 541
Colombia	8	561 100	Nicaragua	1	4 000
Costa Rica	6	105 806	Panama	3	616 364
Cuba	6	226 813	Peru	1	366 936
Dominican Republic	5	288 144	Suriname	5	128 400
Ecuador	5	8 975 200	Trinidad and Tobago	2	3 388
El Salvador	0	0	Uruguay	1	3 290
Guatemala	2	12 400	Venezuela	11	708 394

Source: International Union for Conservation of Nature and Natural Resources, quoted from the World Resources Institute and the International Institute for Environment and Development in collaboration with the United Nations Environment Programme, World Resources 1988-89, Basic Books, Inc., New York, 1988, pp. 294-295 and 302-303.

Note: Marine and coastal protected areas refer to all protected areas that include littoral, coral, island, marine, or estuarine components. The area given is that of the whole protected area, not just the marine component. Data are preliminary.
NA - not applicable.
0 - zero or less than half the unit of measure.

CONCLUSIONS

In several countries in Latin America and the Caribbean fishing contributes significantly to supplies of food, to earnings of foreign exchange and to employment. Summary of relevant statistics is provided in Annex 10. As a result of the expansion of fishing by both regional and non-regional fishing fleets, the annual catch from the marine areas surrounding the region is more and more approaching and in respect of some species even exceeding the maximum sustainable yield. Additional pressure on fishing resources arises from growing water pollution and other interferences by man in the aquatic environment.

This brief review of the relationship between the fisheries and water resources management suggests that more attention should be paid to the protection, conservation and rational utilization of the fishery resource. In particular, the need for additional investigations, particularly in the field of maximum sustainable yield in relation to ocean conditions and processes, is manifest.

The fish processing industry plays an important role in economies of several Latin American and Caribbean countries. It is a notorious source of localized air and water pollution, and its liquid and gaseous emissions rarely receive adequate treatment. This notwithstanding, even in countries with a highly developed fish processing industry it can be considered only to be a lesser source of marine pollution.[243/] Taking into consideration this fact and that conceptually pollution from fish processing plants is only a minor part of the industrial pollution which affects many regional bodies of water, solutions should be sought within the framework of general water pollution control.

Aquaculture is rapidly becoming an important source of foreign exchange due to both technical advances in the production process and successful international marketing. Latin American and Caribbean countries possess significant comparative advantages for aquaculture development and the unexploited potential remains large. Growing water pollution poses an important threat to the possibilities for the development of aquaculture. Ecological and environmental problems associated with aquaculture also warrant attention. Aquaculture has significant potential to help solve problems of poverty, malnutrition and underdevelopment in many rural and coastal areas contributing to better utilization of labour as well as to reuse of human wastes and agricultural residues.

In general, the relationship between fishing and other uses of the fresh water resources of Latin America and the Caribbean is not a critical issue. The scale of interference remains small. There are signs, however, of stress particularly in the most sensitive marine ecosystems such corals and mangrove swamps. If future serious conflicts are to be avoided and if the risks imposed by human activities on the fish resource are to be kept low, greater consideration must be given to the fishery-related use of the water resources in water management decisions.

Notes:

1/ The share of fisheries sector in GDP is most significant in Venezuela (3.0%, 1984), Guyana (2.5%, 1985), Panama (2.3%, 1984), Ecuador (1.5%, 1984), Cuba (1.0%, 1989), Peru (1.0%, 1988), Chile (0.7%, 1988), Mexico (0.6%, 1983), Uruguay (0.6%, 1984), Colombia (0.4%, 1985), and Argentina (0.1%, 1984). United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Economic survey of Latin America and the Caribbean. 1988, LC/G.1577-P, December 1989, p. 296; United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Estudio económico de América Latina y el Caribe . 1989, LC/G.1635-P, December 1990, p. 360; Departamento Administrativo Nacional de Estadística, Colombia estadística, Volume 1, 1987, pp. 148-149; Instituto Nacional de Estadística, Perú: compendio estadístico 1988, Lima, July 1989, p. 285; United Nations Industrial Development Organization (UNIDO), Industrial development strategies for fishery systems in developing countries. Volume 1, PPD.30, 3 April 1987, Sectoral Studies Series Nº 32, Sectoral Studies Branch, Studies and Research Division, p. 72; and Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 73. Some data are preliminary and not directly comparable. In the case of Cuba information refers to global social product. Figures for Colombia and Ecuador include hunting, for Panama - fishing vessels registered in Panama.

2/ Instituto Nacional de Estadística, Perú: compendio estadístico 1988, Lima, July 1989, p. 246 and 285.

3/ Inter-American Development Bank (IDB), Economic and social progress in Latin America. Natural resource. 1983 report, Washington, D.C., p. 79; and Ramon Buzeta, From hunters of wild resources to cultivators of the sea, IDRC Reports, Volume 10, Number 2, July 1991, p. 4.

4/ Constantino Tapias, Oficina Regional de Pesca de la FAO, El medio oceánico y la actividad pesquera, Proyecto CEPAL/PNUMA Estilos de Desarrollo y Medio Ambiente en América Latina, Seminario Regional, Santiago de Chile, November 19-23, 1979, E/CEPAL/PROY.2/R.16, September 1979, p. 34.

5/ Foreign Investment Committee Executive Secretariat, Chile. Foreign Investment Report, November-December 1987, Nº 2, Fishery, p. 5. According to other sources (Mónica Verde, The struggle to harvest food from the sea, IDRC Reports, Volume 10, Number 2, July 1991, p. 6) in Chile there are 53 000 artisanal fishermen.

6/ United Nations Industrial Development Organization (UNIDO), Industrial development strategies for fishery systems in developing countries. Volume 1, PPD.30, 3 April 1987, Sectoral Studies Series Nº 32, Sectoral Studies Branch, Studies and Research Division, pp. vii-viii, 17-18 and 86-87; United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Sustainable development: changing production patterns, social equity and the environment, C/G.1648(CONF.80/2)Rev.1, February 12, 1991, p. 60; Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 78-79; and Ramon Buzeta, From hunters of wild resources to cultivators of the sea, IDRC Reports, Volume 10, Number 2, July 1991, p. 4. Small-scale producers are not necessarily a synonym of artisanal fishermen. In the case of Guyana, information refers to the artisanal sector.

7/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 77.

8/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 76. Information on consumption of fish and fish products in 1969/71 has not been available for a number of countries. The countries where fish consumption declined include Brazil, Belize, Costa Rica, Dominican Republic, El Salvador, Grenada, Honduras, Jamaica, Nicaragua, and Suriname. This decline can be attributed to the fall in real incomes as well as to other factors.

9/ All figures on trade in fishery commodities are from or have been calculated on the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities, Rome, various years.

10/ On the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities. Volume 67. 1988, Rome, 1990, pp. 21 and 23; and United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Statistical yearbook for Latin American and the Caribbean. 1989 edition, LC/G.1606-P, 1990 February, pp. 504-505. The share of fishery commodities in values of exports of goods has been calculated only for Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Peru, Suriname, Trinidad and Tobago, Uruguay, and Venezuela.

11/ 1985-1988 period total.

12/ All figures on nominal catches are from or have been calculated on the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years.

13/ On the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings. Volume 66. 1988, Rome, 1990, pp. 379-381. Figures in the text refer to the 1985-1988 period.

14/ Estimates of sustainable yield have been taken from M.A. Robinson, Trends and prospects in world fisheries, FAO, Fisheries Department, Rome, 1984, quoted from the World Resources Institute and the International Institute for Environment and Development in collaboration with the United Nations Environment Programme, World resources 1988-89, Basic Books, Inc., New York, 1988, pp. 328-329 and 331. Estimated sustainable yield refers to marine fish, crustaceans and cephalopods. It excludes ocean pelagic species (about 3% - 5% of total potential) and molluscs. As a result, estimates of sustainable yield are not directly comparable to the catch data given in the text.

15/ The 1970-1971 and 1987-1988 average annual catches are compared.

16/ Food and Agriculture Organization (FAO) of the United Nations, Agriculture: toward 2000, Rome, 1987, p. 176.

17/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 83.

18/ Inter-American Development Bank (IDB), Economic and social progress in Latin America. Natural resource. 1983 report, Washington, D.C., p. 81.

19/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, pp. 83 and 96.

20/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 84.

21/ Inter-American Development Bank (IDB), Economic and social progress in Latin America. Natural resources. 1983 report, Washington, D.C., p. 81. This estimate is based on the production of 50 to 100 kilograms of fish per hectare per annum.

22/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 90.

23/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 90.

24/ GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing environmental impacts of coastal aquaculture, Reports and studies Nº 47, 1991, p. 1.

25/ Aquaculture Development and Coordination Programme, FAO (1983), quoted from Organization for Economic Co-operation and Development (OECD), Aquaculture: developing a new industry, 1989, p. 8. These figures refer to South America only.

26/ On the basis of information in International Trade Centre, UNCTAD/GATT, Shrimps: a survey of the world markets, Geneva, 1983, pp. 51 and 53-54; Asia-Wide Shrimp Agroindustry Sector Study and INFOFISH International, both quoted from The World Bank Industry and Energy Department, Policy, Planning and Research, Ousa Sananikone, The shrimp industry: global subsector study, Industry and Energy Department Working Paper, Industry Series Paper Nº 18, December 1989, pp. 5, 21 and 35; Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 84; Food and Agriculture Organization (FAO) of the United Nations, The state of food and agriculture 1990, FAO Agricultural Series Nº 23, Rome, 1991, p. 39; The Economist Intelligence Unit, Ecuador. Country profile. 1989-90, London, p. 16; and The Economist Intelligence Unit, Guatemala, El Salvador, Honduras. Country Report, Nº 1, 1991, London, p. 24. According to other sources, shrimp aquaculture production in Ecuador was 27.0 thousand tons in 1985. Estimate of future cultured production of shrimp in Ecuador is based on the assumption that the area under cultivation can be expanded from about 40 000 hectares, the level of the early eighties, to 70 000 hectares and that average yields can be doubled from 0.8 ton/ha/year to 1.6 ton/ha/year. In the Case of Panama, estimate of future cultured production of shrimp is based on the assumption that there are a minimum of 16 000 hectares available for shrimp farming and that average yields can be increased to 1.8 ton/ha/year. However, it is considered that some time is likely to elapse before such level of production is attained.

27/ Secretaría de la Presidencia de la República, Primer informe de Gobierno 1989, quoted from D.R. Nacional Financiera, S.N.C., La economía Mexicana en cifras, 1990, pp. 227-228. Figures for 1989 are preliminary. Aquaculture production includes fresh water fishes, crustacea, molluscs and aquatic animals about (1.6 thousand tons).

28/ Emma Robson, México: la acuicultura ofrece una solución para la dieta y para la deuda, Cooperación Sur, PNUD, May 1989, Nº 1, p. 18.

29/ Steve Anderson and Mark R. Vaughan, Environmental activism troubles firms in Chile, Business Latin America, September 17, 1990, p. 298; Alejandra Costamagna C., Oro naranjo, El Mercurio, 24 February 1991; Foreign Investment Committee Executive Secretariat, Chile. Foreign Investment Report, March-April 1988, Nº 4, Boom in salmon exports, p. 4; and Mario Valle, Fuerte crecimiento tiene producción de salmones en Chile, El Mercurio, 17 November 1991. According to other sources (Mario Valle, Fuerte crecimiento tiene producción de salmones en Chile, El Mercurio, 17 November 1991), in Chile there are 41 companies engaged in salmon farming.

30/ Tecnofish inicia producción masiva del turbot chileno, El Diario, 9 January 1992, p. 21.

31/ United Nations Industrial Development Organization (UNIDO), Industrial development strategies for fishery systems in developing countries. Volume 1, PPD.30, 3 April 1987, Sectoral Studies Series Nº 32, Sectoral Studies Branch, Studies and Research Division, pp. 14 and 100.

32/ All figures on production of fishery commodities are from or have been calculated on the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities, Rome, various years.

33/ 1987-1988 period averages. Reexports are ignored. This note refers to all commodity groups discussed in this chapter.

34/ 1987-1988 period averages. All figures are rounded and approximate. Information has not been available in respect of production of certain commodities by some countries. This note refers to all commodity groups discussed in this chapter.

35/ Perú toma ventaja del auge mundial de la piscicultura, El Mercurio, 28 February 1991 (reprinted from Financial Times). This estimate is attributed to the Organización de Exportadores de Harina de Pescado.

36/ The periods compared are 1970-1971 and 1987-1988.

37/ Information for 1978 and 1979 has not been available.

38/ A.D. McIntyre, Exploitation of marine living resources, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, pp. 513-514.

39/ Food and Agriculture Organization (FAO) of the United Nations, Agriculture: toward 2000, Rome, 1987, p. 176.

40/ Nicholas Lenssen, The ocean blues, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, July-August 1989, Volume 2, Nº 4, p. 30. This information refers to the world as a whole.

41/ On the basis of information in Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, pp. 89-90.

42/ Sector pesquero sufrió baja del 10% en 1990, El Mercurio, 24 March 1991.

43/ H. Jeffrey Leonard, Natural resources and economic development in Central America. A regional environmental profile. Executive summary, pp. 5 and 19.

44/ International Trade Centre, UNCTAD/GATT, Shrimps: a survey of the world markets, Geneva, 1983, p. 50. Information refers to the region of Americas, including East Central Pacific, Southeast Pacific, Southwest Atlantic and West Central Atlantic, excluding Northwest Pacific and Northwest Atlantic.

45/ United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Sustainable development: changing production patterns, social equity and the environment, LC/G.1648(CONF.80/2)Rev.1, February 12, 1991, p. 62.

46/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 83.

47/ Ann Misch, The Amazon: river at risk, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, January-February 1992, Volume 5, Nº 1, p. 36.

48/ Pollution damage hits Paraguayan lake, World Water, December 1985, p. 9. This article refers to the first limnological investigation of this lake conducted by Barbara Rittersbusch and John Fitzpatrick of the Instituto de Ciencias Básicas, of the Universidad Nacional in Asunción, Paraguay.

49/ Andrés Gómez-Lobo, Corporación de Investigaciones Económicas para Latinoamérica (CIEPLAN), Desarrollo sustentable del sector pesquero chileno en los años 80, Encuentro Anual de Economistas de Chile 1990, organized by Departamento de Economía, Facultad de Administración y Economía, Universidad de Chile, pp. 21-32. Some statistics are from Banco Central de Chile.

50/ The Economist Intelligence Unit, Peru. Country Profile. 1989-90, London, p. 16; and Lester R. Brown, Maintaining world fisheries, Worldwatch Institute, State of the world. 1985, W.W. Norton & Company, 1985, p. 77.

51/ Instituto del Mar del Perú (IMARPE), Desembarque total de las principales especies por grupos y según años, Ministerio de Pesquería, IMARPE, Oficina de Estadística y Estudios Económicos Pesqueros, April 1983. This figures refer to *aves guaneras*. This publication provides two estimates of their population. According to another estimate their population declined from 6.0 million in 1971 to 1.2 million in 1972.

52/ Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years. The 1965-1970 period average is influenced by high level of production in 1965 - 170.0 thousand tons. Even excluding this year, however, average annual production fell from 45.5 thousand tons during 1966-1970 to just 27.1 thousand tons during 1971-1986.

53/ Food and Agriculture Organization (FAO) of the United Nations, Agriculture: toward 2000, Rome, 1987, p. 21.

54/ United Nations Industrial Development Organization (UNIDO), Industrial development strategies for fishery systems in developing countries. Volume 1, PPD.30, 3 April 1987, Sectoral Studies Series Nº 32, Sectoral Studies Branch, Studies and Research Division, p. 80.

55/ José Raúl Cañón, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, pp. 102 and 105. These figures refer to fish meal plants located in northern and central-southern areas of Chile. Similar changes have also occurred in other areas, for example, according to Daniel Malfanti, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 123, fish meal and oil output in VIII Region of Chile increased from some 17% - 18% and 3% in 1976, to about 23% and 5% in 1989.

56/ Ricardo Bravo Lyon, La industria pesquera y el medio ambiente: proceso de producción de harina, p. 265; and Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 24.

57/ According to United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, p. 25, cost estimates prepared by a consulting firm in the USA for wastewater treatment plants to achieve various levels of BOD, suspended solids, oil and grease in the treated effluents indicate that the initial plant cost for a system using screening followed by aerated lagoon would be about US$ 28 000 for a wastewater flow of 1.9 l/sec and that for a system featuring screening, flotation and extended aeration would be some US$ 88 000. The plant cost using aerated lagoon instead of extended aeration would be approximately US$ 66 000. These estimates are not necessarily valid for fish processing industry in Latin American and Caribbean countries.

58/ Estimates of División Conjunta CEPAL/ONUDI de Industria y Tecnología on the basis of U.S. Department of Commerce, Manufacturers Pollution Abatement Capital Expenditures and Operating Costs, Final Report, quoted from División Conjunta CEPAL/ONUDI de Industria y Tecnología, Tecnología, competitividad y sustentabilidad, United Nation, United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), LC/L.608, 11 January 1991, p. 95. This information refers to the United States (1986).

59/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 24.

60/ On the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings. Volume 66. 1988, Rome, 1990, p. 4.

61/ Food and Agriculture Organization (FAO) of the United Nations, Agriculture: toward 2000, Rome, 1987, pp. 180-181. Other estimates of losses are also available, for example according to United Nations Industrial Development Organization (UNIDO), Environmental management in fishery-based industries, IO.51, 19 June 1991, Working Papers in Industrial Planning Nº 5, Industrial

Planning Branch, Industrial Institutions and Services Division, p. 4, of each 100 tons of catch, trash fish constitutes 30 tons, spoilage - 15 tons, and loss at fish processing plants - 40 tons.

62/ United Nations Development Fund for Women (UNIFEM), Fish processing, Food Cycle Technology Source Book Nº 4, with the collaboration of the Intermediate Technology Development Group, 1988, pp. 7-8.

63/ Estimated at 10% of average annual nominal catches of fish, crustaceans, molluscs, etc. during the 1985-1988 period, all fishing areas.

64/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 87.

65/ Edith Saa Collantes and Mauricio Silva Celis, Flota industrial pesquera, 1983. "Análisis y consideraciones", Servicio Nacional de Pesca (SERNAP), Departamento de Tecnología, Santiago, November 1983, p. 25.

66/ Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, p. 87.

67/ Anónimo, Diagnóstico pesquero D.G.P., Revista Ministerio de Agricultura, 1975, Bogotá, quoted from Francisco Rodríguez, Contribución al conocimiento de la contaminación y su problemática en el Pacífico Colombiano, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, pp. 257-258 and 272.

68/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 30.

69/ GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing environmental impacts of coastal aquaculture, Reports and studies Nº 47, 1991, p. 1.

70/ A.D. McIntyre, Exploitation of marine living resources, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, pp. 515-519.

71/ Review of some regional experiences in this field is to be found in Rolando E. Vega Aguayo, Iván Valdebenito and Rodrigo Palma, Trucha Arco Iris, su impacto sobre el ecosistema nativo, políticas de desarrollo, Tarea: armonía para el medio ambiente, Versiones abreviadas, Tomo I, 2° Encuentro Científico sobre el Medio Ambiente, Talca, August 4-8, 1986, p. 336-345.

72/ GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing environmental impacts of coastal aquaculture, Reports and studies Nº 47, 1991, p. 4.

73/ Organization for Economic Co-operation and Development (OECD), Aquaculture: developing a new industry, 1989, pp. 15-16.

74/ Annette Bingham, Pig and fish farms endanger Danish water quality, World Water, April 1985, pp. 27-28.

75/ GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution), Reducing environmental impacts of coastal aquaculture, Reports and studies Nº 47, 1991, p. 7.

76/ Berta Morales, El alimento es el desafío para cultivo del salmón, La Epoca, 20 May 1987.

77/ A.D. McIntyre, Exploitation of marine living resources, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, pp. 515-517.

78/ See, for example, Steve Anderson and Mark R. Vaughan, Environmental activism troubles firms in Chile, Business Latin America, September 17, 1990; El cultivo de salmones contaminará Lago Ranco, El Mercurio, 14 May 1989; Suspended instalación de criaderos de salmón, El Mercurio, 17 May 1989; Recurso de protección por pisciculturas en lago, El Mercurio, 22 May 1989; and Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 25.

79/ In the presence of oxygen and moisture, pyrite is converted by microorganisms to oxidized iron and sulfur minerals plus dissolved sulfate and hydrogen ions (i.e. sulfuric acid). Extended drought that expose to the atmosphere previously submerged coastal zone soils, may also result in sulfide mineral oxidation and leaching of sulfuric acid into brackish waters. (From H.J. Simpson and M. Pedini, Acidity impacts on brackish-water aquaculture, Water Quality Bulletin, Volume 12, Nº 4, October 1987, pp. 145-146).

80/ On the basis of information in H.J. Simpson and M. Pedini, Acidity impacts on brackish-water aquaculture, Water Quality Bulletin, Volume 12, Nº 4, October 1987, pp. 145-146, 148 and 167.

81/ Organization for Economic Co-operation and Development (OECD), Aquaculture: developing a new industry, 1989, p. 16.

82/ On the basis of information in United Nations, Economic Commission for Europe (ECE), Strategies, technologies and economics of waste water management in ECE countries, A report on prevailing practice and recent experience in domestic sewage purification and industria waste-water treatment with special emphasis on advanced techniques, prepared under the auspices of the ECE Committee on Water Problems, ECE/WATER/36, New York, 1984, p. 66 and Annex III.

83/ Various, quoted from United Nations, Economic and Social Council, Methodological approaches for the collection and assessment of data on pollutants flowing from industries located in the coastal area of ECE member countries. Addendum, Economic Commission for Europe, Committee on Water Problems, Tenth session, 13-17 November 1978, WATER/R.60/Add.1, 18 September 1978. Specific flow rate includes cooling water.

84/ Much of the discussion presented below is condensed from United Nations Industrial Development Organization (UNIDO), Environmental management in fishery-based industries, IO.51, 19 June 1991, Working Papers in Industrial Planning Nº 5, Industrial Planning Branch, Industrial Institutions and Services Division, pp. 10-12.

85/ United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, p. 24.

86/ United Nations Industrial Development Organization (UNIDO), Environmental assessment and management of the fish processing industry, PPD.15, 12 December 1986, Sectoral Studies Series Nº 28, Sectoral Studies Branch, Studies and Research Division, p. 9.

87/ Guillermo J. Cano, Legislación Latinoamericana (Excluida la Argentina) sobre contaminación ambiental antrópica, Documento presentado en las Jornadas Internacionales Multi-disciplinarías sobre Medio Ambiente y Contaminación Antrópica, organizadas por la Universidad de Mendoza, Mendoza, April 15, 1987, p. 15.

88/ Para Superar Malos Olores, El Mercurio, 29 January 1987. This figure includes 5 000 ton/year of fish residues and 10 000 ton/year of bloodwater.

89/ Contaminación pesquera en mar de Talcahuano, El Mercurio, 8 February 1988; and Multan a 4 plantas pesqueras, El Mercurio, 9 February 1988.

90/ Juan Carlos Heusser and Juan Luis Orellana, Evaluación de impacto ambiental en el sector pesquero, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 141.

91/ Las emisiones: Región por Región, El Mercurio, 29 January 1987.

92/ Julia Pacheco Avila, Armando Cabrera Sansores and Miguel Villasuso Pino, Problemas actuales del recurso hidráulico en el estado de Yucatán, Ingeniería Hidráulica en México, Comisión Nacional del Agua, Volume V, Nº 3, September/December 1990, p. 17.

93/ Oscar Guillén, Fuentes, niveles y efectos de la contaminación marina en el Perú, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 92.

94/ República del Perú, Instituto Nacional de Planificación, Comisión Multisectorial del Plan Nacional de Ordenamiento de los Recursos Hidráulicos, Modelo prospectivo. Informe al horizonte 1990, R.M. Nº 0060-77-PM/ONAJ, December 1980, pp. 44-45.

95/ Figures on production of fishery commodities are from or have been calculated on the basis of information in Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities. Volume 67. 1988, Rome, 1990.

96/ Solange Duhart and Jacqueline Weinstein, Pesca industrial: sector estratégico y de alto riesgo. Volumen I, Colección Estudios Sectoriales Nº 5, Programa de Economía del Trabajo (PET), Academia de Humanismo Cristiano, p. 77.

97/ Perú toma ventaja del auge mundial de la piscicultura, El Mercurio, 28 February 1991 (reprinted from Financial Times).

98/ Estimate os based on regional production of meals, solubles and similar animal feedingstuffs of aquatic animal origin (Annex 3) during the 1987-1988 period. Presence of absence of treatment facilities and possible technology differences are ignored.

99/ The technology of fish meal production and sources of waste waters are described on the basis of information in United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, pp. 6-7 and 24.

100/ Simposio Regional sobre Control de la Contaminación del Agua, Trabajos, Caracas, 1970, organized by PAHO, Ministerio de Sanidad y Asistencia Social, Instituto Nacional de Obras Sanitarias, Caracas, 1972, quoted from Walter A. Castagnino, Polución de agua - modelos y control, CEPIS, División de Salud Ambiental, Serie Técnica 20, pp. 14 and 230.

101/ Deodourizers are salt water scrubbers.

102/ Ramon Ahumada and Anny Rudolph, Residuos líquidos de la industria pesquera: alteraciones ambientales y estrategias de eliminación, Ambiente y Desarrollo, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Volume V, Nº 1, April 1989, p. 152.

103/ Simposio Regional sobre Control de la Contaminación del Agua, Trabajos, Caracas, 1970, organized by PAHO, Ministerio de Sanidad y Asistencia Social, Instituto Nacional de Obras Sanitarias, Caracas, 1972, quoted from Walter A. Castagnino, Polución de agua - modelos y control, CEPIS, División de Salud Ambiental, Serie Técnica 20, pp. 14 and 230.

104/ Estimate os based on regional production of meals, solubles and similar animal feedingstuffs of aquatic animal origin (Annex 3) during the 1987-1988 period. Presence of absence of treatment facilities and possible technology differences are ignored.

105/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 23.

106/ Daniel Malfanti, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 126.

107/ The technology of fish processing and sources of waste waters are described on the basis of information in United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, pp. 3-4 and 24.

108/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 16. This information refers to the mollusc canning plants located between the 10° and 11° Regions.

109/ United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, pp. 4 and 6.

110/ United Nations, Economic and Social Commission for Asia and the Pacific, Industrial pollution control guide-lines. VIII. Fish processing industry, ESCAP - Environment and Development Series, ECU/ED/IPC/8, Bangkok, 1982, p. 12.

111/ United Nations Industrial Development Organization (UNIDO), Environmental management in fishery-based industries, IO.51, 19 June 1991, Working Papers in Industrial Planning Nº 5, Industrial Planning Branch, Industrial Institutions and Services Division, p. 4.

112/ Carl Duisberg Gesellschaft E.V., Resultados del seminario sobre la aplicación de los estudios de impacto ambiental en la planeación de la disposición de los desechos solidos urbanos e industriales generados en una ciudad, Economic Commission for Latin America and the Caribbean (ECLAC), LC/R.601(Sem.41/5), 28 August 1987, p. 6.

113/ Obtendrán gas de los desechos pesqueros, El Mercurio, 19 December 1990.

114/ Ricardo Bravo, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 96.

115/ See, for example, Daniel Malfanti, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, pp. 124-126.

116/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 24. This information refers to Chile but is believed to be representative of Latin America and the Caribbean as a whole.

117/ A.D. McIntyre, Exploitation of marine living resources, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, pp. 509-513.

118/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, pp. 5 and 8.

119/ República del Perú, Instituto Nacional de Planificación, Comisión Multisectorial del Plan Nacional de Ordenamiento de los Recursos Hidráulicos, Modelo prospectivo. Informe al horizonte 1990, R.M. Nº 0060-77-PM/ONAJ, December 1980, p. 47.

120/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 118.

121/ United Nations, ECLA, UNEP, Caribbean Environment Programme Action Plan. Overview on Natural Resources for Food and Agriculture in the Wider Caribbean Region, prepared with the co-operation of the Food and Agriculture Organization (FAO) of the United Nations, E/CEPAL/PROY.3/L.INF.10, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 33; and L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 27.

122/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 27; and ¿Hoteles o salmones?, Revista del Domingo, 11 August 1991.

123/ Daniel López, Investigación y medio ambiente en el sector pesquero, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 156.

124/ United Nations, Economic Commission for Europe (ECE), ECE Symposium on Problems Relating to Environment, Proceedings and Documentation of the Symposium organized by the United Nations Economic Commission for Europe and held from 2 to 15 May 1971 in Prague (Czechoslovakia) with a study tour to the region of Ostrava (Czechoslovakia) and Katowice (Poland), New York, 1971, p. 111.

125/ Marcia D. Lowe, Down the tubes, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, March-April 1989, Volume 2, Nº 2, pp. 25 and 28.

126/ Jon DeBoer, Overview of water reuse for developing countries, United Nations, Department of Technical Co-operation for Development, Natural Resources/Water Series Nº 22, Non-conventional water resources use in developing countries, proceedings of the interregional seminar, Willemstad, Curaçao, Netherlands Antilles, 22-28 April 1985, p. 164.

127/ R. Saenz, Use of wastewater treated in stabilization ponds for irrigation - evaluation of microbiological aspects, Water Quality Bulletin, Volume 12, Nº 2, April 1987, p. 86.

128/ Reuso de acuicultura de las aguas residuales tratadas en las lagunas de estabilización de San Juan, Lima, Perú, Noticias sobre Ingeniería Sanitaria y Ciencias del Ambiente, Nº 52, April 1991, Organización Mundial de la Salud, Organización Panamericana de la Salud, Programa de Salud Ambiental, Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente, página 3.

129/ T. Petr, Fish, fisheries, aquatic macrophytes and water quality in inland waters, Water Quality Bulletin, Volume 12, Nº 3, July 1987, pp. 105-106.

130/ Partly on the basis of information in World Health Organization, Water pollution control. Report of a WHO Expert Committee, Technical Report Series Nº 318, Geneva, 1966, p. 10.

131/ Additional information on water quality criteria for commercial and sorts fishing as well as for protection of aquatic life is to be found in D. McGirr, Ch. Gottschalk and O. Lindholm, Water-quality objectives and criteria, United Nations, Economic and Social Council, Economic Commission for Europe, Senior Advisers to ECE Governments on Environmental and Water Problems, Working Party on Water Problems, Fifth Session, 17-18 October 1991 (Item 5 of the provisional agenda), ENVWA/WP.3/R.21, 15 August 1991.

132/ This description is from D. McGirr, Ch. Gottschalk and O. Lindholm, Water-quality objectives and criteria, United Nations, Economic and Social Council, Economic Commission for Europe, Senior Advisers to ECE Governments on Environmental and Water Problems, Working Party on Water Problems, Fifth Session, 17-18 October 1991 (Item 5 of the provisional agenda), ENVWA/WP.3/R.21, 15 August 1991, p. 14.

133/ S. Holt and M. Segnestam, The seas must live: why coastal and marine protected areas are needed, Paper presented at the Third World Congress on National Parks at the Coastal and Marine Workshop, Bali, Indonesia, 1982, quoted from World Resources Institute and the International Institute for Environment and Development, World resources 1986, Basic Books, Inc., New York, 1986, pp. 141 and 158. This estimate refers to the world catch of marine species. According to Nicholas Lenssen, The ocean blues, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, July-August 1989, Volume 2, Nº 4, p. 31, waters up to 200 miles from the shoreline yield more than 90% of the ocean's fish catch.

134/ Lester R. Brown, Maintaining world fisheries, Worldwatch Institute, State of the world. 1985, W.W. Norton & Company, 1985, p. 81.

135/ W.N. Lindall and C.N. Saloman, Alteration and destruction of estuaries affecting fishery resources of the Gulf of Mexico, Marine Fisheries Review, 1977, Volume 39, p. 1262, quoted from the World Resources Institute and the International Institute for Environment and Development, World resources 1986, Basic Books, Inc., New York, 1986, pp. 146 and 158.

136/ Food and Agriculture Organization (FAO) of the United Nations, Agriculture: toward 2000, Rome, 1987, p. 179.

137/ Cholera fear is affecting exports, Latin American Weekly Report, 14 March 1991, WR-91-10, p. 4. According Cholera claims first political casualty, Latin American Weekly Report, 28 March 1991, WR-91-12, p. 10, restrictions on imports of Peruvian seafood, are estimated to have cost the country close to US$ 300 million in lost export revenues.

138/ Mexico: US tuna embargo prompts dolphin-friendly technology, South-North Development Monitor (SUNS), published by Third World Network in co-operation with Inter Press Service and South Centre, Nº 2689, 30 September 1991, pp. 8-9. The Mexican government has denied the allegations and asured the United States that accidental killings of these sea mammals decreased by about 70% between 1986 and 1990. Mexico has passed a law under which those found guilty of recklessly killing marine animals, particularly dolphins, will go to jail. It has also launched a national programme to protect dolphins from being accidentally killed by tuna fishing fleets. The government has been reported to be going to equip Mexican fishing vessels with dolphin-friendly technology that would permit to catch tuna without harming the endangered marine mammals.

139/ Comisión de Desarrollo y Medio Ambiente de América Latina y el Caribe, Banco Interamericano de Desarrollo, Programa de Naciones Unidas para el Desarrollo, Nuestra propia agenda, 1990, p. 47.

140/ Pan American Health Organization, The situation of drinking water supply and sanitation in the American Region at the end of the decade 1981-1990, and prospects for the future. Volume 1, Regional Conference on Water Supply and Sanitation, Evaluation of the International Drinking Water Supply and Sanitation Decade and Projections towards the Year 2000, Puerto Rico, September 4-6, 1990, pp. XII and 18.

141/ WHO, Offset Publication Nº 15, p. 39; and Pan American Health Organization, The situation of drinking water supply and sanitation in the American Region at the end of the decade 1981-1990, and prospects for the future. Volume 1, Regional Conference on Water Supply and Sanitation, Evaluation of the International Drinking Water Supply and Sanitation Decade and Projections towards the Year 2000, Puerto Rico, September 4-6, 1990, p. 19. These figures are not necessarily directly comparable.

142/ On the basis of information in United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, pp. 90 and 136.

143/ R.A. Ryder, Eutrophication effects on fisheries - the horns of a dilemma, Water Quality Bulletin, Volume 6, Nº 3, July 1981, p. 86.

144/ Some examples are afforded by Lake Maracaibo and Lake Valencia in Venezuela. Eutrophication - a global problem, Water Quality Bulletin, Volume 6, Nº 3, July 1981, p. 60.

145/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 90.

146/ L. Magos, Marine health hazards of anthropogenic and natural origin, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, pp. 463-467.

147/ Wildfire spread of cholera epidemic, Latin American Weekly Report, 21 February 1991, WR-91-07, p. 2; Corinne Schmidt, Cholera epidemic deepens Peruvian economic ills, The Times, February 23, 1991 ("According to the ministry of health, the epidemic began in the fishing towns north of the capital before being carried by sewage, marine life and plankton down the coast to Lima"); and Cholera claims first political casualty, Latin American Weekly Report, 28 March 1991, WR-91-12, p. 10 (Health Minister Carlos Vidal Layseca warned against the risks posed by the "poor man *cebiche*" made with the fish caught in coastal waters polluted by the dumping of raw sewage. However, according to a Health Ministry official, the risk highlighted was not that fish may be contaminated, but that the handling and preparation of the "poor man *cebiche*" was unhygienic). According to On top of cholera, an outbreak of malaria is spreading in Peru, Latin American Weekly Report, 7 March 1991, WR-91-09, p. 1, initial reports that fish and seafood were contaminated have been denied by the government.

148/ L. Magos, Marine health hazards of anthropogenic and natural origin, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, p. 464. Also, according to Bogdan Kwiecinsky, Contaminación marina del Pacífico de Panamá, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 158, one case of shrimp contamination by *Vibrio parhaemolyticus* has been detected in the Bay of Panama.

149/ Las emisiones: región por región, El Mercurio, 29 January 1987.

150/ A.D. McIntyre, Sewage in the sea, United Nations, United Nations Environment Programme, UNEP Regional Seas Report and Studies Nº 114/2, Technical annexes to the report on the state of the marine environment, prepared in co-operation with United Nations, FAO, UNESCO, WHO, WMO, IMO and IAEA, 1990, p. 542.

151/ M.J. Suess, Health aspects of eutrophication, Water Quality Bulletin, Volume 6, Nº 3, July 1981, p. 64.

152/ Confirmada "Marea Roja" en XI Región, El Mercurio, 16 February 1991; Alerta en el sur ante intoxicación por "marea roja", El Mercurio, 31 March 1991; Personal naval y policial hace masivas requisiciones, El Mercurio, 1 April 1991; Permiten venta de mariscos tras marea roja, El Mercurio, 20 April 1991; Dos muertos por brote de marea roja, La Nación, 30 March 1991; Detectan foco de marea roja en zona de Puerto Chacabuco, El Mercurio, 2 April 1991; Identifican a nueva víctima de la "Marea Roja", El Mercurio, 28 December 1991; Contaminante marea roja cause mortandad de aves, El Mercurio, 15 December 1991, and Reiteran advertencia por el consumo de mariscos, El Mercurio, 29 December 1991. Information as to whether these plankton blooms were related to water pollution has not been available.

153/ Crisis en sector pesquero de Magallanes por la "marea roja", El Mercurio, 26 January 1992; Buscan solución a cesantía producida por marea roja, El Mercurio, 2 February 1992.

154/ Nicholas Lenssen, The ocean blues, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, July-August 1989, Volume 2, Nº 4, p. 28. Information as to whether this plankton bloom was related to water pollution and on the number of deaths has not been available.

155/ Mortandad de salmones por la "Marea Café", El Mercurio, 27 September 1988; and Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, pp. 26-27. Information as to whether this plankton bloom was related to water pollution has not been available.

156/ FAO: world commercial fishing suffering from decline in fish, South-North Development Monitor (SUNS), published by Third World Network in co-operation with Inter Press Service and South Centre, Nº 2581, 10 April 1991, p. 6. These words are attributed to the Director General of FAO. Other factors which together with industrial pollution were considered to be "endangering the marine environment and the sustainability of marine resources" were said to include demographic and urban growth, imprudent commercial fishing practices and marine culture.

157/ Arnoldo José Gabaldón, The disposal of toxic or dangerous waste in Latin America and the Caribbean, Marine Policy, Volume 14, Nº 3, May 1990, p. 254.

158/ United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Desarrollo industrial: generación y manejo de los residuos. Elementos para una discusión, LC/R.602(Sem.41/6), August 28, 1987, p. 17.

159/ Comisión de Desarrollo y Medio Ambiente de América Latina y el Caribe, Banco Interamericano de Desarrollo, Programa de Naciones Unidas para el Desarrollo, Nuestra propia agenda, 1990, p. 37.

160/ United Nations, Economic Commission for Europe (ECE), Strategies, technologies and economics of waste water management in ECE countries, A report on prevailing practice and recent experience in domestic sewage purification and industria waste-water treatment with special emphasis on advanced techniques, prepared under the auspices of the ECE Committee on Water Problems, ECE/WATER/36, New York, 1984, p. 19.

161/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 91. Detailed information on the toxicities and effects of various heavy metals on aquatic organisms is to be found on pages 91 and 138.

162/ On the basis of information in United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, pp. 91, 137-138.

163/ United Nations, Economic Commission for Europe (ECE), Strategies, technologies and economics of waste water management in ECE countries, A report on prevailing practice and recent experience in domestic sewage purification and industria waste-water treatment with special emphasis on advanced techniques, prepared under the auspices of the ECE Committee on Water Problems, ECE/WATER/36, New York, 1984, p. 20.

164/ Anitra Thorhaug, Biology and management of seagrass in the Caribbean, AMBIO, Volume X, Nº 6, 1981, pp. 297-298.

165/ A. Thorhaug, N. Blake and P. Schroeder, Bulletin of Marine Pollution, 9, 181 (1978), quoted from Anitra Thorhaug, Biology and management of seagrass in the Caribbean, AMBIO, Volume X, Nº 6, 1981, pp. 297-298.

166/ H.J. Simpson and M. Pedini, Acidity impacts on brackish-water aquaculture, Water Quality Bulletin, Volume 12, Nº 4, October 1987, p. 145. Reduction of fish population has been reported in Scandinavia, Canada and the United States.

167/ María Elena Hurtado, A hard rain begins to fall ..., South, November 1985, p. 150; and Las emisiones: región por región, El Mercurio, 29 January 1987.

168/ H.J. Simpson and M. Pedini, Acidity impacts on brackish-water aquaculture, Water Quality Bulletin, Volume 12, Nº 4, October 1987, p. 145.

169/ Subsecretaría de Recursos Hídricos DIGID, Control de la polución de los recursos hídricos, August 1973, quoted from Secretaria de Estado de Transporte y Obras Publicas, Subsecretaria de Recursos Hídricos, Instituto Nacional de Ciencia y Técnica Hídricas, Instituto de Economía, Legislación y Administración del Agua, La demanda de agua en la República Argentina. Volumen II: Uso industrial, INELA/E/I/12/76, Mendoza, Argentina, 1976, pp. 194 and 241. Information refers to the area where Río Negro enters Río Paraná.

170/ L.R. Tomassi, Encuesta sobre la contaminación marina en Brasil, M.S., 1978, unpublished, quoted from Constantino Tapias, Oficina Regional de Pesca de la FAO, El medio oceánico y la actividad pesquera, Proyecto CEPAL/PNUMA Estilos de Desarrollo y Medio Ambiente en América Latina, Seminario Regional, Santiago de Chile, November 19-23, 1979, E/CEPAL/PROY.2/R.16, September 1979, p. 24.

171/ United Nations Industrial Development Organization (UNIDO), Environmental protection within the context of the work of UNIDO, ID/282, New York, 1982, pp. 19-20.

172/ Bernardo Kucinski, Human sacrifices in Brazil's industrial jungle, South, December 1982, p. 52. It is not known whether contamination of fish by mercury resulted from water pollution of industrial origin or not.

173/ Brazil tackles sugar wastes, World Water, May 1988, p. 10.

174/ Alta contaminación en mariscos de VIII Región, El Mercurio, 30 July 1990. This article refers to studies carried out by Werner Hoffmann from the Departamento de Biología Marina y Oceanografía of the Universidad de Concepción and reports of the Comisión de Estudio y Control de la Contaminación Ambiental de Talcahuano. According to Juan Grau (see Contaminación mortal en la Octava Región, El Mercurio, 6 October 1990), fish and molluscs in the area of the bay of San Vicente are being contaminated by mercury and cadmium.

175/ Manuel Achurra, El sector pesquero y la conservación ambiental, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 31.

176/ H. Weitzenfeld, Water pollution in Colombia's Bay of Cartagena, Water Quality Bulletin, Volume 3, Nº 2, April 1978, p. 15. The electrolytic unit of the industry located in the Mamonal area which was believed to be the main culprit for the presence of mercury in the waters of the Cartagena was partially shut down.

177/ Reuters 31.07.87., quoted from United Nations, Office of the United Nations Disaster Relief Coordinator (UNDRO), Disaster news in brief (1 January - 31 December 1987), p. 29. Information as to whether contamination of clams by toxic waste resulted from water pollution of industrial origin or not has not been available.

178/ Mike Rose, Catalogue of devastation, South, Nº 80, June 1987, p. 107. Information as to the cause of pollution by nickel and polynuclear aromatic hydrocarbons has not been available. It is not clear whether this information refers only to the River Coatzacoalcos or also to the River Tonala. According to Jose Manuel Lopez, The state of the Caribbean marine environment 1988, Caribbean Conservation News, Volume V, Nº 3, September 1988, p. 3, severe heavy metals pollution (lead, cadmium, mercury, and copper) has been detected in biota and sediments of Coatzacoalcos Estuary.

179/ Chanel Ishizaki and Juan Urich, Mercury contamination of food: a Venezuelan case study, Interciencia, July-August 1985, Volume 10, Nº 4, pp. 175 and 177. Mercury concentrations in the fish caught in the Golfo Triste area were compared to those in the Oriente area (off the cities of Boca de Uchire, Puerto Píritu and Puerto La Cruz).

180/ Pan American Health Organization, World Health Organization, Environmental Health Program, Regional program on chemical safety RPCS. Document presented to the XXII Pan American Sanitary Conference, Environmental Series Nº 7, Washington, D.C., 1987, p. 23.

181/ Other estimates of threshold ranges of hydrogen ion exponent (pH) required for fishery development and maintenance of aquatic life both in fresh and saltwater are to be found in Annexes 8 and 9.

182/ Much of this discussion is condensed from H.W. Kitching, Environmental management in mineral resources development, Economic and Social Commission for Asia and the Pacific, Proceedings of the Working Group Meeting on Environmental Management in Mineral Resource Development, Mineral Resources Development Series Nº 49, ST/ESCAP/186, United Nations, New

York, 1982, pp. 21-23.

183/ Stephen Graham, Brazil moves to reverse air and water pollution in the industrial South, Business Latin America, July 3, 1989, p. 207.

184/ Ignacio Schreckinger V., Explotación del oro y contaminación por mercurio en el Ecuador, Ministerio de Energía y Minas, Dirección General de Medio Ambiente, 1987. Document presented at Primer Congreso Ecuatoriano del Medio Ambiente, Quito, 7-14 February 1987, Document 3.1.

185/ Las emisiones: Región por Región, El Mercurio, 29 January 1987; and Juan Carlos Castilla, Fuentes, niveles y efectos de la contaminación marina en Chile, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 39.

186/ Carlos Ominami, Discurso inaugural, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 4.

187/ Oscar Guillén, Fuentes, niveles y efectos de la contaminación marina en el Perú, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 99.

188/ Marc J. Dourojeanni, Renewable natural resources of Latin America and the Caribbean: situation and trends, World Wildlife Fund-U.S., Washington, D.C., p. 250.

189/ United Nations, ECLAC, UNEP, Programa ambiental del Caribe. Plan de acción. El estado de la contaminación marina en la Región del Gran Caribe, E/CEPAL/PROY.3/L.INF.4, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 26.

190/ Black gold at sea, South, Nº 118, December 1990/January 1991, p. 76. According to the US National Academy of Science, quoted from Organization for Economic Co-operation and Development (OECD), The state of the environment, Paris, 1991, Figure 15, marine origins of oil pollution of the seas (1.84 million tons per year) include non accidental maritime transport - 1.08 million tons per year (59%), accidental maritime transport - 0.41 (22%), erosion, natural flows - 0.30 (16%), and production platform - 0.05 (3%); and continental origins of oil pollution of the seas (1.7 million tons per year) include urban and industrial origin - 1.4 million tons per year (82%), and atmospheric origin - 0.3 (18%).

191/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 139.

192/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 139.

193/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 29.

194/ From United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 139.

195/ Estimated on the basis of maps of the geographical distribution of oil slicks from E.M. Levy, M. Ehrhardt, D. Kohnke, E. Sobtchenko, T. Suzuoki, and A. Tokuhiro, Global oil pollution, Intergovernmental Oceanographic Commission, UNESCO, 1981. All areas are approximate. According to D.A. Atwood, F.J. Burton, J.E. Corredor, G.R. Harvey, A.J. Mata-Jimenez, A. Vasquez-Botello, and B.A. Wade, Results of the CARIPOL petroleum pollution monitoring project in the Wider Caribbean, 1987, Marine Pollution Bulletin, 18(10), 540-548, quoted from United Nations Environment Programme (UNEP), Environmental data report, 1989, Prepared for UNEP by the GEMS Monitoring and Assessment Research Centre, London, UK in co-operation with the World Resources Institute, Washington, D.C., UK Department of the Environment, London, pp. 65-67, highest levels of petroleum pollution in the Wider Caribbean region are found: (i) in terms of floating tar concentration (over 1.0 mg/m^2) in Straits of Florida and South Western Caribbean, and to a lesser extent, in Eastern Gulf of Mexico and North Western Caribbean; (ii) dissolved/dispersed petroleum hydrocarbons concentrations (over 1.0 µg/l) in Bay of Campeche, Eastern and Western Gulf of Mexico, and to a lesser extent, in Straits of Florida and North Western and Eastern Caribbean. The levels of pollution - over 1.0 mg/m^2 and over 1.0 µg/l - have been arbitrary chosen.

196/ United Nations, ECLA, UNEP, Caribbean Environment Programme Action Plan. Development and Environment in the Wider Caribbean Region: A Synthesis, E/CEPAL/PROY.3/L.INF.3, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 13.

197/ GESAMP (IMCO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution), The health of the oceans, UNEP Regional Seas Reports and Studies Nº 16, UNEP, 1982, p. 80.

198/ On the basis of information in Offshore Magazine, PennWell Publishing Company, Tulsa, Oklahoma, May 1987, quoted from the World Resources Institute and the International Institute for Environment and Development in collaboration with the United Nations Environment Programme, World resources 1988-89, Basic Books, Inc., New York, 1988, pp. 326 and 331. Small offshore production of oil has been reported in Chile and of natural gas in Trinidad and Tobago.

199/ James Brooke, New effort would test possible coexistence of oil and rain forest, The New York Times, February 26, 1991.

200/ Mauricio Schoijet, Contaminación y recursos naturales renovables, Nueva Sociedad, Venezuela, May/June 1983, p. 143.

201/ La amenaza de la contaminación, Ambiente, Nº 3, 1983.

202/ J.B.C. Jackson, J.D. Cubit, B.D. Keller, V. Batista, K. Burns, H.M. Caffey, R.L. Caldwell, S.D. Garrity, C.D. Getter, C. Gonzalez, H.M. Guzman, K.W. Kaufmann, A.H. Knap, S.C. Levings, M.J. Marshall, R. Steger, R.C. Thompson, E. Weil, Ecological effects of a major oil spill on Panamanian coastal marine communities, Science, 6 January 1989, Volume 243, Nº 4887, p. 37.

203/ Marc J. Dourojeanni, Renewable natural resources of Latin America and the Caribbean: situation and trends, World Wildlife Fund-U.S., Washington, D.C., p. 251.

204/ Black gold at sea, South, Nº 118, December 1990/January 1991, p. 76.

205/ Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fertilizer. Volume 39. 1989, Rome, 1990, p. 23. Figures in the text are for 1988.

206/ United Nations, ECLA, UNEP, Caribbean Environment Programme Action Plan. Overview on Natural Resources for Food and Agriculture in the Wider Caribbean Region, prepared with the co-operation of the Food and Agriculture Organization (FAO) of the United Nations, E/CEPAL/PROY.3/L.INF.10, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 37.

207/ Nicholas Lenssen, The ocean blues, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, July-August 1989, Volume 2, Nº 4, p. 30. Information as to the cause of high sedimentation load has not been available.

208/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 32; and quoted from the same source (reference to Cartegena Bay) Ali, A., Use of pesticides in agriculture and their effects on various water supplies, 1978, proceedings of a conference workshop on Environmental Health Strategy, Grenada, Pan American Health Organization, Washington, D.C.

209/ Francisco Szekely, Vicente Sánchez, Eduardo Neira, Jorge Montaño, Joseph Hodara, Raúl Benítez Zenteno, Iván Restrepo, Fernando Ortiz Monasterio, Jaime Hurtubia, Salvador Henríquez Aybar, El medio ambiente en México y América Latina, Serie Ecología y Sociedad a cargo de Vicente Sánchez, Editorial Nueva Imagen, Mexico, 1978, p. 130.

210/ R. Reid, The Caribbean region water resources management problems, Water Quality Bulletin, Volume 3, Nº 2, April 1978, p. 4.

211/ Jose Manuel Lopez, The state of the Caribbean marine environment 1988, Caribbean Conservation News, Volume V, Nº 3, September 1988, p. 3.

212/ Various, quoted from United Nations Environment Programme (UNEP), Environmental data report, 1989, Prepared for UNEP by the GEMS Monitoring and Assessment Research Centre, London, UK in co-operation with the World Resources Institute, Washington, D.C., UK Department of the Environment, London, p. 166 and Table 1.53. Data of limited comparability. Information refers to the 1971-1975 period.

213/ United Nations, Economic Commission for Latin America and the Caribbean (ECLAC), Sustainable development: changing production patterns, social equity and the environment, LC/G.1648(CONF.80/2)Rev.1, February 12, 1991, p. 60.

214/ T. Petr, Fish, fisheries, aquatic macrophytes and water quality in inland waters, Water Quality Bulletin, Volume 12, Nº 3, July 1987, p. 105.

215/ Marlise Simons, The Bay's a thing of beauty, The New York Times, September 16, 1987.

216/ Aspectos de contaminación en la Región del Biobío, Asociación Interamericana de Ingeniería Sanitaria y Ambiental, Capitulo Chileno, Boletín Informativo, Nº 5, January 1989, pp. 4-5.

217/ Las emisiones: región por región, and El 98% de las aguas no tiene tratamiento, El Mercurio, 29 January 1987.

218/ Empresa de Energía Eléctrica de Bogotá, División de Protección Ambiental y Recursos Naturales, Aspectos ambientales en el área de influencia del proyecto Guavio, III Congreso Colombiano de Cuencas Hidrográficas, Cali, Valle, August 1985, pp. 32-33. Information concerning the source of high turbidity and whether it is natural or man-induced has not been available.

219/ José Joaquín Villamil, Situación ambiental y factores condicionantes en la zona costera de República Dominicana, p. 15.

220/ Francisco Szekely, Vicente Sánchez, Eduardo Neira, Jorge Montaño, Joseph Hodara, Raúl Benítez Zenteno, Iván Restrepo, Fernando Ortiz Monasterio, Jaime Hurtubia, Salvador Henríquez Aybar, El medio ambiente en México y América Latina, Serie Ecología y Sociedad a cargo de Vicente Sánchez, Editorial Nueva Imagen, Mexico, 1978, pp. 148-149.

221/ Secretaría de Agricultura y Recursos Hidráulicos, Comisión del Plan Nacional Hidráulico, Plan Nacional Hidráulico 1981. Anexo 2. Disponibilidad de Agua y Suelo, p. 6-30.

222/ Mike Rose, The cost of Mexico's filthy riches, South, Nº 80, June 1987, p. 106.

223/ Bogdan Kwiecinsky, Contaminación marina del Pacífico de Panamá, Programa de las Naciones Unidas para el Medio Ambiente, Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 158. Also one case of shrimp contamination by *Vibrio parhaemolyticus* has been detected in the Bay of Panama.

224/ United Nations, ECLA, UNEP, Caribbean Environment Programme Action Plan. Overview on Natural Resources for Food and Agriculture in the Wider Caribbean Region, prepared with the co-operation of the Food and Agriculture Organization (FAO) of the United Nations, E/CEPAL/PROY.3/L.INF.10, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 37; and United Nations, ECLA, UNEP, Caribbean Environment Programme Action Plan. Development and Environment in the Wider Caribbean Region: A Synthesis, E/CEPAL/PROY.3/L.INF.3, 25 October 1979, Meeting of Government Nominated Experts to Review the Draft Action Plan for the Wider Caribbean Region, Caracas, Venezuela, 28 January - 1 February 1980, p. 13.

225/ On the basis of information provided in International Commission on Large Dams (ICOLD), World register of dams, Paris, 1984.

226/ Emilio Castanheira, Balbina goes on line, International Dams Newsletter, Volume 2, Nº 5, September/October 1987, pp. 4 and 12.

227/ Gwynne Power, Will Tucuruí dam damage Amazon ecology?, World Water, January/February 1985, p. 37.

228/ E. Goldsmith and N. Hildyard, The social and environmental effects of large dams. Volume one: Overview, A Report to the European Ecological Action Group (ECOROPA), Wadebridge Ecological Centre, UK, 1984, pp. 92 and 94.

229/ United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, pp. 106-109.

230/ Coral bleaching: it's a cause for concern in the Caribbean, Caribbean Conservation News, Volume V, Nº 11, December 1990, p. 5; and Leslie Roberts, Greenhouse role in reef stress unproven, Science, 19 July 1991, Volume 253, pp. 258-259.

231/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 28.

232/ H. Jeffrey Leonard, Natural resources and economic development in Central America. A regional environmental profile. Executive summary, pp. 19-20.

233/ Comisión de Desarrollo y Medio Ambiente de América Latina y el Caribe, Banco Interamericano de Desarrollo, Programa de Naciones Unidas para el Desarrollo, Nuestra propia agenda, 1990, p. 34.

234/ H. Jeffrey Leonard, Natural resources and economic development in Central America. A regional environmental profile. Executive summary, p. 19; and John C. Ryan, Belize's reefs on the rocks, WorldWatch, A Bimonthly Magazine of the Worldwatch Institute, November-December 1991, Volume 4, Nº 6, p. 7.

235/ H. Jeffrey Leonard, Natural resources and economic development in Central America. A regional environmental profile. Executive summary, p. 5. Reduction in catches was attributed primarily to severe over-exploitation and increased destruction of mangrove breeding grounds.

236/ H. J. Simpson and M. Pedini, Acidity impacts on brackish-water aquaculture, Water Quality Bulletin, Volume 12, Nº 4, October 1987, pp. 148 and 167.

237/ Ramon Buzeta, From hunters of wild resources to cultivators of the sea, IDRC Reports, Volume 10, Number 2, July 1991, p. 5.

238/ World Resources Institute and the International Institute for Environment and Development, World resources 1986, Basic Books, Inc., New York, 1986, p. 148.

239/ L. Davidson, Environmental assessment of the Wider Caribbean Region, UNEP Regional Seas Reports and Studies Nº 121, Prepared in co-operation with Greenpeace, UNEP, 1990, p. 28.

240/ Anitra Thorhaug, Biology and management of seagrass in the Caribbean, AMBIO, Volume X, Nº 6, 1981, p. 295.

241/ World Resources Institute and the International Institute for Environment and Development, World resources 1986, Basic Books, Inc., New York, 1986, p. 152. Estimates are based on the indirect assessments of resource vulnerability determined primarily by the extent of the resource, the economic capacity for exploitation of the resource, the density of human populations available to exploit the resource, and the growth rate of these populations.

242/ World Resources Institute and the International Institute for Environment and Development in collaboration with the United Nations Environment Programme, World resources 1988-89, Basic Books, Inc., New York, 1988, p. 143.

243/ José Raúl Cañón, Las empresas pesqueras y el medio ambiente, Ciclo "Acción ambiental: ¿Obstáculo o impulso al desarrollo?", Seminario Sector Pesquero, 7-8 September 1990, Centro de Investigación y Planificación del Medio Ambiente (CIPMA), Serie Documentos de Seminario, p. 100. This information refers to Chile.

ANNEXES

Annex 1

LATIN AMERICA AND THE CARIBBEAN: NOMINAL CATCHES BY MARINE FISHING AREAS
(Thousands of tons)

Country	1985	1986	1987	1988	Average	(%)
Atlantic, Northwest						
Cuba	23.5	24.8	28.8	16.9	23.5	0.16
Atlantic, Western Central						
Antigua and Barbuda	2.4	2.4	2.4	2.4	2.4	0.02
Aruba	0.8	0.8	0.8	0.8	0.8	0.01
Bahamas	7.6	5.9	7.1	7.2	6.9	0.05
Barbados	3.9	4.2	3.7	9.1	5.2	0.04
Belize	1.4	1.4	1.5	1.5	1.5	0.01
Colombia	10.6	10.4	9.7	10.6	10.3	0.07
Costa Rica	0.4	0.3	0.3	0.3	0.3	-
Cuba	79.7	78.4	81.1	78.2	79.3	0.55
Dominica	0.6	0.6	0.7	0.7	0.6	-
Dominican Republic	15.8	16.3	18.5	16.8	16.9	0.12
French Guiana	2.5	3.3	5.3	4.8	4.0	0.03
Grenada	1.4	2.1	2.2	2.0	1.9	0.01
Guadeloupe	8.4	8.5	8.6	8.2	8.4	0.06
Guatemala	0.2	0.2	0.1	0.1	0.1	-
Guyana	41.4	39.4	40.8	40.9	40.6	0.28
Haiti	7.2	7.7	7.8	7.8	7.6	0.05
Honduras	7.4	9.5	6.2	6.5	7.4	0.05
Jamaica	9.4	9.4	7.9	8.5	8.8	0.06
Martinique	4.6	4.0	4.5	3.0	4.0	0.03
Mexico	265.2	253.1	261.7	260.2	260.0	1.81
Montserrat	0.1	0.1	0.1	0.1	0.1	-
Netherlands Antilles	1.0	1.1	1.1	1.2	1.1	0.01
Nicaragua	2.2	1.5	2.2	1.5	1.9	0.01
Panama	0.6	0.8	1.0	1.8	1.0	0.01
Puerto Rico	1.5	1.3	1.2	1.6	1.4	0.01
Saint Kitts and Nevis	1.5	1.5	1.5	1.5	1.5	0.01
Saint Lucia	1.1	0.8	0.7	0.9	0.9	0.01
Saint Vincent and Grenadines	0.5	0.6	0.7	0.7	0.6	-
Suriname	3.9	3.5	5.1	5.1	4.4	0.03
Trinidad and Tobago	2.9	3.0	3.2	3.2	3.1	0.02
Turks and Caicos Islands	1.3	1.6	1.3	1.4	1.4	0.01
Venezuela	218.5	222.6	235.4	213.3	222.4	1.55
Virgin Islands (British)	0.3	0.3	0.3	0.3	0.3	-
Virgin Islands (U.S.)	0.6	0.6	0.5	0.6	0.6	-
Sub-total	707.0	697.4	725.1	702.4	707.9	4.92
Atlantic, Eastern Central						
Cayman Islands	0.4	0.4	0.4	0.4	0.4	-
Cuba	12.7	5.5	3.3	4.1	6.4	0.04
Honduras	-	7.1	15.5	15.5	9.5	0.07
Panama	7.2	8.8	3.5	3.2	5.7	0.04
Sub-total	20.3	21.8	22.8	23.2	22.0	0.15

Annex 1 (cont. 1)

Country	1985	1986	1987	1988	Average	(%)
Atlantic, Southwest						
Argentina	396.8	411.7	551.5	482.6	460.7	3.20
Brazil	627.1	570.7	500.7	530.0	557.1	3.87
Chile	-	-	0.4	1.3	0.4	-
Cuba	4.6	4.0	7.2	5.0	5.2	0.04
Falkland Islands (Malvinas)	-	-	-	2.9	0.7	0.01
Uruguay	137.6	140.0	136.7	107.1	130.4	0.91
Sub-total	1 166.0	1 126.3	1 196.5	1 129.0	1 154.5	8.02
Atlantic, Southeast						
Cuba	35.6	25.0	37.5	24.6	30.7	0.21
Sub-total	35.6	25.0	37.5	24.6	30.7	0.21
Atlantic, Antarctic						
Chile	2.6	3.3	4.1	5.9	4.0	0.03
Sub-total	2.6	3.3	4.1	5.9	4.0	0.03
Indian Ocean, Western						
Panama	6.2	8.0	8.0	9.0	7.8	0.05
Sub-total	6.2	8.0	8.0	9.0	7.8	0.05
Pacific, Eastern Central						
Colombia	12.4	17.0	13.6	23.5	16.7	0.12
Costa Rica	18.2	20.3	19.5	19.6	19.4	0.13
Ecuador	1 085.6	1 000.4	678.1	767.3	882.9	6.13
El Salvador	12.7	17.9	19.3	12.2	15.5	0.11
Guatemala	2.5	1.8	1.8	2.2	2.1	0.01
Honduras	2.0	3.7	0.8	0.5	1.8	0.01
Mexico	848.1	931.8	984.0	925.5	922.3	6.41
Nicaragua	1.9	0.9	2.6	3.1	2.1	0.01
Panama	276.7	126.1	166.5	97.2	166.6	1.16
Venezuela	22.3	38.0	40.4	44.0	36.2	0.25
Sub-total	2 282.4	2 158.0	1 926.7	1 895.1	2 065.5	14.35
Pacific, Southeast						
Chile	4 801.2	5 567.4	4 809.3	5 201.6	5 094.9	35.40
Costa Rica	1.5	-	-	-	1.5	0.01
Cuba	46.9	89.4	40.4	87.0	65.9	0.46

Annex 1 (conclusion)

Country	1985	1986	1987	1988	Average	(%)
Ecuador	0.4	2.1	0.1	0.1	0.7	-
Peru	4 108.1	5 581.4	4 547.1	6 597.6	5 208.6	36.19
Venezuela	7.7	3.9	6.0	6.0	5.9	0.04
Sub-total	8 965.9	11 244.2	9 403.0	11 892.4	10 376.3	72.10
TOTAL	13 209.5	15 308.7	13 352.4	15 698.4	14 392.3	100.00

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings. Volume 66. 1988, Rome, 1990, pp. 379-381.

Annex 2

NOMINAL CATCHES BY SPECIES, 1984-1988
(Thousands of tons)

Species	1984	1985	1986	1987	1988	Average	(%)
Atlantic, Western Central							
Gulf menhaden	982.9	883.5	828.5	907.1	638.7	848.1	38.7
American cupped oyster	219.4	219.9	182.8	170.5	154.9	189.5	8.6
Calico scallop	395.7	125.6	16.9	85.4	121.7	149.1	6.8
Round sardinella	55.5	59.0	84.0	86.6	61.6	69.3	3.2
Northern brown shrimp	65.5	70.9	76.9	68.1	63.5	69.0	3.1
Blue crab	46.8	44.2	42.8	49.4	57.8	48.2	2.2
Northern white shrimp	40.8	44.6	53.3	42.6	35.8	43.4	2.0
Atlantic Menhaden	3.5	47.5	33.7	26.0	33.9	28.9	1.3
Others	790.3	756.6	727.6	725.4	729.0	745.8	34.0
Total	2 600.5	2 251.6	2 046.5	2 161.0	1 897.1	2 191.4	100.0
Pacific, Southeast							
South American pilchard	5 361.3	5 814.4	4 333.3	4 686.4	4 998.1	5 038.7	47.3
Chilean jack mackerel	2 313.9	2 148.2	1 960.9	2 681.8	3 245.7	2 470.1	23.2
Anchoveta (Peruvian anchovy)	93.7	986.8	4 945.3	2 100.5	3 613.1	2 347.9	22.0
Patagonian grenadier	26.8	18.7	37.1	131.8	211.6	85.2	0.8
South Pacific hake	45.3	47.1	74.3	64.3	149.8	76.2	0.7
Patagonian hake	31.5	31.7	38.5	56.6	69.3	45.5	0.4
Chub mackerel	205.9	86.7	41.4	57.1	56.1	89.4	0.8
Taca clam	29.5	32.3	37.2	35.0	43.8	35.6	0.3
Eastern Pacific bonito	28.3	9.5	5.1	19.4	34.6	19.4	0.2
South Pacific breams	12.8	20.5	41.4	48.0	30.4	30.6	0.3
Araucanian herring	38.3	38.3	37.7	32.1	29.8	35.2	0.3
Others	362.2	395.6	431.8	365.0	380.5	387.0	3.6
Total	8 549.5	9 629.7	11 984.0	10 278.2	12 862.8	10 660.9	100.0
Pacific, Eastern Central							
California pilchard	278.3	372.3	470.5	477.1	446.1	408.9	16.3
Yellowfin tuna	157.1	247.5	296.3	308.4	307.5	263.4	10.5
Chub mackerel	336.3	160.7	157.5	163.3	198.2	203.2	8.1
Californian anchoveta	135.0	153.7	123.0	167.0	119.3	139.6	5.6
Western white shrimp	41.8	37.2	54.1	79.8	81.8	58.9	2.3
Skipjack tuna	101.4	164.7	86.7	84.4	97.4	106.9	4.3
Deepbody thread herring	78.5	38.2	39.9	47.5	76.6	56.1	2.2
Bigeye tuna	60.7	80.7	101.2	98.6	75.3	83.3	3.3
Pacific Anchoveta	116.0	245.3	110.4	190.8	60.2	144.5	5.8
Others	838.5	1 318.3	1 226.3	860.0	975.8	1 043.8	41.6
Total	2 143.7	2 818.5	2 665.9	2 476.9	2 438.3	2 508.6	100.0
Atlantic, Southwest							
Argentine hake	254.9	371.7	377.8	438.9	436.1	375.9	20.6

Annex 2 (conclusion).

Species	1984	1985	1986	1987	1988	Average	(%)
Argentine shortfin squid	43.3	43.7	55.1	117.5	106.2	73.2	4.0
Southern blue whiting	113.3	95.2	103.9	84.9	101.4	99.7	5.5
Blue grenadiers	-	0.2	0.2	44.1	82.6	25.4	1.4
Atlantic croaker	72.3	57.4	70.1	71.4	73.6	69.0	3.8
Brazilian sardinella	137.2	124.0	126.2	91.6	65.2	108.8	6.0
Patagonian grenadier	5.5	21.5	40.7	49.4	59.5	35.3	1.9
Grenadiers	31.0	9.2	15.1	27.2	50.4	26.6	1.5
Others	790.5	844.4	906.9	1 240.6	1 252.7	1 007.0	55.3
Total	1 448.0	1 567.3	1 696.1	2 165.5	2 227.7	1 820.9	100.0
Inland waters (South America)							
Nile tilapia	0.2	0.3	0.3	0.9	0.8	0.5	0.1
Characins	146.7	136.3	140.4	152.1	150.2	145.1	40.8
Freshwater, siluroids, etc.	60.9	61.9	67.8	62.0	59.7	62.5	17.6
Rainbow trout	0.8	1.1	1.4	1.6	2.3	1.5	0.4
Silversides (=Sand smelts)	0.2	0.4	1.1	1.1	1.3	0.8	0.2
Giant river prawn	-	-	-	0.8	0.8	0.3	0.1
River prawns	8.8	10.2	10.0	8.1	7.6	8.9	2.5
Others	119.8	117.8	140.0	158.5	144.8	136.1	38.3
Total	337.4	327.9	361.1	385.1	367.5	355.8	100.0

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings. Volume 66. 1988, Rome, 1990, pp. 321, 335-336, 344-345, 366-367 and 371-372.

Annex 3

LATIN AMERICA AND THE CARIBBEAN: PRODUCTION OF FISHERY COMMODITIES, 1987-1988
(Tons)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
1. Fish, fresh, chilled or frozen					
Argentina	210 900	160 600	185 750	25.2	1.34
Bahamas	159	170	165	-	-
Belize	35	27	31	-	-
Brazil	172 250	173 600	172 925	23.5	1.25
Chile	58 428	79 799	69 114	9.4	0.50
Cuba	82 957	94 156	88 557	12.0	0.64
Ecuador	35 342	23 500	29 421	4.0	0.21
French Guiana	496	530	513	0.1	-
Mexico	63 360	63 521	63 441	8.6	0.46
Peru	31 800	75 823	53 812	7.3	0.39
Uruguay	56 009	47 799	51 904	7.1	0.37
Venezuela	19 931	20 585	20 258	2.8	0.15
Regional sub-total	731 667	740 110	735 889	100.0	5.31
World total	13 588 929	14 143 923	13 866 426	-	100.00
1a. Fish fillets, fresh or chilled					
Argentina	33 700	27 000	30 350	44.5	9.20
Brazil	37 000	38 000	37 500	55.0	11.37
Chile	84	288	186	0.3	0.06
Ecuador	125	114	120	0.2	0.04
Uruguay	104	1	53	0.1	0.02
Regional sub-total	71 013	65 403	68 208	100.0	20.68
World total	315 993	343 702	329 848	-	100.00
1b. Fish fillets, frozen					
Argentina	97 150	57 100	77 125	59.9	4.83
Belize	35	27	31	-	-
Brazil	10 000	11 000	10 500	8.2	0.66
Chile	2 481	2 985	2 733	2.1	0.17
Cuba	6 075	4 883	5 479	4.3	0.34
Ecuador	1 996	3 441	2 719	2.1	0.17
Peru	4 812	8 626	6 719	5.2	0.42
Uruguay	29 687	16 822	23 255	18.1	1.46
Venezuela	164	85	125	0.1	0.01
Regional sub-total	152 400	104 969	128 685	100.0	8.06
World total	1 590 036	1 601 417	1 595 727	-	100.00
1c. Fish, frozen (excluding fillets)					
Argentina	80 050	76 500	78 275	14.5	0.66
Bahamas	159	170	165	-	-
Brazil	125 250	124 600	124 925	23.2	1.05
Chile	55 863	76 526	66 195	12.3	0.55
Cuba	76 882	89 273	83 078	15.4	0.70
Ecuador	33 221	19 945	26 583	4.9	0.22
French Guiana	496	530	513	0.1	-
Mexico	63 360	63 521	63 441	11.8	0.53
Peru	26 988	67 197	47 093	8.7	0.39

Annex 3 (cont. 1).

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Uruguay	26 218	30 976	28 597	5.3	0.24
Venezuela	19 767	20 500	20 134	3.7	0.17
Regional sub-total	508 254	569 738	538 996	100.0	4.51
World total	11 682 900	12 198 804	11 940 852	-	100.00
Fish fillets, fresh or chilled	71 013	65 403	68 208	9.3	20.7
Fish fillets, frozen	152 400	104 969	128 685	17.5	8.1
Fish, frozen (excluding fillets)	508 254	569 738	538 996	73.2	4.5
Regional sub-total	731 667	740 110	735 889	100.0	5.3
2. Fish, dried, salted or smoked					
Argentina	7 800	11 121	9 461	13.1	0.17
Belize	4	2	3	-	-
Brazil	21 390	21 850	21 620	30.0	0.39
Chile	1 345	3 017	2 181	3.0	0.04
Colombia	4 627	9 989	7 308	10.1	0.13
Ecuador	117	148	133	0.2	-
Guatemala	42	82	62	0.1	-
Guyana	182	437	310	0.4	0.01
Mexico	657	816	737	1.0	0.01
Peru	22 605	20 554	21 580	29.9	0.38
Suriname	607	447	527	0.7	0.01
Uruguay	25	22	24	-	-
Venezuela	6 488	9 764	8 126	11.3	0.14
Regional sub-total	65 889	78 249	72 069	100.0	1.28
World total	5 593 681	5 627 771	5 610 726	-	100.00
2a. <u>Fish meal fit for human consumption</u>					
Argentina	-	221	111	100.0	2.84
Regional sub-total	-	221	111	100.0	2.84
World total	1 643	6 138	3 891	-	100.00
2b. <u>Cod (not in fillets), dried, whether or not salted</u>	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	39 677	46 077	42 877	-	100.00
2c. <u>Fish, dried, salted or in brine</u>					
Argentina	7 800	10 900	9 350	13.0	0.20
Belize	4	2	3	-	-
Brazil	21 350	21 850	21 600	30.1	0.45
Chile	1 261	2 888	2 075	2.9	0.04
Colombia	4 627	9 989	7 308	10.2	0.15
Ecuador	117	148	133	0.2	-
Guatemala	42	82	62	0.1	-
Guyana	182	437	310	0.4	0.01
Mexico	657	816	737	1.0	0.02
Peru	22 605	20 554	21 580	30.0	0.45
Suriname	607	447	527	0.7	0.01

Annex 3 (cont. 2)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Uruguay	25	22	24	-	-
Venezuela	6 488	9 764	8 126	11.3	0.17
Regional sub-total	65 765	77 899	71 832	100.0	1.51
World total	4 704 807	4 836 568	4 770 688	-	100.00
2d. Fish, smoked					
Brazil	40	-	20	15.8	-
Chile	84	129	107	84.2	0.01
Regional sub-total	124	129	127	100.0	0.02
World total	847 554	738 988	793 271	-	100.00
Fish meal fit for human consumption	-	221	111	0.3	2.84
Cod (not in fillets), dried, whether or not salted	-	-	-	-	-
Fish, dried, salted or in brine	65 765	77 899	71 832	99.6	1.51
Fish, smoked	124	129	127	0.2	0.02
Regional sub-total	65 889	78 249	72 069	100.0	1.28
3. Crustaceans and molluscs, fresh, frozen, dried, salted, etc.					
Argentina	34 781	27 032	30 907	15.2	1.43
Bahamas	1 597	1 810	1 704	0.8	0.08
Belize	551	582	567	0.3	0.03
Brazil	16 510	18 000	17 255	8.5	0.80
Chile	11 260	14 970	13 115	6.5	0.61
Colombia	3 452	5 584	4 518	2.2	0.21
Cuba	13 836	11 764	12 800	6.3	0.59
Ecuador	50 708	52 510	51 609	25.4	2.39
El Salvador	2 812	2 574	2 693	1.3	0.12
French Guiana	3 085	3 070	3 078	1.5	0.14
Guatemala	775	1 786	1 281	0.6	0.06
Guyana	2 713	2 578	2 646	1.3	0.12
Honduras	2 732	2 815	2 774	1.4	0.13
Mexico	50 247	45 894	48 071	23.7	2.23
Nicaragua	1 108	1 183	1 146	0.6	0.05
Panama	1 760	1 337	1 549	0.8	0.07
Peru	4 538	2 902	3 720	1.8	0.17
Suriname	397	291	344	0.2	0.02
Uruguay	2 294	2 691	2 493	1.2	0.12
Venezuela	892	687	790	0.4	0.04
Regional sub-total	206 048	200 060	203 054	100.0	9.42
World total	2 217 290	2 095 102	2 156 196	-	100.00
3a. Crustaceans, fresh, frozen, salted, in brine or dried					
Argentina	2 520	14 367	8 444	5.1	0.80
Bahamas	1 597	1 810	1 704	1.0	0.16
Belize	402	425	414	0.3	0.04
Brazil	16 510	18 000	17 255	10.5	1.63
Chile	4 095	4 222	4 159	2.5	0.39
Colombia	3 044	5 306	4 175	2.5	0.40
Cuba	13 836	11 764	12 800	7.8	1.21

Annex 3 (cont. 3)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Ecuador	50 648	52 484	51 566	31.3	4.89
El Salvador	2 812	2 574	2 693	1.6	0.26
French Guiana	3 085	3 070	3 078	1.9	0.29
Guatemala	775	1 786	1 281	0.8	0.12
Guyana	2 713	2 578	2 646	1.6	0.25
Honduras	2 732	2 815	2 774	1.7	0.26
Mexico	47 112	42 696	44 904	27.3	4.25
Nicaragua	1 108	1 183	1 146	0.7	0.11
Panama	1 760	1 337	1 549	0.9	0.15
Peru	3 370	2 400	2 885	1.8	0.27
Suriname	397	291	344	0.2	0.03
Uruguay	3	-	2	-	-
Venezuela	892	687	790	0.5	0.07
Regional sub-total	159 411	169 795	164 603	100.0	15.60
World total	1 017 039	1 093 850	1 055 445	-	100.00
3b. Molluscs, fresh, frozen, salted, in brine or dried					
Argentina	32 261	12 665	22 463	58.4	2.04
Belize	149	157	153	0.4	0.01
Chile	7 165	10 748	8 957	23.3	0.81
Colombia	408	278	343	0.9	0.03
Ecuador	60	26	43	0.1	-
Mexico	3 135	3 198	3 167	8.2	0.29
Peru	1 168	502	835	2.2	0.08
Uruguay	2 291	2 691	2 491	6.5	0.23
Regional sub-total	46 637	30 265	38 451	100.0	3.49
World total	1 200 251	1 001 252	1 100 752	-	100.00
Crustaceans, fresh, frozen, salted, in brine or dried	159 411	169 795	164 603	81.1	15.60
Molluscs, fresh, frozen, salted, in brine or dried	46 637	30 265	38 451	18.9	3.49
Regional sub-total	206 048	200 060	203 054	100.0	9.42
4. Fish products and preparations, whether or not in airtight containers					
Argentina	15 200	15 600	15 400	4.5	0.28
Brazil	51 500	52 100	51 800	15.2	0.95
Chile	60 362	63 005	61 684	18.1	1.14
Colombia	619	730	675	0.2	0.01
Costa Rica	2 000	2 100	2 050	0.6	0.04
Cuba	10 748	6 816	8 782	2.6	0.16
Ecuador	33 962	26 903	30 433	8.9	0.56
Mexico	54 870	63 104	58 987	17.3	1.09
Peru	78 535	48 889	63 712	18.7	1.17
Uruguay	8	13	11	-	-
Venezuela	45 628	48 399	47 014	13.8	0.87
Regional sub-total	353 432	327 659	340 546	100.0	6.27
World total	5 427 232	5 440 552	5 433 892	-	100.00

Annex 3 (cont. 4)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
4a. Salmons, canned					
Chile	2	5	4	100.0	-
Regional sub-total	2	5	4	100.0	-
World total	81 125	74 633	77 879	-	100.00
4b. Herrings, sardines, anchovies, etc., canned					
Argentina	6 200	6 300	6 250	2.6	1.10
Brazil	43 000	43 500	43 250	18.2	7.61
Chile	36 996	26 075	31 536	13.3	5.55
Costa Rica	1 000	1 100	1 050	0.4	0.18
Ecuador	23 357	16 948	20 153	8.5	3.54
Mexico	36 206	38 923	37 565	15.8	6.61
Peru	76 302	45 537	60 920	25.7	10.72
Venezuela	37 492	36 015	36 754	15.5	6.47
Regional sub-total	260 553	214 398	237 476	100.0	41.77
World total	600 457	536 498	568 478	-	100.00
4c. Tunas, bonitos, billfishes, etc., canned					
Argentina	1 500	2 000	1 750	3.5	0.18
Brazil	3 500	3 600	3 550	7.1	0.37
Chile	326	189	258	0.5	0.03
Colombia	619	730	675	1.3	0.07
Costa Rica	1 000	1 000	1 000	2.0	0.10
Cuba	1 837	1 846	1 842	3.7	0.19
Ecuador	9 782	8 462	9 122	18.2	0.95
Mexico	17 511	23 105	20 308	40.4	2.11
Peru	1 315	1 725	1 520	3.0	0.16
Venezuela	8 095	12 334	10 215	20.3	1.06
Regional sub-total	45 485	54 991	50 238	100.0	5.21
World total	931 162	996 603	963 883	-	100.00
4d. Miscellaneous fish products, canned					
Argentina	7 500	7 300	7 400	14.0	0.47
Brazil	5 000	5 000	5 000	9.5	0.32
Chile	23 038	36 736	29 887	56.6	1.90
Cuba	8 911	4 970	6 941	13.1	0.44
Ecuador	823	1 493	1 158	2.2	0.07
Mexico	1 153	1 076	1 115	2.1	0.07
Peru	918	1 627	1 273	2.4	0.08
Uruguay	8	13	11	-	-
Venezuela	41	50	46	0.1	-
Regional sub-total	47 392	58 265	52 829	100.0	3.36
World total	1 592 391	1 554 727	1 573 559	-	100.00
4e. Fish products in airtight containers	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	220 952	193 267	207 110	-	100.00
4f. Fish products and preparations, not in airtight containers	No significant regional production				

Annex 3 (cont. 5)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Regional sub-total	-	-	-	-	-
World total	2 001 145	2 084 824	2 042 985	-	100.00
Salmons, canned	2	5	4	-	-
Herrings, sardines, anchovies, etc., canned	260 553	214 398	237 476	69.7	41.77
Tunas, bonitos, billfishes, etc., canned	45 485	54 991	50 238	14.8	5.21
Miscellaneous fish products, canned	47 392	58 265	52 829	15.5	3.36
Fish products in airtight containers	-	-	-	-	-
Fish products and preparations, not in airtight containers	-	-	-	-	-
Regional sub-total	353 432	327 659	340 546	100.0	6.27
5. Crustacean and mollusc products and preparations, whether or not in airtight containers					
Argentina	1 020	1 015	1 018	7.3	0.22
Chile	9 043	9 845	9 444	67.7	2.08
Ecuador	10	-	5	-	-
El Salvador		530	530	3.8	0.12
Mexico	940	916	928	6.7	0.20
Peru	451	284	368	2.6	0.08
Uruguay	7	6	7	-	-
Venezuela	1 695	1 611	1 653	11.8	0.36
Regional sub-total	13 166	14 207	13 952	100.0	3.08
World total	426 698	479 991	453 345	-	100.00
5a. Crustacean products, canned					
Argentina	20	15	18	0.8	0.02
Chile	364	556	460	21.8	0.47
El Salvador	na	530	530	25.1	0.54
Mexico	386	338	362	17.1	0.37
Venezuela	1 061	429	745	35.2	0.76
Regional sub-total	1 831	1 868	2 115	100.0	2.17
World total	88 654	106 277	97 466	-	100.00
5b. Mollusc products, canned					
Argentina	1 000	1 000	1 000	8.6	0.74
Chile	8 679	9 289	8 984	77.5	6.64
Ecuador	10	-	5	-	-
Mexico	554	578	566	4.9	0.42
Peru	446	229	338	2.9	0.25
Uruguay	7	6	7	0.1	-
Venezuela	547	853	700	6.0	0.52
Regional sub-total	11 243	11 955	11 599	100.0	8.57
World total	132 661	138 126	135 394	-	100.00
5c. Crustaceans and molluscs, prepared or or preserved, not elsewhere included					
Peru	5	55	30	12.6	0.13
Venezuela	87	329	208	87.4	0.88

Annex 3 (cont. 6)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Regional sub-total	92	384	238	100.0	1.00
World total	22 489	24 883	23 686	-	100.00
5d. Crustaceans and molluscs preparations, not in airtight containers	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	182 894	210 705	196 800	-	100.00
Crustacean products, canned	1 831	1 868	1 850	13.5	1.90
Mollusc products, canned	11 243	11 955	11 599	84.7	8.57
Crustaceans and molluscs, prepared or preserved, not elsewhere included	92	384	238	1.7	1.00
Crustaceans and molluscs preparations, not in airtight containers	-	-	-	-	-
Regional sub-total	13 166	14 207	13 687	100.0	3.02
6. Oils and fats, crude or refined, of aquatic animal origin					
Argentina	1 000	2 500	1 750	0.5	0.12
Brazil	2 800	2 800	2 800	0.7	0.19
Chile	172 159	187 981	180 070	47.9	12.14
Colombia	140	100	120	-	0.01
Ecuador	8 818	16 011	12 415	3.3	0.84
Mexico	14 965	9 665	12 315	3.3	0.83
Panama	13 782	5 596	9 689	2.6	0.65
Peru	109 086	203 273	156 180	41.6	10.53
Uruguay	552	181	367	0.1	0.02
Regional sub-total	323 302	428 107	375 705	100.0	25.32
World total	1 430 458	1 536 658	1 483 558	-	100.00
6a. Fish liver oils	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	27 273	28 093	27 683	-	100.00
6b. Oils and fats (other than fish liver oil)					
Argentina	1 000	2 500	1 750	0.5	0.12
Brazil	2 800	2 800	2 800	0.7	0.19
Chile	172 159	187 981	180 070	47.9	12.39
Colombia	140	100	120	-	0.01
Ecuador	8 818	16 011	12 415	3.3	0.85
Mexico	14 965	9 665	12 315	3.3	0.85
Panama	13 782	5 596	9 689	2.6	0.67
Peru	109 086	203 273	156 180	41.6	10.75
Uruguay	552	181	367	0.1	0.03
Regional sub-total	323 302	428 107	375 705	100.0	25.86
World total	1 399 110	1 506 724	1 452 917	-	100.00
6c. Oils and fats of marine mammals	No significant regional production				

Ann 3 (cont. 7).

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Regional sub-total	-	-	-	-	-
World total	1 414	527	971	-	100.00
6d. Oils and fats of aquatic animals, not elsewhere included	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	2 661	1 314	1 988	-	100.00
Fish liver oils	-	-	-	-	-
Oils and fats (other than fish liver oil)	323 302	428 107	375 705	100.0	25.86
Oils and fats of marine mammals	-	-	-	-	-
Oils and fats of aquatic animals, not elsewhere included	-	-	-	-	-
Regional sub-total	323 302	428 107	375 705	100.0	25.32
7. Meals, solubles and similar animal feedingstuffs, of aquatic animal origin					
Argentina	20 300	15 000	17 650	0.7	0.27
Brazil	26 000	30 000	28 000	1.2	0.43
Chile	1 081 092	1 112 229	1 096 661	45.8	16.65
Colombia	230	150	190	-	-
Cuba	5 580	9 525	7 553	0.3	0.11
Ecuador	116 701	166 079	141 390	5.9	2.15
El Salvador	-	8	4	-	-
Mexico	104 280	78 548	91 414	3.8	1.39
Panama	31 367	20 262	25 815	1.1	0.39
Peru	821 417	1 126 242	973 830	40.6	14.78
Uruguay	10 940	7 604	9 272	0.4	0.14
Venezuela	4 945	4 876	4 911	0.2	0.07
Regional sub-total	2 222 852	2 570 523	2 396 688	100.0	36.38
World total	6 410 777	6 763 877	6 587 327	-	100.00
7a. Fish meal from white-fish (ground-fish)					
Argentina	20 300	15 000	17 650	35.8	9.23
Chile	22 940	39 640	31 290	63.4	16.37
Mexico	417	373	395	0.8	0.21
Regional sub-total	43 657	55 013	49 335	100.0	25.81
World total	186 891	195 364	191 128	-	100.00
7b. Fish meal from oily fish					
Brazil	26 000	30 000	28 000	1.2	0.45
Chile	1 057 553	1 071 836	1 064 695	45.4	17.28
Colombia	230	150	190	-	-
Cuba	5 580	9 525	7 553	0.3	0.12
Ecuador	116 701	166 079	141 390	6.0	2.29
El Salvador	-	4	2	-	-
Mexico	103 863	78 175	91 019	3.9	1.48
Panama	31 367	20 262	25 815	1.1	0.42
Peru	821 417	1 126 242	973 830	41.5	15.80
Uruguay	10 940	7 604	9 272	0.4	0.15
Venezuela	4 945	4 876	4 911	0.2	0.08

Annex 3 (conclusion)

Commodity group / country	1987	1988	Average	(%) a/	(%) b/
Regional sub-total	2 178 596	2 514 753	2 346 675	100.0	38.08
World total	5 995 060	6 329 676	6 162 368	-	100.00
7c. Miscellaneous meals of aquatic animal origin					
Chile	599	753	676	99.7	2.93
El Salvador	-	4	2	0.3	0.01
Regional sub-total	599	757	678	100.0	2.94
World total	26 246	19 838	23 042	-	100.00
7d. Solubles from fish and marine mammals	No significant regional production				
Regional sub-total	-	-	-	-	-
World total	202 580	218 999	210 790	-	100.00
Fish meal from white-fish (ground-fish)	43 657	55 013	49 335	2.1	25.81
Fish meal from oily fish	2 178 596	2 514 753	2 346 675	97.9	38.08
Miscellaneous meals of aquatic animal origin	599	757	678	-	2.94
Solubles from fish and marine mammals	-	-	-	-	-
Regional sub-total	2 222 852	2 570 523	2 396 688	100.0	36.38

Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities. Volume 67. 1988, Rome, 1990.

\- - none or negligible or not available;
na - data not available;
a/ - share in regional production of commodity or commodity group in question;
b/ - share in world production of commodity or commodity group in question.

Annex 4

LATIN AMERICA AND THE CARIBBEAN: ACTUAL AND ESTIMATED POTENTIAL CATCH
(Thousands of tons)

Species	Main fishing countries	Estimated potential	Actual average annual catch			Current situation
			1970/74	1975/79	1980/84	
Atlantic, Western Central (FAO code 31)						
Crabs	US, Mexico	50 - 150	34	39	48	Moderately exploited
Grunt	Guyana, US, Venezuela	Some hundreds	64	61	39	Unequal exploitation, some areas are fully exploited
Horse mackerel	Mexico, US, Venezuela	30 - 50	21	22	23	Moderately-fully exploited
Lobsters	Cuba	40	20	22	23	Moderately-fully exploited
Mullet	US, Mexico	Unknown	27	23	31	Uncertain
Other pelagics	Barbados, Venezuela, Mexico, US	200 - 400	151	164	300	Moderately-fully exploited
Oysters	US, Mexico	Unknown	162	172	207	Big potential for cultivation
Sardinella	Venezuela	Some hundreds	44	40	50	Moderately exploited
Scallops	US, Venezuela	Unknown	9	14	150	Moderately-fully exploited
Sharks, rays	Mexico, Venezuela	50 - 100	8	12	21	Moderately exploited
Shrimps	US, Mexico	210	170	165	175	Mostly fully exploited
Snapper, grouper	Brazil, Cuba, US, Mexico, Venezuela	100	45	40	59	Unequal exploitation, some areas are fully exploited
Squid	Mexico, Venezuela	100 - 1 000	5	7	10	Almost unexploited
Tuna species	Cuba, Venezuela	Some hundreds	27	35	59	Bigger species moderately exploited
Atlantic, Southwest (FAO code 41)						
Argentine anchovy	Argentina, Uruguay	1 000	32	20	18	Almost unexploited
Argentina red shrimp	Argentina	Unknown	-	-	11	Fully exploited a/
Atlantic croaker	Argentina, Brazil, Uruguay	100	56	84	79	Moderately-fully exploited
Hake	Argentina, Brazil, Uruguay	600	153	316	330	Moderately exploited
Other shrimp and prawns	Brazil	60 - 80	50	54	53	Fully exploited
Sardinella	Brazil	200	164	165	226	Fully exploited
Southern blue whiting	Poland, USSR	300	-	11	131	Moderately exploited
Sprat	Argentina	Some hundreds	-	-	-	Unexploited
Squid	Argentina, Brazil, Japan, Poland, Uruguay	Some hundreds	4	43	151	Some areas fully exploited
Weakfish	Argentina, Brazil, Uruguay	100	42	58	75	Moderately-fully exploited

Annex 4 (conclusion)

Species	Main fishing countries	Estimated potential	Actual average annual catch			Current situation
			1970/74	1975/79	1980/84	
Pacific, Eastern Central (FAO code 77)						
Albacore	US, Japan	100 - 200	15	20	24	Moderately exploited
Big eye tuna	Japan	100	42	69	62	Moderately exploited
Californian pickard	Mexico	Variable	58	143	353	Moderately exploited
Central Pacific anchoveta	Panama	Some hundreds	38	107	142	Moderately-fully exploited
Horse mackerel	Ecuador, US, Mexico	Some hundreds	68	366	414	Moderately exploited
North Pacific anchovy	Mexico	500 - 1 000	92	238	280	Little exploited
Other oceanic species	US, Japan	b/ 100 - 500	28	42	49	Little exploited
Pacific jack mackerel	US	100 - 500	19	27	18	Little exploited
Pacific thread herring	Ecuador, Panama	Some hundreds	17	19	51	Moderately exploited
Shrimp	Ecuador, Mexico, Panama	100	78	71	105	Fully exploited
Skipjack tuna	US, Mexico	250	61	121	108	Moderately exploited
Tuna	US, Mexico	n/a	9	8	2	Moderately exploited
Yellowfin tuna	US, Mexico	200 - 250	165	197	144	Fully exploited
Pacific, Southeast (FAO code 87)						
Anchovy	Chile, Peru	500 - 2 000	6 959	2 251	884	Depleted
Hake	Chile, Peru	100 - 200	139	194	84	Moderately-fully exploited
Horse mackerel	Chile, Peru	100 - 500	33	163	142	Moderately exploited
Jack mackerel	Chile, Peru, USSR	2 000 - 5 000	173	776	1 842	Moderately exploited
Sardine	Chile, Peru	3 000 - 6 000	103	1 512	3 741	Fully exploited
Sauries	Chile, Peru	Some hundreds	-	-	-	Unexploited
Squid	Chile, Peru	Some hundreds	<1	<1	2	Almost unexploited

Source: FIDI/FISHDAB, quoted from Food and Agriculture Organization (FAO) of the United Nations, Potentials for agricultural and rural development in Latin America and the Caribbean. Annex V. Crops, livestock, fisheries and forestry, LARC 88/3, Rome 1988, pp. 104-106.

a/ - current situation is uncertain.
b/ - estimated potential is uncertain.
n/a - information not available.

Annex 5

LOCATION OF FISH PROCESSING PLANTS, BY COUNTRY AND MAJOR HYDROGRAPHIC DIVISION

CHILE: FISH PROCESSING PLANTS a/

Major hydrographic division	City / locality	Number of industries	Type of processing										
			L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11
Arid Pacific hydrographic system	Antofagasta	10		•	•		•	•			•	•	
	Arica	11		•	•		•	•	•				
	Caldera	11	•	•	•	•	•	•	•				
	Coquimbo	31	•	•	•	•	•	•	•				
	Iquique	15	•	•	•		•	•	•				
	Mejillones	5		•				•	•				
	Taltal	2		•			•						
	Tocopilla	5		•	•			•	•				
Central Chile hydrographic system	Constitución	2		•						•			•
	Coronel	7		•		•	•	•	•				
	Metropolitan Region	21	•	•	•	•	•						
	Quintero	8	•	•	•		•	•	•	•			•
	San Antonio	14	•	•			•	•	•				
	Talcahuano	40	•	•	•	•	•	•	•				
	Tome	1	•	•			•	•	•				
	Valparaiso	13	•	•	•	•	•	•	•				
South Pacific hydrographic system	Ancud	10	•	•			•						
	Aysén	13		•		•	•	•			•		
	Calbuco	16	•	•	•		•	•	•				
	Castro	20	•	•		•	•						
	Magallanes	36	•	•		•	•	•					
	Puerto Montt	47	•	•	•	•	•	•		•			
	Puerto Saavedra	4		•		•	•						
	Quellón	11	•	•			•				•		
	Valdivia	7	•	•									
Total (processes)		n/a	92	242	28	17	120	58	53	4	5	1	2
Total number of industries		361	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

COLOMBIA: FISH AND FISH PROCESSING PLANTS b/

Major hydrographic division	Area	Industry	Number of industries	Treatment	Discharge to the sea
Tropical Pacific hydrographic system	Buenaventura	Food products	8	Without treatment	Directly
	Tumaco	Food products	3	Without treatment	Directly
	Guapi	Meal	1	Without treatment	Indirectly

ECUADOR: FISH AND FISH PROCESSING PLANTS c/

Major hydrographic division	Province	Location	Number of industries
Tropical Pacific hydrographic system	Esmeraldas	Tonchique	1
	Manabí	Jaramijó	2
		Manta	8
Tropical Pacific hydrographic system		Salango	1

Annex 5 (cont. 1)

Major hydrographic division	Province	Location	Number of industries
Tropical Pacific hydrographic system (continued)	Guayas	Valdivia	2
		Monteverde	1
		Libertad	1
		Salinas	6
		Sta. Rosa	4
		Anconcito	2
		Posorja	6
		Chanduy	9
		Guayaquil	25
Arid Pacific hydrographic system	El Oro	P. Bolívar	3
		Machala	1

PANAMA: FISH AND FISH PROCESSING PLANTS d/

Major hydrographic division	Location	Number	Discharge area
Tropical Pacific hydrographic system	Chiriquí	1	bank of the river/sea-shore (David river basin)
	Coclé	4	directly to the river (Zaratí river basin)
	Los Santos	1	directly to the river (La Villa river basin)
	Panamá	19	bank of the river/sea-shore (Juan Díaz river basin)
	Panamá	20	directly to the river (Juan Díaz river basin)

PERU: FISH AND FISH PROCESSING PLANTS e/

Major hydrographic division	Location	Fish meal	Canning	Refrigeration	Total
Arid Pacific hydrographic system	Ate-Vitarte	-	1	-	1
	Atico	1	-	-	1
	Caleta Cruz *	-	-	1	1
	Callao	4	11	2	17
	Carquin	2	-	-	2
	Casma	-	1	-	1
	Chaclacayo *	-	-	1	1
	Chala	-	1	-	1
	Chancay	2	1	-	3
	Chiclayo	-	1	-	1
	Chimbote	7	16	-	23
	Coishco	-	3	-	3
	Culebras	1	-	-	1
	Huacho	-	1	-	1
	Huarmey	1	1	-	2
	Ilo	4	2	-	6
	La Planchada	1	-	-	1
	Lima	-	5	-	5
	Máncora	-	-	1	1
	Matarani	-	-	1	1
	Mollendo	1	3	-	4
	Paita	-	2	7	9
	Parachique *	-	1	-	1
	Pisco	4	3	1	8
	Piura	-	1	3	4
	Pto. Chicama	1	1	-	2
	Pucusana	-	1	-	1
	Sechura	-	2	-	2
	Supe	5	-	-	5
	Tacna	-	1	-	1

Annex 5 (conclusion)

Major hydrographic division	Location	Fish meal	Canning	Refrigeration	Total
Arid Pacific hydrographic system (<u>continued</u>)	Tambo de Mora	3	-	-	3
	Trujillo	-	1	-	1
	Vegueta	-	1	-	1
	Ventanilla *	-	1	-	1
	Zorritos	-	-	2	2

URUGUAY: FISH PROCESSING PLANTS f/

		1985	1986	1987
Plants	Active	30	29	27
	Idle	2	3	5
	Total	32	32	32
Activities	Fresh fishery products	11	12	7
	Frozen fishery products	18	19	19
	Dried, salted products	5	3	2
	Canned fishery products	3	2	2
	Fish meals	9	9	9
	Oils	4	4	3
	Proteins	1	1	-
	Total	51	50	42
Refrigeration ships in operation		9	11	6
Personnel employed by fish industry plants	High season (August 31)	7 197	7 534	7 936
	Low season (April 30)	6 565	6 432	7 393

<u>Source</u>: a/ - Armada de Chile, Dirección General del Territorio Marítimo y de Marina Mercante, <u>Boletín estadístico marítimo. Edición 1991. Período: enero-diciembre 1990</u>, pp. 65-70. Some plants are engaged in more than one activity.

b/ - Francisco Rodríguez, Contribución al conocimiento de la contaminación y su problemática en el Pacífico Colombiano, Programa de las Naciones Unidas para el Medio Ambiente, <u>Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste</u>, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 287.

c/ - Lucía Solórzano, Fuentes, niveles y efectos de la contaminación marina en Ecuador, Programa de las Naciones Unidas para el Medio Ambiente, <u>Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste</u>, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, pp. 213-215.

d/ - Bogdan Kwiecinsky, Contaminación marina del Pacífico de Panamá, Programa de las Naciones Unidas para el Medio Ambiente, <u>Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste</u>, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, pp. 160-161, fishing industries (code A 1.1) which discharge their effluent directly and indirectly to the sea.

e/ - Oscar Guillén, Fuentes, niveles y efectos de la contaminación marina el Perú, Programa de las aciones Unidas para el Medio Ambiente, <u>Fuentes, niveles y efectos de la contaminación marina en el Pacífico Sudeste</u>, Informes y Estudios del Programa de Mares Regionales del PNUMA, Nº 21, Preparado en colaboración con la Comisión Permanente del Pacífico Sur, PNUMA 1983, p. 91, fishing industries which discharge their effluent directly to the sea.

f/ - Instituto Nacional de Pesca, quoted from República Oriental del Uruguay, Dirección General de Estadística y Censos, <u>Anuario estadístico. Uruguay, 1988</u>, Tables Nº 9.07 and 9.09, some plants are engaged in more than one activity.

L01 - fresh and chilled, L02 - frozen, L03 - dried and salted, L04 - smoked, L05 - canned, L06 - meal, L07 - oil, L08 - agar-agar, L09 - dehydration, L10 - algin, and L11 - carrageenan.
n/a - not available or not applicable.
* - exact location not available, assumed to be located on the coast.

Annex 6

FISH LANDINGS, BY COUNTRY AND REGION
(Thousands of tons)

ARGENTINA: PRODUCTION OF FISH AND MOLLUSCS, BY ZONES a/

Zone	1980	1981	1982	1983	1984	Average	(%)
Marine and coastal areas							
- Altura	291.3	268.2	375.9	331.2	259.5	305.2	78.1
- Mar del Plata	61.0	64.8	66.7	55.6	38.2	57.3	14.7
- Quequén	4.2	5.0	5.2	3.3	1.9	3.9	1.0
- San Antonio Oeste	17.4	8.8	5.8	5.8	3.1	8.2	2.1
- Other	3.0	5.1	6.1	5.9	2.8	4.6	1.2
Sub-total	376.9	351.9	459.6	401.8	305.5	379.1	97.1
Rivers and lakes							
Río de la Plata	1.3	0.1	5.3	6.1	0.4	2.6	0.7
Lagoons	0.5	0.3	0.3	-	-	0.2	0.1
Río Paraná	4.9	4.8	8.4	8.2	8.7	7.0	1.8
Other	1.7	4.5	1.4	0.3	0.2	1.6	0.4
Sub-total	8.4	9.7	15.4	14.6	9.3	11.5	2.9
TOTAL	385.3	361.6	475.0	416.4	314.8	390.6	100.0

BRAZIL: FISH PRODUCTION, BY REGIONS AND STATES b/

Region	Federal entity	1983	1984	1985	Average	(%)
North	Acre	2.619	3.449	3.089	3.052	0.3
	Amapá	3.661	3.479	4.142	3.761	0.4
	Amazonas	38.213	56.076	46.611	46.967	5.0
	Pará	107.899	89.867	93.786	97.184	10.4
	Rondônia	2.491	2.196	2.040	2.242	0.2
	Roraima	117	73	71	87	-
	Sub-total	155.000	155.140	149.739	153.293	16.4
Northeast	Alagoas	3.967	5.559	6.302	5.276	0.6
	Bahia	38.779	41.770	37.605	39.385	4.2
	Ceará	31.119	39.286	49.607	40.004	4.3
	Maranhão	89.365	75.894	71.501	78.920	8.4
	Paraíba	7.454	8.825	9.605	8.628	0.9
	Pernambuco	6.292	6.604	7.439	6.778	0.7
	Piauí	2.880	3.816	5.425	4.040	0.4
	Rio Grande do Norte	9.973	11.565	12.309	11.282	1.2
	Sergipe	4.337	4.930	4.457	4.575	0.5
	Sub-total	194.166	198.249	204.250	198.888	21.2
South	Paraná	2.734	4.064	4.132	3.643	0.4
	Rio Grande do Sul	82.249	79.197	96.885	86.110	9.2
	Santa Catarina	140.033	172.541	167.005	159.860	17.1
	Sub-total	225.016	255.802	268.022	249.613	26.6

Annex 6 (cont. 1)

Region	Federal entity	1983	1984	1985	Average	(%)
Southeast	Espírito Santo	7.526	7.845	16.211	10.527	1.1
	Minas Gerais	5.546	8.599	7.922	7.356	0.8
	Rio de Janeiro	161.871	181.662	201.078	181.537	19.4
	São Paulo	120.962	143.112	113.838	125.971	13.4
	Sub-total	295.905	341.218	339.049	325.391	34.7
Centre-west	Mato Grosso do Sul	2.196	2.017	1.825	2.013	0.2
	Mato Grosso	6.963	5.264	7.339	6.522	0.7
	Goiás	1.340	1.160	1.213	1.238	0.1
	Federal District	110	60	100	90	-
	Sub-total	10.609	8.501	10.477	9.862	1.1
TOTAL		880.696	958.910	971.537	937.048	100.0

CHILE: PRODUCTION OF FISH MEAL AND OIL, 1989 c/

Region	Location	Fish meal	Fish oils
Region I	Arica	203.809	38.291
	Sub-total	203.809	38.291
Region II	Iquique	355.388	59.131
	Mejillones	102.005	18.729
	Tocopilla	94.683	15.230
	Sub-total	552.076	93.090
Region III	Caldera	46.170	4.813
	Chanaral	n/a	n/a
	Sub-total	46.170	4.813
Region IV	Coquimbo	20.748	2.969
	Sub-total	20.748	2.969
Region V	Quintero	n/a	n/a
	San Antonio	n/a	n/a
	Valparaiso	n/a	n/a
	Sub-total	n/a	n/a
Region VIII	Coronel	132.527	29.223
	Talcahuano	372.839	87.641
	Tome	6.465	1.489
	Sub-total	511.831	118.353
Region X	Calbuco	n/a	n/a
	Valdivia	n/a	n/a
	Sub-total	n/a	n/a
TOTAL		1 334.634	257.516

Annex 6 (cont. 2)

COLOMBIA: INDUSTRIAL AND ARTISANAL FISHERY PRODUCTION, BY ZONES d/

	Industrial and artisanal production (tons)			Distribution of production, by zones (%)		
	1975	1980	1985	1975	1980	1985
Atlantic Ocean	11.033	5.115	10.623	16.6	6.7	15.1
Pacific Ocean	13.387	24.179	12.444	20.1	31.7	17.7
Inland waters	42.075	46.903	47.368	63.3	61.6	67.3
TOTAL	66.495	76.197	70.435	100.0	100.0	100.0

MEXICO: VOLUME OF FISH PRODUCTION BY STATES, 1985-1989 e/

Federative entities	1985	1986	1987	1988	1989	Average	(%)
Pacific coast							
Baja California	283.5	263.3	302.2	231.8	270.0	270.2	19.3
Baja California Sur	67.1	67.2	69.3	90.3	104.0	79.6	5.7
Sonora	345.7	440.9	468.1	437.1	500.0	438.4	31.3
Sinaloa	124.4	142.3	141.6	141.9	150.0	140.0	10.0
Nayarit	15.9	12.5	14.2	15.4	19.0	15.4	1.1
Jalisco	10.8	20.1	22.6	22.3	24.0	20.0	1.4
Colima	6.4	8.1	6.6	7.4	6.5	7.0	0.5
Michoacán	29.0	35.3	44.6	41.0	45.0	39.0	2.8
Guerrero	14.7	17.2	16.8	17.7	19.0	17.1	1.2
Oaxaca	11.5	18.7	16.4	14.6	15.0	15.2	1.1
Chiapas	16.4	14.1	15.6	18.9	20.0	17.0	1.2
Sub-total	925.4	1 039.7	1 118.0	1 038.4	1 172.5	1 058.9	75.5
Caribbean and Gulf coasts							
Tamaulipas	50.2	43.5	52.2	54.4	54.0	50.9	3.6
Veracruz	103.4	101.3	108.8	119.5	122.0	111.0	7.9
Tabasco	33.6	29.5	33.0	31.1	37.0	32.8	2.3
Campeche	72.3	67.3	67.7	65.9	66.0	67.8	4.8
Yucatán	35.1	36.2	35.2	34.1	36.0	35.3	2.5
Quintana Roo	5.8	5.6	6.3	4.9	5.5	5.6	0.4
Sub-total	300.4	283.4	303.2	309.9	320.5	303.4	21.6
Land-locked entities							
Aguascalientes	1.2	2.0	1.8	1.9	1.2	1.6	0.1
Coahuila	1.5	1.7	2.4	2.3	2.5	2.1	0.1
Chihuahua	0.6	0.7	1.1	0.7	1.2	0.9	0.1
Distrito Federal	-	-	-	-	-	-	-
Durango	2.8	3.1	3.8	3.7	4.0	3.5	0.2
Guanajuato	2.1	4.3	5.4	6.3	5.3	4.7	0.3
Hidalgo	4.1	3.8	4.2	3.8	3.0	3.8	0.3
México Edo.	11.2	10.6	12.1	13.0	11.5	11.7	0.8
Morelos	0.7	0.8	2.3	2.8	2.3	1.8	0.1
Nuevo León	0.4	0.4	0.4	0.4	0.4	0.4	-
Puebla	1.6	2.7	2.8	3.2	3.6	2.8	0.2
Querétaro	0.9	0.2	2.3	2.4	2.5	1.7	0.1
San Luis Potosí	1.8	1.9	1.9	1.9	1.7	1.8	0.1
Tlaxcala	0.7	1.1	1.6	1.5	1.0	1.2	0.1
Zacatecas	0.5	0.6	1.5	2.0	1.8	1.3	0.1
Sub-total	30.1	33.9	43.6	45.9	42.0	39.3	2.8

Annex 6 (cont. 3)

Federative entities	1985	1986	1987	1988	1989	Average	(%)
TOTAL	1 255.9	1 357.0	1 464.8	1 394.2	1 535.0	1 401.6	100.0

PERU: FISH LANDINGS, BY DEPARTMENTS f/

Departments	Landings of principal marine species for human consumption						
	1984	1985	1986	1987	1988	Average	(%)
Ancash	1 546	2 179	3 356	2 091	3 100	2 454	52.5
Arequipa	69	17	111	120	150	93	2.0
Ica	397	302	356	633	750	488	10.4
La Libertad	29	3	50	105	100	57	1.2
Lambayeque	88	60	32	35	50	53	1.1
Lima	338	326	792	824	850	626	13.4
Moquegua	286	535	280	259	250	322	6.9
Piura	369	538	496	436	550	478	10.2
Tumbes	9	10	13	13	14	12	0.3
Other	4	3	7	5	3	4	0.1
Ship factories	153	137	37	27	66	84	1.8
TOTAL	3 288	4 110	5 530	4 548	5 883	4 672	100.0

Departments	Landings of anchovy for fish meal production						
	1984	1985	1986	1987	1988	Average	(%)
Ancash	-	503	2 210	452	1 110	855	47.1
Arequipa	2	2	73	85	110	54	3.0
Ica	-	150	305	588	830	375	20.6
La Libertad	-	2	44	1	1	10	0.5
Lambayeque	-	-	-	-	-	-	-
Lima	2	42	624	467	720	371	20.4
Moquegua	19	145	226	171	200	152	8.4
Piura	-	-	-	-	-	-	-
Tumbes	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-
Ship factories	-	-	-	-	-	-	-
TOTAL	23	844	3 482	1 764	2 971	1 817	100.0

VENEZUELA: FRESH FISH LANDED, BY STATES g/

Federal entity	1987	(%)
Federal district	1.912	0.7
States		
- Anzoategui	6.903	2.4
- Apure	8.053	2.8
- Aragua	643	0.2
- Barinas	2.222	0.8
- Bolivar	2.850	1.0
- Carabobo	579	0.2

Annex 6 (conclusion).

Federal entity	1987	(%)
- Cojedes	194	0.1
- Falcon	29.420	10.1
- Guarico	5.291	1.8
- Lara	-	-
- Merida	321	0.1
- Miranda	1.139	0.4
- Monagas	5.239	1.8
- Nueva Esparta	38.665	13.3
- Portuguesa	944	0.3
- Sucre	152.460	52.5
- Tachira	1.333	0.5
- Trujillo	231	0.1
- Yaracuy	-	-
- Zulia	29.601	10.2
Federal territories		
- Amazonas	429	0.1
- Delta Amacuro	2.133	0.7
TOTAL	290.562	100.0

Source: a/ - República Argentina, Presidencia de la Nación, Secretaría de Planificación, Instituto Nacional de Estadística y Censos, República Argentina. Anuario estadístico. 1983-1986, p. 344.
b/ - Secretaria de Planejamento e Coordinação da Presidência da República, Fundação Instituto Brasileiro de Geografia e Estatística, Anuário 1986 estatístivo do Brasil, 2[a] edição, Rio de Janeiro, 1987, p. 296; including aquatic mammals.
c/ - Sistema de Información Pesquera, Boletín de Estadísticas Nº 10, Diciembre 1989, CORFO-IFOP, 1989.
d/ - República de Colombia, Departamento Administrativo Nacional de Estadística, Colombia. Estadística 1989. Vol.II Municipal, pp. 655-656.
e/ - Secretaría de la Presidencia de la República, Primer informe de Gobierno 1989, quoted from D.R. Nacional Financiera, S.N.C., La economía Mexicana en cifras, 1990, pp. 223-224, figures for 1989 are estimates, landings in Baja California, Baja California Sur and Sinaloa include landings in foreign ports.
f/ - Ministerio de Pesquería, Oficina de Presupuesto y Planificación, Oficina de Estadística, quoted from Instituto Nacional de Estadística, Perú: compendio estadístico 1988, Lima, July 1989, pp. 291-292, 1988 figures are provisional.
g/ - Ministerio de Agricultura y Cría, quoted from República de Venezuela, Presidencia de la República, Oficina Central de Estadística e Informática, Anuario estadístico de Venezuela. 1987, p. 293.

Note: The discrepancy in some totals is due to approximations in the decimal fractions.
n/a - information not available.

Annex 7

FISHING AND QUALITY STANDARDS FOR SURFACE WATERS

	Dissolved oxygen, minimum allowable (mg/l)	Solids allowable		Coliforms maximum allowable per 100 ml
		Dissolved (mg/l)	Other	
Fish propagation and wildlife	4.0 to 6.0 a/	None	No floating solids or settleable solids that form deposits	Mean of 5 000
Shellfish harvesting	4.0 to 6.0 b/	None		Mean of 70 c/

Source: Mark J. Hammer, Water and waste-water technology, 1975, John Wiley & Sons, Inc., p. 149.

a/ - depending on warm or cold water fishes, fresh water or saltwater;
b/ - depending on local conditions;
c/ - with no more than 10% of samples exceeding 230 coliforms per 100 ml.

Annex 8

WATER QUALITY FOR AQUATIC LIFE

Determination	Unit	Threshold concentration a/	
		Freshwater	Saltwater
Total dissolved solids	mg/l	2 000 b/	-
Electrical conductivity	µmhos/cm 25°C	3 000 b/	-
Temperature, maximum	°C	34	34
- for salmonid fish	°C	23	23
Range of pH	pH	6.5-8.5	6.5-9.0
Dissolved oxygen, minimum	mg/l	5.04 c/	5.04 c/
Floatable oil and grease	mg/l	0	0
Emulsified oil and grease	mg/l	10	10
Detergent, ABS	mg/l	2.0	2.0
Ammonia (free)	mg/l	0.5 b/	-
Arsenic	mg/l	1.0 b/	1.0 b/
Barium	mg/l	5.0 b/	-
Cadmium	mg/l	0.01 b/	-
Carbon dioxide (free)	mg/l	1.0	-
Chlorine (free)	mg/l	0.02	-
Chromium, hexavalent	mg/l	0.05 b/	0.05 b/
Copper	mg/l	0.02 b/	0.02 b/
Cyanide	mg/l	0.02 b/	0.02 b/
Fluoride	mg/l	1.5 b/	1.5 b/
Lead	mg/l	0.1 b/	0.1 b/
Mercury	mg/l	0.01	0.01
Nickel	mg/l	0.05 b/	-
Phenolic compounds, as phenol	mg/l	1.0	-
Silver	mg/l	0.01	0.01
Sulfide, dissolved	mg/l	0.5 b/	0.5 b/
Zinc	mg/l	0.1	-

Source: McGauhey, P.H., Engineering management of water quality, McGraw-Hill, New York, 1968; and McKee, J.W., and H.W. Wolf, Water quality criteria, 2nd ed., California State Water Quality Control Board, Sacramento, Calif., 1963, quoted from Urban stormwater hydrology, Water Resources Monograph 7, David F. Kibler, editor, American Geophysical Union, Washington, D.C., 1982, pp. 166 and 187.

a/ - Threshold concentration is the value that normally might not be deleterious to fish life. Waters that do not exceed these values should be suitable habitats for mixed fauna and flora.

b/ - Values not to be exceeded more than 20% of any 20 consecutive samples, nor in any 3 consecutive samples. Other values should never be exceeded. Frequency of sampling should be specified.

c/ - Dissolved oxygen concentrations should not fall below 5.0 mg/l more than 20% of the time and never below 2.0 mg/l.

Annex 9

COASTAL WATER STANDARDS FOR FISHING AND ENVIRONMENTAL CONSERVATION

Purpose of utilization	Hydrogen ion exponent (pH)	COD a/ (ppm)	Dissolved oxygen (ppm)	Coliforms b/ (MPN/100 ml)	N-hexane extracts c/
- Fishery d/	7.8 - 8.3	3 or less	5 or more	e/	not detectable
- Conservation of environment	7.0 - 8.3	8 or less	2 or more	n/a	n/a

Source: Y. Kimura, Marine water quality standards, Environmental Engineering Course, Japan Society of Water Pollution Research, 1982, quoted from United Nations, Economic and Social Commission for Asia and the Pacific, Marine environmental problems and issues in the ESCAP region, Proceedings of the Regional Technical Workshop on the Protection of the Marine Environment and Related Ecosystems, Asian Institute of Technology, 20-28 February 1985, ST/ESCAP/349, Bangkok, Thailand, June, 1985, p. 143.

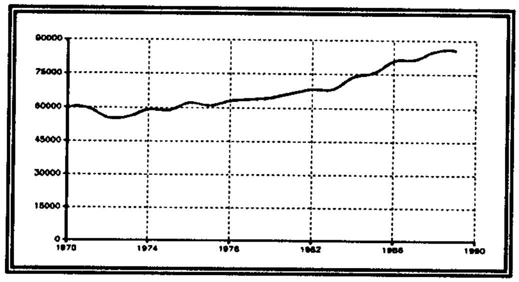
ppm - parts per million;
a/ - chemical oxygen demand;
b/ - number of coliform groups (most probable number (MPN) per 100 ml);
c/ - oil content, etc.;
d/ - includes conservation of environment and industrial water use;
e/ - the standard value adopted for culture farms of oysters to be served raw is set at 70 (page 143).

Annex 10

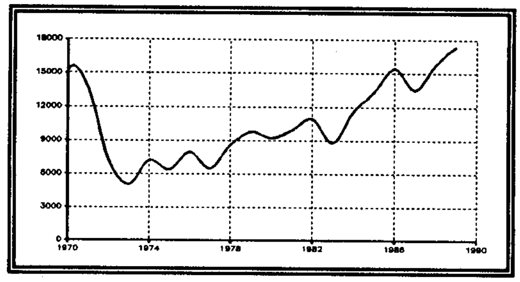
SUMMARY OF RELEVANT STATISTICS, SELECTED AREAS AND COUNTRIES, 1970-1989

A. Nominal catch of fish, crustaceans, molluscs, etc. in marine fishing areas

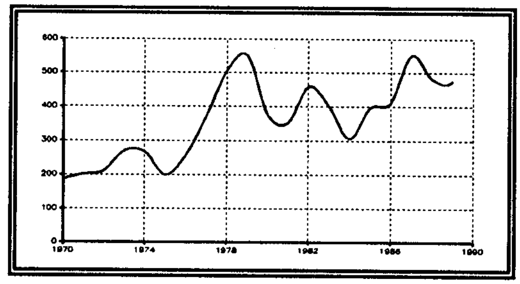
World	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	85 757.9	63 736.1	85 757.9
Minimum	55 451.4	55 451.4	64 515.8
Average	67 463.1	59 827.5	75 098.6
Growth rate (%) a/	1.9	0.8	3.0



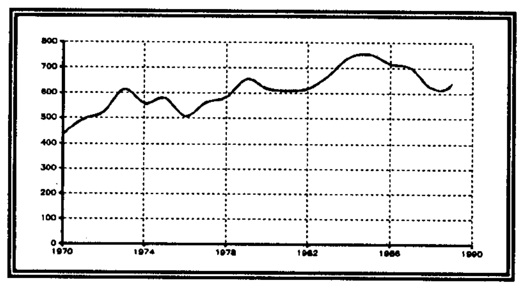
Latin America and the Caribbean	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	17 359.1	15 198.8	17 359.1
Minimum	5 026.5	5 026.5	8 784.0
Average	10 670.8	8 752.1	12 589.5
Growth rate (%) a/	0.7	-4.8	5.9



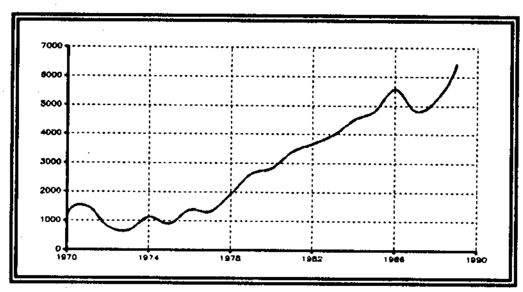
Argentina	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	551.6	551.6	551.5
Minimum	186.1	186.1	305.5
Average	361.5	301.7	421.4
Growth rate (%) a/	5.1	12.8	-1.5



Brazil	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	755.7	656.3	755.7
Minimum	432.7	432.7	611.5
Average	610.7	551.2	670.2
Growth rate (%) a/	2.1	4.7	-0.3

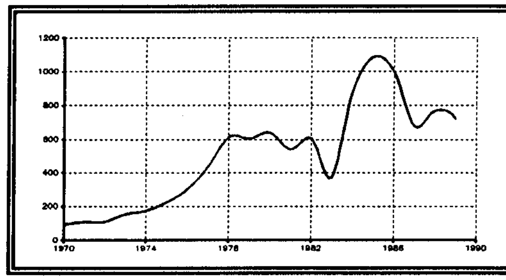


Chile	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	6 452.2	2 630.3	6 452.2
Minimum	667.7	667.7	2 816.7
Average	2 932.2	1 343.5	4 520.9
Growth rate (%) a/	9.3	9.1	9.4

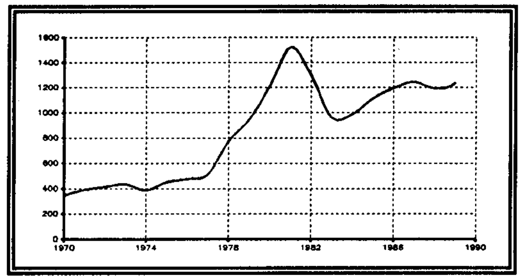


Annex 10 (cont. 1)

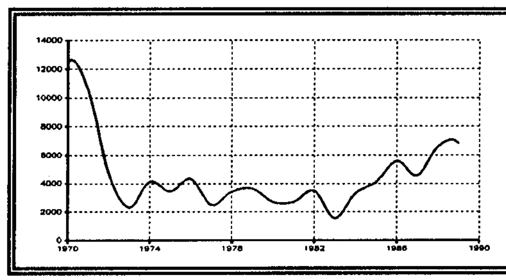
Ecuador	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	1 086.1	614.3	1 086.1
Minimum	91.4	91.4	371.0
Average	505.3	281.0	729.6
Growth rate (%) a/	11.5	23.4	1.8



Mexico	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	1 521.2	948.4	1 521.2
Minimum	344.1	344.1	964.1
Average	855.4	513.2	1 197.6
Growth rate (%) a/	7.0	11.9	2.7

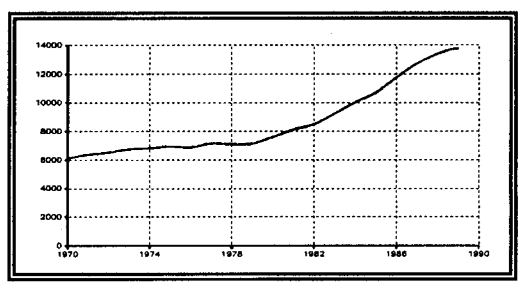


Peru	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	12 532.9	12 532.9	6 815.4
Minimum	1 536.5	2 323.2	1 536.5
Average	4 647.2	5 157.8	4 136.6
Growth rate (%) a/	-3.2	-12.8	6.5

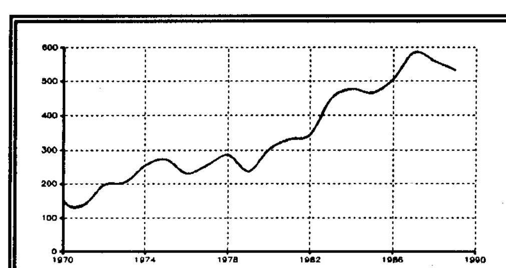


B. Nominal catch of fish, crustaceans, molluscs, etc. in inland waters

World	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	13 776.7	7 170.6	13 776.7
Minimum	6 087.8	6 087.8	7 616.2
Average	8 689.2	6 790.6	10 587.7
Growth rate (%) a/	4.4	1.8	6.8

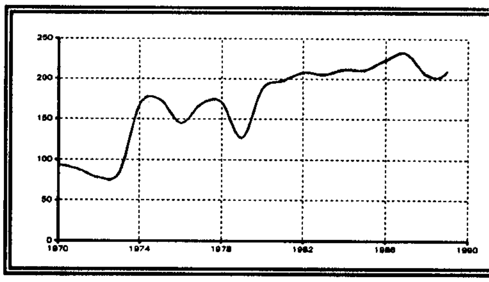


Latin America and the Caribbean	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	585.1	285.7	585.1
Minimum	137.5	137.5	302.1
Average	338.9	222.5	455.2
Growth rate (%) a/	6.8	5.0	8.4

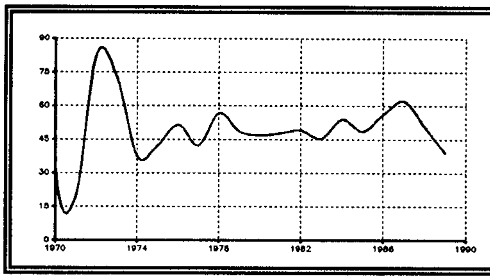


Annex 10 (cont. 2)

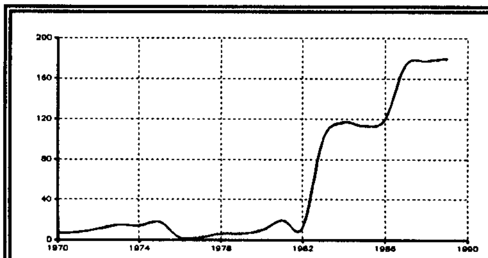
Brazil	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	232.2	173.5	232.2
Minimum	77.8	77.8	187.6
Average	169.4	129.6	209.2
Growth rate (%) a/	4.4	3.4	5.2



Colombia	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	82.8	82.8	62.1
Minimum	19.3	19.3	38.8
Average	49.3	48.6	49.9
Growth rate (%) a/	0.8	4.3	-2.2

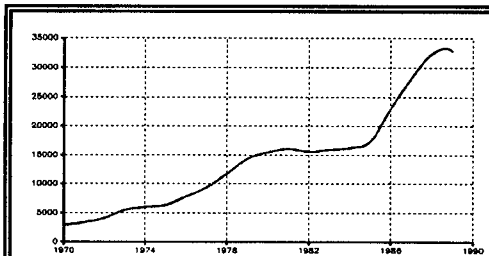


Mexico	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	179.7	17.8	179.7
Minimum	2.3	2.3	9.8
Average	55.7	9.1	102.3
Growth rate (%) a/	18.4	-1.2	39.4

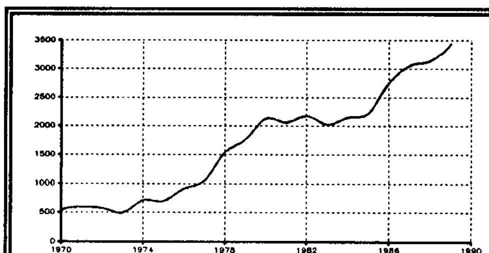


C. Exports of fishery commodities

World	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	32 786.7	14 342.8	32 786.7
Minimum	2 944.7	2 944.7	15 494.1
Average	14 243.2	7 174.1	21 312.3
Growth rate (%) a/	13.5	19.2	8.6

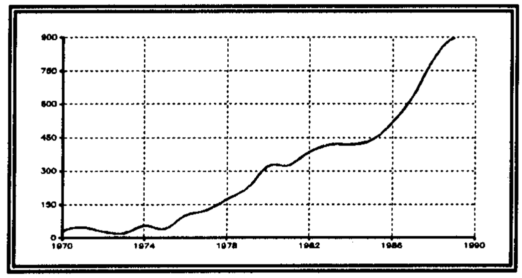


Latin America and the Caribbean	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	3 446.6	1 759.5	3 446.6
Minimum	494.6	494.6	2 028.1
Average	1 702.3	887.3	2 517.4
Growth rate (%) a/	10.2	13.9	7.0

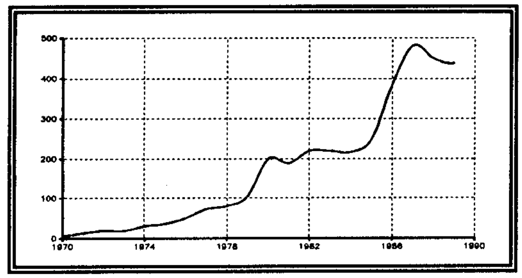


Annex 10 (cont. 3)

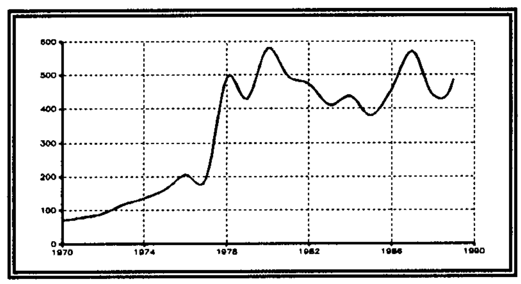
Chile	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	895.8	225.2	895.8
Minimum	19.8	19.8	323.0
Average	300.2	83.9	516.5
Growth rate (%) a/	20.2	26.4	14.8



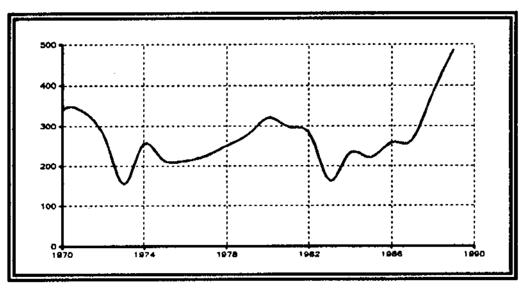
Ecuador	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	481.0	104.4	481.0
Minimum	5.5	5.5	188.8
Average	173.8	43.3	304.4
Growth rate (%) a/	25.9	38.7	15.4



Mexico	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	580.0	490.4	580.0
Minimum	71.5	71.5	378.3
Average	334.8	197.1	472.5
Growth rate (%) a/	10.6	22.0	1.2

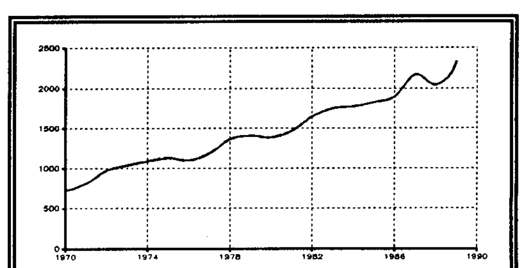


Peru	Millions of US dollars		
	1970-1989	1970-1979	1980-1989
Maximum	486.5	339.2	486.5
Minimum	155.1	155.1	163.4
Average	273.0	254.8	291.1
Growth rate (%) a/	1.9	-2.2	5.8



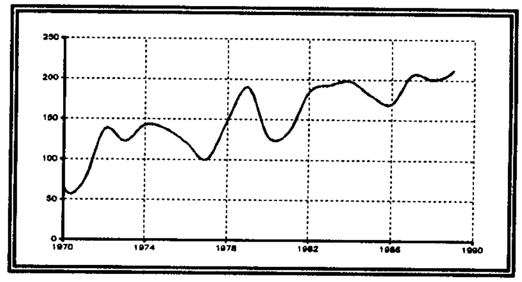
C. Production of fresh, frozen, dried, salted, etc. crustaceans and molluscs

World	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	2 335.7	1 405.9	2 335.7
Minimum	730.0	730.0	1 385.1
Average	1 456.0	1 082.1	1 829.9
Growth rate (%) a/	6.3	7.6	5.2

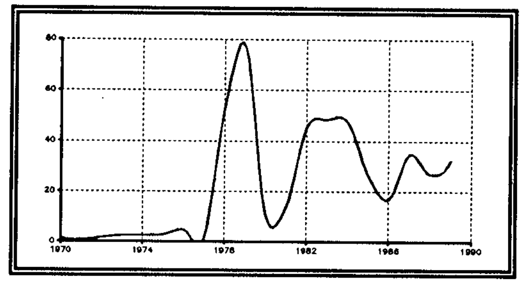


Annex 10 (cont. 4)

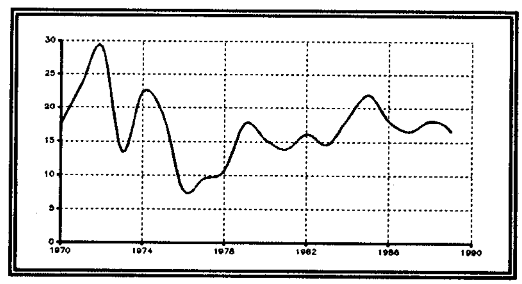
Latin America and the Caribbean	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	212.2	190.1	212.2
Minimum	65.7	65.7	128.5
Average	152.2	123.7	180.7
Growth rate (%) a/	6.4	12.5	1.1



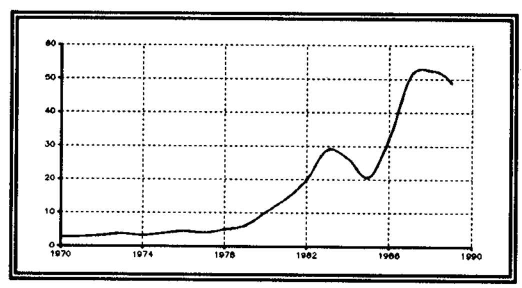
Argentina	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	77.3	77.3	48.4
Minimum	0.8	0.8	11.0
Average	22.5	14.8	30.3
Growth rate (%) a/	18.5	57.4	-8.3



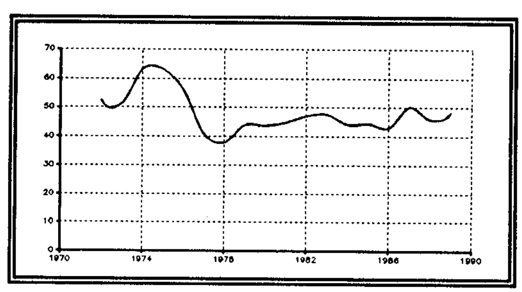
Brazil	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	29.2	29.2	22.0
Minimum	7.8	7.8	13.9
Average	17.0	17.1	17.0
Growth rate (%) a/	-0.3	0.1	-0.7



Ecuador	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	52.5	6.2	52.5
Minimum	2.8	2.8	10.1
Average	17.2	4.0	30.4
Growth rate (%) a/	16.2	9.2	22.9



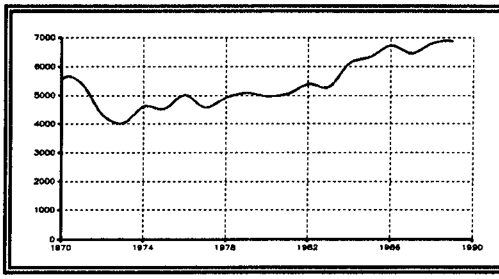
Mexico b/	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	63.1	63.1	50.2
Minimum	37.9	37.9	43.0
Average	48.2	51.1	45.9
Growth rate (%) a/	-0.5	-2.5	1.0



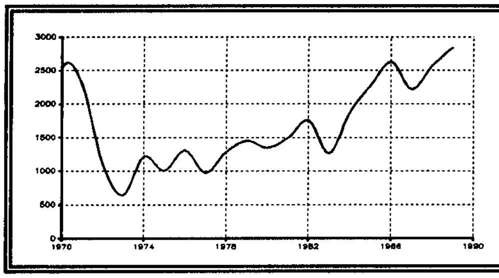
Annex 10 (conclusion)

D. Production of meals, solubles and similar animal feedingstuffs of aquatic animal origin

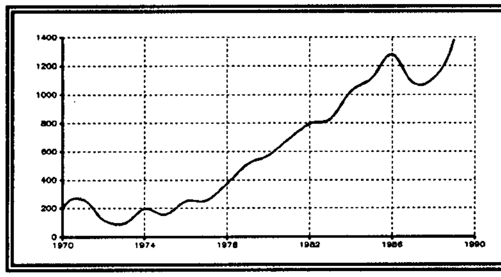
World	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	6 877.7	5 540.0	6 877.7
Minimum	4 030.0	4 030.0	4 972.8
Average	5 403.7	4 802.8	6 004.6
Growth rate (%) a/	1.1	-0.9	3.1



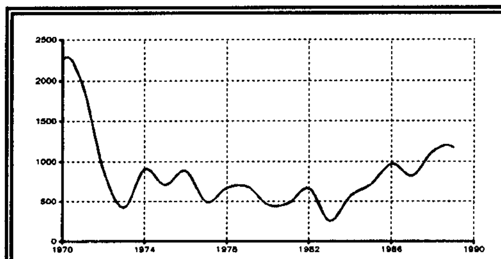
Latin America and the Caribbean	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	2 847.0	2 524.7	2 847.0
Minimum	639.4	639.4	1 260.3
Average	1 702.7	1 377.7	2 027.7
Growth rate (%) a/	0.6	-6.0	7.0



Chile	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	1 381.2	512.6	1 381.2
Minimum	93.3	93.3	571.9
Average	614.7	241.8	987.5
Growth rate (%) a/	10.8	11.2	10.4



Peru	Thousands of tons		
	1970-1989	1970-1979	1980-1989
Maximum	2 255.8	2 255.8	1 169.2
Minimum	251.7	423.0	251.7
Average	854.7	986.4	722.9
Growth rate (%) a/	-3.4	-12.4	5.4



Source: Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Catches and landings, Rome, various years; and Food and Agriculture Organization (FAO) of the United Nations, FAO yearbook. Fishery statistics. Commodities, Rome, various years.

Note: This annex is based on the latest available information which may differ from that in the main text, tables, figures and other annexes.
a/ - average annual growth rate has been calculates as a geometric mean.
b/ - data for 1970 and 1971 have not been available.