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Analysis of Chilean Fisheries Expansion Alternatives

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ANALYSIS OF CHILEAN FISHERIES
EXPANSION ALTERNATIVES

By
LUIS ALBERTO ADRIASOLA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
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1976

DOCTOR OF PHILOSOPHY DISSERTATION

OF

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ABSTRACT

This dissertation investigates the expansion of the Chilean fisheries focusing on the processing and marketing activities for seven fish species that represent over 90% of the catch and for two groups of the remaining fish species. A review is made of the current condition of the Chilean fisheries, its expansion potential and some possible expansion alternatives. It is established that there exists an ample potential for the expansion of the catch and physical production of fishery commodities. A model is developed to characterize the economic system formed by the fisheries extractive and related activities and assess the profitability of investment under different expansion alternatives. This model includes (a) the random generation of a catch, that is normally distributed, for 9 fish species or groups of fish species; (b) the optimal allocation of fish harvested to 25 fish processing and 125 marketing activities, by means of a separable programming model that simulates the behavior of fish processors and distributors in the country's five fishing zones. The results of the model of the fishery economic system indicate static rates of return on investment in the different zones and determines the intertemporal internal rate of return for the investment in different zones.

The major conclusion of the study is that it is economically feasible to expand the output of both processed and unprocessed fishery commodities, particularly in Zone II.

The study concludes with a discussion of future directions for research, including improvement of the quality of the basic data used, and to a lesser degree refinement of the model, to improve the accuracy and reliability of the results.

To my parents,

my wife

and

our children

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INTRODUCTION

The current state of the Chilean fisheries, as characterized by its performance since 1965, gives a clear indication that its development is at a point of stagnation. This poses an important challenge to this nation of over 10,000,000 inhabitants, where, despite the access to marine food resources, a significant part of the population suffers from some degree of malnutrition.

An indication of the evolution of the primary fishing activities in Chile is presented in Figure 1 and Table 1. It shows that until 1960 the average yearly catch did not exceed 300,000 metric tons. Spurred by the success of the Peruvian anchoveta fisheries, and by incentives provided by the Chilean government, mainly in the form of tariffs and tax exemptions and subsidized credits, a number of enterprises, both publicly and privately owned, started the exploitation of the anchoveta resource off the Chilean coast. As a result of this effort the sector had an explosive rate of physical growth of nearly 35% per year during the period between 1960 and 1965. After 1965, and during the last ten years, the Chilean catch has fluctuated around 1,000,000 metric tons, giving the impression that the limit of the sustainable yield of Chilean fishery resources has been reached.

Contrasting with this evidence are the findings of stock assessment research carried out by the Instituto de Fomento Pesquero (IFOP), the national agency in charge of these investigations, that

Figure 1 Chilean Landings of Fish and Shellfish

Source: Servicio Agrícola y Ganadero, Division de Caza y Pesca

Table 1 Chilean Landings, 1930-1974, in Metric Tons of Fish and Shellfish

Year	Fish	Shellfish	Total or Average Landings per Year
1930-34	15,573	7,748	23,321
1935-39	26,097	7,393	33,490
1940-44	28,044	9,607	37,651
1945-59	45,180	16,621	61,801
1950-54	85,647	24,011	109,658
1955-59	173,846	43,976	222,832
1960	304,666	35,037	339,703
1961	338,810	40,932	429,751
1962	586,434	52,129	638,563
1963	705,682	56,538	762,220
1964	1,093,561	67,703	1,161,264
1965	642,957	65,782	708,739
1966	1,309,139	74,270	1,383,409
1967	969,011	83,814	1,052,825
1968	1,291,041	84,845	1,375,886
1969	1,009,840	85,309	1,095,149
1970	1,082,252	99,069	1,181,821
1971	1,389,022	97,901	1,483,923
1972	690,407	101,496	791,903
1973	581,417	82,593	664,010
1974	1,047,808	80,432	1,128,240

Source: SAG, Division de Pesca.

estimate the maximum sustainable yield (M.S.Y.) of the Chilean fisheries at 2,000,000 metric tons per year.¹ Arguments are made for the expansion of the Chilean fisheries based on this evidence. The fact that expansion has not come about is used as grounds to contend that either the physical potential does not really exist or is not by itself enough to make the expansion of the fisheries sector as attractive as the expansion of other sectors of the economy.

The Chilean government, accepting IFOP's estimates of available resources, has postulated the following objectives for fisheries development:²

- (1) to make the fisheries (a) a source of sustained food reserves for the country (b) an important factor of the national economy that may permit the satisfaction of the basic needs of a constantly increasing (domestic) population and may contribute to the solution of the world food crisis.

Towards this end, the utilization of current catches must be

1

Oscar F. Guzmán "Situación y Perspectivas de la Explotación de los Principales Recursos Pesqueros de Chile", in Seminario Sobre las Perspectivas de Desarrollo del Sector Pesquero Chileno, Viña del Mar, Septiembre 1974, Asociación de Profesionales Pesqueros de Chile, Escuela de Pesquerías y Alimentos, Universidad Católica de Valparaíso, 1975.

2

José T. Merino "Política Pesquera Nacional", issued at the inauguration of the Month of the Sea, San Vicente, Talcahuano, May 5, 1975. Printed by Instituto de Fomento Pesquero, Santiago, 1975 (author's translation).

improved and subsequently the extraction of currently exploited species increased rationally in the cases where this is possible and the exploitation of potential resources and culture must be encouraged.

(2) to expand the per capita consumption of fishery products as a solution to the food and nutrition problem of the (domestic) population, through campaigns to promote the consumption of these products, in fresh or processed form.

(3) to make a positive impact on the balance of trade, generating a market for Chilean fishery products of quality standards that are internationally accepted.

(4) to generate significant employment opportunities, through the establishment of units linked to the marine and continental fisheries that are effectively productive.

The State, through its pertinent agencies, will have the responsibility to (a) insure a rational exploitation of the fishery resources, (b) direct and supervise the development of the sector, (c) plan fisheries economic activity giving due consideration to the right of private activity but will not accept that the renewable natural resources be irrationally exploited.

The above stated objectives may be summarized as:

1. The maximization of the sustained production of food from fishery resources, both for internal consumption as

well as exports;

2. The maximization of productive employment opportunities for the population.

These two goals are different and are not normally reached simultaneously. Under the current condition of the Chilean economy, however, there appears to exist a relative abundance of labor, making the second objective not inconsistent with the first. The relative abundance of natural resources on the other hand permits the achievement of both objectives at a relatively low opportunity cost to the national economy.

Clearly though, even after accepting IFOP's assessment of potential physical yields, there remain questions to be answered concerning the economic feasibility of expanding the production of fishery commodities, and on the implications of that expansion. This study will seek to answer two of the most important among these questions, i. e., (1) Whether there exists, in economic terms, a potential for fisheries development in Chile, and (2) What are some of the implications of the expansion of the fisheries output.

To assess the economic potential, the fisheries economic system will be assumed to behave as if it were maximizing profits, knowing fully well it may not be entirely so, as in reality the system is mixed, and the net revenues associated with that behavior will be evaluated.

The internal rate of return on investment and the net benefit

to the economy will be used to evaluate alternative approaches to the expansion of the sector. A limited set of alternatives including

- a) the current conditions
- b) expanded fresh and fishmeal capacities
- c) expanded fresh, frozen, canning and fishmeal capacities

will be used to test the performance of the system under an expanded catch of marine fish species which may be as large as twice the current catch.

The first Chapter of this study includes a review of the current situation of the Chilean fisheries, an examination of the limits that constrain fisheries expansion, and the outline of two expansion alternatives. Chapter II presents a methodology of analysis to be used to evaluate the performance of the fisheries economic system under the expanded catch. Chapter III presents the results of the analysis performed and Chapter IV, the conclusions and a discussion of their implications and policy ramifications.

CHAPTER I

THE CHILEAN FISHERIES: A CASE FOR DEVELOPMENT

The development of a fisheries requires the consideration of a number of factors. The most important are:

- a) the approximate location and abundance of resources and the nature of their exploitation. These factors determine the characteristics and size of the fleet required for their extraction.
- b) the nature of the marketing system and the alternative adjustments required from it to absorb the increased catch.

The objectives of this Chapter are to describe the Chilean fisheries and related activities, to characterize the operation of these activities in an economic system, and to outline alternatives for the expansion of the contribution of the sector to the national economy.

1. The Chilean Fishery Resources.

Chile has over 2,500 miles of mainland sea coast, and claims a 200-mile fishery zone. Although the narrowness of the continental shelf off the Chilean coast limits in part the productivity of the primary fishing activity, it is still considerable enough to place Chile among the ten major fishing nations of the world.

The vast physical extent to the Chilean fishing grounds can be divided into six zones. These are shown in Figure 2. The first fishing zone runs from the border with Perú to south of Taltal and includes the ports of Arica, Iquique, Tocopilla, Mejillones,

Figure 2 Chilean Fishery Zones I to VI.

Source: Patricio Arana "Investigación Pesquera en Chile," in Seminario sobre Perspectivas, p. 87.

Antofagasta, and Taltal. The main conventional resources in this zone are the pelagic species -- anchoveta (engraulins ringen - anchovy), jurel (trachurus murphyi - mackerel), and sardina (strangomera benticki, sardinops sagax musica -- pilchard). Potential resources yet unexploited include mainly the agujilla species (scomberesox stolatus - saury), also a pelagic fish. The anchoveta and sardina resources of this zone have been heavily exploited over the past ten years.

The second fishery zone runs from south of the port of Taltal and includes the ports of Coquimbo and the fishing villages Guanaqueros and Tongoy. The main fishery resources under exploitation in this zone are again the pelagic species jurel, anchoveta and sardinas, although with a lower intensity. The agujilla species is available in greater concentration in this zone.

The third fishery zone runs from the fishing village of Los Vilos, about 150 miles south of Coquimbo, to the Golfo de Arauco, and includes the ports of Quintero, Valparaíso, San Antonio, Constitución, Tomé, Talcahuano, and San Vicente. Main resources in this zone, among the pelagic species, are anchoveta, jurel, sardina (clupea fueguensia - herring), and the demersal species merluza (merluccius gayi gayi - hake) and congrios (genypterus - cuskeel). Also important are the crustaceans camarón (heterocarpus reedi - shrimp) and langostino (pleuroncodes monodon). A characteristic of this zone is the openness of the sea, restricting bad weather fishing operations to sheltered waters for all but vessels of large

displacement. Even under this condition, the pressure on some species, particularly crustaceans, is fairly intense.

The fourth fishery zone runs from Golfo de Arauco to Puerto Montt and includes the ports of Valdivia, Corral, Puerto Montt, Ancud and Calbuco. The main species under exploitation in this area include the demersal species merluza and the variety of mollusks (ameghinomia antigua, mesoderma donacium - clams; mytilus edulis, aulacomya ater - mussels.). Unexploited species include mainly merluza de cola (macrurus magellanicus - grenadier). Climatic conditions in this zone are quite severe, and road access to the coast is not as available as in the northern and central zones.

The fifth fishery zone runs from the south of Ancud Island to the Golfo de Penas and includes mainly the port of Puerto Aguirre. The fisheries in this zone present a marked difference between the open seas and the sheltered waters. In the open seas, demersal species, led by the merluzas and congrios, are predominant, although there are also important pelagic resources of which the mackerels are the most important. While fishing operations in the open seas are often impeded by the severe weather, extractive activities in the waters of the channels and fiords can be carried out under almost any weather conditions even with small vessels. The resources found in sheltered waters are mainly shellfish - cholgas, choritos, almejas, etc., while the largest concentrations of merluza de cola are found in the open seas.

The sixth fishery zone runs from the Golfo de Penas to the Cabo de Hornos and includes the ports Puerto Natales, Punta Arenas and Porvenir. The open sea fishery resources in this zone are quite sparse, while the sheltered waters offer significant amounts of shellfish, mainly mussels.

The Antarctic waters provide little in the way of conventional resources, under climatic conditions that restrict fishing to the three summer months. In these waters, however, lies the most spectacular opportunity for the expansion of the world food supply in the krill (euphausia spp) a loose link in the food chain between plankton and the almost extinct whales. The maximum sustainable yield of this protein rich crustacean is variously assessed at 5¹ million metric tons per year for the resources in Chilean waters, to 100 million metric tons per year for those in the Antarctic waters² as a whole. The extractive as well as processing technology for the commercial exploitation of this fishery are still under development.

A list of the Chilean marine fish species is shown in Appendix A.

1

Guzmán, op. cit., p. 120.

2

Gordon Campleman, "Chile: The Last Frontier of Fisheries Expansion," Fishing News International, Vol. 14, No. 9, September 1975, p. 37.

2. The Extractive Activities.

Extractive operations are carried out at two different levels: the industrial and the artisanal. Industrial operations are characterized by the intense use of capital (i.e., large vessels, expensive fishing gear and electronic equipment for fish search and communications to shore, etc.), large scale of operation (volume fishing by trawling, purse seining, etc.), fairly advanced technology, and normally, a close association with fish processing facilities. Industrial fishing accounts for over 92% of the catch in the country. The set of activities related to each of these levels of operation are often referred to as the artisanal and industrial subsectors of the fisheries sector of the economy.

More than 240 industrial vessels operate out of the 22 fishing ports in the Chilean coast. The main characteristics of the industrial fleet are shown for each fishery zone in Table 2. Over 90% of the industrial catch goes to fish or crustacean meal production, and the rest to the production of commodities for direct human consumption either in canned or frozen form and not infrequently also to the fresh fish market.

Table 2 - Fleet Distribution - Industrial Sub Sector

Fishery Zone	Resources	Type of Fishing	No. of Vessels	Hold Capac. metric tons	Main Ports	State of Fleet
Norte Grande	Pelagic	Purse Seine	93	12,580	Arica Iquique Antofagasta	Good
Norte Chico	Pelagic	Purse Seine	7	580	Coquimbo Caldera	Good
Centro	Demersal Pelagic	Trawl Purse Seine	28	12,563	Valparaíso San Antonio	Poor/Fair
Sur	Demersal Pelagic	Trawl Purse Seine	22 6	1,541	Valdivia Calbuco	Fair/Poor
Extremo Sur	Shellfish	Diving	9	419	Punta Arenas	Fair

Source: José Muga et al., "Perspectivas de Desarrollo de la Industria Pesquera en Chile," Seminario Sobre Perspectivas, passim; Comité Sectorial Pesquero, Plan de Desarrollo Industrial Pesquero Discussion Paper, Corporación de Fomento, Santiago 1972, passim.

The artisanal activities are characterized by a more intense use of labor (small owner operated vessels, often not powered), manual fishing methods, backward technology, and fresh market dependency. This subsector accounts for nearly 8% of the total catch in the country, almost all of which goes into the fresh market. The artisanal catch constitutes approximately two-thirds of the supply of fresh fishery products and nearly one-half of the total supply of fishery products for direct human consumption (landed weight), with the remaining half marketed in frozen or canned form.

Artisanal fishing methods include mainly the use of hand line, long line and gill nets, for fishing, and diving for the extraction of shellfish. To some extent, the most developed among the artisanal fishermen use purse seines. There are approximately 17,000 fishermen operating some 5,300 vessels out of 189 fishing communities. A breakdown by zone and region of the number of artisanal fishing communities, fishermen and fishing vessels is shown in Table 3.

Because of the differences in the operation of each subsector, i.e., factor intensity, volume vs. selective fishing, integration or lack of integration with processing operations, they have specialized in clearly separate markets. The raw materials for processing plants is supplied by industrial extractive activities, and the fresh fish market is supplied mostly by artisanal fisherm directly or through intermediaries. Accordingly, while the industrial fishery specializes in exploitation of abundant stocks of either pelagic or demersal

Table 3 - Artisanal Fishing Activities in Chile

Zone	Region	Main Fishing Communities	Number of			Vessels	Main Fishing Activities	Average Production/yr	Population
			Communities	Organizations	Fishermen				
North	1	Arica Iquique	4	3	713	135	Handlining Longlining Gill nets		220,000
	II	Tocopilla Antofagasta Taltal	11	5	1100	184	Handlining Longlining Gill nets	6,830	310,000
Central North	III	Chanaral Caldera Huasco	14	3	230	176	Shell fishing (diving) Handlining Longlining Gill nets	4,770	190,000
	IV	Coquimbo	15	7	1750	305	Shell fishing, Land and Long- lining, Gill nets and purse seining		420,000
Central	V	Valparaíso Sn. Antonio	26	13	3457	807	Same as above		1,220,000
	VI	VALDIVERIA AREA	7	1	300	3	Shellfishing		590,000
	VII		13	3	351	133	Shellfishing, Longlining Gill Nets	38,370	770,000
	VIII	Falcanuano San Vicente	36	9	3525	2000	Shell and Crustacean fishing, Hand and Longlining, Trawling, Gill nets and purse seining		1,510,000
	IX	Valdivia	4	1	310	258	Shell fishing Hand and Long- lining	29,470	750,000
Central South	X	Pto. Montt Calbuco Ancud	45	13	4662	732	Shell fishing Crustacean fishing		990,000
Far South	XI	Pto. Aguirre	6	1	452	443	Shell fishing		60,000
	XII	Pta. Arenas	8	5	330	103	Shell and Crustacean fishing	3,610	110,000
			189	69	17,182	6299		82,010	10,000,000

Source: Gonzalo Campos, "Estado Actual de la Pésquería Artesanal," Paper presented at the V meeting of the Comisión Coordinadora de las Investigaciones Científicas-Vina del Mar, October 1975

resources, most of which goes to reduction, the artisanal fishermen fish for the finer species of white fish, which fetch the best prices in the fresh market.

The total catch during 1974, with its percent distribution for each species or group of species that comes from each subsector is shown in Table 4.

The average catch of the most important species of fish and shellfish during the 1970-1973 period is shown in Table 5.

3. Marketing and Distribution of Fishery Products.

Fish may be marketed for direct human consumption in fresh or preserved form (canned, frozen, dry salted, smoked, etc.) or for industrial consumption in the form of semi-processed goods to be used in the production of other goods. A breakdown of the Chilean fishery production during 1970 to 1973 is shown in Table 6.

Fresh Fish Marketing

The marketing channels for fresh fish are shown in Figure 3. Over two-thirds of the fish and shellfish marketed in fresh form is supplied by artisanal fishermen. On its way to the consumer this fraction of the supply may pass directly from the fisherman to the household, or through one or two middlemen in a local market to three or more in the case of a great demand center where passage through a large wholesale market (terminal) is required.

Different types of fish merchants buy at the terminals and eventually sell to the consumer either in established retail outlets

Table 4 1974 Extraction and Utilization of Chilean Fishery Resources..

Species	Catch Distribution - 1974		1974 Catch Metric Tons	% Going into Fishmeal in 1974
	Artisanal (%)	Industrial (%)		
Anchoveta	0.5	99.5	383,374.4	100
Sardina	4.4	95.6	398,824.1	95
Jurel	8.2	91.8	194,383.3	91
Sierra	100.0	0	3,826.3	0
Tunidos	20.0	80.0	1,345.1	0.1
Corvina	48.0	52.0	2,377.6	0
Merluza	87.5	12.5	43,067.3	26.3
Congrios	30.7	69.3	5,349.1	0
Cojinova	86.0	14.0	911.6	2.6
Robalo	99.8	0.2	827.6	0
Other fish	65.2	34.8	13,522.4	49.8
Subtotal Fish	<u>5.3</u>	<u>94.7</u>	<u>1,047,808.5</u>	<u>92.1</u>
Camaron-Langostino	0	100.0	35,047.1	58.2*
Other Crustaceans	100.0	0	2,127.6	0
Almeja	100.0	0	6,938.0	0
Cholga/Chorito	100.0	0	20,91 .6	0
Loco	100.0	0	5,928.1	0
Other Shellfish	100.0	0	9,482.0	0
Subtotal Shellfish	<u>56.4</u>	<u>43.6</u>	<u>80,430.4</u>	
Grand Total	9.8	90.2	1,128,238.9	

Source: SAG Division de Proteccion Pesquera "Sintesis Estadistica de Pesca 1974,"
Santiago, 1975.

*Utilizing the waste from the production of main products.

Table 5 Selected Measures of Chilean Landings 1970-1973

Species	<u>Landings in Metric Tons</u>			
	Minimum	(Yr)*	Average	Maximum (Yr)*
Total Landings	664,486.3	(73)	1,031.158.4	1,486,923.1 (71)
Anchoveta	191,795.7	(73)	577,363.0	966,865.0 (71)
Sardina	68,098.6	(70)	140,484.1	167,509.0 (73)
Jurel	87,002.9	(72)	119.758.5	150,442.1 (71)
Merluza	46,500.7	(73)	66,916.9	88,275.9 (70)
Langostino	25,272.5	(73)	34,097.3	40,397.5 (70)
Cholga	10,602.0	(73)	13,954.0	16,533.3 (71)
Camaron	7,719.2	(72)	8,738.3	9,655.9 (70)
Chorito	5,923.3	(70)	7,975.4	9,096.5 (72)
Sierra	4,344.6	(72)	5,837.1	7,150.3 (70)
Bonito	1,680.3	(71)	3,784.1	4,551.7 (70)

*Indicates the Year in which minimum or maximum production occurred.

Source: Anuarios y Sintesis Estadistica de Pesca S.A.G.

Table 6 Selected Measures of Chilean Fishery Production 1970-73

Product Form	Minimum	(Yr)*	Average	% of Total Quantity	Maximum (Yr)
Fish Meal	93,341,7	(73)	168,148,0		263,130,8 (71)
Fish Oil	11,132,1	(73)	23,451,8		62,517,8 (71)
Subtotal for Industrial Consumption	104,473,8	(73)	196,599,8	63%	325,648.6 (71)
Fresh	84,740,8	(71)	96,042,8	84%	101,082,7 (72)
Frozen	5,516,9	(72)	10,005,5	7%	20,120.4**(73)
Canned	10,358,8	(73)	11,113,6	8%	11,913,2 (70)
Dry Salted	186,7	(72)	219,9	1%	305,2 (71)
Smoked	47,5	(71)	43,7		60,9 (72)
Subtotal for Direct Human Consumption	<u>105,579,1</u>	<u>(71)</u>	<u>117,425,5</u>	<u>37%</u>	<u>131,84,1 (72)</u>
TOTAL PRODUCTION	206,277,9	(73)	314,025,3	100%	431,227,9 (71)

*Indicates year in which minimum or maximum production occurred.

**This figure includes nearly 15000 MT of frozen merluza fished and processed by USSR factory ships, under a special contract.

Source: Anuario y Sintesis Estadistica de PESCA-SAG

Figure 3 - Marketing Channels for Fresh Fishery Products

* Institutional consumption covers Industries and Commerce (non-food)-hospitals, police, schools, military, etc. while commercial refers to establishments where fish is expended - restaurants, hotels, etc.

(pescaderías) and public markets (mercados) or periodic fairs, where agricultural produce and fish are sold usually once a week (ferias) or by mobile sidewalk vendors and traders (canasteros).

The industrial supply of fresh fishery products, mainly merluza, jurel and congrio negro, is partly sold at the wholesale markets and merchandised by pescaderías, mercados, ferias or canasteros in the same manner as the supply that comes from the artisanal fishermen. There is also a significant level of direct marketing to the consumer, carried out by one company so far, Pesquera Chile-Arauco, and to the supermarket chains and institutions by several industrial suppliers.

Some artisanal fishermen's cooperatives have attempted to market their catch directly to consumers in distant markets, but these efforts have had, so far, little success. Better results have been obtained by them in their local markets where the cooperatives usually provide facilities and services for the sale of the member's catch, open normally to consumers and merchants as well, e.g. Cooperativa San Antonio in San Antonio. In other cases the cooperatives have succeeded in establishing fish food outlets -- restaurants, e.g. Cooperative El Membrillo, Valparaíso, or permanent retail outlets in distant markets (Cooperativa Puertecito from San Antonio recently inaugurated an outlet in the Feria del Mar in Santiago).

Processing and Distribution of Frozen and Canned Fishery Products

The industrial processing of fishery commodities is carried out at the nearly 95 plants that operate in the country. Marketing of the production is slightly different for frozen or canned products. Because of the need for refrigeration and the relatively high costs of frozen commodities (langostino, white fish fillets, etc.) those commodities are marketed mostly to the higher income consumers, usually through supermarket chains, or exported.

Canned fishery products, on the other hand do not require special preservation during the distribution process. For this reason the commodities are retailed not only by supermarkets but also by the more traditional stores (almacenes), as well as the corner stores in the low income areas. Current exports of Chilean canned fishery products is negligible.

Marketing and Exports of Fish Meal and Oil

Approximately 80% of the Chilean production of fishmeal is exported and the rest goes into the domestic market. Most of the domestic consumers of fishmeal are either agricultural feeds manufacturers, or producers of pork or poultry who mix their own feeds. Fishmeal manufacturers usually sell either to wholesale dealers of agricultural commodities, to agricultural cooperatives, or directly to the consumers.

The marketing channels for processed fishery products are shown in Figure 4.

Figure 4 - Marketing Channels for Processed Fishery Products

4. The Fisheries and Related Activities as an Economic System.

The fisheries and related activities can be conceptualized as a socioeconomic system formed by the following subsystems:

(a) A supply subsystem with the following components:

- Fishery resources
- Extractive activities

artisanal

industrial

- Processing activities

for intermediate goods: fish or crustacean
meal and oil

for final goods, in fresh, frozen, canned or
other forms

(b) A demand subsystem with the following components:

- Marketing activities

wholesale

retail

- Domestic markets, the Chilean households in the
different regions of the country

- Export markets, the countries that currently do, or
potentially may, import Chilean fishery products

(c) A supporting activities subsystem with the following
1
components:

1

Note: This subsystem will not be treated in the analysis that is performed on the subsequent chapters.

- Resource research and management (stock assessment and fishery regulation)
- Landings and distribution infrastructure: ports, roads, public provision of distribution facilities including frozen storage
- Shipbuilding and maintenance dockyards
- Market research and information services
- Education, i.e. technical and professional development

The operation of the entire system can be characterized by the interaction between the demand for an supply of goods and services under the constraints imposed by nature (size and yield of the resource stocks) the size of the markets and the capacity of supporting activities.

The demand for fishery products and supply of labor or capital for fishing and other activities results from the utility maximizing behavior of the consumer, constrained by his endowment of resources; while the supply of fishery products and demand for labor and capital services result from the profit maximizing behaviour of the firms, constrained by the production function and availability of natural resources. The interaction between these two sets of functions yields a vector of short run equilibrium inputs (i.e. capital, labor and other inputs) and a vector of short run equilibrium outputs that in real life is reflected by the amounts of each commodity that are transacted in the market.

Constraints on Fisheries Performance

The primary constraints that may limit the output of the fisheries is naturally the availability of fishery resources. Considering the fact that these are renewable, the size of fish populations and their reproduction rate determine the maximum sustainable yield for each species, i.e. maximum amount that can be extracted during a period (usually stated in annual terms) without decreasing the size and yield of the population for the following periods. This constraint is one that rational exploitation of the fisheries would have to adhere to in order to maximize long run yield. Within these constraints, the extractive capacity of the fleet and the landings infrastructure provide additional constraints.

Given the availability of fishery resources, another set of constraints appear in the capacity to transfer and/or distribute fishery commodities. These capacities are in the short run fixed, but over long periods of time may be changed in response to shifts in the demand for these commodities. Both in the short and long run, however, the availability of other production factors may become another constraining factor.

Finally, the size of markets may constitute an additional constraint.

5. Expansion Alternatives for the Chilean Fisheries

The principal sources for the expansion of the contribution of the Chilean fisheries to the economy are:

- (a) Expansion of the extraction of natural resources
from (i) currently underexploited species, (ii) currently
unexploited species.
- (b) Fish and shellfish cultures, and
- (c) The improved utilization of fishery resources

Expansion of the Catch from Natural Resources

Estimates made by IFOP place the maximum sustainable yield from fishery resources at nearly 2,000,000 metric tons per year. A breakdown of the current and potential catch by species is given in Table 7 . It shows that the possibilities of expansion of the catch from conventional resources may come mainly from:

jurel,	which could yield an additional 110,000 m.t./yr.
sierra (<u>thyrsites atun</u> - mackerel)	20,000 m.t./yr.
merluza and other white fish	84,000 m.t./yr.
cholgás (<u>aulacomya ater</u> -mussels)	243,000 m.t./yr.
choritos (<u>mytilus edulis</u> - mussels)	17,400 m.t./yr.

The new species, yet unexploited, include:

agujilla (scombersox stolatus - saury) that could yield
105,000 m.t./yr. and
merluza de cola (macruronus magellanicus) that could
yield 140,000 m.t./yr.

Table 7 Average Landings, Current and Potential

Fish	Current Average Landings - 1970-73 M.T. Per Year	Potential Yield
Anchoveta	577,363,0	780,000,0
Sardina	140,484,1	120,000,0
Jurel	119,758,5	230,000,0
Merluza	66,916,9	108,500,0
Bonito	3,784,1	20,000,0
Sierra	5,837,1	26,000,0
Agujilla	--	140,000,0
Merluza de cola	--	105,000,0
Other Fish	21,630,8	65,000,0
TOTAL FISH	935,775,5	1,594,500,0
<u>Shellfish</u>		
Cholgas	13,954,0	257,390,0
Choritos nat.	7,975,4	25,500,0
Lang. + Camaron	42,835,6	39,600,0
Other Shellfish	30,618,8	34,098,5
TOTAL SHELLFISH	95,383,8	346,588,5
GRAND TOTAL	1,031,158,3	1,951,088.5

In addition, by improved management of currently over-exploited species, the anchoveta catch could increase by some 200,000 metric tons over the extraction rate during the reference period, to its estimated M.S. Y.¹ It is interesting to note, however, that preliminary results of the 1974 fishing year indicated an unexpected increase in the catch of sardines (clupea fueguensia, strangomera benticcki, sardinops sagax). This may be caused by the interaction between two species (anchoveta and sardines) that feed on the same grounds or by errors in the classification of the catch over the past ten years, whereby catches of clupeoid fish may have been reported as anchoveta.

Fish and Shellfish Cultures

Estimates of the potential yield from fresh fish cultures are made at 92,000 metric tons per year, based mostly on the possibilities afforded by the central and southern zones of the country.²

1

During the period of reference (1970 to 1973) the anchoveta catch varied from a high of 967 thousand metric tons in 1971 to a low of 192 in 1973, apparently in response to two years of over-fishing. The resulting average is some 200 thousand metric tons below the estimated sustainable yield of the resource under more rational exploitation.

2

Gabriel Dazarola, Juan Delard, Alfredo Valenzuela, "Perspectivas de los Cultivos de Agua Dulce en Chile," in Seminario Sobre Perspectivas, pp. 175-186.

The state of the art in this field is, however, at a very early stage and much biological research remains to be done before financial analysis of commercial undertakings can be performed, and the necessary investment is attracted.

Estimates of the potential yield from shellfish culture, (mainly mussels) are made at 81,600 metric tons per year. Research on the costs and benefits associated with this culture indicate an annual rate of return of 18.6% vis a vis the 17.3% that the exploitation of natural choritos yields.¹

Utilization of Fishery Resources

Fishery resources may be used to feed people or animals and also to produce goods that satisfy other human needs. Among the latter, fish oil is used in the production of many non-food commodities, and other fish parts have been used to produce goods that are not food. By far the most important use for fishery resources is as food, either for direct human consumption or, via another step in the food chain, as cattle or poultry feed to produce other animal food for human consumption, or just to feed animals that render services that satisfy other human needs.

Two sets of forces dictate what the actual use of fishery

1

Luis E. González, et. al., "Perspectivas de Desarrollo de la Conquilicultura en Chile", Seminario Sobre Perspectivas, p.152.

resources are. On one hand, given the organic composition of each species, a fish may yield different proportions of their landed weight in different products. As an example, jurel may give around 19.8% of fishmeal and 3.5% of oil in the reduction process; 36.1% of fillet; 47.8% of minced flesh; 44% in smoked goods; 40.2% in canned goods. The organic composition also determines organoleptic characteristics (the way each product looks, smells and tastes) for the different products that can be made from each species of fish.

The other set of forces is provided by consumers' tastes and is manifested through their preferences and willingness to pay for each product.

The interaction of these forces over a long period of time results in an infrastructure for the extraction and transformation of fishery resources. This infrastructure provides a set of "capacity" constraints that limit in the short run the amounts of each product that may be produced, and cannot be expanded from one period to the next, but may be expanded by efforts that are sustained over several periods.

The suitability of some of the species under conventional exploitation for different forms of marketing is shown in Table 9 .

In the case of the unexploited species it would appear that the agujilla may make a good canned product, while the merluza de cola seems to have most promise in the form of frozen minced

Table 8 Suitability of Conventional Underexploited Marine Species for Different Forms of Marketing

Species	Forms:	Fresh	Frozen	Canned	Fish Meal
jurel		Fair	Bad	Good	Good
sierra		Good	Fair	Good	Good
Merluza and white fish		Good	Good	Fair	Good
cholgas		Good	Fair	Good	--
choritos		Good	Fair	Good	--

Source: Seminario Sobre La Utilizacion de Especies Marinas Sub-Utilizadas en Chile, Universidad Catolica de Valparaiso, September 1975

fish flesh, or as input in the production of fish protein concentrate.

Improvement in the Utilization of Currently Extracted Resources

The average utilization of the Chilean fishery resources during 1970-73 is shown in Table 9 . It can be seen from this Table that during the period observed, 99% of the anchoveta, 39% of the merluza, 93% of the sardinas and 76% of the jurel were directed to the production of fishmeal.

The average contribution to the gross value of the production during the same period of one metric ton of each of these species in the different forms that they may be marketed is shown in Table 10. The estimated average contribution to the net returns of the producer from one metric ton of product in each of the basic forms during the same period was:

	US\$
Fresh	110
Frozen	164
Canned	140
Fishmeal and Oil	50

It can be argued then that better uses can be made of the catch, even within current technological and capacity constraints.

1

This product is not considered in this study, as its production and marketing do not appear yet to be commercially feasible, unless in the context of governmental spending programs. For further details see references 3, and 53 .

Table 9 Utilization of Chilean Fishery Resources
(% of each species destined to each use)

Species	U S E S					Total
	Fresh	Frozen	Canned	Other F.H.C.	Fish Meal	
bonito	19.9	--	78.2	--	1.9	100
merluza	31.4	20.9	.2	8.1	39.4	100
anchoveta	.1	.1	--	.6	99.2	100
sardina	2.5	--	4.5	--	93.0	100
jurel	9.7	1.4	11.3	1.4	76.2	100
sierra	93.0	--	5.0	2.0	--	100
choritos	31.5	--	68.5	--	--	100
cholgas	38.0	--	49.6	12.4	--	100
camaron	10.6	87.7	1.7	--	--	100
langostino	5.4	89.2	5.4	--	--	100

Source: Anuario y Sintesis Estadistica de Pesca,
SAG/IFOP

Table 10 Fish Contribution to Product Value in Alternative
Uses¹
(US\$ Per Ton of Raw Material)

Species	Product Forms			
	Fresh	Frozen	Canned	Fish Meal and Oil
bonito	420	115*	407	59
merluza	250	150**	--	59
jurel	150	40*	264	59
sierra	500	--	450	59
sardina	250	40*	270	59
anchoveta	--	40*	264	59
camaron/lang.	450	265**	240	--
choritos/ cholgas	300	--	68	--

¹The stated contribution reflects only the difference in yields, and has no other cost elements included.

*Frozen round

**frozen fillets or tails

If we take the merluza as an example, it makes excellent fresh or frozen products, both fetching returns to the producer three times greater and making a contribution to GNP almost five times greater than when used to make fishmeal. This argument can be repeated for jurel, sardina, and to a lesser degree for anchoveta.

There are several explanations for the persistence of this apparent malallocation of resources. Factors that prevent the utilization of fishery resources in their "best" uses include technological as well as economic considerations. There are limits to the extent that all good raw material can be devoted to the production of food for direct human consumption for technical reasons: some of the catch is bound to become bruised during the extraction and handling operations and becomes unsuitable for direct human consumption. Most important, however, is an economic consideration: the price elasticity of demand, i.e. if output of fishery commodities is significantly increased, the impact of this expansion on price may be such that price may drop beyond the point needed for the producer to meet costs. Beyond some level of sales, then, this makes the domestic market prospects look unpromising for Chilean producers. In the exports markets, however, this is not the case as the entire potential Chilean production is not likely to affect prices.

In the light of the above discussion, the Chilean fish processors have not been irrational in making their decisions. They

would have been if they had had the option to produce and sell all of the alternative commodities. As it happens many fishmeal plants do not have alternative freezing and/or canning processing lines. More important, however, is the fact that although there is evidence of excess processing capacity¹ stable exports market opportunities have existed so far only for fishmeal and oil. From the producer's point of view the market for other products (fresh, canned, frozen) has seemed to be at a saturation point in the domestic cases, and nonexistent in the case of exports.

The utilization of fishery resources is not itself a controllable variable, but rather the result from the interaction of the different components of the economic system described in Section 4, each of them formed by numbers of variables. To change the current utilization of Chilean fishery resources changes must occur first in the variables that determine the economic system, and those changes must sustain themselves long enough to permit the adjustment of the processing and marketing infrastructure.

Alternatives for Expansion

The three sources for the expansion of the Chilean fisheries discussed in the preceding subsections do not necessarily imply exclusive alternatives. They do, however, imply alternatives in

¹CORFO's assessment of capacity utilization in 1971 indicated utilization rates of 34%, 13% and 15% for reduction, freezing and canning capacities respectively. A comparison of registered capacity during 200 shifts against actual average production in 1970-73 indicates utilization rates of 50, 20 and 25% for the same facilities.

the measure that they require resources that are scarce, and their use in the implementation of one line of expansion will leave fewer resources left to implement the others. All of these ways to expand the contribution of the Chilean fisheries to the economy require the investment of capital resources that are scarce. With this consideration in mind the field of choice can be narrowed down assigning a lower priority to the aquaculture option. On one hand the uncertain state of the technology (biological research on productivity, disease control, etc.) in the case of fish culture, and on the other, the estimation of profitabilities that hardly are better than those associated with the extraction of natural resources for shellfish culture, do not warrant a concentration of effort in this option when there are unexploited natural resources that can be exploited at similar costs.

The other two sources of improvement, i.e. "expansion of the catch" and "improvements in the utilization of the catch" imply alternatives between themselves only to the extent that one be enhanced at the cost of not enhancing the other. The alternatives are not so much whether to expand the catch or utilize it better, as efforts to implement one would make it possible and more attractive to develop the other. The two efforts are in fact complements of each other. Steps to establish a long-term position among world suppliers of fishery commodities should consider:¹

¹Shorter term strategies may consider temporary leasing of the fishing grounds, charging a fixed fee per ton extracted and/or the marketing of semi-processed goods, or similar arrangements.

- development of the technical capacity to produce products, from available resources, of a quality acceptable in the exports market
- expansion of the market opportunities for these products
- expansion of the catch and production from the available resources.

The development alternatives present themselves in a different context now: which line of fishery production to invest in?

Canneries? Frozen production? or balanced combinations of canned or frozen products and fishmeal, depending on the characteristic of each species and the technological possibility of the joint production of main and by-products?

The basic alternatives which will be analyzed in the following chapters are:

Alternative 1 - Efforts are made to utilize the expanded catch with the currently available facilities, expanding the fresh market opportunities to its limit and, when necessary, fishmeal production capacity until all the expected catch can be processed.

Alternative 2 - The fresh market is expanded as in Alternative 1, while processing capacity for the production of fully elaborated frozen and canned fishery commodities is expanded as required to exploit currently underutilized species (jurel, sardinas) and unutilized species (agujilla, merluza de cola), and fish-meal capacity is expanded only as required to process by-products from the production of frozen and canned commodities.

The analysis of these alternatives will be carried out by focusing on the following nine fish species or group of fish species:

1. anchoveta	5. other pelagic fish species
2. jurel - sierra	6. merluza
3. sardina	7. congrios
4. agujilla	8. merluza de cola
	9. other demersal fish species

CHAPTER II

SIMULATION OF ECONOMIC PERFORMANCE ;

DESCRIPTION OF THE MODEL

To evaluate the effects of changes in the economic system formed by the fisheries and related activities, a tool is needed that may permit the analysis of its performance over time. The specific objectives of this analysis are:

- (a) to examine the response of the system to the relaxation of the fishery resources and processing capacity constraints,
- (b) to explore the implications of the expanded output in the different markets for fishery commodities,
- (c) to explore the implication of the expansion of the output fisheries commodities on employment, and
- (d) to estimate the capital requirements and the economic benefits associated with the expansion of fishery production.

The analysis will focus on the eight most important fish species, i.e. anchoveta, jurel, sierra, sardina, agujilla, merluza, congrios, merluza de cola, and two composites of the remaining fish species, i.e. other pelagic fish, and other demersal fish.

The analytical tool proposed is a model that replicates the variability in physical extraction by generating catches that deviate

randomly from the expected mean catch for each species, and characterizes processing and marketing behavior by the profit maximizing allocation of the fishery resources among their alternative uses. Discrete time increments are effected and changes in exogenous variables and other conditions constraining the system are made, and their effect on performance is evaluated.

This Chapter is devoted to the description of the model, its underlying assumptions and the data used.

Section 1 describes the stochastic elements of the extractive activity

Section 2, the simulation of extractive activity

Section 3, the economic elements of the processing and marketing activities

Section 4, the use of a profit maximizing separable programming model to characterize the fish marketing and processing activities, and

Section 5, the evaluation of processing and marketing activities.

Section 1 -- The stochastic elements

One of the most complex characteristics of fishery related activities is the presence of elements that are beyond human control and that affect the extractive activity in what appears to be a random manner. Among these elements the most important are (a) the weather, which affects the ease with which fish may be found and also the number and duration of safe fishing trips, (b) the interaction among fish populations, as well as with other forms of animal and vegetable life in the oceans, conforming a delicate balance in the ecology, the behavior of which is unpredictable once it is upset, (c) the currents with their important effect on the concentration of marine food and fish populations, (d) errors in the measure of the extraction rates and estimation of the size of fish populations. The variability in this case rises from the lack of accurate information on stock sizes and rates of extraction, thus bringing in an additional source of departure from the expected catch.

There are, in sum, a number of factors that determine fish concentration and catchability that are still beyond human control. If we add to this the fact that fish are not easily seen and that fish schools are mobile, we can expect the results of the fishing activity to be highly variable. In analyzing economic activities that are generated by the availability of a raw material which is so variable it is imperative to account for this variability

if we desire to capture to a meaningful extent the decision environment. One way to accomplish this is the generation of a variable catch that deviates randomly from its expected value.

Section 2 -- Simulation of the Extractive Activity

The procedure to follow to simulate the extractive activities includes:

- Generation of national catch for each species
- Distribution of the catch among fishery zones

Generation of the national catch - The current average rates of extraction for the principal fish species under conventional exploitation in Chile are shown in Table 11, along with their standard deviations.

If we assume normality in the distribution of the deviations around the mean catch for each species, and independence among the different fish species, we can simulate extractive activity by generating a normally distributed random variable $C(I)$, i.e. the national catch of a given species in a given year.

The first assumption, i.e., normality in the distribution of the deviations from the mean may not hold true when account is made of long run trends in the exploitation of each resource. In the short run, however, this assumption will generally hold true.

Table 11 - Fish Catch Frequency Distribution Parameters
(Metric Tons)

Species	Catch 1968-72	Standard De- viation from Mean		Potential Catch(MSY)
		Mean Catch 1968-72	Catch 1970-73	
Anchoveta	759,588	250,670	577,363	780,000
Jurel	47,604	35,226	119,758	230,000
Sardina	87,433	29,727	140,484	120,000
Sierra	8,890	3,827	5,837	25,500
Agujilla*	*	*	*	140,000
Other Pelagic Fish	25,120	15,825	17,455	60,150
Merluza	84,054	25,200	66,917	108,500
Congrios	3,670	700	4,019	10,000
Merluza de Cola*	*	*	*	105,000
Other Demersal Fish	5,322	3,353	3,491	38,800

Notes: (*) Species currently unexploited

Sources: Guzmán O., op.cit.

The second assumption, i.e., independence of fish populations, may be questioned on the grounds that there are important predator-prey interactions between some species and competition for the same fishing grounds among others. Again the effect of these interactions becomes important in the long run, and is not significant in the short run.

Simulation of Zonal Catch - The zonal catch is arrived at by distributing the simulated national annual catch among five fishery zones¹, according initially to the proportions in which they have shared the catch of each species over the years 1968 to 1972. These shares are shown in Table 12 for the actual catch during the period indicated, along with the shares of potential catch based on the estimated concentrations of fish populations in each zone, towards which the distribution of the catch in the long run will be changed.

1

For the purposes of this analysis fishery zones V and VI have been merged.

Table 12 - Catch Distribution by Zone

Species	Zones:	<u>Current (1968-1972)</u>					<u>Potential</u>				
		North	C. North	Cen- tral	South	Far South	North	C. North	Cen- tral	South	Far South
Anchoveta		0.95	.01	0.04	0.0	0.0	.89	.05	.06	.0	.0
Jurel		.78	.10	.12	0.0	0.0	.43	.22	.22	.09	.04
Sardina		.06	.02	.92	0.0	0.0	.08	.08	.84	.00	.00
Agujilla*		.0	.0	.0	.0	.0	.21	.50	.21	.08	.0
Other Pelagic Sp.		.72	.07	.17	.03	.01	.58	.08	.08	.08	.18
Merluza		.0	.02	.97	.01	.0	.0	.01	.69	.23	.07
Congrios		.09	.12	.71	.07	.01	.04	.10	.36	.20	.30
Merluza de Cola*		.0	.0	.0	.0	.0	.0	.0	.0	.19	.81
Other Demersal Sp.		.20	.12	.49	.09	.10	.04	.05	.17	.28	.46

* Species currently unexploited

Source: O. Guzmán, op. cit.

The catch simulator replicates short run extraction, under conditions (mean catch, fleet mix and strength, catch distribution among fishery zones, etc.) that are given to it at the beginning of each annual period. From year to year these conditions may be changed to reflect the expected changes in the fleet, to incorporate new species and fishing grounds to the extractive process, and in general to reproduce the effect of a gradual increase in the catch of each species to eventually reach their maximum sustainable yields.

Section 3 - Simulation of Processing and Distribution

The need to simulate the behavior of the economic agents involved in the decisions that determine what use is made of the fish landings requires an analytical framework that is consistent with what, in this respect, economic theory tells us: if the processors are attempting to maximize profits, within the constraints imposed on their possibilities of choice by the production function, availability of inputs and the capacity of their installations (in the short run), they will buy inputs until the cost of the last unit equals the revenue associated with its contribution to production, and will produce commodities to the point where the cost of the last unit produced equals the revenue it generates. As there is no evidence to suggest that Chilean fish processors are not profit maximizers the assumption is made that that is, in effect, their objective.

A relatively simply analytical tool that permits the examination of this type of behavior is linear programming. Its basic structure is the following for the problem under consideration.

$$\text{Max } Z = \sum_{i=1}^I \text{NRPU}_i * Q_i, \text{ where } \text{NRPU}_i = \text{net return associated}$$

with the production and sale of each unit of Q_i

$$\text{Subject to } (A_{ij}) * (Q_i) \leq B_j$$

Where

A is a matrix of technological coefficients, and

B is a vector of resource or capacity constraints, and

$A, Q, B \geq 0$ for all i 's and j 's.

The optimal solution to this problem gives the optimal level for each activity and the imputed value of the scarce resources (raw material, capacities), an indication of the marginal contribution to profits that could be expected from the relaxation of each of the binding constraints.

Other advantages of the use of linear programming are the fact that its stage of implementation in computers is fairly advanced and its solution algorithms provide an efficient way of handling large problems, which may include non-linear functions, separated into linear segments. This property is utilized in this application to handle the net revenue functions faced by the processors of fishery commodities.

The background of this technique is as follows: Given a non-linear function $NR=f(Q)$, that is separable, i.e.

$$f(Q)=f_1(Q_1) + f_2(Q_2) + f_3(Q_3)\dots,$$

that function can be represented by the summation of the products of linear coefficients, that represent either the value of the function at given values of its argument or the change in its value over a range of values of the argument, and auxiliary variables that indicate the relevant points or segments of the function, i.e. which of the separated variables are to be considered, given the functional relationship. Two methods are predominantly used to solve numerically the separable programming problem. One is based on the use of increments (delta method), and is best represented by the routine implemented in IBM's Mathematical Programming System. This uses segments that represent the change in the separated function value over specified increments in the value of its argument and, accordingly, auxiliary equations that include the functional relationships and zero-one variables that force all the segments up to the relevant one to be active and those following it to be inactive. This method requires then a constraint relating the changes in the value of the function over each segment to the corresponding change in the independent variable, an auxiliary equation formed by zero-one variables and a set of zero-one constraints for those variables. The other method is based on a polygonal approximation to the total function value and has been in use since the early sixties.

This method is best represented by applications such as made by Duloy and Norton⁶⁵, which separate the function into segments that represent total function values at appropriate values of its argument. The auxiliary equations in this case include a constraint that reflects the functional relationship and a constraint that forces one or a set of adjacent segments that add to one, to be active and the rest inactive. Under conditions of convexity or concavity this will require a single constraint besides the constraint that reflects the functional relationship.

The major disadvantage of linear programming lies in the rigid nature of its structure. In this case the basic structure of the model is a matrix of technological coefficients that is not expected to change over time. The remaining elements, i.e. objective function and constraints may be expected to remain reasonably constant during yearly periods. For the replication of long run operation, the elements that could change will be changed parametrically.

Section 4 - Optimization of Fish Processing and Fresh Fish Marketing

Estimation of Costs - Given the total fixed cost for a determined plant size, the fixed cost per unit (FCPU) is calculated dividing total fixed cost by the output, i.e.

$$FCPU = \frac{TFC}{Q}$$

The total variable cost for each process has been estimated and is approximately linear until capacity utilization is approached, when it is assumed that it increases at an exponential rate. Average variable cost (VCPU) will be constant then until nearly 90% of capacity utilization is reached. Average total cost (ATC) will then be $ATC = FCPU + VCPU$

The three cost functions mentioned are shown graphically for a typical process in Figure 5.

Estimation of Prices - A 24 months series of wholesale fresh fish market transactions and a 10 year series of canned products aggregated output and price levels were collected and analyzed to derive single equation estimates of the price of each commodity as a function of quantity and other variables. (Parametric prices are used for those fishery commodities that are currently exported, i.e., frozen products and fishmeal.)

Cannonical correlation analysis was used to establish initially the relevant relationships among the different variables. Least squares multiple regression was used subsequently to estimate the parameters of the relation between the relevant variables. A second stage estimation was added as a function of the output predicted on the first stage. The price or price relationships used are shown for all commodities in Appendix B.

Fig. 5

Estimation of Net Revenue Functions - The net revenue function that results from the combination of cost and demand functions has been separated into five segments for each of the commodities under consideration. The net revenue and associated output at the extreme points of each segment are listed for these commodities in Table 13.

Table 13 - Total Net Revenue (in US\$) and Associated Outputs (in MT/yr)
for Zonal Production of Selected Fishery Commodities

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Anchoveta	TNR	-300,000	900,000	2,000,000	3,200,000	2,640,000
Canned	Q	4,000	6,000	8,000	10,000	12,000
Anchoveta	TNR	-2,500,000	7,500,000	18,750,000	15,000,000	18,750,000
Fishmeal & Oil	Q	50,000	100,000	150,000	200,000	250,000
Jurel	TNR	200,000	600,000	750,000	600,000	500,000
Fresh	Q	10,000	20,000	30,000	40,000	50,000
Jurel	TNR	115,000	250,000	360,000	100,000	-250,000
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	60,000	5,400,000	11,250,000	12,600,000	300,000
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	60,000
Sardina	TNR	10,000	20,000	30,000	40,000	50,000
Fresh	Q	10,000	20,000	30,000	40,000	50,000
Sardina	TNR	60,000	5,400,000	11,250,000	12,600,000	300,000
Canned	Q	3,000	6,000	9,000	12,000	15,000

Table 13 (cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Sardina	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Agujilla	TNR	60,000	5,400,000	11,250,000	12,600,000	300,000
Canned	Q	3,000	6,000	9,000	12,000	15,000
Agujilla	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic	TNR	750,000	1,500,000	2,250,000	2,400,000	1,500,000
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	60,000	540,000	11,250,000	12,600,000	300,000
Canned	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	1,200,000	2,500,000	3,000,000	3,000,000	2,500,000
Fresh	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	-200,000	80,000	1,200,000	2,400,000	-240,000
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Table 13 (cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Congrio	TNR	125,000	250,000	375,000	500,000	625,000
Fresh	Q	500	1,000	1,500	2,000	2,500
Congrio	TNR	-2,000,000	80,000	1,200,000	2,500,000	-2,400,000
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Congrio	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Merluza de Cola	TNR	-2,000,000	80,000	1,200,000	2,500,000	-2,400,000
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal	TNR	750,000	1,200,000	2,250,000	2,500,000	1,500,000
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal	TNR	-2,000,000	80,000	1,200,000	2,400,000	-2,400,000
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal	TNR	100,000	400,000	750,000	1,200,000	1,250,000
Fishmeal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Allocation of Fish Resources - Given the catch by species, the costs associated with each process, and the demand for each fishery commodity, the net return per unit of product (NRPU) is determined for each of the n products. The function

$$\sum_{i=1}^m \text{NRPU}_i \times Q_i \text{ is formed, for } i=1 \text{ to } 1$$

to be maximized subject to the capacity constraints

$$\sum_{i=1}^m Q_{ij} \leq B_j, \text{ for process } j=1 \text{ to } 4;$$

and the 9 resource constraints

$$\sum_{j=1}^n c_{ij} Q_{ij} \leq R_i \text{ for resources } i=1 \text{ to } 9.$$

Each $\text{NRPU}_i \times Q_i$ is separated into five linear segments that represent total revenue at each output level, in the form shown graphically in Figure 6. Constraints that represent the functional relation between output and total revenues and logical restrictions, to ensure that only one or adjacent segments that add to one are active, are also included to complete the basic structure of the model that characterizes the short run profit maximizing behavior of the fish processors and distributors in each of the country's five fishing zones. The difference in the treatment of each fishery zone is provided by the capacity and resource constraints. A list

Fig. 6 - SEPARATION OF NET REVENUE FUNCTION -
CANNED PRODUCTS

of the separable programming variables is shown on Appendix C, while the capacity constraint vectors, for each fishery zone are shown in Table 14.

Table 14 - Current and Projected Zonal Capacities
for the Production of Fishery Commodities
(in Metric Tons¹)

Process	<u>ZONES</u>					
	I Norte		II Norte Chico		III Centro	
	Current	Projected	Current	Projected	Current	Projected
<u>Development Alternative A</u>						
Fresh ²	9,250	21,000	13,950	16,000	85,300	85,000
Frozen	17,000	17,000	160	160	8,630	8,630
Canned	13,620	13,620	5,000	5,000	16,920	16,920
Fishmeal	262,000	262,000	5,440	25,000	70,800	70,800
<u>Development Alternative B</u>						
Fresh ²	9,250	21,000	13,950	16,000	85,300	85,000
Frozen	17,000	37,000	150	17,000	8,630	25,230
Canned	13,620	46,770	5,000	23,100	16,920	51,400
Fishmeal	262,000	200,000	5,440	21,440	70,800	50,000

Notes: (1) Based on the utilization of required facilities in 200 eight-hour shifts during the year.

(2) Base for projection of fresh fish consumption and the production capacity required to match it.

Fresh consumption in reference period (1970-73) (10,000,000 inhabitants): fish, 7.2 kgs. ; shellfish, 4.4 kgs. = Total of 11.6 kgs.

Target for 1980 (12,210,000 inhabitants): fish, 14.33 kgs. ; shellfish, 8.8 kgs. = Total of 23.1 kgs.

Target for 1983 (12,848,000 inhabitants): fish, 14.40 kgs. ; shellfish, 23.25 kgs. = Total of 23.25 kgs.

Source: Current capacities: Servicio Agrícola y Ganadero, División de Pesca y Caza.

Projected capacities: Adriasola, L.A., "Situación Actual y Potencial de Desarrollo del Sector Pesquero en Chile - Un Análisis Preliminar", Centro de Planeamiento, Departamento Industrias, Universidad de Chile, Santiago, Chile, 1975, p. 27.

<u>ZONES</u>						
		IV Sur	V Austral		Nation's Total	
Process	Current	Projected	Current	Projected	Current	Projected
<u>Development Alternative A</u>						
Fresh ²	7,500	35,000	--	28,000	116,000	185,000
Frozen	400	400	--	--	26,190	26,190
Canned	13,226	3,226	1,000	1,000	39,766	39,766
Fishmeal	--	16,300	--	1,700	338,240	370,800
<u>Development Alternative B</u>						
Fresh ²	7,500	35,000	--	28,000	116,000	185,000
Frozen	400	13,720	--	28,000	26,190	120,950
Canned	3,226	5,670	1,000	2,560	39,776	129,500
Fishmeal	--	15,000	--	15,000	383,240	301,440

Long-run Simulation - In the simulation of long run operation, different sets of NRPU's, B_j 's and R_i 's may be entered as parametric changes to the model. These changes should reflect in the case of net returns per unit the interaction between supply and domestic and export demand. In the first case as production increases for a given plant size, average cost first decreases and then increases as utilization approaches capacity. For expansions of plant size, average costs shift reflecting economies of scale. In the case of demand, domestic prices change to reflect the effect on price of the increased outputs of the different commodities, and exports prices could be changed to reflect the changes in the position of Chilean fishery commodities in the world market (i.e. prices significantly lower than the competition to gain entrance, and slightly lower once a position in the market has been assured.).

In the case of B_j 's changes, they reflect the expansion of processing capacity, and the R_i 's the introduction of new species and changes in the shares of the catch for each zone.

Sensitivity Analysis- Different optimal solutions to the separable programming problem may result in front of changes in the input data. The principal changes that are of interest to investigate refer to the level of the constraints, and the coefficients of the objective (net revenue) function. Practically all the relevant changes in the level of the constraints are covered by the changes in the conditions considered by the situation (initial and projected) and the differences among zonal constraints. It is interesting then to test to some extent the sensitivity of overall results

to changes in the coefficients of the objective function. Two types of changes are tested. In one case a flat 10% increase or decrease in the net revenues for all commodities is considered. The consideration of changes in relative prices is precluded by the large number of possible combinations and the scope and limited resources available for this study.

A second type of change in the objective function coefficients refers to the consideration of different objective functions for the different zones. The structure of the separable programming model as stated in this section, considers a general objective function, that is applied to all of the fishery zones, and reflects the net revenues shown on Table 13. This objective function is based on the simplifying assumption that transportation costs and demands faced by producers of fishery commodities in all zones are the same. In the actual performance of the fisheries economic system this is naturally not the case, particularly since the Chilean geography presents a contrast between the concentration of the sources of raw material and supply of fishery commodities with the concentration of the demand centers. The detailed examination of the spatial relationship between supply and demand centers is beyond the scope of this study. A partial aspect of the implications of the spatial relationship can be obtained however by incorporating transportation costs to the net revenue function, using one

market in the central zone (Santiago) as a reference demand center. The resulting net revenue functions (objective function coefficients) are shown on Appendix D. Different objective functions result then for each zone, reflecting the impact of the cost of transporting all commodities to the reference market.

Section 5 - Evaluation of Performance

The optimal solution to the linear programming model gives for each year and each zone, the optimal outputs for each commodity, the net returns associated with them and the scarcity values for each capacity or resource that constrains production.

The net returns to the producer are an adequate indicator of private performances in the production or marketing of each commodity. Aggregation of zonal results leads to yearly performance, that can be stated in relation to investment. Aggregation of yearly performance leads to long run performance that can be stated in terms of internal rates of return on investment.

Social performance may be partially evaluated on the basis of output, associated net returns and contribution to employment.

A flow chart of the simulation of the operation of the Chilean fisheries and related activity is shown in Figure 7.

Fig. 7 FLOW CHART
SIMULATION OF FISHERIES OPERATION

CHAPTER III

SIMULATION OF ECONOMIC PERFORMANCE: RESULTS

The objective of this chapter is to present the results of the simulated operation of the fisheries economic system under the two expansion alternatives defined in Chapter I, pages 40 and 41. The two alternatives consider an increase in the availability of fishery resources, and differ on the adjustments done to transform the increased catch into final products. In the case of fresh production the adjustment involved is increasing the extractive capacity while in the production of processed commodities, the adjustment involved is the expansion of processing facilities. Alternative A considers solely the expansion of fresh production and fishmeal processing capacities while the current capacity for other processing methods is held constant. Alternative B considers the expansion of fresh production as well as conventional food processing capacities (canning, freezing), while fishmeal processing capacity is reduced in those zones where it is excessive.

1. Initial and Projected Conditions

The initial and projected conditions for the operation of the processing subsystem are given by

- a) the current and potential expected catch, shown in Table 11, page 46, that determine the level of the resource

constraints at a national level.

- b) the current and potential zonal catch distribution shown in Table 12, page 48 , that along with a) determine the level of the resource constraints at the zonal level.
- c) the current and potential zonal processing capacities shown in Table 14, page 62 , that determine the level of the capacity constraints for each zone.
- d) the net revenue function associated with the production of each commodity, shown in Table 13, page 56 , that determines the coefficients for the objective function; and
- e) the investment embodied in existing facilities and that required to effect capacity increases, shown in Table 15, page 70 , information utilized to complete the computations of returns on investment.

For both alternatives the investment required to expand capacity is made at the beginning of the third year of the simulation, and the capacity expansion is effected at the beginning of the fifth period.

2. Short-Run Performance

The indicators of yearly performance are

- a) output and associated prices for each commodity
- b) net revenues and static return on investment
- c) slack available and associated shadow prices for the

Table 15 Estimated Investment in the Production of Fishery Commodities
in US\$ of 1975 x 1000

		ZONES AND TERMS									
Norte		Norte Chico		Centro		Sur		Austral		National Total	
Current	LR	Current	LR	Current	LR	Current	LR	Current	LR	Current	LR
Development Alternative A											
Fresh	925 2,100	1,395 1,600		8,530 8,530		750 3,500		-- 2,800		11,600 34,230	
Frozen	11,684 11,684	110 110		5,931 5,931		275 275		-- --		18,000 18,000	
Canned	13,720 13,720	5,037 5,037		17,045 17,045		3,250 3,250		1,007 1,007		40,060 40,060	
Fishmeal	90,620 90,626	1,882 8,647		24,490 24,490		-- 3,250		-- 558		17,000 129,989	
Total	116,949 118,730	8,424 15,394		55,996 55,996		4,275 12,663		1,007 4,395		186,660 222,270	
Development Alternative B											
Fresh	925 2,100	1,395 1,600		8,530 8,530		750 3,500		-- 2,800		11,600 34,230	
Frozen	11,684 25,430	1,100 11,684		5,931 17,341		275 9,430		-- 19,244		18,000 83,129	
Canned	13,720 47,116	5,037 23,271		17,045 51,780		3,250 5,712		1,007 2,579		40,060 130,458	
Fishmeal	90,620 69,775	1,882 8,647		24,490 17,295		-- 5,188		-- 5,188		117,000 134,133	
Total	116,949 143,821	8,424 45,202		55,996 94,946		4,275 23,830		1,007 29,811		186,660 381,950	

Source: IFOP, Sección Estudios Económicos for current investment in processing facilities and linear projections for expanded capacities. In the case of extraction for fresh marketing, assumed to be carried out by artisanal fishermen, an average investment of US\$650 per fisherman, and a productivity of 6.5 metric tons per year is initially assumed and projected linearly for the estimation of investment required for expanded output.

constraints limiting production at each zone

d) employment

The optimal yearly output of each commodity is shown in Table 16 , pages 72 and 73 .

The net revenue and rate of return on investment for each zone and year are shown in Table 17, page 74 , and the slack available and shadow prices for the 13 constraints is shown for each zone and selected periods in Table 18, page 75 .

Table 16 - Separable Programming Results
Summary of Annual Outputs by Commodity (MT/yr.)
Alternative A.

Commodity	Yr. 1	Yr. 2	Yr. 3	Yr. 4	Yr. 5	Yr. 6	Yr. 7	Yr. 8	Yr. 9	Yr. 10
1. Canned Anch	0	4,712	640	0	0	0	0	0	0	0
2. Anch FM	85,000	156,100	62,890	124,800	172,300	97,180	110,800	171,300	173,000	173,000
3. Fresh Jur. S	0	0	0	2,030	76,910	86,940	73,520	80,000	79,440	69,270
4. Frozen Jur. S	0	15,000	0	0	15,000	0	0	15,000	15,000	15,000
5. Canned J. S.	12,690	6,925	13,920	18,200	24,260	26,310	24,500	24,000	24,500	21,580
6. Jr. S. FM	0	0	0	0	2,191	0	0	2,037	1,467	754
7. Fresh Sard	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
8. Canned Sard	17,410	15,970	14,550	14,300	7,920	9,822	12,420	7,920	7,920	1,341
9. Sard FM	25,380	11,420	9,205	17,320	18,710	3,746	14,760	17,070	10,940	5,667
10. Canned Agu	0	0	0	0	7,583	3,633	2,848	7,846	7,343	16,850
11. Agu FM	0	0	0	0	16,760	31,820	11,540	18,720	19,650	13,250
12. OPF Fresh	9,003	7,373	9,000	11,360	41,480	23,650	39,520	25,880	36,590	43,420
13. OPF Canned	6,346	8,384	7,157	3,555	0	0	0	0	0	0
14. OPF Fishmeal	6,431	0	3,775	2,513	6,033	785	5,000	1,379	4,221	7,209
15. Fresh Merluza	49	174	53	0	0	2,075	1,385	79	2,514	1,009
16. Frozen Merluza	9,111	9,010	8,941	9,190	8,790	8,790	8,790	8,790	8,790	8,790
17. MZA FM	11,490	6,517	3,089	19,660	202,300	12,120	13,830	18,370	15,960	19,990
18. Fresh Cong	3,432	3,554	3,433	3,093	5,602	8,645	8,289	7,085	8,871	8,096
19. Frozen Cong	32	0	32	15	0	0	0	0	0	0
20. Cong. FM	0	0	0	0	0	0	0	0	0	0
21. Frozen MDeC	0	0	0	0	400	400	400	400	400	400
22. MDeC FM	0	0	0	0	4,695	3,799	4,059	5,245	4,641	3,184
23. ODF Fresh	879	1,186	2,576	927	16,690	17,510	14,460	11,080	13,700	18,640
24. ODF Frozen	251	0	736	965	0	0	0	0	0	0
25. ODF Fishmeal	0	0	0	0	0	0	0	0	0	0
<u>SubTotals</u>										
Fresh	23,363	22,287	25,062	27,410	150,682	148,820	147,174	134,124	151,115	150,43
Frozen	9,394	24,010	9,709	10,170	15,400	9,190	9,190	24,190	24,190	24,190
Canned	36,446	35,991	36,267	36,055	39,763	39,765	36,920	39,766	39,763	39,771
Fishmeal	128,301	174,037	79,049	164,293	240,989	149,450	159,979	234,111	229,979	223,284

Table 16- Separable Programming Results
Summary of Annual Outputs by Commodity (MT/yr.)
Alternative B.

Commodity										
1. Canned Anch	20,540	7,712	2,786	256	18,530	20,000	20,000	20,000	20,000	20,000
2. Anch FM	83,870	154,400	61,800	124,700	166,800	86,160	99,770	165,800	167,400	167,500
3. Fresh Jr.S.	0	0	0	2,030	71,920	97,260	60,920	80,090	82,380	58,000
4. Frozen Jr.S.	0	12,000	0	0	15,000	0	0	15,000	15,000	15,000
5. Canned J.S.	12,690	6,925	13,920	18,200	36,760	40,210	38,630	36,760	36,610	36,990
6. Jr. S.FM.	0	0	0	0	0	0	0	0	0	0
7. Fresh Sard	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
8. Canned Sard	15,360	12,970	12,400	14,050	19,340	12,800	17,740	18,746	16,020	12,610
9. Sard FM	26,180	12,590	10,040	17,420	16,300	2,584	12,680	14,746	9,155	2,178
10. Canned Agu	0	0	0	0	31,050	30,360	25,230	31,470	31,620	31,070
11. Agu.FM	0	0	0	0	7,615	21,400	28,170	9,509	10,190	7,707
12. OPF Fresh	9,003	7,373	9,000	11,360	34,710	7,210	29,380	10,640	24,760	30,470
13. OPF Canned	6,346	8,384	7,157	3,555	14,670	7,893	13,900	8,618	12,990	17,960
14. OPF Fishmeal	6,431	0	3,775	2,513	0	0	0	0	0	716
15. FreshMerluza	49	174	53	0	0	2,075	1,385	79	2,514	1,009
16. Frozen Merluza	9,111	9,010	8,941	9,190	21,560	23,820	23,150	20,120	21,660	25,350
17. MZA FM	11,490	6,517	3,089	19,660	14,100	4,600	6,653	12,700	9,524	18,250
18. FreshCong	3,432	3,554	3,433	3,093	5,602	8,645	8,289	7,085	8,871	8,096
19. Frozen Cong	32	0	32	15	0	0	0	0	0	0
20. Cong FM	0	0	0	0	0	0	0	0	0	0
21. Frozen MdeC.	0	0	0	0	28,140	24,540	25,490	29,250	27,310	24,360
22. MdeC FM	0	0	0	0	14,300	8,160	9,779	15,000	12,890	7,857
23. ODF Fresh	879	1,186	2,576	927	16,690	17,510	14,460	11,080	13,700	18,640
24. ODF Frozen	251	0	736	265	0	0	0	0	0	0
25. ODF Fishmeal	0	0	0	0	0	0	0	0	0	0
Subtotals										
Fresh	23,363	22,287	85,062	27,410	138,922	142,700	124,434	118,974	142,225	126,215
Frozen	9,394	24,010	9,677	9,470	64,700	48,360	48,640	64,370	63,970	64,710
Canned	36,450	35,991	36,263	36,061	120,350	111,263	115,500	115,594	117,240	118,630
Fishmeal	127,971	173,507	78,704	164,293	219,115	122,904	157,052	217,749	209,159	198,208

Table 17 - Separable Programming Results: Net Revenues in US\$ x 10³
and Return on Investment % by Zone and Year
Internal Rate of Return by Zone

	ZONE I		ZONE II		ZONE III		ZONE IV		ZONE V		NATIONAL
Alternative A	NR	ROI	NR	ROI	NR	ROI	NR	ROI	NR	ROI	NR
Year 1	30,000	25	6,500	47	23,000	26	990	14	280	28	60,680
2	38,000	32	4,100	29	20,000	22	550	8	140	14	63,110
3	27,000	21	5,900	27	23,000	25	850	3	230	2	56,690
4	34,000	27	7,200	33	25,000	26	630	2	160	1	67,080
5	39,999	31	10,000	46	28,000	32	8,000	30	6,200	40	91,990
6	31,000	24	8,800	40	27,000	30	7,400	28	5,000	36	79,380
7	32,000	26	9,200	42	28,000	31	7,700	29	6,200	40	83,150
8	39,000	31	9,200	42 1	27,000	31	6,800	26	4,800	31	87,480
9	39,000	31	9,900	45	28,000	31	7,700	29	6,200	40	91,240
10	39,000	31	10,000	47	29,000	32	8,300	31	6,600	43	93,080
IRR	34%		59%		24%		15%		23%		
Alternative B											
1	30,000	24	6,500	47	23,000	25	990	14	280	28	60,300
2	38,000	32	4,100	29	20,000	22	550	8	140	14	62,550
3	27,000	16	5,900	11	22,000	16	850	2	230	5	56,190
4	34,000	20	7,200	14	25,000	18	6,300	2	160	4	67,300
5	68,000	39	32,000	63	47,000	35	13,000	34	11,000	28	171,600
6	48,000	28	29,000	56	44,000	33	12,000	32	10,000	25	144,300
7	56,000	33	31,000	61	43,000	32	12,000	33	11,000	27	154,500
8	62,000	36	32,000	61	45,000	33	12,000	31	9,900	24	160,800
9	65,000	37	31,000	61	47,000	34	13,000	33	11,000	27	166,800
10	64,000	37	31,000	59	47,000	35	13,000	35	12,000	29	166,600
IRR	33%		50%		30%		18%		12%		

Notes: (*) Sums may not check due to rounding errors.

Table 18 -

Slack Available in Metric Tons per Year and Associated Shadow Prices in US\$ x 10³

Constraint	ZONE I				ZONE II				ZONE III				ZONE IV				ZONE V			
	Initial Slack	ShP	Final Slack	ShP	Initial Slack	ShP	Final Slack	ShP	Initial Slack	ShP	Final Slack	ShP	Initial Slack	ShP	Final Slack	ShP	Initial Slack	ShP	Final Slack	ShP
A. Alternative A																				
1. Fresh Capacity	0	0.18	0	0.03	3,000	0	0	.03	7,200	0.0	32,000	0.0	7,100	0.0	2,500	0.0	0	.25	0	.03
2. Frozen	17,000	0	2,000	0	0	.13	0	.13	0	.13	0	0.13	79	0.0	0	0.14	0	.15	0	.15
3. Canning	0	1.2	0	1.2	0	.60	0	1.2	0	.44	0	1.2	2,500	0.0	0	1.2	770	.0	0	1.2
4. Fishmeal	170,000	0.0	100,000	0.0	4,300	0.0	3,700	0.0	31,000	0.0	0	0.0	0	0.0	7,100	0.0	0	.03	0	.03
5. Anchoveta Av	0	0.0	160,000	0.0	0	.03	0	.03	0	.03	0	0.03	0	.12	0	.026	0	.12	0	.02
6. Jurel	10,000	0.0	60,000	0.0	0	.26	26,000	0.00	0	.005	0	0.005	0	.50	0	0.03	0	.50	0	.00
7. Sardina	0	0.005	0	0.005	0	.28	0	.005	0	.005	0	0.005	0	.54	0	0.01	0	.54	0	.002
8. Agujilla	0	0.005	0	0.005	0	.28	0	.005	0	.35	0	0.005	0	.54	0	0.005	0	.54	0	.00
9. OP Fish	0	0.006	0	0.006	0	.25	0	.22	0	.31	0	0.25	0	.48	0	0.25	0	.48	0	.00
10. Merluza	0	0.06	0	0.06	0	.06	0	.006	0	.006	0	0.006	0	.06	0	0.006	0	.00	2,700	.00
11. Congrio	0	0.06	0	0.22	0	.25	0	.22	0	.12	0	0.12	0	.25	0	0.25	36	.00	0	.095
12. Merluza de Cola	0	0.07	0	0.07	0	.007	0	.007	0	.007	0	0.007	0	.07	0	0.006	0	.00	7,100	.00
13. OD Fish	0	0.06	0	0.09	0	.10	0	.09	0	.10	0	0.10	0	.10	0	0.10	0	.00	0	.088
B. Alternative B																				
1. Fresh Capacity	0	0.18	0	0.03	13,000	.00	0	.03	72,000	0.0	52,500	0.00	7,100	.00	6,500	0.0	0	.25	180	.00
2. Frozen	17,000	0.00	22,000	0.00	0	.13	17,000	.00	0	.13	9,200	0.00	79	.00	0	0.13	0	.15	8,500	.00
3. Canning	0	1.20	2,000	0.00	0	.60	0	.45	0	.25	12,000	0.00	2,500	.00	0	0.12	770	.00	0	1.20
4. Fishmeal	170,000	0.00	110,000	0.00	4,300	.00	4,600	.00	31,000	0.00	5,200	0.00	0	.00	12,000	0.00	0	.03	7,100	.00
5. Anchoveta Av	0	0.03	130,000	0.00	0	.03	0	.03	0	0.026	0	0.03	0	.12	0	0.03	0	.12	0	.03
6. Jurel	10,000	0.00	53,000	0.00	0	.26	7,800	.00	0	0.40	0	0.03	0	.50	0	0.03	0	.50	0	.03
7. Sardina	0	0.005	0	0.54	0	.28	0	.35	0	0.05	0	0.05	0	.54	0	0.03	0	.54	0	.03
8. Agujilla	0	0.005	0	0.005	0	.28	0	.005	0	0.43	0	0.005	0	.54	0	0.03	0	.54	0	.03
9. OP Fish	0	0.006	0	0.005	0	.25	0	.31	0	0.38	0	0.48	0	.25	0	0.25	0	.48	0	.03
10. Merluza	0	0.06	0	0.06	0	.006	0	.06	0	0.006	0	.006	0	.06	0	0.006	0	.00	0	.06
11. Congrio	0	0.06	0	.22	0	.25	0	.22	0	0.12	0	.12	0	.25	0	0.25	36	.00	0	.12
12. Merluza de Cola	0	0.07	0	.07	0	.007	0	.07	0	0.007	0	.075	0	.07	0	0.007	0	.00	0	.006
13. OD Fish	0	0.06	0	.09	0	.10	0	.09	0	0.10	0	.10	0	.10	0	0.10	310	.00	0	.10

Notes: * on first year of simulation

** on year 10 of simulation.

Table 19
A Summary of the Yearly Performance:
Net Revenues and Aggregate Returns on Investment

Year	Net Revenue Alternative A	Aggreg. ROI%	Net Revenue Alternative B	Aggreg. ROI%
1	60,068,000	32	60,080,000	32
2	63,110,000	34	62,550,000	34
3	56,690,000	26	56,290,000	15
4	67,080,000	30	67,030,000	18
5	91,990,000	41	171,600,000	45
6	79,380,000	36	144,300,000	38
7	83,150,000	37	154,500,000	40
8	87,480,000	39	160,800,000	42
9	91,240,000	41	166,800,000	44
10	93,080,000	42	166,600,000	44

A summary of the yearly performance, shown on Table 19, indicates that net revenues for both alternatives are nearly the same during the first five years, when the current conditions hold for both cases. Starting on year five of the simulation, when capacity increases are effected, the net revenues for Alternative A increase to approximately 150% of the initial level, and to approximately 300% of the initial level for Alternative B, while the aggregate rates of return on investment increase with reference to the initial rates by nearly 32% for Alternative A and by 37% for Alternative B.

3. Long-run Performance

The indicators of long-run performance are

- a) gross output
- b) employment
- c) internal rate of return on investment

The total outputs and levels of employment associated with the ten year operation of the sector under the two alternatives are shown in Table 20, while a comparison of the initial and final output and employment levels are shown in Table 21, page 78 . The internal rate of return on the investment made on each zone is shown in Table 22, page 79 .

Table 20

Ten Year Output of Fishery Commodities
and Associated Employment
as function of output

Type of Product	ALTERNATIVE A		ALTERNATIVE B	
	Product Weight in MT	Employment in Man Years as f(Q)	Product Weight in MT	Employment in Man Years as f(Q)
Fresh	980,000	116,114	890,000	105,450
Frozen	170,000	16,521	410,000	39,844
Canned	380,000	27,182	840,000	60,086
Fishmeal	1,800,000	5,812	1,600,000	5,167
TOTALS	3,330,000	165,629	3,740,000	210,547

Table 21

Summary of Annual Results
Capacity and Output (in Metric Tons per Year)
Employment as Function of Capacity
(in Man Years per Year)

	<u>Initial (yr. 1)</u>			<u>Final - Alternative A (yr. 10)</u>			<u>Final - Alternative B (yr. 10)</u>		
	Capacity	Simu- lated Output	Required Employ- ment(1)	Capacity	Simu- lated Output	Required Employ- ment(1)	Capacity	Simu- lated Output	Required Employ- ment(1)
Fresh	116,000	23,348	13,738	185,000	150,435	21,920	185,000	126,215	18,480
Frozen	26,190	9,394	2,544	26,190	24,190	2,544	120,950	64,710	11,754
Canned	39,766	36,446	2,846	39,766	37,771	2,846	129,500	118,630	9,260
Fishmeal	<u>338,240</u>	<u>128,301</u>	<u>1,092</u>	<u>375,000</u>	<u>223,254</u>	<u>1,214</u>	<u>389,680</u>	<u>198,208</u>	<u>1,240</u>
TOTALS	520,196	197,489	20,220	626,760	435,650	28,521	825,130	507,763	44,174

Notes: (1) as function of capacity.

Table 22 -

Long- Run Return on Investment

Zone	Current Investment	Additional Investment		10-Year Internal Rate of Return on Total Investment		
		Alt. A	Alt. B	Alt. A	%	Alt. B
I	116,949,000	1,781,000	26,872,000	34		33
II	8,424,000	6,970,000	36,778,000	59		50
III	55,996,000	0	38,950,000	34		30
IV	4,275,000	8,388,000	19,555,000	15		18
V	1,007,400	3,388,000	28,804,000	23		12
National Total	186,651,400	20,527,000	150,959,000			

4. Discussion of Results

Output Behavior

The outputs under both alternatives do not differ in the first five periods. This is to be expected as the initial conditions are the same. Starting on period 5 and through to the end of the simulation differences exist in the composition of the output with a higher production of fishmeal for Alternative A and higher production of frozen and canned products for Alternative B. As the extraction of fishery resources is increased nearly 100% (year 5 to the end of simulation) average output of fishery commodities increases by approximately 80% in Alternative A and 100% for Alternative B, with the composition of average output broken down as shown in Table 23, page 81 .

As can be seen, the effect that the increase in capacity has on output is important but it is not the most important one.

Table 23 - Impact of Capacity Change on National Output

	<u>Before Change</u>		<u>After Change</u>	
	Average		Average	
	Capacity	Output	Capacity	Output
	(5 yrs.)		(5 yrs.)	
<u>Alternative A</u>				
Fresh	116,000	24,530	185,000	147,057
Frozen	26,190	13,320	26,190	17,125
Canned	39,776	36,190	39,776	39,291
Fishmeal	338,240	<u>172,609</u>	370,800	<u>206,265</u>
Total		246,649		409,738
<u>Alternative B</u>				
Fresh	116,000	24,530	185,000	132,245
Frozen	26,190	13,320	120,950	59,125
Canned	39,776	36,190	129,500	116,429
Fishmeal	338,246	<u>172,609</u>	383,240	<u>187,364</u>
Total		246,649		495,163

What really allows the increased production is the increased availability of fishery resources (nearly 200% of initial availability) particularly in zones where they were a constraining element under initial conditions. This is apparent from the fact that under initial conditions simulated capacity utilization is quite low, except for the canning process.

The relation between the fresh and canned fish production in the initial years (24,350 tons to 36,190 tons) does not correspond

to the current situation of the Chilean fisheries, (average fresh production is nearly 60,000, while average canned production is nearly 12,000). This is a sign that the relation between the prices used for these commodities over-values canned production, a clear indication of the weakness of the price information utilized for those commodities.

Price Behavior

The prices associated with the output of the different commodities produced, shown in Table 24, page 83 , reveal that for outputs of domestically consumed commodities that almost treble, the prices in the domestic market drop nearly 2% for canned products and experience an almost insignificant decrease for fresh jurel and merluza. The price of congrio however drops a significant amount (over 5%).

It is clear that the price ratio between canned and fresh commodities does not correspond to reality, and implies a composition of consumption that overstates canned products by a factor of 3. Furthermore, the price elasticity of demand for canned products, implied by the prices on Table 24 is another indication of the limited success that estimation efforts have had in these commodities. This is largely due to the quality of the aggregated information utilized which does not recognize the variety of canned fishery commodities.

The projected expansion of output implies a per capita

Table 24 - Separable Programming Results:
Summary of Annual Output and Prices for Selected Commodities
(Outputs in Metric Tons, Prices in US\$/Ton)

Commodity	<u>1</u>		<u>2</u>		<u>3</u>		<u>4</u>		<u>5</u>	
	Q	P	Q	P	Q	P	Q	P	Q	P
<u>Alternative A</u>										
Canned Prod	36,446	2,418	35,991	2,418	36,267	2,418	36,055	2,418	39,763	2,416
Fresh Jurel	0	167	0	167	0	167	2,030	167	76,910	136
Fresh Merluza	49	283	174	283	53	283	0	283	0	283
Fresh Congrio	3,432	690	3,554	688	3,433	690	3,093	694	5,602	670
Fresh OP	9,003	*	7,373	*	9,000	*	11,360	*	41,480	*
Fresh OD	879	*	1,186	*	2,576	*	927	*	16,690	*
Frozen Prod	9,394	*	24,010	*	9,709	*	10,170	*	15,400	*
Fishmeal	128,301	*	174,037	*	79,047	*	164,293	*	240,989	*
<u>Alternative B</u>										
Canned Prod	36,450	2,418	35,991	2,418	36,263	2,418	36,061	2,418	120,350	2,390
Fresh Jurel	0	167	0	167	167	167	2,030	166	71,920	136
Fresh Merluza	49	283	174	283	53	283	0	283	0	283
Fresh Congrio	3,432	690	3,554	688	3,433	690	3,093	694	5,602	670
Fresh OP	9,003	*	7,373	*	9,000	*	11,360	*	34,710	*
Fresh OD	879	*	1,186	*	2,576	*	927	*	16,690	*
Frozen Prod	9,394	*	24,010	*	9,677	*	9,470	*	64,700	*
Fishmeal	127,971	*	173,507	*	78,704	*	164,293	*	219,115	*

* Parametric Prices: Fresh OP and OD: US\$375/MT
Frozen Product(Merluza): 880/MT
Fishmeal and Oil: 272.5/MT

Table 24 (Cont.)

Commodity	<u>6</u>		<u>7</u>		<u>8</u>		<u>9</u>		<u>10</u>	
	Q	P	Q	P	Q	P	Q	P	Q	P
<u>Alternative A</u>										
Canned Prod	39,765	2,416	36,920	2,417	39,766	2,416	39,763	2,416	39,771	2,416
Fresh Jurel	86,940	131	73,520	137	80,000	131	79,440	131	69,270	136
Fresh Merluza	2,075	282	1,385	282	79	283	2,514	282	1,009	282
Fresh Congrio	8,645	638	8,280	640	7,085	650	8,871	636	8,096	643
Fresh OP	23,650	*	39,520	*	25,880	*	36,590	*	43,420	*
Fresh OD	17,510	*	14,460	*	11,080	*	13,700	*	18,640	*
Frozen Prod	9,190	*	9,190	*	24,190	*	24,190	*	24,190	*
Fishmeal	149,450	*	159,979	*	234,111	*	229,879	*	223,254	*
<u>Alternative B</u>										
Canned Prod	111,263	2,393	115,500	2,392	115,594	2,392	117,240	2,391	118,630	2,391
Fresh Jurel	97,260	131	60,920	141	80,090	131	82,380	132	58,000	143
Fresh Merluza	2,075	282	1,385	282	79	283	2,514	282	1,009	282
Fresh Congrio	8,645	638	8,289	640	7,085	650	8,871	636	8,096	643
Fresh OP	7,210	*	29,360	*	10,640	*	24,760	*	30,470	*
Fresh OD	11,750	*	14,460	*	11,080	*	13,700	*	18,640	*
Frozen Products	48,360	*	48,640	*	64,370	*	63,910	*	64,710	*
Fishmeal	122,904	*	15,702	*	217,749	*	209,159	*	198,208	*

* Parametric prices (see previous page)

consumption of fish of 23.25 kg., that is twice the current one, with a composition that should remain constant unless the relative prices change significantly. That level of fish consumption should be based on price ratios to other food commodities that favor the consumption of fishery products, that is the price levels for these commodities would have to decrease.

An important element in the recognition of the relationship between price and quantity at the different marketing levels is a linkage between the demand faced by each (zonal) producer and the entire market demand. This element has not been included in this analysis, due to its limited scope. It would certainly be required in a more comprehensive application of the model proposed in this study.

Net Revenues and Return on Investment

Net revenues during the first four years remain at a level near US\$60,000,000 for both alternatives A and B, increasing after capacity expansion is effected to approximately US\$85,000,000 for alternative A and to nearly US\$160,000,000 per year for alternative B. Static rates of return on investment differ from zone to zone, with the highest at 47% (Zone II) and lowest at 14% (Zone IV) before expansion. During the two years before expansion the ROI decreases significantly for some activities, as investment in expansion is effected on year 3 while the added output and revenue does not materialize until the end of year 5. This decrease in ROI levels is sharper for alternative B, where investment in expansion is heavier. After year five with the expansion of output and net revenues the rates of return increase above their initial levels for all zones. These increases are sharper in alternative B for all zones except for zone V, where the increase in ROI is higher for alternative A.

Interpretation of the Shadow Prices

The shadow prices indicate the scarcity value of the constraints they are associated with, showing the potential contribution that a unitary relaxation of them would make to the objective function value.

Table 18 shows on a zone by zone basis the initial and final availability of unused slack and the shadow prices associated with each constraint. Examination of this table shows that the comple-

mentary slackness property that falls out from the relationship between the primal of the maximization problem under consideration and its dual is met throughout. This property requires that the product of the value of each slack variable and its associated shadow price be zero. In practical terms it implies that if a constraint is not binding, i.e., if it has unused slack, its potential contribution to the objective function value has to be zero. If on the other hand, all the resource or capacity is used up, that is the value of the slack is zero, its potential contribution to the value of the objective function, given by the shadow price, must be equal to or greater than zero.

Accordingly, the constraints the relaxation of which would contribute most to the value of our objective are, initially, the capacity for canning fishery products, particularly in Zone I and II which show shadow prices of 1200 and 600 US\$/ton of capacity expanded respectively.

Contrast between the final shadow prices of both expansion alternatives, indicate that the expansion considered for canning capacity in Zone I is more than required, while for zone II is insufficient, as there is still a high shadow price attached to that constraint after expansion. It can be also observed that as the catch is increased and processing capacity is held constant on Alternative A, the shadow price of canning increases in Zones II and III to its highest value, 1200 US\$/ton of capacity.

Another important conclusion from the examination of the

shadow prices is that only in Zone V there exists some scarcity of fishmeal processing capacity, and as evidenced by the value of the slack variable, there is considerable over capacity, particularly in Zones I and III.

The apparent attractiveness of the canning process as suggested by the high shadow prices must be taken with some reservation, as this is due to the high price used for canned products in relation to the other commodities, particularly to fresh products. If as indicated earlier the relative prices are biased towards canning, this suggestion could prove quite misleading. The validation of the prices utilized is an important pre-requirement to the application of the model's results since the accuracy of the signals given by the shadow prices will not be better than the accuracy of the prices used to run the model.

Long-Run Results

The simulated operation of the fisheries economic system during a ten year period yields results, shown in Table 20 and 21, that indicate that aggregate capacity utilization after expansion is nearly 70% for Alternative A and 60% for Alternative B, and that final employment as a function of capacity output is 2.2 times greater than initial employment for expansion Alternative B and 1.4 times greater for Alternative A. Employment as function of the simulated ten year output however is nearly twice as great for Alternative B, with both expansion alternatives exceeding current output levels by

margins of 100 to 200%.

Investment required for the expansion of production capacity (table 15) adds to US\$20,527,000 for Alternative A and US\$150,959,000 for Alternative B. Internal rates of return on the total investment tied down in processing are higher for expansion Alternative A in zones I, II, III and V, and for expansion Alternative B in zone IV.

Sensitivity Analysis Results

The sensitivity of the system's performance was tested under two types of changes:

- flat increases or decreases in the net revenues per unit from the production and marketing of all commodities
- consideration of different objective functions for the different zones, recognizing the different costs of transportation that different zones would face in reaching the Santiago market. (The net revenue functions associated with the production in each zone are shown in Appendix D.)

The effect of increases or decreases in unitary net revenues did not change the level nor composition of the outputs, although as expected net revenues and returns on investment did increase or decrease by the same proportion that net revenues per unit were changed.

The effect of introducing different objective functions for each zone on the output and net revenues is described below:

Output Behavior Under Zonal Objective Functions

The level and composition of output that result from the operation of the model with different objective functions for each zone (Appendix E) changes since the attractiveness of the production of several commodities in zones away from the center becomes adversely affected by the costs of transportation to the reference market (central zone).

As in the case of single objective functions, the resulting composition of output shows an output ratio between canned and fresh products that is much greater than the ratio encountered in the operation of the real life system.

A notable difference in these results as opposed to those obtained under a single objective function, is that the optimal outputs are the same for the two expansion alternatives, showing only a response to the expansion of raw material availability, and none to the different extent of expansion of capacities for processing canned or frozen products. This indicates that contribution to the objective functions rather than the capacity constraints are limiting output, as in all cases the variable cost of transportation eventually limits the attractiveness of production.

In this case as well as for the operation under a single objective function, interyear variation in output levels is due to the randomly generated variation in the catch available for processing and secondly to the fact that after year five, the level of the catch

available for processing is doubled.

The level of output of fresh commodities is significantly lower for the results of the model run under different objective function for each zone than under one aggregated objective function. This is to be expected as these commodities are the most severely affected by transportation and refrigeration costs.

Net Revenue and Return on Investment under Zonal Objective Functions.

Initial levels of the net revenue and returns on investment under this condition (Appendix F) are lower than for a single objective function. The use of zonal objective functions makes the increase in resource availability improve considerably the profitability of Zones II to III, by expanding their output and revenues from those commodities that are not affected by transportation costs. Under expansion alternative B net revenues remain at the same level as in expansion alternative A, with a higher investment tied down, yielding therefore lower rates of return, in several cases below the initial ones.

5. Accuracy and Reliability of Results

The application of the separable programming model to the simulation of the economic system formed by the fisheries and related activities provides a reasonably close replication to its real life operation, but has not yet become an accurate tool for predicting the behavior of the system. Its main weakness has been

its failure to reflect real life output composition. This is due mainly to the quality of the input information, particularly the prices of canned commodities and their sensitivity to changes in output, and to a lesser extent production costs. Improvement of the input data and validation of results constitute an iterative fine tuning process that is required for the improvement of the results from the application of this model.

CHAPTER IV

CONCLUSIONS AND POLICY RAMIFICATIONS

1. Summary of Results

The most important conclusion from the first chapter is that there exists an important potential for the expansion of the physical production of the Chilean fisheries. Another conclusion is that this physical potential has not been realized, in part due to lack of information on the profit potential of investment in such activities, and in part due to lack of some services (usually of governmental provision) and infrastructure required for the successful expansion of productive activities.

The simulated operation of the fisheries economic system has given the following results:

- a) as the extraction of fishery resources is expanded to meet their availability in Chilean waters, investment in the production of commodities from them offers returns on investment that are quite attractive for some zones and processes, with internal rates of return on the overall investment tied down that range from 12% to 59%. Expansion of existing processing capacities enhances the already achieved profitability of investment in processing facilities only in the central and southern zones, while in the other zones profitability of invest-

ment decreases slightly if capacity is expanded. The existing over-capacity for fishmeal processing in Zones I and II exceeds the requirements of the expanded extraction and would allow for reductions of up to 25% to 30%.

- b) under the estimated market conditions output may be doubled and even trebled at attractive levels of return, for those commodities that have an outlet in the domestic market alone. The consideration of international market opportunities would make returns on investment in the production of these commodities more attractive yet.
- c) the employment implications of the expansion of the production of fishery commodities are different for different output mixes. As fishmeal is the least labor intensive process, expanding its output makes the least contribution to employment. On the opposite extreme, fresh extraction, freezing and canning provide the higher needs for labor services, in that order.
- d) the estimated investment required to expand fishery commodity production is approximately 20 million dollars for Alternative A and nearly 150 million for Alternative B. The internal rates of return associated with the total investment tied down on each zone are higher for Alternative A in all but one case (Zone IV),

suggesting the convenience of holding the investment constant and expanding the utilization of existing facilities, improving therefore the profitability of investment already tied down in those facilities.

2. Qualifications

The stated results are valid for the following conditions:

- a) fishery stocks and sustainable yields as estimated by IFOP ²⁷
- b) assumptions underlying simulation of fisheries extraction (independence of fish populations, random distribution of deviations from expected catch, etc.) hold.
- c) assumptions underlying the separable programming model (i.e. profit maximizing behavior on the part of processors, processing activity at zonal level reflected by single operator's behavior, etc.) hold
- d) cost and demand functions utilized in this study (Appendix B)
- e) availability of port and road infrastructure as required to land and distribute the output of fishery commodities

Of these conditions the most weakly met is d), therefore

these results must be considered with much reservation. Their sensitivity to price relations requires that more extensive research be done on the demand and cost function used to run the model. In its present state the results from the application of this model can best be regarded as providing useful information on the relative advantage of investment in different zones. However, improvements in the cost and price data utilized to run the model are required before it can be used as a tool for assessing the relative advantage of investment in the production of different commodities or predicting the system's performance.

3. Policy Ramifications

Given the national objectives of fishery exploitation and in the light of the results of the analysis performed, the following recommendations would seem in order:

- given the availability of marine fish resources, efforts should be encouraged to exploit them rationally to their full potential, providing the fishery management and research required to generate such activity and prevent overexploitation.
- along with the expansion of the supply of fishery commodities efforts should be made to shift the demands for these commodities in the domestic market.
- research on the costs and benefits associated with the governmental investment in the provision of services and

infrastructure required for the production and marketing of fishery commodities should be carried out.

- given the zonal availability of processing facilities and the concentration of fishery resources, services such as ports and transportation infrastructure should be made available so as to encourage the investment in processing facilities where required.
- marketing services should be provided to ensure the timely dissemination of information on prices for both domestic and export commodities.

The operation of the sector's extractive processing and marketing activities should be left to private activity, ensuring however, that resources are not overexploited and that competition is not hampered.

4. Limitations of the Present Study

Price and Cost Information

Prices are the most critical set of data required for the application of the model utilized in this study. The information available on the domestic prices of Chilean fishery commodities is limited in the number of observations and there are some questions as to its accuracy. Because of the complexity of the Chilean economy a host of other variables should be considered in their estimation. A comprehensive demand study should provide more

sophisticated economic estimators of demand. The focus of this study and the nature of the information available have not warranted, however, a more rigorous effort at demand and cost estimation. Pricing of export commodities (fishmeal and frozen products) has been parametric.

The reader is warned, therefore, about the questionable accuracy of the estimated costs and prices, which are determinant for the composition of the optimal outputs, and for the profitability of the different investment patterns. Also troublesome for the latter is the estimation of the current and required investments. There is a strong possibility that the estimations of current investments are overvalued, and that needed investment is undervalued, making returns on investment appear more attractive than what they are really.

Model Structure

The structure of the separable programming model as utilized in this study implies the following assumptions:

- productive activities in each zone are represented by a single profit maximizing producer, that has the option to sell fish fresh, frozen or canned, or to reduce to fishmeal the catch available to him. Processors in all zones face the same demand functions for commodities sold in the domestic market, or parametric prices for export commodities.
- There is one domestic market where fresh and canned

products are consumed and one export market that buys the outputs of fishmeal and oil and frozen products.

Abstraction is made of spatial relationships between supply and demand centers, although this is partially considered in the sensitivity analysis.

- there is a single activity in the extraction of the fishery resources and their transformation into each of the 25 fishery commodities considered.

5. Extension of Economic Research on the Production of Fishery Commodities in Chile

After some adjustment in the input data (cost and prices) the model presented in this study can give results that are reasonably useful for governmental policy and private investment decision making.

To make this tool a more accurate simulator of economic performance and improve its reliability for the analysis of investment, the following improvements would be required:

- efforts should be spent on the development of substantially more detailed cost and price information with which to feed the model
- disaggregation of zonal rates of returns by process to yield more information on the attractiveness of specific investment opportunities in fresh, frozen, canning, or reduction processes within each zone

- different stages in the replication of the processors behavior should be considered and linkages should be provided between the resolution of the separable program at the national level and its resolution at the zonal levels
- zonal disaggregation of processing activities should be coupled to zonal disaggregation of marketing activities - Each of these should recognize the demand and supplies at each locale and their spatial relationships.
- performance in different periods could be linked in a sequential manner so that the results of the operation in one period be made use of in the next period, e.g., making investment in one period function of the shadow prices that fall out from the optimal solution of the programming problem in the previous period
- consideration should be made of other inputs or resources utilized in the production of fishery commodities, such as labor, that may or could become scarce on a regional context.

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Marine Species in Chilean Waters

Common Spanish Name	Rough English Equivalent	Scientific Name
Agujilla	Saury	<u>Scombersox stolatus</u>
Anchoveta	Anchovey	<u>Engraulins ringen</u>
Atun alets amarilla	Tuna	<u>Thunus albacares</u>
Atun aleta larga	Tuna	<u>Thunus ala lunga</u>
Azulejo		<u>Prionace glauca</u>
Bacalao de Juan Gernandez	Cod	<u>Polyprion oxygeneius</u>
Bacalao de profundidad	Cod	<u>Dissostichus amissus</u>
Blanquillo		<u>Prolatilus jugularis</u>
Bonito	Bonito	<u>Sarda chilensis</u>
Breca de Juan Fernandez		<u>Chilodactilus gayi</u>
Brotula		<u>Salilota australis</u>
Caballa		<u>Pneumatophorus peruanis</u>
Cabinza		<u>Isacia conceptionis</u>
Cabrilla		<u>Sebastodes oculatus</u>
		<u>Helicolenis lengerichi</u>
Cachurreta		<u>Euthymus pelamis</u>
Chancharro		<u>Sebastodes chilensis</u>
Cojinova		<u>Neptomenus crassus</u>
Congrio colorado	Cusk eel	<u>Genypterus chilensis</u>
Congrio dorado	Cusk eel	<u>Genypterus reedi</u>
Congrio negro	Cusk eel	<u>Genypterus maculatus</u>
Corvina		<u>Cilus montti</u>
Jurel	Mackerel	<u>Trachurus murphyi</u>
Lenguado	Sole	<u>Paralichtye microps</u>
Lisa		<u>Mugil cephalus</u>
Lisa del norte		<u>Mugil curema</u>
Machuelo		<u>Icevoontia maculata</u>
Marrajo		<u>Isufus Oryrinchus</u>
Merluza	Hake	<u>Merluccius gayi gayi</u>
Merluza espanola	Hake	<u>Merluccius polylepis</u>
Merluza de cola	Grenadier	<u>Macruronus magellanicus</u>
Merluza de tres aletas	Hake	<u>Micromesistius australis</u>

Common Spanish Name	Rough English Equivalent	Scientific Name
Pejegallos		<u>Callorhynchus callorhynchus</u>
Pejerrey	Smelt	<u>Odontesthes regia</u>
Pez espada	Swordfish	<u>Xiphias gladius</u>
Reineta		<u>Lepidotus australis</u>
Robalo		<u>Eleginops maclovinus</u>
Sardina comun	Pilchard	<u>Strangomera bentincki</u>
Sardina espanola	Pilchard	<u>Sardinops sagax musica</u>
Sardina de los canales	Herring	<u>Clupea fueguensis</u>
Sierra	Snake mackerel	<u>Thyrsites atun</u>
Tollo	Shark	<u>Mustelus mento</u>
Vidriola de Juan Fernandez		<u>Seriola mazatlanica</u>
Almeja	Clam	<u>Protothaca thaca</u>
Berberecho		<u>Ameghinomya antiqua</u>
Calamar	Squid	<u>Tagelus dombeii</u>
Camaron	Shrimp	<u>Loligo gahi</u>
Centolla	King crab	<u>Heterocarpus reedi</u>
Cholga	Mussels	<u>Lithodes antarctica</u>
Chorito	Mussels	<u>Aulacomya ater</u>
Choro	Mussels	<u>Mytilus edulis chilensis</u>
Erizo	Sea urchin	<u>Choremytilus chorus</u>
Jaiva mora	Crab	<u>Loxechinus albus</u>
Jaiva peluda	Crab	<u>Homalaspis plana</u>
Jibia		<u>Cancer cetosus</u>
Langosta de Isla de Pascua	Lobster	<u>Dosidicus gigas</u>
Langosta de Juan Fernandez	Lobster	<u>Palinurus pascuensis</u>
Langostino amarillo		<u>Jasus frontalis</u>
Langostino colorado		<u>Cervimunida johni</u>
Loco	Snail	<u>Pleuroncodes monodon</u>
		<u>Concholepas concholepas</u>

Common Spanish Name	Rough English Equivalent	Scientific Name
Macha	Clam	<u>Mesodesma donacium</u>
Ostion		<u>Chlamys argopecten purpurata</u>
Ostra	Oyster	<u>Ostrea chilensis</u>
Picoroco		<u>Megabalamus psittacus</u>
Piure		<u>Pyura chilensis</u>
Pulpo	Squid	<u>Octopus vulgaris</u>
Taca		<u>Protothaca thaca</u>
Krill		<u>Euphausia superba</u>

Source: Guzman, op.cit., p. 131.

APPENDIX B

Prices and Costs for Chilean Fishery Commodities

1. Prices, or price relationships

(P in 1975 US\$/metric ton - Q in metric tons)

Fresh Commodities (1)

Congrio	P= 724-.00099 Q
Merluza	P= 283-.000027 Q
Jurel	P= 167-.000039 Q
Other Pelagic	P= 375
Other Demersal	P= 375

Processed Commodities (2)

Canned Commodities	P= 2430-.00034 Q
Frozen Commodities	P= 880
Fishmeal	P= 220
Fish Oil	P= 300

Notes: Costs, Prices and Price Relationships developed from information collected from:

(1) Sociedad de Terminales Pesqueros - Corporacion de Fomento de la Produccion - Santiago, Chile.

(2) U.N./F.A.O. Statistical Yearbook, several years.

Appendix B (Continued)

2. Average Production Cost⁽³⁾, in US\$ 1975 per metric ton of product

	Average Variable Cost	Average Fixed Cost at Capacity	Average Total Cost at Capa- city Output.
Fresh Commodities	218.4	50	268.4
Frozen Commodities	393	240	633
Canned Commodities	510	14	524

(3) IFOP, Sección Estudios Económicos, and Bakovic and Balic/ESPES
op.cit.

APPENDIX C

- List of Separable Programming Variables

No.	Code	Description	Tpye
1	ANCN	Canned Anchoveta Production	real
2	ANCN1	" " Sales - Segment 1	"
3	ANCN2	" " " " 2	"
4	ANCN3	" " " " 3	"
5	ANCN4	" " " " 4	"
6	ANCN5	" " " " 5	"
7	ANFM	Anchoveta Fish Meal Production	
8	ANFM1	" " Sales - Segment 1	"
9	ANFM2	" " " " 2	"
10	ANFM3	" " " " 3	"
11	ANFM4	" " " " 4	"
12	ANFM5	" " " " 5	"
13	JUSFS	Jurel Sierra, Fresh Production	
14	JUSFS1	" " Fresh Sales - Segment 1	"
15	JUSFS2	" " " " 2	"
16	JUSFS3	" " " " 3	"
17	JUSFS4	" " " " 4	"
18	JUSFS5	" " " " 5	"
19	JUSFZ	Jurel Sierra, Frozen Production	
20	JUSFZ1	" " " Sales - Segment 1	"
21	JUSFZ2	" " " " 2	"
22	JUSFZ3	" " " " 3	"
23	JUSFZ4	" " " " 4	"
24	JUSFZ5	" " " " 5	"
25	JUSCN	Jurel Sierra Canned Production	
26	JUSCN1	" " " Sales - Segment 1	"
27	JUSCN2	" " " " 2	"
28	JUSCN3	" " " " 3	"
29	JUSCN4	" " " " 4	"
30	JUSCN5	" " " " 5	"
31	JUSFM	Jurel Sierra Fish Meal Production	
32	JUSFM1	" " " Sales Segment 1	"
33	JUSFM2	" " " " 2	"
34	JUSFM3	" " " " 3	"
35	JUSFM4	" " " " 4	"
36	JUSFM5	" " " " 5	"
37	SARFS	Fresh Sardina Production	
38	SARFS1	" " Sales - Segment 1	"
39	SARFS2	" " " " 2	"
40	SARFS3	" " " " 3	"
41	SARFS4	" " " " 4	"
42	SARFS5	" " " " 5	"

Appendix C - (Cont.)

No.	Code	Description	Type
43	SARCN	Canned Sardina Production	Real
44	SARCN1	" " Sales - Segment 1	"
45	SARCN2	" " " " 2	"
46	SARCN3	" " " " 3	"
47	SARCN4	" " " " 4	"
48	SARCN5	" " " " 5	"
49	SARFM	Sardina Fish Meal Production	
50	SARFM1	" " Sales - Segment 1	"
51	SARFM2	" " " " 2	"
52	SARFM3	" " " " 3	"
53	SARFM4	" " " " 4	"
54	SARFM5	" " " " 5	"
55	AGCN	Canned Aguijilla Production	
56	AGCN1	" " Sales - Segment 1	"
57	AGCN2	" " " " 2	"
58	AGCN3	" " " " 3	"
59	AGCN4	" " " " 4	"
60	AGCN5	" " " " 5	"
61	AGFM	Agujilla Fish Meal Production	
62	AGFM1	" " Sales - Segment 1	"
63	AGFM2	" " " " 2	"
64	AGFM3	" " " " 3	"
65	AGFM4	" " " " 4	"
66	AGFM5	" " " " 5	"
67	OPFS	Other Pelagic Fish Fresh Production	
68	OPFS1	" " " " Sales - Segment 1	"
69	OPFS2	" " " " " " 2	"
70	OPFS3	" " " " " " 3	"
71	OPFS4	" " " " " " 4	"
72	OPFS5	" " " " " " 5	"
73	OPCN	Other Pelagic Fish Canned Production	
74	OPCN1	" " " " Sales - Segment 1	"
75	OPCN2	" " " " " " 2	"
76	OPCN3	" " " " " " 3	"
77	OPCN4	" " " " " " 4	"
78	OPCN5	" " " " " " 5	"
79	OPFM	Other Pelagic Fish Meal Production	
80	OPFM1	" " " Sales - Segment 1	"
81	OPFM2	" " " " " 2	"
82	OPFM3	" " " " " 3	"
83	OPFM4	" " " " " 4	"
84	OPFM5	" " " " " 5	"

Appendix C - (Cont.)

No.	Code	Description	Type
85	MZFS	Fresh Merluza Production	
86	MZFS1	" " Sales - Segment 1	"
87	MZFS2	" " " " 2	"
88	MZFS3	" " " " 3	"
89	MZFS4	" " " " 4	"
90q	MZFS5	" " " " 5	"
91	MZFZ	Frozen Merluza Production	
92	MZFZ1	" " Sales - Segment 1	"
93	MZFZ2	" " " " 2	"
94	MZFZ3	" " " " 3	"
95	MZFZ4	" " " " 4	"
96	MZFZ5	" " " " 5	"
97	MZFM	Merluza Fish Meal Production	
98	MZFM1	" " Sales - Segment 1	"
99	MZFM2	" " " " 2	"
100	MZFM3	" " " " 3	"
101	MZFM4	" " " " 4	"
102	MZFM5	" " " " 5	"
103	CGFS	Fresh Congrio Production	
104	CGFS1	" " Sales - Segment 1	"
105	CGFS2	" " " " 2	"
106	CGFS3	" " " " 3	"
107	CGFS4	" " " " 4	"
108	CGFS5	" " " " 5	"
109	CGFZ	Frozen Congrio Production	
110	CGFZ1	" " Sales - Segment 1	"
111	CGFZ2	" " " " 2	"
112	CGFZ3	" " " " 3	"
113	CGFZ4	" " " " 4	"
114	CGFZ5	" " " " 5	"
115	CGFM	Congrio Fish Meal Production	
116	CGFM1	" " Sales - Segment 1	"
117	CGFM2	" " " " 2	"
118	CGFM3	" " " " 3	"
119	CGFM4	" " " " 4	"
120	CGFM5	" " " " 5	"
121	MZCFZ	Frozen Merluza de Cola Production	
122	MZCFZ1	" " Sales - Segment 1	"
123	MZCFZ2	" " " " 2	"
124	MZCFZ3	" " " " 3	"
125	MZCFZ4	" " " " 4	"
126	MZCFZ5	" " " " 5	"
127	MZCFM	Merluza de Cola Fish Meal Production	
128	MZCFM1	" " Sales - Segment 1	"
129	MZCFM2	" " " " 2	"
130	MZCFM3	" " " " 3	"
131	MZCFM4	" " " " 4	"
132	MZCFM5	" " " " 5	"

Appendix C - (Cont.)

No.	Code	Description	Type
133	ODFS	Other Demersal Fish Fresh Production	Real
134	ODFS1	" " " " Sales - Segment 1	"
135	ODFS2	" " " " " " 2	"
136	ODFS3	" " " " " " 3	"
137	ODFS4	" " " " " " 4	"
138	ODFS5	" " " " " " 5	"
139	ODFZ	Other Dermersal Fish Frozen Production	
140	ODFZ1	" " " " Sales - Segment 1	"
141	ODFZ2	" " " " " " 2	"
142	ODFZ3	" " " " " " 3	"
143	ODFZ4	" " " " " " 4	"
144	ODFZ5	" " " " " " 5	"
145	ODFM	Other Dermersal Fish Meal Production	
146	ODFM1	" " " Sales - Segment 1	"
147	ODFM2	" " " " " 2	"
148	ODFM3	" " " " " 3	"
149	ODFM4	" " " " " 4	"
150	ODFM5	" " " " " 5	"
151	FSHPK	Fresh Fish Production Capacity Available	Slack
152	FZPK	Frozen Fish Production Capacity Available	"
153	CANPK	Canned Fish Production Capacity Available	"
154	FMPK	Fish Meal Production Capacity Available	"
155	ANAV	Anchoveta Available	"
156	JUSAV	Jurel Sierra Available	"
157	SARAV	Sardina Available	"
158	AGAV	Agujilla Available	"
159	OPAV	Other Pelagic Fish Available	"
160	MEAV	Merluza Available	"
161	CGAV	Congrio Available	"
162	MZCAV	Merluza de Cola Available	"
163	ODAV	Other Dermersal Fish Available	"
164	FNANON	Canned Anchoveta Net Revenue Functional	"
165	GDANON	Canned Anchoveta Net Revenue Auxiliary	"
166	FNANFM	Anchoveta Fish Meal Net Revenue Functional	"
167	GDANFM	Anchoveta Fish Meal Net Revenue Auxiliary	"
168	FNJUSFS	Fresh Jurel-Sierra Net Revenue Functional	"
169	GDJUSFS	Fresh Jurel-Sierra Net Revenue Auxiliary	"
170	FNJUSFZ	Frozen Jurel-Sierra Net Revenue Functional	"
171	GDJUSFZ	Frozen Jurel-Sierra Net Revenue Auxiliary	"
172	FNJUSCN	Canned Jurel-Sierra Net Revenue Functional	"
173	GDJUSCN	Canned Jurel-Sierra Net Revenue Auxiliary	"
174	FNJUSFM	Jurel Sierra Fish Meal Net Revenue Functional	"
175	GDJUSFM	Jurel Sierra Fish Meal Net Revenue Auxiliary	"

Appendix C- (Cont.)

No.	Code	Description	Type Slack
176	FNSARFS	Fresh Sardina Net Revenue Functional	"
177	GDSARFS	Fresh Sardina Net Revenue Auxiliary	"
178	FNSARCN	Canned Sardina Net Revenue Functional	"
179	GDSARCN	Canned Sardina Net Revenue Auxiliary	"
180	FNSARFM	Sardina Fish Meal Net Revenue Functional	"
181	GDSARFM	Sardina Fish Meal Net Revenue Auxiliary	"
182	FNAGCN	Canned Agujilla Net Revenue Functional	"
183	GDAGCN	Canned Agujilla Net Revenue Auxiliary	"
184	FNAGFM	Agujilla Fish Meal Net Revenue Functional	"
185	GDAGFM	Agujilla Fish Meal Net Revenue Auxiliary	"
186	FNOPFS	Other Pelagic Fish Net Revenue Functional	"
187	GDOFES	Other Pelagic Fish Net Revenue Auxiliary	"
188	FNOPCN	Other Pelagic Fish Net Revenue Functional	"
189	GDOPCN	Other Pelagic Fish Net Revenue Auxiliary	"
190	FNOPFM	Other Pelagic Fish Net Revenue Functional	"
191	GDOPFM	Other Pelagic Fish Net Revenue Auxiliary	"
192	FNMZFS	Fresh Merluza Net Revenues Functional	"
193	GDMZFS	Fresh Merluza Net Revenues Auxiliary	"
194	FNMZFZ	Frozen Merluza Net Revenue Functional	"
195	GDMZFZ	Frozen Merluza Net Revenue Auxiliary	"
196	FNMZFM	Merluza Fish Meal Net Revenue Functional	"
197	GDMZFM	Merluza Fish Meal Net Revenue Auxiliary	"
198	FNCGFS	Fresh Congrio Net Revenue Functional	"
199	GDCGFS	Fresh Congrio Net Revenue Auxiliary	"
200	FNCGFZ	Frozen Congrio Net Revenue Functional	"
201	GDCGFZ	Frozen Congrio Net Revenue Auxiliary	"
202	FNCGFM	Congrio Fish Meal Net Revenue Functional	"
203	GDCGFM	Congrio Fish Meal Net Revenue Auxiliary	"
204	FNMCfZ	Frozen Merluza de Cola Net Revenue Functional	"
205	GDMCFZ	Frozen Merluza de Cola Net Revenue Auxiliary	"
206	FNMCFM	Merluza de Cola Fish Meal Net Revenue Functional	"
207	GDMCFM	Merluza de Cola Fish Meal Net Revenue Auxiliary	"
208	FNODFS	Other Dermersal Fresh Fish Net Revenue Functional	"
209	GDODFS	Other Dermersal Fresh Fish Net Revenue Auxiliary	"
210	FNODFZ	Other Dermersal Frozen Fish Net Revenue Functional	"
211	GDODFZ	Other Dermersal Frozen Fish Net Revenue Auxiliary	"
212	FNODFM	Other Dermersal Fish Meal Net Revenue Functional	"
213	GDODFM	Other Dermersal Fish Meal Net Revenue Auxiliary	"

Appendix D- Total Net Revenue (in US \$ x 10³) and Associated Outputs (in MT/Yr)
for Zonal Production of Selected Fishery Commodities

		Zone 1				
Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Achoveta	TNR	1,104	960	-2,340	-8,160	-16,500
Canned	Q	3,000	6,000	9,000	12,000	15,000
Anchoveta	TNR	6,150	12,300	18,450	24,600	30,750
Fish Meal & Oil	Q	5,000	100,000	150,000	200,000	250,000
Jurel	TNR	-70	-200	-240	-640	-950
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Jurel	TNR	10	20	30	40	60
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	1,104	960	-2,340	-8,160	16,500
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	60,000
Sardina	TNR	-50	-100	-150	-200	-250
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Sardina	TNR	1,104	960	-2,340	-8,160	-16,500
Canned	Q	3,000	6,000	9,000	12,000	15,000
Sardina	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Agujilla	TNR	1,140	960	-2,340	-8,160	-16,500
Canned	Q	3,000	6,000	9,000	12,000	15,000

Appendix D (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Agujilla Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic Fresh	TNR	36	72	108	144	180
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Canned	TNR	1,104	960	-2,340	-8,160	-16,500
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Fresh	TNR	0	0	0	0	0
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Frozen	TNR	0	0	0	0	0
	Q	4,000	8,000	12,000	16,000	20,000
Merluza Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Congrio Fresh	TNR	188	306	354	332	240
	Q	1,500	1,000	1,500	2,000	2,500
Congrio Frozen	TNR	68	136	204	272	340
	Q	400	800	1,200	1,600	2,000
Congrio Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Merluza de Cola Frozen	TNR	440	880	1,320	1,760	1,300
	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal Fresh	TNR	156	312	468	624	780
	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal Frozen	TNR	286	636	804	1,072	1,340
	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D - Total Net Revenue (in US \$ x 10³) and Associated Outputs (MT/yr)
for Zonal Production of Selected Fishery Commodities

		Zone II				
Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Anchoveta	TNR	1,179	1,110	-2,115	-7,860	-16,125
Canned	Q	3,000	6,000	9,000	12,000	15,000
Anchoveta	TNR	6,150	12,300	18,400	24,600	30,750
Fish Meal & Oil	Q	50,000	100,000	150,000	200,000	250,000
Jurel	TNR	18	-24	-126	-288	-510
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Jurel	TNR	10	20	30	40	50
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	1,179	1,110	-2,115	-7,860	-16,125
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	60,000
Sardina	TNR	38	76	114	152	190
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Sardina	TNR	1,179	1,110	-2,115	-7,860	-16,125
Canned	Q	3,000	6,000	9,000	12,000	15,000
Sardina	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Agujilla	TNR	1,179	1,110	-2,115	-7,860	-16,125
Canned	Q	3,000	6,000	9,000	12,000	15,000
Agujilla	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic	TNR	36	72	108	144	180
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	45	30	-45	-180	-375
Fresh	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	668	1,336	2,004	2,672	3,340
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Congrio	TNR	232	394	486	508	460
Fresh	Q	500	1,000	1,500	2,000	2,500
Congrio	TNR	68	136	204	272	340
Frozen	Q	400	800	1,200	1,600	2,000
Congrio	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q					

Appendix D (Cont.)

Commodity		Segment 1 ,	Segment 2	Segment 3	Segment 4	Segment 5
Merluza de Cola	TNR	440	880	1,320	1,760	2,200
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal	TNR	420	840	1,260	1,680	2,100
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal	TNR	286	536	804	1,072	1,340
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D - Total Net Revenue (in US \$ x 10³) and Associated Outputs (in MT/Yr)
for Zonal Production of Selected Fishery Commodities

		Zone III				
Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Anchoveta	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Anchoveta	TNR	6,150	12,300	18,450	24,600	30,750
Fish Meal & Oil	Q	50,000	100,000	150,000	200,000	250,000
Jurel	TNR	40	20	-60	-200	-400
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Jurel	TNR	10	20	30	40	50
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Sardina	TNR	60	120	180	240	300
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Sardina	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Sardina	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D(Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Agujilla	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Agujilla	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic	TNR	366	732	1,098	1,464	1,830
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	1,203	1,158	-2,043	-7,764	-16,005
Canned	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	67	74	21	-92	-265
Fresh	Q	10,000	20,000	30,000	40,000	50,000
Merluza	TNR	668	1,336	2,004	2,672	3,340
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Congrio	TNR	248	426	534	572	540
Fresh	Q	500	1,000	1,500	2,000	2,500
Congrio	TNR	618	136	204	272	340
Frozen	Q	400	800	1,200	1,600	2,000
Congrio	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D(Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Merluza de Cola Frozen	TNR	400	880	1,320	1,760	2,200
	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal Fresh	TNR	486	972	1,458	1,944	2,430
	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal Frozen	TNR	286	536	804	1,072	1,340
	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D - Total Net Revenue (in US \$ x 10³) and Associated Outputs (in MT/yr)
for Zonal Production of Selected Fishery Commodities

		Zone IV				
Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Anchoveta	TNR	1,152	1,056	-2,196	-7,968	-16,260
Canned	Q	3,000	6,000	0,000	12,000	15,000
Anchoveta	TNR	6,150	12,300	18,450	24,600	30,750
Fish Meal & Oil	Q	50,000	100,000	150,000	200,000	250,000
Jurel	TNR	-10	-80	-210	-400	-650
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Jurel	TNR	10	20	30	40	50
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	1,152	1,056	-2,196	-7,968	-16,260
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Sardina	TNR	10	20	30	40	50
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Sardina	TNR	1,152	1,056	2,196	7,968	16,260
Canned	Q	3,000	6,000	9,000	12,000	15,000
Sardina	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D - (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Agujilla Canned	TNR	1,152	1,056	-2,196	-7,968	16,260
	Q	3,600	6,000	9,000	12,000	15,000
Agujilla Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic Fresh	TNR	210	420	630	340	1,050
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Canned	TNR	1,152	1,056	-2,196	-7,968	-16,260
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Fresh	TNR	17	-26	-129	-292	-515
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Frozen	TNR	668	1,336	2,004	2,672	3,340
	Q	4,000	8,000	12,000	16,000	20,000
Merluza Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Congrio Fresh	TNR	233	396	489	512	465
	Q	500	1,000	1,500	2,000	2,500
Congrio Frozen	TNR	63	136	204	276	340
	Q	400	800	1,200	1,600	2,000
Congrio Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Merluza de Cola Frozen	TNR	440	880	1,320	1,760	2,200
	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal Fresh	TNR	336	672	1,008	1,344	1,680
	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal Frozen	TNR	286	536	804	1,072	1,340
	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D - Total Net Revenue (in US \$ x 10³) and Associated Outputs (in MT/YR)
For Zonal Production of Selected Fishery Commodities

		Zone V				
Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Anchoveta	TNR	1,137	1,026	-2,241	-8,028	-16,335
Canned	Q	3,000	6,000	9,000	12,000	15,000
Anchoveta	TNR	6,150	12,300	18,450	24,600	30,750
Fish Meal & Oil	Q	50,000	100,000	150,000	200,000	250,000
Jurel	TNR	-42	-144	-306	-528	-310
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Jurel	TNR	10	20	30	40	50
Frozen	Q	5,000	10,000	15,000	20,000	25,000
Jurel	TNR	1,137	1,026	-2,241	-8,028	-16,335
Canned	Q	3,000	6,000	9,000	12,000	15,000
Jurel	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Sardina	TNR	0	0	0	0	0
Fresh	Q	1,000	2,000	3,000	4,000	5,000
Sardina	TNR	1,137	1,026	-2,241	-8,028	-16,335
Canned	Q	3,000	6,000	9,000	12,000	15,000
Sardina	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix D (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Agujilla Canned	TNR	1,137	1,026	-2,241	-8,028	-16,335
	Q	3,000	6,000	9,000	12,000	15,000
Agujilla Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Other Pelagic Fresh	TNR	114	228	342	456	570
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Canned	TNR	1,137	1,026	-2,241	-8,028	-16,335
	Q	3,000	6,000	9,000	12,000	15,000
Other Pelagic Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Fresh	TNR	-5	-70	-120	-280	-625
	Q	10,000	20,000	30,000	40,000	50,000
Merluza Frozen	TNR	668	1,336	2,004	2,672	334
	Q	4,000	8,000	12,000	16,000	20,000
Merluza Fish Meal	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000
Congrio Fresh	TNR	217	364	441	448	385
	Q	500	1,000	1,500	2,000	2,500
Congrio Frozen	TNR	68	136	204	272	340
	Q	400	800	1,200	1,600	2,000
Congrio Fish Meal & Oil	TNR	1,230	2,460	3,690	4,920	6,150
	Q	10,000	20,000	30,000	40,000	50,000

Appendix D- (Cont.)

Commodity		Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Merluza de Cola	TNR	440	880	1,320	1,760	2,220
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Merluza de Cola	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000
Other Demersal	TNR	240	480	720	960	1,200
Fresh	Q	3,000	6,000	9,000	12,000	15,000
Other Demersal	TNR	286	536	804	1,072	1,340
Frozen	Q	4,000	8,000	12,000	16,000	20,000
Other Demersal	TNR	1,230	2,460	3,690	4,920	6,150
Fish Meal & Oil	Q	10,000	20,000	30,000	40,000	50,000

Appendix E- Separable Programming Results: Summary of Annual Outputs by Commodity (MT/YR)
Alternative A - Zonal Objective Functions

Commodity	Year								
	1	2	3	4	5	6	7	8	9
1 Canned Anch	10,820	14,890	12,220	11,810	0	0	805	0	0
2 Anch FM	79,040	165,500	56,600	118,300	202,700	97,180	110,300	194,000	208,600
3 Fresh Jr. S.	5,231	5,000	6,913	15,000	25,000	25,000	25,000	25,000	25,000
4 Frozen Jr. S	0	0	0	0	0	0	0	0	0
5 Canned J.S.	6,597	4,523	7,158	8,551	3,998	1,000	4,630	2,889	2,491
6 Jr.S.FM	0	0	0	0	0	0	0	0	0
7 Fresh Sard	7,00	5,000	5,000	9,282	10,780	11,380	11,070	12,000	11,490
8 Canned Sard	18,080	15,970	15,400	15,180	6,298	1,920	13,100	5,189	4,791
9 Sard FM	25,630	12,270	9,719	17,090	21,250	6,594	14,300	19,680	13,280
10 Canned Agu	0	0	0	0	29,470	36,850	21,230	31,690	32,480
11 Agu FM	0	0	0	0	8,230	18,880	4,377	9,424	9,853
12 OPF Fresh	14,150	7,001	11,340	8,081	30,600	11,650	27,520	13,880	24,590
13 OPF Canned	907	449	727	518	0	0	0	0	0
14 OPF Fish Meal	8,161	4,039	6,541	4,662	8,126	3,093	7,308	3,686	6,529
15 Fresh Merluza	549	674	553	243	197	2,716	2,402	1,228	1,000
16 Frozen Merluza	9,031	9,010	8,941	9,094	8,790	8,790	8,790	8,790	8,790
17 MZA FM	11,490	6,517	3,089	19,660	20,440	12,120	13,830	18,370	14,530
18 Fresh Cong	2,754	2,791	2,755	2,663	4,485	6,225	5,869	5,016	5,951
19 Frozen Cong	109	115	109	95	400	400	400	400	400
20 Cong FM	0	0	0	0	0	330	186	0	1,352
21 Frozen MdeC	0	0	0	0	0	0	0	0	0
22 MdeC FM	0	0	0	0	4,855	3,959	4,219	5,405	6,676
23 ODF Fresh	879	922	2,576	927	16,020	16,810	13,880	10,640	13,150
24 ODF Frozen	251	263	736	265	667	700	578	443	548
25 ODF Fish Meal	0	0	0	0	0	0	0	0	0
Subtotals									
Fresh	30,563	21,388	29,137	36,196	87,032	73,781	85,741	67,764	81,181
Frozen	9,441	9,388	9,786	9,455	9,657	9,890	9,763	9,663	9,738
Canned	36,404	35,832	35,505	36,059	39,766	38,770	39,765	45,768	29,762
Fish Meal	124,321	188,326	75,949	159,712	265,601	142,156	154,410	250,565	260,820

Appendix E - Separable Programming Results: Summary of Annual Outputs by Commodity (MT/YR)
Alternative B - Zonal Objective Functions

Commodity	Year								
	1	2	3	4	5	6	7	8	9
1 Canned Anch	10,820	14,890	12,220	11,810	0	0	804	0	0
2 Anch FM	79,040	105,500	56,500	113,300	202,700	97,130	110,300	194,900	208,600
3 Fresh Jr. S.	5,231	5,000	6,913	15,000	25,000	25,000	25,000	25,000	25,000
4 Frozen Jr.S.	0	0	0	0	0	0	0	0	0
5 Canned J.S.	6,597	4,523	7,158	8,551	3,998	1,000	4,630	2,889	2,491
6 Jr.S.FM	0	0	0	0	0	0	0	0	0
7 Fresh Sard	7,000	5,000	5,000	9,282	10,780	11,330	11,070	12,000	11,490
8 Canned Sard	18,030	15,970	15,400	15,180	6,298	1,920	13,100	5,189	4,791
9 Sard FM	25,630	12,270	9,719	17,090	21,250	6,594	14,300	19,680	13,280
10 Canned Agu	0	0	0	0	29,470	36,850	21,230	31,690	32,480
11 Agu FM	0	0	0	0	8,230	18,8860	4,377	9,424	9,853
12 OPF Fresh	14,150	7,001	11,340	8,081	30,600	11,650	27,520	13,880	24,590
13 OPF Canned	907	449	729	518	0	0	0	0	0
14 OPF Fish Meal	8,161	4,039	6,541	4,662	8,126	3,093	7,308	3,686	6,529
15 Fresh Merluza	549	674	553	243	197	2,716	2,402	1,228	1,000
16 Frozen Merluza	908	9,010	8,941	9,094	8,790	8,790	8,790	8,790	8,790
17 MZA FM	11,490	6,517	3,089	19,660	20,440	12,120	13,830	18,370	14,530
18 Fresh Cong	2,754	2,791	2,755	2,663	4,485	6,225	5,869	5,016	5,951
19 Frozen Cong	109	115	109	96	400	400	400	400	400
20 Cong FM	0	0	0	0	0	330	186	0	1,352
21 Frozen MdeC	0	0	0	0	0	0	0	0	0
22 MdeC FM	0	0	0	0	4,855	3,959	4,219	5,405	6,676
23 ODF Fresh	879	922	2,576	927	16,020	16,810	13,830	10,640	13,150
24 ODF Frozen	251	263	736	265	667	700	578	443	548
25 ODF Fish Meal	0	0	0	0	0	0	0	0	0
Subtotals									
Fresh	30,563	21,388	29,137	36,196	87,032	73,781	35,741	67,764	81,181
Frozen	9,441	9,388	9,786	9,455	9,857	9,390	9,768	9,663	9,738
Canned	36,404	35,832	35,505	36,059	39,766	33,770	39,765	45,763	29,762
Fish Meal	124,321	183,326	75,949	159,712	265,601	142,150	154,420	250,565	260,320

Appendix F

Net Revenues and ROI under Zonal OB Functions

Alt. A	Year	Zone I		Zone II		Zone III		Zone IV		Zone V		National
		NR	ROI	NR	ROI	NR	ROI	NR	ROI	NR	ROI	NR
	1	25,630	14	2,345	31	15,390	32	313	9	42	8	43,730
	2	25,630	22	2,345	28	15,390	27	313	7	42	4	43,730
	3	13,000	11	2,300	15	15,000	27	350	3	69	2	30,880
	4	20,000	17	3,100	20	18,000	33	300	2	49	1	41,730
	5	37,000	32	9,400	61	25,000	44	7,200	57	3,000	67	81,560
	6	28,000	23	9,200	60	23,000	42	7,000	56	2,700	62	69,860
	7	24,000	21	8,400	55	21,000	38	6,600	52	2,900	65	63,250
	8	37,000	31	9,200	60	24,000	43	7,000	55	2,500	57	79,510
	9	39,000	33	9,600	62	24,000	43	7,300	57	3,300	74	83,000
	10	38,000	32	9,500	62	23,000	41	7,400	58	3,000	67	80,900

Alt. B												
	1	16,000	14	2,600	31	18,000	32	380	9	86	8	37,240
	2	26,000	22	2,300	28	15,000	27	310	7	43	4	43,730
	3	13,000	8	2,300	5	15,000	15	350	1	69	0.2	30,880
	4	20,000	12	3,100	7	18,000	18	300	1	49	0.2	41,730
	5	37,000	23	9,400	21	25,000	24	7,200	30	3,000	10	81,560
	6	28,000	17	9,200	20	23,000	23	7,000	30	2,700	9	69,860
	7	24,000	15	8,400	19	21,000	21	6,600	28	2,900	10	63,250
	8	27,000	22	9,200	20	24,000	24	7,000	29	2,500	8	79,510
	9	39,000	24	9,600	21	24,000	23	7,300	30	3,300	11	83,030
	10	38,000	23	9,500	21	23,000	23	7,400	31	3,000	10	80,900