PROCEEDINGS

of the Second Conference of the

LOAN COPY ONLY

International Institute of Fisheries Economics & Trade

Volume 2: A Compendium of Papers on Seafood Trade and Markets

Christchurch, New Zealand
August 20-23, 1984

Oregon State University
Sea Grant College Program
ORESU-W-84-001 C2

Proceedings of the Second Conference of the
International Institute of Fisheries Economics and Trade

Volume 2: A Compendium of Papers on Seafood Trade and Markets

August 20-23, 1984
Christchurch, New Zealand

This volume of the proceedings of the 1984 conference of the International Institute of Fisheries Economics and Trade contains papers which focus on international seafood trade and on aspects of seafood markets. They were prepared, in part, through funding support provided by the Oregon State University Sea Grant College Program. Support for the conference was also provided by the following: New Zealand Ministry of Agriculture, New Zealand Fishing Industry Board, Oregon State University's Department of Agricultural and Resource Economics, the University of Canterbury Centre for Resource Management, Air New Zealand, and Ferons Seafood Limited. Their valuable contributions towards the success of the conference are gratefully acknowledged.

Ordering Publications

Copies of this publication and its companion volume (Volume 1: Economic Recovery, Fisheries Economics, and Seafood Trade) are available at cost from the International Institute of Fisheries Economics and Trade, Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon 97331, USA.

This publication is the result, in part, of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant No. NA81AA-D-00086 (Project No. R/PPA-20). The U.S. Government is authorized to produce and distribute reprints for governmental purposes, notwithstanding any copyright notation that may appear hereon.

The Oregon State University Sea Grant College Program is supported cooperatively by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, by the state of Oregon, and by participating local governments and private industry.

July 1985

Table of Contents

Page

Seafood Trade Models

Economic Recovery an
Seafood Market

The Soviet Union's Fishing Industry and USSR's Foreign Trade in Fishing Industry Products

Jan Solecki
University of British Columbia
Vancouver, British Columbia, Canada

The last ten years, or as the Soviet economists would put it, the period of the last two five year plans (1976-80 and 1981-85) have not been kind to the Soviet economy. As can be seen from Table 1, the performance of the Soviet economy has been disappointing. Outputs of the primary industrial commodities, such as steel, coal, fertilizers, tractors, have suddenly leveled out or even declined. Grain harvests, measured against plans or against a standard per capita norm of 750 kg. per person per year, fell far short of the requirements (see Table 2). The need for the fishing industry to step in, to ease the difficulties in food supplies, was obvious, but the introduction of the 200-mile economic zone has resulted in catches below the expected planned ones (see Table 3). And this is not surprising. Within the sea areas declared 200-mile zones by other countries the Soviet Union used to harvest six million tons (mil. t.) of aqua-products (K.A. Bekiashev, #9, 1977). In the remaining years of the X Five Year Plan, after the introduction of the new restrictions in 1976, Soviet landings instead of rising as planned to 11,142 mil. t. have actually declined and in 1982 were still below the 1976 level (see Table 3).

Neither the current XI Five Year Plan (1981-85) nor the Supplies Program (Prodovolstvennaia Programma) issued in mid-1982 gave target figures for fishing industry landings in 1985 or 1990. The XI FYP bids the industry "to increase the volume of commercial edible fish products (including canned) by 10-12%... to increase the yield from inland waters and coastal seas of the USSR, and at an increased rate to enhance the production of fish in pens, ponds, lakes and other fish breeding enterprises to insure an increase in the output from these enterprises by 1.8 to 2 (Anon. Ekonomicheskaia Gazeta, #49, 1980) times by means of strengthening cooperation internationally and forming joint ventures to maintain at a sufficiently high level Soviet catches in the fishing zones of other nations (N.P. Kudriavtsev, #1, 1981). Per capita consumption of fish in 1985 is to rise to 18.2 kg. per year compared to 7.0 kg. in 1950, 15.4 kg. in 1970 and 16.8 kg. in 1975 (see Table 5). But this was to be achieved by using 80% of the landings for food production compared with 63.9% in 1975 and 72.4% in 1980 (see Table 4).

But the main emphasis in the future will still be given to the use of the open seas outside of the 200-mile zones, to the USSR's own 200-mile zone and the 200-mile zones of other countries. In spite of the official pronouncements calling for increased landings from inland waters the situation has not improved. The catches from these waters dropped from 350 thousand t. in 1976 to 203 thousand t. in 1980, mainly due to pollution by industrial and agricultural effluents and to the operation of water intake points without fish protection devices (I.V. Nikonorov, #6, 1982).

XI FYP provides for an increase in the output of live and chilled fish of 40.8%, smoked fish 12.3%, dried 24.6%, delicatessen (balyks) and culinary products 16%. The increase in catches from fresh water bodies is to be 1.7-1.8 fold (N.P. Kudriavtsev, #1, 1981). The Supplies Program (Anon. Prodovolstvennaia programma SSSR, 1982) introduced on May 24, 1982 appears to have raised the targets for the fishing industry. The output of commercial fish from fish breeding enterprises was to increase during the decade about three times. Output of edible fish was to rise by 1985 to 4.2 mil. t. and by 1990 to 4.3-4.5 mil. t. Canned fish production figures are 3 billion and not less than 3.2 billion standard cans respectively. The total volume of landings is to rise to 9.77 mil. t. and the output of fish meal to reach 500 thousand tons (E.A. Romanov, #12, 1982).

To cope with its assignments the fishing industry has at its disposal 90 scientific research, design and construction organizations, 68 academic institutions, 351 production and research/production

---

* Unless stated otherwise, the number refers to the Russian language journal Rybnoe Khoziaistvo (Fisheries Economy), published in the USSR.

Table 1. Output of Selected Commodities in the USSR

Year	El. Po. Bd. Kwh	Steel Mil. T.	Coal Mil. T.	Oil Mil. T.	Fertil. Mil. T.	Cars Thous.	Tractors Thous.	Wood Mil. m^3(S)	Paper Thous. T.	Shoes Mil. Prs.	Grain Mil. T.	Meat[2] Mil. T.	Butter[2] Th. T.	Popul. Mil.
1950	91.2	27.3	261	37.9	1.2	64.6	117	266	1193	203	81.2	1.6 ?	336 ?	181.6
1960	292	65.3	510	148	3.3	139	239	370	2421	419	125.5	4.4 8.7	737 848	216.3
1970	741	116	624	353	13.1	344	459	385	4185	679	186.8	7.1 12.3	963 1067	241.7
1975	1039	141	701	491	22.0	1201	550	395	5215	698	140.1	9.9 15.0	1231 1356	253.3
1976	1111	145	712	520	22.6	1239	562	385	5389	724	223.8	8.4 13.4	1263 1356	255.6
1977	1150	147	722	546	23.5	1280	569	377	5459	736	195.7	9.1 14.7	1408 1500	257.9
1978	1201	151	723	572	23.7	1312	576	362	5548	740	237.4	9.6 15.3	1381 1472	260.1
1979	1238	149	718	586	22.1	1314	557	354	5249	740	179.3	9.6 15.5	1325 1409	262.4
1980	1295	148	716	603	24.8	1327	555	357	5288	744	189.1	9.2 15.0	1278 1373	264.5
1981	1326	148	704	609	26.0	1324	559	358	5399	738	160.0(?)	9.3 15.2	1210 1318	266.6
1982	1367	147	718	613	26.7	1307	555	356	5439	734	180.0(?)	9.3 15.4	1290 1403	268.8

1. Ob itogakh vypolnenia gosudarstvennogo plana ekonomicheskogo i sotsialnogo razvitia SSSR v 1982 g. (On the results of the fulfillment of the national plan for economic and social development of the USSR in 1982. Ekonomicheskaia Gazeta 1983, #5, January, p. 3).

2. Top figure - without the production from private plots; lower figure includes the private plots production.

Source: Narodnoe Khoziaistvo SSSR (USSR National Economy). Statistical Year Books, Finansy i Statistika, Moscow, 1958-1982.

Table 2. Grain Output Planned, Needed and Harvested, Mil. T.

Year		Planned		Needed*		Harvested	
1950		-		133.8		81.2	
1960		-		159.3		125.5	
1961				162.2		130.8	
1962				165.0		140.2	
1963				167.6	837.0	107.5	651.7
1964				170.0		152.1	
1965				172.2		121.1	
1966				174.1		171.2	
1967				176.1		147.9	
1968		847.2[1]		177.9	888.9	169.5	837.8
1969				179.6		162.4	
1970				181.2		168.8	
1971	195 x 5			182.9		181.2	
1972				184.7		168.2	
1973		975[2]		186.4	932.1	222.5	907.7
1974				188.2		197.5	
1975				189.9		140.1	
1976	215 x 5			191.7		223.8	
1977	220 x 5			193.4		195.7	
1978		1075[3]		195.0	975.2	237.4	1025.[illegible]
1979		1100		196.8		179.2	
1980				198.3		189.2	
1981	238 x 5			199.9		160.0	
1982	243 x 5	1190[4]	(714)	201.6	604.9	180.0	530
1983		1215	(729)	203.4		190.0	
1984							
1985							

* It is assumed that 3/4 of a tonne per capita per year is needed.

1. Directives of XXIII Congress of CPSU on the five year plan for the development of national economy the USSR over 1966-1970 required an increase of 30% over the output of the previous FY period. The output during 1961-65 was 651.7 mil. t.: therefore, 1966-70 was to be 847.2. Izd. Polit. Lit. Moscow, 1966, p. 30.

2. Directives of the XXIV Congress of CPSU on the five year plan for the development of the national economy of the USSR over 1971-75. Izd. Pol. Lit. Moscow, 1971, p. 33.

3. Main directions of the development of the national economy of the USSR over 1976-80. Politizdat, Moscow, 1976, p. 50.

4. Main directions of the economic and social development of the USSR for 1981-85 and for the period to 1990. Politizdat Moscow, 1981, p. 46.

Table 3. Output of the USSR Fishing Industry

Year	Fish, etc. Landings Mil. T.		Canned Fish Output Mil. S.C.*		Edible Fish Products Mil. T.
1917	893				
1920	257				
1922	483				329.7[4]
1930	1,283		161.2		
1940	1,404		124		823.7[4]
1950	1,755		200		
1960	3,541		726		
1961	5,774		977		
1970	7,828	1976-80[2]	1,393		
1975	10,357	Plan	2,207		4,000[5]
1976	10,478	10,514	2,377		
1977	9,651	10,671	2,467		
1978	9,230	10,828	2,669		
1979	9,359	10,985	2,913		
1980	9,526	11,142	2,830	P. 3000[3]	4,700P[3]
1981	9,600		2,927		
1982	10,000		2,853		
1985P			3,000		4,200[6]
1990P			3,200		4,300-4,500[6]

*s.c. = standard can = 353.4 grams

1. Narodnoe Khoziaistvo SSSR (USSR National Economy) Statistical Year Books. Statistika Moscow.

2. Narodnoe Khoziaistvo SSSR 1922-1977 (USSR National Economy 1922-1977). Statistika Moscow, 1978, p. 21.

3. V. Kamentsev. Perspektivy rozvitia rybnogo Khoziaistva Planovoe Khoziaistvo 1978, #1, p. 9-18.

4. E.A. Romanov. Rybnaia promyshlennost za 60 let. Rybnoe Khoziaistvo 1982, #12, pp. 3-11.

5. M.G. Ilchuk, L.P. Kuzmina, N.F. Kalishchuk, O.I. Rodionova, T.V. Senko, M.G. Spitsina, L.A. Filippovich, V.V. Chernova. Ekonomika organizatsia i planirovanie proizvodstva na predpriatiakh rybnoi promyshlennosti (Economics, Organization and Planning of the Output at the Enterprises of the Fishing Industry). Legkaia i pishchevaia promyshlennost. Moscow, 1982, p. 303.

6. Prodovolstyennaia Programma SSSR na period do 1990 goda (USSR Supplies Program for the Period up to 1990). Pravda, 27.v.1982.

Table 4. Utilization: Percent of the Catch

1975	63.9[2]	63.8[3]	
1980	70.0[1]	74.4[3]	72.4[4]
1981	73.1[2]		
1982	75.0[1]		
1985	76.0[1]	75.0[2]	

1. N.P. Kudriavtsev. Prodovolstvennaia programma i rybnoe Khoziaistvo (Supplies Program and the Fisheries). Rybnoe Khoziaistvo 1982, #9, pp. 3-4.

2. E.A. Romanov. Rybnaia promyshlennost' za 60 let (60 Years of the Fishing Industry). Rybnoe Khoziaistvo. 1982, #12, pp. 3-11.

3. N.P. Kudriavtsev, 1st Deputy Minister of the Fishing Industry of the USSR. Rybnoe khoziaistvo v odinnadtsatoi piatiletke (Fisheries in the Eleventh Five Year Plan). Rybnoe Khoziaistvo, 1981, #1, pp. 3-7.

4. L.I. Borisochkina. Puti povyshenia vypuska pishchevoi rybnoi produktsii (Ways of Increasing the Output of Edible Fish Commodities). Rybnoe Khoziaistvo 1983, #12, pp. 60-62.

Table 5. Per Capita Fish Consumption in the USSR

1913	6.7[1]
1950	7.0[1]
1955	9.1[1]
1960	9.9[1]
1965	12.6[1]
1970	15.4[1]
1975	16.8[1]
1980	17.6[2]
1981	18.0[2]
1982	18.4[2]
1985P	18.2[3]
1990P	19.0[4]

1. N.P. Sysoev. Ekonomika rybnoi promyshlennosti (Economics of the Fishing Industry). Pishchevaya Promyshlennost) Moscow 1976, p. 17.

2. Statisticheski yezhegodnik stran-chlenov Soveta Ekonomicheskoi Vzaimopomoshchi 1983. Finansy i Statistika (Statistical Year Book of the Comecon Member Countries 1983). Moscow 1983, p. 48.

3. V.M. Kamentsev. Zadachi rybakov v razvitii Prodovolstvennoi Programmy Strany (Fishermen's Tasks in the Development of the Supplies Program). Rybnoe Khoziaistvo, 1983, #12, pp. 15-17.

4. S.A. Studenetski. Prodovolstvennaia programma i zadachi rybokhoziaistvennoi nauki (Supplies Program and the Tasks of the Fisheries Economics Science). Rybnoe khoziaistvo 1983, #1, p. 3.

amalgamations and industrial enterprises, 440 trading organizations (382 of these retail outlets of which 116 were opened during 1975-80 period), over 250 refrigeration plants with one time capacity of nearly 400,000 tons of fish. In all the fishing industry has 54 fishing, refrigeration basis for the fleet, 19 ports, 244 fish processing, 198 fish breeding, 66 ship repair and metal working plants, 17 packaging material manufacturing and 7 net knitting enterprises (E.A. Romanov, #12, 1982).

The Ministry of Fishing of the USSR was instructed to undertake measures to considerably expand and renovate the assortment of fish products, improve the quality and taste, double the output of live and chilled fish during the decade. During the current decade 200-240,000 tons of refrigeration capacity is to be commissioned.

The pressure to meet the targets, to produce more edible products from constant and even diminishing catch has indeed led to increased output, but with some undesirable consequences. "The wholesale trade system handled by Soyuzrybpromsbyt (All Union Fish Products Selling Organization) and the retail organizations of the fisheries enterprises amalgamations (centres) began to experience difficulties in selling some types of fishing industry products, including such items as frozen ocean fish classed as small group II and III, in particular moiva, frozen sardines, salted and marinated products, pastes from scad, mackerel and some other species of fish. Delays in selling these products resulted in tying up transportation and other vessels and box cars which in turn affected the work of fishing vessels at sea and resulted in certain restraints to production" (E.A. Romanov, #12, 1983).

An important consideration from the Soviet point of view is to secure an adequate resource base for fisheries operations. Being the owner of the largest fishing fleet the USSR has tried to establish and maintain good relations with other countries. At the start of the eighties the Soviet Union had 66 bilateral agreements with 39 countries and 13 multilateral (V.M. Kamentsev, #2, 1982).

Fishing Fleet

The mainstay of the Soviet fishing industry is its fishing fleet. In 1978 it gave the country 90% of the total catch, about 85% of fish products, 40% of canned fish and nearly all the fish meal. Eighty percent of the industry's production capacity was its fishing fleet (Kamentsev, #1, 1978). However, by the beginning of 1981 this figure dropped to 79% indicating a tendency towards giving a greater importance to shore installations (N.P. Kudriavtsev, #1, 1981).

As is the case with many other resources in the USSR there is a considerable disproportion between the production capacity and the demand for fishing industry products. North Western, Baltic and the Far Eastern regions of the USSR with only 10.8% of the country's population had 86.8% of the capital equipment of the industry. In 1977 they employed 72.5% of the industry's labor, caught 77.8% of fish and produced 73.9% of industry's gross output (Sysoyev, #1, 1980). Given below are details of the composition of the Soviet fishing fleet (see Table 6).

Table 6. Fleet of the USSR's Ministry of Fishing Industry Registered in the USSR on July 1, 1982 (Self Propelled Vessels of Gross Capacity of 100 reg. tonnage and above)

Type of Vessel	Number	Gross Registered Tonnage	Deadweight Tonnage
1. Passenger and Passenger/Cargo	11	6,653	5,650
2. Dry Cargo	544	1,436,297	1,361,298
3. Tankers	107	230,256	286,012
4. Technical	30	18,377	9,530
5. Fishing	2,569	3,307,442	1,839,886
6. Specialized	214	1,589,286	1,211,586
7. Auxiliary	336	138,234	90,770
TOTAL	3,811	6,726,545	4,804,730

1. A vessel carrying more than 12 passengers.

2. A vessel for transporting non-liquid cargo.

3. A vessel for transporting liquid cargo.

4. Cranes, dredges, barges, floating workshops, pump stations, etc.

5. Fishing and fishing-and-processing vessels.

6. Research expeditionary, geographic, training vessels, whalers, processing vessels which do not do any fishing.

7. Tugs, rescue vessels, messenger carriers, pilot carriers, oil cleaners, divers, fish protection sanitation vessels, port fuel supply vessels, vessels for collecting waste oil, bilge water collectors, etc. (Rybnoe Khoziaistvo 1983 No. 4, p. 54).

Fishing Industry's Position in the Soviet Economy

Difficulties experienced by the USSR in agriculture enhanced the position and the status of the fishing industry. Due to the increase in the volume of landings and especially due to more intense use of the catch, the per capita consumption of fishing industry products already in 1982 reached 18.4 kg., which exceeded the growth rate envisaged by the Supplies Programme and the initial norm established by the scientists (E.A. Romanov, #12, 1983). As can be seen from Table 7, whereas 1980 consumption of meat amounted to only 70% of the norm recommended, of milk 78%; of eggs 82% that of fish was 97%, and position of fish had further improved between 1980 and 1982. By 1983 in meat/fish contribution to diet, fish accounted for one quarter of the total amount. Furthermore to obtain one kilogram of fish protein the state has to spend only about one third of what is needed for meat production (S.A. Studenetski, #1, 1983).

In 1977-78 fishing industry employed 800,000 people of whom 160,000 had university or specialized training (A.A. Ishkov, #11, 1977). This is equivalent to 20% compared with 23.6% for the national labor force as a whole. According to a later source (M.G. Ilchuk, et al.), on January 1, 1981, in the complex fishing industry organization were employed over 850,000 people of whom in the fish handling branch there were 438,000 people engaged directly in the production processes. The value of capital assets of the

Table 7. Per Capita Annual Consumption of Selected Food Products in the USSR

Commodity	Recommended Norm Per Year	1965	1970	1975	1980	Percent of the Norm	1990P
Meat and meat products, kg.	82	41	48	57	58	(70)	70
Milk and milk products, kg.	405	251	307	316	314	(78)	330-340
Eggs, units	292	124	159	216	239	(82)	260-266
Vegetables, kg.	146	72	82	89	93		126-135
Fruit, kg.	113	28	35	37	34		66-70
Vegetable oil, margarine, kg.	9	7.1	6.8	7.7	8.8		13.2
Fish and fish products, kg.	18.2	12.6	15.4	16.8	17.6	(97)	19
Bread, pastry products	110	156	149	141	139		135
Potato, kg.	97	142	130	120	112		110
Sugar, kg.	40	34.2	38	40.9	44.4		45.5

Source: S.A. Studenetski. Prodovolstvennaia programma i zadachi rybokhoziaistvennoi nauki (Consumer Suppliers Programme and the Task of the Fisheries Science). Rybnoe Khoziaistvo. 1983, #1, p. 3.

industry amounted to 10 billion. "...Fishing industry accounted for 8% of the gross output of the food producing industries of the country (M.G. Ilchuk, et al.)

In spite of the set back caused by the introduction of the 200-mile economic zone, the Soviet Union takes an optimistic view of the future possibilities for the fishing industry. It is said that "the present day knowledge about world oceans makes it possible to assert that its biological production amounts to hundreds of billions of tons, while only an insignificant amount is utilized; 75 million tons. It is pointed out that according to FAO, in 1980 approximately 30 million tons of bioresources of shelfs have not been used (S.A. Studenetski, #1, 1983).

One of the features of the Soviet Union's stand in respect to the fisheries resources is her stressing the outsiders' right to unutilized resources of the 200-mile economic zone of other countries. While discussing the III UN Conference on the Law of the Sea V.I. Ikriannikov of the Ministry of the Fishing Industry of the USSR states "The most important stand of the convention in respect to live resources of the economic zone is the obligation by the coastal state, side by side with the conservation of the resources, to insure their optimum utilization, and arising from this a position about the obligation to permit foreign fishermen to enter the economic zone to harvest residue of the allowable catch" (V.I. Ikriannikov, #5, 1983). (Emphasis mine, J.S.)

Natural Resources of the Soviet Fishing Industry

Restrictions placed on the Soviet fishing industry operations by foreign countries have encouraged the Soviet scientists to take a closer look at their own resources, consisting of continental shelf, the resources of the shore line, and those of the inland waters.

The USSR's continental shelf area, excluding Aral and Caspian Seas, amounts to 6.6 million sq. km. or approximately one fourth of that available in the world. Furthermore, the area of the shelf less than 50 m. deep (also excluding Aral and Caspian Seas) amounts to 3.2 mil. sq. km. or nearly 50% of the shelf area of the USSR and 11.8% of the world shelf. The overall length of the shore line in the USSR is more than 60 thousand km. (V.P. Zaitsev, #8, 1978). However 80% of the USSR's shelf is in the Arctic region and requires special attention (A. Alekseev, L. Dushkina, et al., Pravda 4, August 1978). For example, the White Sea is considered particularly vulnerable because of the pollution coming from rivers emptying into it and which already now threaten the flora and fauna of the sea (A. Alekseev, L. Dushkina, et al.). The area of the shelf adjoining oil and gas bearing regions of the USSR amounts to 2.5 mil. sq. km. or nearly 40% of the total. The most promising as possible sources of mineral resources are Caspian, Okhotsk and Bering Seas, a fact not necessarily favoring the fishing industry. (For details of the USSR's continental shelf see Table 8). Furthermore, the Soviet Union has in all 377 thousand sq. km. c shoreline waters less than 25 m. deep of which 38 thousand sq. km. are thought to be suitable for mariculture. It is estimated that between 348-800 thousand t. of plant vegetation, 290-850 thousand t. of crustaceans and 340-900 thousand t. of fish could be bred within this shallow zone alone (P.A. Moiseev, #2, 1980) (see Table 9).

Table 8. USSR's Continental Shelf, Thousand Sq. Km.

Sea	Total Area	Shelf Area	Shelf Less Than 50 m. Deep	Length of Coastlir
Aral	66	66	65	6,617
Caspian	394	250	156	6,100
Azov	39	39	39	2,686
Black	413	120	48	2,040
Baltic	385	385	216	1,200
White	89	89	60	2,500
Barents	1,405	660	70	4,600
Kara	883	800	880	950
Laptev	650	480	370	7,500
E. Siberian	901	860	660	5,918
Chukotka	582	582	190	1,620
Bering	2,304	1,020	440	5,251
Okhotsk	1,590	620	150	10,440
Japan	980	80	30	3,070
TOTAL		6,051	3,374	60,492

Note: The area of the shelf of the Barents and Kara Seas is shown within the limits of 200 m. isobath, the length of the coastline of Caspian, Black, Baltic, Barents, Chukotka, Bering and Japan Seas - portions within the limits of the USSR.

Source: V.P. Zaitsev. Ispolzovanie prirodnykh resursov shelfa i ego preobrazovanie (Utilization of th Natural Resources of the Shelf and its Re-shaping). Rybnoe Khoziaistvo. 1978, No. 8, pp. 8-1

The size of the Soviet Union guarantees the availability of natural conditions for inland fishing and fish cultivation. Within the USSR there are 600,000 km. of rivers that can be of value to the fishing industry, there are 280,000 lakes with an area of 25 million hectares, and there are over 200 large reservoirs with an area of nearly 6 million ha. (V. Kamentsev, #1, 1978).

Mariculture in the USSR (similarly as elsewhere) is a relatively new field. The reasons given for havi neglected it are: (1) traditional orientation to fishing in seas and oceans and the consequent commitment of labor and material to it, (2) relatively severe climate over the large portion of the shelf, (3) anthropogenic action upon inner seas, (4) unfavorable geomorphology of the coastline in many regions and (5) absence of experience, and lack of a material and technical base necessary for cultivating marine organisms on an industrial scale. In the USSR, mariculture has ceased to be an obje of purely scientific research and development but has not as yet become a sphere of industrial cultivation of valuable sea species. However, promising lines have been chosen, and these are: Far East: Breeding of salmon, okhotsk herring, scallop, mussels, oysters, sea cucumbers, laminaria, gratsilaria and kostaria. For the Sea of Azov and the Black Sea: mullet, flounder, sturgeons, banded sea perch, steelhead salmon, mussels, glacilaria. For the European North: Atlantic salmon, coho salmor mussels, laminaria. For Baltic basin: rainbow trout, sea trout and coho salmon. Ranching forms of marine aquaculture have been developed and popularized. These are combined with artificial reproductior mainly of salmon and sturgeons. Over 60 fish rearing enterprises located within coastal regions and on inner seas release annually over a billion juveniles of salmon and over 100 million of sturgeons. Regional enterprises of ranching type are mainly for salmon in the Far East and for sturgeons in the South of the country, where in the face of intense anthropogenic interference it was possible not only t maintain but also to increase the populations of the very valuable diadromous fish. In the Sea of Okhotsk natural spawning conditions have been improved since 1976. Here 50,000 sq. m. of artificial spawning grounds have been put out which has helped in rebuilding the population of Okhotsk herring. By 1985 it is planned to put out some 700,000 sq. m. of such spawning grounds.

The USSR has had some experience with successful results in pen breeding of sturgeons and salmons in the coastal waters of the Baltic, Sea of Azov and the Black Sea, mainly in fishing collective farms (kolkhozes). Further success would depend on building storm resistent pen structures, on perfecting rearing methods, better medical care and the supply of the appropriate food. Cultivation of invertebrae

Table 9. USSR's Shallow Water Zones and Their Potential for Mariculture

Region		Area, thous. km.^{2}		Coefficient of Shoreline Irregularity	Possible Yield, t./ha.			Possible Output, thous. t.		
		0-25 m. Deep	Of Which Usable for Mariculture		Plants	Invertebrae	Fish	Plants	Invertebrae	Fish
North Boreal	Bering	150	15	2.8	20- 60	100-200	20-100	40-120	20- 80	40- 80
	Okhotsk	30	3	1.9	10- 40	160-200	10- 30	20- 80	10- 40	10- 40
	TOTAL	180	18	-	-	-	-	60-200	30-120	50-120
	Barents	20	2	2.0	20- 60	100-200	20-100	20- 60	10- 40	10- 50
	White	30	3	4.0	20- 60	100-200	15- 50	20- 60	10- 40	5- 30
	Baltic	80	8	3.5	10- 40	-	100-200	4- 30	-	40- 90
	TOTAL	130	13	-	-	-	-	44-150	20- 80	55-170
South Boreal	Okhotsk	10	1	1.9	20- 60	100-200	10-500	100-170	20- 80	40- 80
	Japan	8	1	2.2	20-100	200-300	100-200	140-210	100-250	100-200
	TOTAL	18	2	-	-	-	-	240-380	120-330	140-200
	Black	10	1	1.8	20- 80	300-400	200-300	4- 70	120-320	55-170
	Azov	39	4	3.8	-	-	200-300	-	-	40-160
	TOTAL	49	5	-	-	-	-	4- 70	120-320	95-320
	Pacific Ocean	198	20	-	-	-	-	300-480	150-450	190-400
	Atlantic Ocean	179	18	-	-	-	-	48-320	140-400	150-500
	TOTAL	377	38	-	-	-	-	348-800	290-850	340-900

Source: P.A. Moiseev. Osnovnye napravlenia razvitia marikultury (The Main Directions for the Development of Mariculture). Rybnoe Khoziaistvo. 1980, #2, pp. 21-55.

and especially bivalve molluscs commercially is the most common. In the Far Eastern USSR there exist particularly favorable conditions, though opportunities also exist in Azov Sea. It is possible to cultivate commercially Yezo scallop, Pacific oyster and Mediterranean mussels. Since the late seventi in Posyet Bay experimental/commercial cultivation of sea cucumbers and oysters has been carried out. Annually up to ten million sea cucumbers have been collected and placed in pens. The first batches of commercial product have now been collected. Work is also being done on acclimatization of species. Thus, Far Eastern mullet is being introduced into the Caspian and Black Seas, Black Sea mullet is bein introduced into the Caspian and the Far Eastern pink salmon have been introduced into Barents and Whit Seas (S.A. Patin, #2, 1984). Sterlet and Lena sturgeon were introduced in the Oka (V.K. Kiselev, #6, 1978).

Enthusiasm is expressed about breeding fish in ponds. This type of fish breeding was started in the thirties. In 1960, the area of ponds amounted to over 50,000 ha. and 14,100 tons of fish were grown i them, mainly carp. During 1960-1975 the area of ponds trebled and the output increased tenfold. By 1 pond area increased still further to reach 208,700 ha. and the output of fish climbed to 166.4 thousan t. Yield reached 1060 kg./ha. of marketable fish (E.A. Romanov, #12, 1982). By 1985 65,000 ha. of ne ponds are to be built while 30% of the existing ones are to be rebuilt and re-equipped. The output of commercial fish from them is to rise to 300,000 tons. Yield from ha. in ponds is to reach 1480 kg. I 1982 yield from feeding ponds was 1220 kg./ha. and the plan for 1984 sets a target of 1380 kg./ha. (E. Romanov, #1, 1984).

Reservoirs. Extensive hydroelectric construction programs carried out in the USSR during the past thr decades have resulted in an area of reservoirs covering over 11 million ha., 50% of which are consider to be suitable for fishing industry operations. There are in the USSR over 200 large reservoirs of wh 120 serve hydroelectric projects. In addition next to thermal power stations there are cooling ponds with a total area of 140 thousand ha.

Annual catch from large reservoirs has been 50-60,000 tons. The average productivity has been 10-12 kg./ha., but in some reservoirs the yields have been considerably higher, for example in Tsimlanski Reservoir 50 kg./ha., at Kremenchug 40, in Kahovski approximately 30 kg./ha.

Based on the reservoirs there are at present 18 fish breeding plants and hatcheries capable of produci 250 million larvae, 141 million yearlings and 69 million two-year old fish. Over the past two decades 3.2 million breeders, nearly 30 million different size fish, 400 million young and over a billion of larvae of 33 commercial species of fish have been introduced into reservoirs. Among the plant eating species introduced were bream, zander, wild carp (sazan), carp, carassius, sturgeon, peled, omul, white-fish, cisco, blue bream, vimba, roach and others.

From the reservoirs are caught annually 10,000 tons of acclimated fish, of which 6,000 tons were plant feeding.

Over the same period of time 861 million food organisms have been introduced into reservoirs, fish ladders and platforms, fish lifts (hydraulic and mechanical) and fish sluices and other devices have be installed (M.L. Kashintsev).

Utilization of hot water from thermal, and atomic power stations and also of geothermal waters is considered to be promising in fish breeding and is being given considerable attention. It is stated th in such water fish grows and reproduces 2-3 times faster than can be reared all the year round. They grow more intensely and have a high rate of survival during the subsequent rearing in ponds. Output of fish in such cooling bodies of water can in the not too distant future reach 100,000 tons. In the cooling pond of Zmievskaia power station in Kharkov oblast and in floating pens the yield obtained was over 100 kg. of carp per sq. m. At Mironovski enterprise in the Ukrain equipped with pools, in winter the yield of trout has been 60 kg. per sq. m. of the rearing area. "Utilization of warm waters makes i possible to create a new, more progressive branch of industrial fish breeding. It results in a considerable saving of agricultural land, the production base is close to industrial centres, it can be fully mechanized thus resulting in a rise in labor productivity 2.5-3 fold. The area occupied for such installations is hundred times less and the yield exceeds the yield from ponds by thousand times" (V. Kamentsev, #1, 1978). It is suggested that in the future construction of fish breeding enterprises should be included in the preparation of the plans for the construction of the power stations and be financed as part of such construction.

The optimistic forecasts and valuations found in the Soviet press and technical literature should not b taken as likely to be realizable. There is evidence to show that like any other economy, the Soviet on is prone to malfunctioning. For example on 11 February 1983 Pravda published some of the results of an examination of 20 fish breeding enterprises, which over the previous seven years received some 40 milli Rubles in investments. The results of the examination showed that the production capacity in them was being utilized only 64%. The Don carp was found so debilitated that its weight dropped from 500 to 338 gr. More than 25% of the feeding area became shallow due to neglect. Out of 13 reed cutting machines eight were out of commission. A model enterprise could not even supply itself with fish stocks. As a result the Novocherkask combine of Donrybprom, created in 1975, gave in 1982 2,700 kg. of fish instead o 8,000 and the situation in others was even worse.

Expenditure of feed exceeded the norm by 1.5 times. In Kuibyshev production group the Suskanski enterprise produced less than 50% of 10,500 kg. planned. One third of the ponds were found to be salinated, overgrown with weeds, becoming mud patches. Fish food was sold on the side, part of it was stolen. For example in Solutsevski fish breeding enterprise out of 395 tons of fish food 217 were sold illegally. Average weight of fish was 200 gr. A similar situation was found in Briansk in Kaluga Oblast. Trained specialists hired by the industry left their jobs. Out of 590 specialists hired one year earlier 360 left. As a result the head of the Administration of pond fish breeding of the Ministry of Fisheries of the Russian Soviet Federated Socialist Republic, A. Korenevski, was sacked, Deputy Minister P. Sypugin was reprimanded and other corrective measures were taken (Pravda, 11 February 1983).

An interesting manifestation of the Soviet desire to hold on to the right to use common marine resources is their attitude to the restriction on whaling which they have been vigorously fighting.

> Analysis of the material data on the evaluation of the state of reserves of whales shows that there are adequate grounds to maintain into the future the existing rational whaling in various regions of the World ocean on the essential condition that it is done in accordance with the objective recommendations of the Scientific Committee of the International Whaling Commission and observing the currently operative regulations for whaling, while maintaining strict international control.
>
> Certain decisions taken during the last few years by the IWC, specifically banning pelagic hunting of whales (except for Balaenopteridae), and also complete banning of the operations after 1985, (apart from hunting by the aboriginees) have no scientific basis. Furthermore, they have been taken in the absence of any recommendations of this kind from the Scientific Committee.
>
> Such an action by IWC only shows the one-sided and extremely biased approach by a number of countries, with the U.S. at the head, with respect to whaling, all of which harms international cooperation in the field and also contradicts the principles of rational utilization of the resources of the World Ocean...
>
> ...Although there exist full possibilities to retain whaling on scientific grounds, the actions of the opponents of whaling are in essence directed at changing the IWC exclusively into an environment protection agency (M.V. Ivashin, R.G. Borodin, #10, 1983).

Two months later the subject was raised again in the same tone.

> The Soviet Union strictly adheres to the principle laid down at the International Convention on regulations of the whaling industry (1946) and the existing regulations on whaling. In these circumstances it is so much more surprising that a number of environment protection organizations accuse the USSR of violating some of the positions of the convention. Furthermore, some of them presume to have the right to check upon the actions of the USSR, as for example in respect to the utilization of grey whales (which have been killed for their own needs by the Chukotka population).
>
> In spite of the tense situation in the IWC, the Soviet specialists, on the basis of the present level of knowledge with respect to the various problems of biology, support the idea of rationale use of resources of whales, bearing in mind the recommendations of the Scientific Committee of the IWC (I.V. Nikonorov and M.V. Ivashin, #12, 1983).

USSR's Foreign Trade in Fishing Industry Products

As can be seen from Table 10 the share of the fishing industry products in the Soviet Union's exports in recent years has steadily declined from 0.73 of one percent in 1970 to 0.28 in 1982. Furthermore, although exports continued to grow in absolute terms until 1979, so did the imports, so that after 1979 there has been a perceptible drop in the net exports by the industry amounting to over 50 million rubles.

Looking at the individual commodities (see Table 11) we can see that the volume of fish exports dropped from 484 thousand tons in 1980 to 303 thousand in 1982, or by 59.7% while the value declined from R.122.6 million to 89.7 or by 36.6%. During the same period the volume of exports of canned fish dropped from 91.9 million standard cans (s.c.) to 70.0 or by 30% and this value dropped from R.38.8 million to R.34.2 million or 13.4%. Exports of canned salmon dropped from 18.0 to 11.6 million s.c. or by 55% while the value declined from R.12.1 million to R.10.3 million or by 17%. Exports of canned crab dropped from 5.2 million s.c. to 5.0 million or by 4% while the value increased from R.17 million to R.17.5 million or by 3%. Exports of whale meat decreased in volume from R.10.3 to R.10.0 million or by 1% while the value rose from 12.9 to 13.4 thousand tons or by 4%. Exports of fish meal dropped in volume from 22.5 thousand tons to 8.9 or more than two and one half times while the value dropped from R.5.24 million to 2.4, or a little more than two times. We can see therefore that in almost every case the drop in value of exports was less than in volume, indicating that the USSR was able to raise the prices. (See Tables 11 and 12).

Table 11. Exports of Principal Commodities of the USSR Fishing Industry (Value in Millions of Rubles)

Year	Fish and Fish Products	Fish		Canned Fish		Canned Salmon		Canned Crab		Whale Blubber		Whale Meat		Fish Meal		Caviar and Fish Eggs	
	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
1950	8.1	17.1	3.2	9.6	2.6	9.1	1.9	4.5	1.4	112	0.9	-	-	-	-	112	0.9
1960	32.6	51.6	8.2	53.5	14.8	7.9	2.4	12.0	7.7	34,600	6.3	-	-	4.0	0.484	199	1.8
1970	83.8	244	32.3	62.9	19.0	15.2	6.2	12.4	14.6	34,100	7.8	13.5	7.8	12.1	1.8	1,000	5.6
1975	157.4	491	91.5	98.5	35.6	14.2	8.7	7.9	15.0	4,000	0.9	15.0	4.1	17.9	3.4	2,100	6.9
1976	157.8	470	89.0	98.5	35.8	17.3	10.7	6.3	13.3	1,900	0.4	18.0	8.1	18.0	3.5	1,600	7.7
1977	155.3	404	80.7	110.1	39.5	19.4	13.7	4.5	12.2	900	0.2	13.3	11.5	13.6	3.1	1,400	8.1
1978	174.6	460	99.2	90.5	34.1	17.8	11.7	3.9	15.0	1,100	0.3	9.0	11.5	21.4	4.3	1,200	10.2
1979	208.4	474	123.8	84.2	35.9	18.7	13.4	4.2	19.0	500	0.1	8.8	12.0	20.3	4.4	700	13.2
1980	209.8	484	122.6	91.9	38.8	18.0	12.1	5.2	17.0	1,000	0.3	10.3	12.9	22.5	5.2	800	10.3
1981	191.1	374	102.6	90.6	44.9	18.0	15.3	4.4	13.4	-	-	9.3	12.7	11.9	2.8	487	12.0
1982	179.2	303	89.7	70.0	34.2	11.6	10.3	5.0	17.5	-	-	10.0	13.4	8.9	2.4	1,445	13.5

Source: Vneshniaia Torgovla SSSR (USSR Foreign Trade). Finansy i Statistika. Moscow. Yearbooks 1959-1982.

Table 12. Changes in Prices of Fishing Industry Products Exported by the USSR

Year	Fish Per T/R	% Change in P	Canned Fish Per s.c./R	% Change in P	Canned Salmon Per s.c./R	% Change in P	Canned Crab Per s.c./R	% Change in P	Whale Blubber per T/R	% Change in P	Whale Meat per T/R	% Change in P	Fish Meal Per T/R	% Change in P
1960	159.05	100.0	0.28	100	0.30	100	0.64	100	182.4	100	-	-	121	100
1970	132.66	83.4	0.30	107	0.41	137	1.18	184	229.2	126	199.8	100	149	123
1980	253.58	159.4	0.42	150	0.68	226	3.25	507	291.6	160	1,248.5	625	233	193
1982	296.31	186.2	0.49	175	0.89	297	3.53	552	-	--	1,332.2	667	275	227

Source: Vneshniaia Torgovla SSSR (USSR Foreign Trade). Statistical Yearbooks, 1960-1982. Finansy i Statistika. Moscow.

Table 10. USSR's Foreign Trade in Fishing Industry Products Mil. R.

Year	Total Exports	Fish. Ind. Exports	% of A	Total Imports	Fish Ind. Imports	% of B	Net Exports
1970	11,520	83.8	0.73	10,565	14.9	0.14	68.9
1975	24,030	157.4	0.66	26,669	25.0	0.09	132.4
1976	28,022	157.8	0.56	28,733	20.3	0.07	137.5
1977	33,256	155.3	0.47	30,097	33.5	0.11	121.8
1978	33,668	174.6	0.52	34,557	29.9	0.09	144.7
1979	42,426	215.9	0.51	37,881	34.1	0.09	181.8
1980	49,635	214.4	0.43	44,462	58.9	0.13	155.5
1981	57,108	199.1	0.34	52,631	55.7	0.11	143.4
1982	63,165	179.2	0.28	56,411	51.6	0.09	127.6

U.S. $100 = R.81.45 Ekonomicheskaia Gazeta #28, 1984, July.

Source: Vneshuiaia Toryovla SSSR (USSR Foreign Trade) Finansy i Statistika, Moscow, Yearbooks 1970-1972.

The most important importers of fish from the USSR were Japan which in 1982 took 63,293 tons valued at R.12.4 million. Cuba took 41,962 tons valued at R.24.4 million, Portugal 29,997 tons valued at R.7.9 million, Egypt 21,942 tons valued at R.8.2 million and Nigeria 18,663 tons valued at R.4.9 million. The prices these countries paid per ton were: Japan, R.196.2; Cuba, R.582.2; Portugal, R.265.7; Egypt, R.374.4; Nigeria, R.313.5. The average price was R.296.3.

The most important importers of canned fish were Czechoslovakia which took 23,444,000 s.c. valued at R.9.2 million, followed by Cuba with 13,352,000 valued at R.6.3 million, France 5,004,000 valued at R.3.3 million, Poland 4,430,000 valued at R.1.8 and Hungary 3,621,000 s.c. valued at R.1.4 million, paying respectively: Czechoslovakia, R.0.39; Cuba, R.0.47; France, R.0.67; Poland, R.0.41; Hungary, R.0.40; with the average price being R.0.49.

The most important importers of canned crab were France, which took 2,332,000 s.c. valued at R.7.1 million, Japan 1,419,000 s.c. valued at R.6.2 million, Belgium 585,000 s.c. valued at R.1.9, Netherlands 142,000 s.c. valued at 0.4 million and West Germany 119,000 s.c. valued at R.0.5 million. They paid respectively: France, R.3.02; Japan, R.4.33; Belgium, R.3.37; Netherlands, R.3.15; W. Germany, R.3.93; with the average price being R.3.53 per standard can. Except for a very small amount going to Czechoslovakia all canned crab went to hard currency countries.

The USSR's imports of fishing industry products came primarily from Iceland which supplied R.36.2 million worth out of the total R.51.5 million imported. From Iran came R.1.7 million worth of fish and R.5.7 million worth of black caviar.

All difficulties notwithstanding the Soviet fishing industry has managed to give the economy in 1982 R.127.6 million worth of exports net, or 156.7 million U.S. dollars.

Internal Trade

In Table 13 are given figures of the USSR's retail trade inside the country and the position of the fishing industry products in it. As can be seen from the table, the rate of growth of the fishing industry products sales, taking 1940 as one, has been 14.53 times compared with the rise in the overall value of retail trade for the country of 13.10 times.

The share of fish products in total retail trade has declined from 3.9% in 1940 to 3.4% in 1982. The share of fish in the fishing industry sales reached the peak of 60.6% in 1970 and by 1982 dropped to 52.7%, the share of herring dropped steadily from 32.8% in 1965 to 8.4% in 1982 while the share of canned products of the industry grew from 9.2% in 1940 to 40.8% in 1981. It dropped 2% in 1982 to stand at 38.9%. The current aim is to give the country more fresh and lightly chilled fish as against frozen, and also to provide the population with fish products packaged for individual consumption rather than in large containers (see Table 13).

Conclusion

In conclusion it can be said that the fishing industry continues to maintain its important position both at home and in terms of its contribution to foreign trade. In the future the main efforts will be directed towards securing as much as possible of the resources of the open oceans, even though it is recognized that to do this will require heavy investments to improve the methods of locating and

Table 13. Retail Trade Turnover in State and Cooperative Trade Organizations, Including Commercial Feeding. Mil. R.

Year	Total Consumer Goods A	Increase Over Time	Fish & Fish Products B	Increase Over Time	B Percent of A	Fish C	C/B	Herring D	D/B	Canned Fish E	E/B
1940	11,357	1.00	347	1.0	3.9	194	55.9	121	34.9	32	9.2
1965	60,452	5.32	2,318	6.68	3.8	1,059	45.7	761	32.8	498	21.5
1970	86,168	7.59	3,046	8.78	3.5	1,846	60.6	469	15.4	731	24.0
1975	112,729	9.93	3,743	10.79	3.3	2,249	60.0	303	8.1	1,191	31.8
1980	137,336	12.09	4,778	13.77	3.5	2,478	51.9	360	7.5	1,940	40.6
1981	142,140	12.51	4,904	14.13	3.5	2,536	51.7	367	7.5	2,001	40.8
1982	148,856	13.10	5,042	14.53	3.4	2,658	52.7	425	8.4	1,959	38.9

Source: Narodnoe Khoziaistvo SSSR v 1982 godu (USSR National Economy in 1982). Statistical Yearbooks 1958-1982. Finansy i Statistika. Moscow. 1983, p. 432 (and for the previous years).

harvesting the riches of the sea. This will involve expenditures on new types of fishing vessels and gear.

Utilization of resources of other nations' economic zones will continue to be another important goal to be achieved through negotiations and cooperation in operations. Following the general trend of the day, more effort will be put into mariculture and to developing and utilizing inland water resources, but because of the clash with the needs of agriculture and in particular with the industries, which are accorded a higher degree of priority, some lack of success in this area will be tolerated.

The priority accorded to the fishing industry will depend on how well administrative problems in agriculture will be resolved and to a considerable extent on the vagaries of weather and international relations. In spite of its huge size, the Soviet Union has a limited amount of agricultural land; only about 10% of the land area, while her population continues to grow adding the equivalent of the population of New Zealand every 18 months. Providing the population with food will continue to be a challenge and there will always be a place for the fishing industry. Most important from the rest of the world's point of view is that the Soviet fishing industry will be encouraged to be aggressive in the struggle for the resources of the world's oceans.

References

1. K.A. Bekiashev, V.M. Rumiantsev. Pravovoe regulirovanie rybolovstva v pribrezhnykh vodakh SSSR (Legal regulating of fisheries within the coastal waters of the USSR). Rybnoe Khoziaistvo. 1977, #9, pp. 56-59.

2. Anon. Osnovnye napravlenia ekonomicheskogo i sotsialnogo razvitia SSSR na 1981-85 gody i na period do 1990 goda (The main directions of the economic and social development of the USSR over 1981-85 and for the period up to 1990). Ekonomisheskaia Gazeta #49, December 1980, p. 8.

3. N.P. Kudriavtsev, 1st Deputy Minister of the Fishing Industry of the USSR. Rybnoe khoziaistvo v odinnadtsatoi piatiletke (Fisheries in the eleventh Five Year Plan). Rybnoe Khoziaistvo, 1981, #1, pp. 3-7.

4. I.V. Nikonorov. Vosproizvodstvo i okhrana rybnykh zapasov (Restocking and protection of fish reserves). Rybnoe Khoziaistvo. 1982, #6, pp. 27-30.

5. N.P. Kudriavtsev. op cit.

6. Anon. Prodovolstvennaia programma SSSR na period do 1990 goda (USSR Consumer Supplies program for the period up to 1990). Pravda. 27.V.1982.

7. E.A. Romanov. Rybnaia promyshlennost za 60 let (60 Years of the Fishing Industry). Rybnoe Khoziaistvo. 1982, #12, pp. 3-11.

8. Ibid.

9. E.A. Romanov. Rentabelnost' produktsii i nekotorye osobennosti v napravlennosti raboty otrosli (Profitability of preduction and some special features in the orientation of the industry). Rybnoe Khoziaistvo. 1983, #12, pp. 15-17.

10. V.M. Kamentsev. Minister of the Fishing Industry, appointed in April, 1984. Plany namechennye XXVI syezdom KPSS vypolnim (We shall fulfill the plans outlined by the XXVI Congress of the CPSU). Rybnoe Khoziaistvo 1982, #2, pp. 3-8.

11. V.M. Kamentsev (at the time 1st Deputy Minister of the Ministry of Fishing Industry). Perspektivy razvitia rybnogo khoziaistva vnutrennikh vodoyomov (Prospects of developing inland waters fisheries). Planovoe Khoziaistvo. 1978, #1, pp. 9-18.

12. N.P. Kudriavtsev. op cit.

13. N.P. Sysoev. Tekhnicheski progress i razmeshchenie rybodobyvaiushchei promyshlennosti (Technical progress and the location of the fishing industry). Rybnoe Khoziaistvo. 1980, #1, pp. 17-20.

14. E.A. Romanov. Rentabelnost' produktsii. (See No. 9.)

15. S.A. Studenetski. Prodovolstvennaia programma i zadachi rybokhoziaistvennoi nauki (Consumer Suppliers Programme and the task of the fisheries science). Rybnoe Khoziaistvo. 1983, #1, p. 3.

16. A.A. Ishkov. Otechestvennoe rybnoe khoziaistvo (National Fisheries Industry). Rybnoe Khoziaistvo. 1977, #11, pp. 3-6.

17. M.G. Ilchuk, L.P. Kuzmina, N.F. Kalishchuk, O.I. Radionova, T.V. Senko, M.G. Spitsina, L.A. Filippovich, V.V. Chernova. Ekonomika, organizatsia i planirovanie proizvodstva na predpriatiakh rybnoi promyshlennosti (Economics, organization and planning of the output at the enterprises of the fishing industry). Legkaiai pishchevaia promyshlennost'. Moscow. 1982, p. 303.

18. S.A. Studenetski. Prodovolstvennaia programma. Op cit. (See No. 15.)

19. V.I. Ikriannikov. K itogam III Konferentsii OON po morskomu pravu (On the results of the III UN Conference on the Law of the Sea). Rybnoe Khoziaistvo. 1983, #5, pp. 49-54.

20. V.P. Zaitsev. Ispolzovanie prirodnykh resursov shelfa i ego preobrazovanie (Utilization of the natural resources of the shelf and its re-shaping). Rybnoe Khoziaistvo. 1978, #8, pp. 8-10.

21. A. Alekseev, L. Dushkina, L. Ryzhkov, V. Khlebovich. Postizhenie moria (Mastering the sea). Pravda 4, August 1978.

22. Ibid.

23. P.A. Moiseev. Osnovnye napravlenia razvitia marikultury (The main directions for the expansion of mariculture). Rybnoe Khoziaistvo. 1980, #2, pp. 21-25.

24. V.M. Kamentsev. Perspektivy razvitia ... op cit. (See No. 11.)

25. S.A. Patin. Marikultura v SSSR (Mariculture in the USSR). Rybnoe Khoziaistvo. 1984, #2, pp. 22-25.

26. V.K. Kiselv. Bolshe vnimania okhrane i vosproizvodstvu rybnykh zapasov (More attention needed to the protection and re-building of fish stocks). Rybnoe Khoziaistvo. 1978, #6, pp. 3-5.

27. E.A. Romanov. 1982.12. Op cit. (See No. 7.)

28. E.A. Romanov. Rubnoe khoziaistvo v 1984 godu (Fisheries economy in 1984). Rybnoe Khoziaistvo. 1984, #1, pp. 3-7.

29. M.L. Kashintsev. Spravochnik po rybnomu khoziaistvu (Reference book on fisheries). Pishchevaia Promyshlennost'. Moscow, 1980. A review by A.I. Isaev and E.I. Karpova. In Rybnoe Khoziaistvo. 1981, #5, p. 80.

30. V.M. Kamentsev. Perspektivy Razvitia. Op. cit. (See No. 11.)

31. Anon. Rybka iz pruda (Fish from ponds). Pravda. 11 February 1983.

32. M.V. Ivashin, R.G. Borodin. Otsenka zapasov kitov i ikh ratsionalnoe ispolzovanie (Evaluation of whale populations and their rational utilization). Rybnoe Khoziaistvo. 1983, #10, pp. 31-34.

33. I.V. Nikonorov and M.V. Ivashin. O rabote Mezhdunarodnoi Kitoboinoi Kommissi (On the work of the International Whaling Commission). Rybnoe Khoziaistvo. 1983, #12, p. 21.

The New Ocean Regime: Implications for International Seafood Trade

Extended Fisheries Jurisdiction and International Seafood Trade

Richard S. Johnston and Arthur Siaway
Department of Agricultural and Resource Economics
Oregon State University
USA

The year 1977 will have a special place in history. By the end of that year, most of the coastal nations of the world, both developed and developing, had declared extended fishing zones. The significance of this development is that it "...brought the bulk of the world's commercial fish stocks under undisputed management authority" (Copes, 1982, p. 39). An expected consequence of this extension of fishery jurisdiction by coastal states was a "...more economical use of fish resources, in which stock depletion through overfishing is avoided and higher returns are obtained per unit of fishing effort" (Copes, 1983, p. 39). Whether there were to be concomitant increases in world seafood production would depend on the profitability of harvesting underexploited species and the impacts of public management on stocks currently being fished (Crutchfield, 1980).

What of the impacts of extended fishery jurisdiction on international trade in seafoods? It is tempting to predict that, even with little or no increase in production, trade would increase. After all, prior to extended fishery jurisdiction, distant water fleets accounted for a significant portion of the world's catch. Thus displacement of these fleets by the countries off whose coasts they fished could be expected to lead to an increased import demand by the distant-water fishing nations and resulting export activity by the newly-endowed coastal states. Indeed, the data support such a prediction. Between 1976 and 1982 world harvest of fish, crustaceans, and molluscs increased from 69.4 to 76.7 million metric tons, an increase of 10.5% (FAO, 1983). During that same period, seafood trade, on a volume basis, rose by more than 27% (ibid).[1/] Thus, world seafood trade increased more than did world seafood production. In addition, the world's leading distant-water fishing nations experienced harvest reductions during the period, while significant increases in landings were posted by a number of coastal nations with expanded fisheries jurisdiction.

Here, then is a major development with potentially important impacts on worldwide economic activity, including international trade. This paper examines the hypothesis that extended fisheries jurisdiction (efj) has led to an increase in international seafood trade at both global and national levels. The laboratory for the latter is the United States. Discussion of the underlying theoretical issues appears in the Appendix. The alternative hypothesis is that, while there have been significant developments in international seafood trade since the advent of efj, these developments may have had more to do with overall world economic conditions than with territorial changes in the oceans.

Extended Fisheries Jurisdiction and Global Seafood Trade

To determine whether the extension of fisheries jurisdiction during the mid-1970s generated an increase in international seafood trade, a relatively simple model was developed in which it was hypothesized that, over time, seafood trade has been positively related to world landings, efj, and global economic conditions. The rationale for the last hypothesized relationship is that factors which increase or decrease economic activity in total will have a similar effect on trade, including seafood trade. In the

Special thanks are due Susan Hanna and Bruce Rettig for helpful comments on an earlier draft and to Mary Brock for computational, typing, and editorial assistance. Earlier versions of this paper were presented at the 72nd Statutory Meeting of the International Council for the Exploration of the Seas and the Eighth Annual Seminar of the University of Virginia's Center for Ocean Law and Policy. Suggestions by participants in these conferences are very much appreciated. This work is a result of research sponsored, in part, by the Oregon State University Sea Grant College Program supported by NOAA Office of Sea Grant, U.S. Department of Commerce, under Grant Number NA81AA-D-00086.

presence of an economic recession, for example, it is likely that demand for seafood will fall, with a commensurate decline in both imports and exports.

To test these hypotheses, the following equation was estimated via ordinary least squares:

$$\underset{(2.15)}{WT = 62737.2} - \underset{(-2.09)}{452.93\ GDP} + \underset{(3.02)}{.004\ (WL)(GDP)}$$

$$- \underset{(-4.16)}{7796.12\ B_1} + \underset{(2.32)}{288.59\ (GDP)(B_2)} - \underset{(-2.01)}{52536.60\ B_2} \qquad (1)$$

where WT = world trade in fishery products, on a live weight equivalent basis, in 1000 metric ton units.

GDP = index number for world gross domestic product, where 1963 = 100.

WL = world landings of aquatic organisms, in 1000 metric ton units.

B_1 = binary variable assuming the value unity for 1970-1982 and zero for 1950-1969. This variable was included to account for a change in the way marine mammals and aquatic plants were reported by the FAO.

B_2 = binary variable assuming the value unity for 1950-1976 and zero for 1977-1982, the "efj variable."

and t statistics appear in parentheses.

This particular functional form was selected, in part, because preliminary analysis uncovered a high degree of collinearity between WL and GDP. In addition, this specification permits B_2 to serve as both a shift variable and as a determinant of how changes in global economic conditions would affect world seafood trade. (In terms of the production possibilities curves of Appendix A, this specification allows for a shift in the curve and a change in its slope.)

Data were yearly for the period 1950-1982 and principal data sources were annual volumes of the U.N. Statistical Yearbook and the FAO Yearbook of Fishery Statistics. The R^2, F, and Durbin-Watson statistics for the above equation were .92, 58.2 and 1.09, respectively.2/

The estimated coefficients suggest a positive relationship between seafood trade and fish landings, as expected. The results also suggest that seafood trade and global economic activity (GDP) are affected by similar factors but that this relationship changed with the increase in extended fisheries jurisdiction. In particular, the results suggest that:

$$\frac{\partial WT}{\partial GDP} = -452.93 + .004\ (WL) + 288.59\ (B_2)$$

$$= -452.93 + .004\ (WL) + 288.59, \text{ for the years before 1977, and}$$

$$= -452.93 + .004\ (WL), \text{ for the years 1977-1982.}$$

At the mean value of WL (52,500 thousand metric tons)

$$\frac{\partial WT}{\partial GDP} = 45.66, \text{ for 1950-1976}$$

$$= -242.93, \text{ for 1977-1982}$$

Thus, it appears that international seafood trade and global economic activity were positively related before the plethora of extended fishing zones in the 1970s, after which the relationship became a negative one. However,

$$\frac{\partial WT}{\partial B_2} = 288.59\ (GDP) - 52536.60.$$

which is 4604, a positive number, calculated at the 1977 level of GDP.3/ This result suggests that extended fisheries jurisdiction has been associated with decreased levels of international seafood trade. Another interpretation is possible, however. When $\frac{\partial WT}{\partial B_2}$ is calculated at the mean level of GDP for the entire 1950-82 period ($\overline{GDP}$ = 128, approximately the 1967 value), its sign is negative, suggesting that, had efj occurred earlier, it would have been associated with increased seafood trade.

This highlights one of the difficulties of using time series data to uncover the influence of a variable which is collinear with other key explanatory variables. At the time of efj, world landings of aquatic organisms were increasing. At the same time, economic expansion was occurring globally, perhaps masking any influence of extended fisheries jurisdiction on international seafood trade. The somewhat surprising, albeit tentative, finding of a dampening effect of efj on trade could be the result of exporting nations experiencing reduced harvest opportunities and importing nations finding expanded harvest opportunities. Had efj occurred earlier, it could have had a positive effect on trade because of different trading positions of the affected nations. Studies of the impacts of public policies often abstract from the time of policy implementation. Here is a case when timing may have been important because the policy change took place when trading relationships were being realigned.

A Simultaneous Equations Approach

In the discussion to this point it has been assumed that the relationship between seafood trade and global landings is causal in one direction. However, it could be argued that both the decision to fish and the decision to engage in seafood trade are made in response to similar economic signals. If so, this calls for another approach to uncover economic relationships. In particular, it suggests the need to specify a model which recognizes the interdependence between seafood trade and landings of aquatic organisms.

To estimate the parameters of such a model, a simultaneous equations procedure, two-stage least squares, was used to estimate the following equations:[4/]

$$\begin{aligned} WT = & \underset{(31332.3)}{-94254.1} + \underset{(3.16)}{9.42}\, WL - \underset{(931.30)}{2651.35}\, GDP + \underset{(31108.5)}{88121.0}\, B_2 \\ & + \underset{(3181.17)}{684.71}\, B_3 - \underset{(3.28)}{8.74}\, (WL)(B_2) + \underset{(989.40)}{2548.56}\, (GDP)(B_2) \end{aligned} \qquad (2)$$

$$\begin{aligned} WL = & \underset{(3887.58)}{-2561.98} - \underset{(.44)}{.58}\, WT + \underset{(.22)}{1.30}\, WL_{t-1} - \underset{(2026.04)}{3731.38}\, B_1 \\ & - \underset{(1075.37)}{322.93}\, B_2 \end{aligned} \qquad (3)$$

where B_3 is a binary variable introduced to account for an apparent structural change which may have occurred in 1972,[5/] WL_{t-1} stands for world landings in the previous year, and all other variables have their earlier definitions. Figures in parentheses are calculated standard errors.

The reduced form equation for WT, estimated via ordinary least squares,[6/] is

$$\begin{aligned} WT = & \underset{(-.09)}{-1232.33} - \underset{(-1.37)}{89.63}\, GDP - \underset{(-.08)}{1219.92}\, B_2 - \underset{(-4.37)}{8359.03}\, B_3 \\ & + \underset{(5.23)}{375.98}\, (GDP)(B_2) + \underset{(3.87)}{.46}\, WL_{t-1} - \underset{(-2.80)}{3764.65}\, B_1 \end{aligned} \qquad (4)$$

where the figures in parentheses are t-statistics, and the R^2, F, and Durbin-Watson statistics are .99, 1573.6, and 2.30 respectively. The results are consistent with the earlier findings, although a somewhat different interpretation emerges. From equations (2), (3) and (4) it appears that the direct influence of efj, represented by B_2, on seafood trade depends upon the assumed levels of world landings and GDP.[7/] Had efj occurred before 1958 (i.e., had WL and GDP been at their pre-1958 levels) the influence would have been negative. For the 1958-76 period, the effect would have been positive.

However, inspection of the estimated coefficients in equation (4) reveals that, when the interdependence between landings and trade is considered, permitting efj to affect world trade both directly (equation (2)) and through landings (equation (3)), the "net" effect is negative. That is, the results suggest that, no matter when efj occurred, it would have had a dampening effect on world seafood trade.

The coefficient on the "structural change" variable, B_3,[8/] in equation (4) suggests that, whatever occurred in 1972, it had a dampening effect on global seafood trade, although the reason for this may lie in how landings and trade are related to each other. Consider, for example, the estimated relationship between WT and WL. According to equation (2) international seafood trade is positively related to world landings. Equation (3), however, suggests that world landings are negatively related to seafood trade and positively related to lagged values of landings. A possible explanation for this is that, as opportunities to participate in international trade increase, there is expanded pressure on the fishery resource, leading to a decline in yields. On the other hand, if landings do increase, so will trade.

Thus, the 1972 structural change appears to have expanded trade, which in turn dampened landings and, eventually, reduced trade. The "net" effect is a negative relationship between the 1972 structural change and seafood trade. The issue requires further study, including the impact of B_3 on WL_{t-1}.

What about the relationship between global seafood trade and international economic conditions? As before, the results suggest that, had efj not occurred, the net effect of a change in GDP would have been a change in world seafood trade in the same direction. Extended fisheries jurisdiction appears to have changed the relationship to a negative one. This could be the result of fish importing nations becoming net exporters at terms of trade which dramatically favor non-seafood items (see discussion of Figure A-6 in the Appendix).

While there may have been an impact of efj on total world landings, this impact has not been uncovered by the present analysis. World landings did increase over the 1977-82 period; it is not apparent, however, that this growth differs from the pre-efj rate. However, efj does appear to have affected global seafood trade, perhaps through a reallocation of property rights in the world's fishery resources.

These results are highly tentative. Furthermore, they are somewhat mixed. Statistical estimation is hampered by multicollinearity. The most one can conclude from this exercise is that, while global seafood trade has increased in recent years, it cannot be concluded that this is a result of extended fisheries jurisdiction.

For any given country, however, this may not be the case. In the next section, discussion focuses on one country, the United States, and the impacts of that country's extended fisheries jurisdiction on its own imports and exports of fish and shellfish products.

Extended Fisheries Jurisdiction and U.S. Seafood Trade

One objective of the Magnuson Fisheries Conservation and Management Act of 1976 ("the Magnuson Act") was "to achieve full domestic utilization of the marine fishery resources available for U.S. exploitation, including those resources not under U.S. jurisdiction" (Gordon). The extension of the U.S. fishery conservation zone to 200 nautical miles was expected by many to increase production possibilities for the U.S.

With the declaration of the Magnuson Act it would not have been unreasonable to anticipate increased domestic landings and, thus, either less reliance on seafood imports or increased export activity by the U.S., or both. In fact, what has happened? The average annual harvest by U.S. commercial fishermen during the three years immediately prior to the MFCMA was 5 billion lbs. By 1980-82 this figure had increased to 6.8 billion lbs., an increase of over thirty percent. The dollar value of fishery exports (measured in 1972 dollars) rose from an average of $251 million to one of $552 million, an increase of over 120% over the same period![9] On the import side, the dollar value also rose, from a 1973-75 average of $1,428 million to a 1980-82 average of $2,126 million. On a per-capita basis, this represented an increase of 38%. Thus, while imports have increased over the period, exports have increased even more significantly, lending support to the hypothesis that, at least for the U.S., extended fisheries jurisdiction has led to increased export activity and a substitution of domestically harvested seafoods for imports.

A closer look at the data suggests the need for caution in attributing changes in trade activity to extended fisheries jurisdiction, however. A comparison of trends in the seafoods sector with trends in other sectors displays some remarkable similarities.[10] Indeed, both imports and exports show the following pattern over the 1962-82 period: relatively steady growth between 1962 and 1971, rapid growth between 1971 and 1973, a dip in 1974-75 followed by exponential growth to 1980 and a decline since then (with some evidence of recovery in late 1983).

Of particular interest to the authors was the "take-off," beginning around the time at which the Magnuson Act was passed, in both imports and exports. Certainly there has been a substantial increase in the volume of U.S. salmon exported since 1976. Much of this can be attributed to the Magnuson Act, which strengthened the ability of the U.S. to control the interception of North American salmon by the Japanese distant water fleets. One result has been increased salmon landings by U.S. fishermen and concomitant increases in exports to Japan. With respect to groundfish, the U.S., a net importer, has increased domestic landings. Through various joint venture arrangements, this has been accompanied by expanded exports of "underutilized" species. On the other hand, imports of all groundfish, taken together, have increased substantially since 1976.

What is going on here? In a recent article, McCalla argues persuasively that agricultural trade is importantly affected by international monetary policy. He further argues that, especially since the early 1970s, following the movement to a more flexible exchange rate system, global economic conditions have resulted from foreign government responses to real interest rates, the strength of the U.S. dollar, and its role as a reserve currency. This allows him to explain the worldwide inflations of 1973-74 and 1979-80, as well as the 1975-76 and 1981-82 recessions. These have been accompanied by income and price fluctuations in the U.S. agricultural sector.

It is unlikely that seafood markets are immune from such changes in worldwide economic conditions. Data limitations preclude the development of an econometric model to separate roles of macroeconomic, microeconomic, and property rights changes in seafood trade but some preliminary analysis merits consideration. Table 1 contains estimates of the following relationship:

$$Y = \alpha_0 + \alpha_1 X + \alpha_2 M \tag{6}$$

where Y represents U.S. exports of fishery products, X represents U.S. exports of agricultural products, and M is a binary variable designed to capture the possible impacts of the Magnuson Act (M = 0 for 1961-77 and 1 for 1978-82. Implementation of the Act did not occur until 1977 and it was hypothesized that resulting effects on trade would not appear until the following year.). Various versions of this equation were specified. For example, a similar equation was estimated for U.S. imports of fishery products, with X then representing U.S. imports of agricultural products. Other modifications included specification of X as U.S. imports or exports of all merchandise (as opposed to agricultural products). Finally, separate equations were estimated for "edible" and "edible plus non-edible" fishery products.

The reasoning underlying the model is as follows: it is unlikely that either the agricultural or the "all commodities" sectors of the U.S. economy have been directly affected by the Magnuson Act. If seafood imports and exports can be "explained" by changes in the non-seafood sectors of the economy, with little "left over" to be attributed to the Magnuson Act this would suggest that recent macroeconomic (and, perhaps, microeconomic) events may have swamped any effects of extended fisheries jurisdiction on seafood trade. Clearly the model is naive, in that it does not permit the uncovering of cause and effect relationships. Nonetheless, the results are instructive.[11/]

The first four equations of Table 1, which pertain to seafood exports, suggest a strong relationship between U.S. exports of fishery products and export activity in other sectors of the economy. These equations also suggest, however, that the Magnuson Act may, indeed, have had a positive effect on U.S. seafood exports.

In the last four equations of Table 1, which pertain to seafood imports, the results are somewhat mixed. U.S. seafood imports are related to imports of other goods, both agricultural and non-agricultural. However, the effect of the Magnuson Act on seafood imports is less clear. Part of the difficulty may lie in the collinearity between the two "independent" variables in the estimating equations, although for no equation in Table 1 was the calculated r^2 value in excess of .65.

Inclusion of a variable to represent annual U.S. landings of fish and shellfish had little effect on the magnitudes of the estimated coefficient.[12/] For all of the revised export equations (1-4) the estimated coefficient on the landings variable was negative. For the import equations it was negative for equations 6 and 8; positive for 5 and 7. For the export equations the calculated t-statistic ranged from -1.34 (equation 4) to -2.13 (equation 1). For equations 5-8 the standard error consistently exceeded the estimated coefficient. Thus, inclusion of the landings variable does not affect the conclusion: U.S. exports of seafoods have been affected by general economic conditions and by the Magnuson Act. The relationships between seafood imports and imports of non-seafood items does not appear to have been affected by extended fisheries jurisdiction.[13/]

Conclusions

Both global trade in seafoods and U.S. exports of seafoods have very likely been affected by both worldwide economic conditions and harvesting opportunities afforded by extended fisheries jurisdiction. This is suggested by a preliminary analysis of aggregate trade data. At the global level, however, the impact of efj seems to have been a negative one. A downward shift in the relationship between trade and its determinants accompanied efj, according to the present analysis. In addition, the impact on trade of changes in worldwide economic conditions appears to have changed with efj. Prior to 1977, increases in global GDP were associated with increases in seafood trade among the countries of the world. After efj this relationship appears to have changed to a negative one. Because of statistical problems with the analysis, it is probably safest to conclude simply that there is not sufficient evidence to support the hypothesis that recent increases in global seafood trade can be attributed to extended fisheries jurisdiction.

U.S. trade in seafoods has no doubt also responded to changes in landings and economic conditions. Again, the role of extended fishery jurisdiction is not clear. Perhaps it is too soon for this role to have shown itself. Nonetheless, it appears reasonable to conclude that any attempt, either conceptual or empirical, to understand the relationship between seafood trade and the changing ownership of the sea will have to consider macroeconomic factors as well. This finding, while not particularly surprising, suggests some challenging research and points to the need to recognize the interdependence between the seafood sector and its non-seafood counterpart.

Table 1. Estimates of U.S. Seafood Import and Export Equations.

Equation Number	Dependent Variable	Constant Term	Estimated Coefficients for EXAG	XREAL	IAG	IREAL	M	Adjusted R^2	Durbin Watson Statistics
1	EFPR	-44943 (-1.55)	15857 (6.38)				258848 (7.46)	.94	1.50
2	EFPR	-50208 (-1.80)		3.41 (6.82)			213691 (5.65)	.95	1.53
3	USEXR	-36444 (-1.37)	17868 (7.80)				258434 (8.07)	.96	1.46
4	USEXR	-38385 (-1.42)		3.76 (7.78)			212219 (5.80)	.96	1.48
5	IFPR	-374273 (-2.00)			195910 (7.04)		130905 (1.21)	.84	0.80
6	IFPR	355081 (6.33)				11.15 (11.34)	-234990 (-2.48)	.93	1.41
7	USIR	-377094 (-1.63)			227339 (6.61)		450965 (3.36)	.87	1.01
8	USIR	463175 (6.60)				13.06 (10.62)	169400 (0.14)	.94	1.62

Variable Definitions and Means

		Mean (1961-1982)
EFPR	U.S. exports of edible fishery products in real terms	219640
USEXR	U.S. exports of edible and nonedible fishery products in real terms	2541410
IFPR	U.S. imports of edible fishery products in real terms	1058910
USIR	U.S. imports of edible and nonedible fishery products in real terms	1353970
EXAG	U.S. exports of agricultural commodities in real terms	12.98
XREAL	U.S. exports of all merchandise in real terms	64950
IAG	U.S. imports of agricultural commodities in real terms	7.16
IREAL	U.S. imports of all merchandise in real terms	67937
M	Binary variable assuming value 0 for years 1961-1977 and 1 otherwise	

All value figures were deflated by the GNP deflator (1972=100).

Data Sources: National Marine Fisheries Service, Fisheries of the United States, various volumes.
U.S. Government Printing Office, Economic Report of the President, various volumes.

Note: t-ratios are in parentheses beneath the estimated coefficients;
all regressions were estimated with annual data for 1961-1982.

Footnotes

1. These figures pertain to the 158 countries covered by the FAO data. While there are aggregation problems associated with using product weight in measuring trade volume, they are probably less severe than those associated with the corresponding value figures.

2. Caution must be used in interpreting these results. There is still some multicollinearity present, especially among GDP, (WL)(GDP) and B_1. Indeed, the equation estimated to correct for autocorrelation (as suggested by the relatively low value of the Durbin-Watson statistic) generated lower estimated t-statistics, although the signs on the coefficients were retained.

3. Recall that B_2 assumes the value "1" for the pre-efj period. Thus the estimated effect of efj on WT, taken in isolation, is a negative one.

4. Equation (2) differs from equation (1) because it was expected that two stage least squares would reduce the effects of collinearity between WL and GDP.

5. This was uncovered through an inspection of the ratio of trade to landings and may be the result of changes in oil prices, currency realignment, or shifts in the world money supply. See McCalla.

6. Rather than through solution of structural equations (2) and (3). The resulting estimated parameters are unbiased, though less efficient (asymptotically) than those derived through solving (2) and (3) simultaneously. See Kennedy, p. 122.

7. $\frac{\partial WT}{\partial B_2} \lessgtr 0$ as $WL \gtrless 10.0095 + 291.6\ GDP$, from equation (2).

8. A variable added to give a name to our ignorance.

9. These figures include direct sales by U.S. fishermen to foreign processors but exclude deliveries by U.S. fishermen to foreign ports.

10. See Johnston for a more thorough discussion of the issue.

11. Annual data for 1961-82 were used in the analysis.

12. Exceptions were equations (5) and (8), where the coefficient on variable M were cut by approximately 50%.

13. Susan Hanna correctly points out that this analysis considers only extended fisheries jurisdiction by the U.S. and that the relationship may have been affected by extended fisheries jurisdiction elsewhere.

References

Anderson, Lee G. 1977. The Economics of Fisheries Management. Baltimore, Maryland: The Johns Hopkins University Press.

Batra, Raveendra N. 1973. Studies in the Pure Theory of International Trade, New York, St. Martin's Press.

Chacholiades, Miltiades. 1978. International Trade Theory and Policy. New York, McGraw-Hill.

Chen, Tzy-Ning and Darrell L. Hueth. 1983. "Welfare Considerations in the Development of a Joint Venture Policy." In Proceedings of the International Seafood Trade Conference, pp. 461-471, Fairbanks, Alaska Sea Grant College Program.

Copes, Parzival. 1982. "Optimizing the Use of Ocean Fish Resources in the Context of Extended National Jurisdictions." In H.E. English and Anthony Scott (eds.), Renewable Resources in the Pacific, pp. 33-48, Ottawa, International Development Research Center.

_________. 1983. "Extended Jurisdiction and its Effect on World Trade in Seafood." In Proceedings of the International Seafood Trade Conference, pp. 27-41. Fairbanks: Alaska Sea Grant College Program.

Crutchfield, James A. 1979. "Marine Resources: The Economics of U.S. Ocean Policy." The American Economic Review 69(2):266-271.

_________. 1980. "Marine Resources." In Susan Hanna et al. (eds.). Conflict in Use of Ocean Resources, pp. 39-53. Corvallis: Oregon State University Sea Grant College Program.

Crutchfield, Stephen R. 1983. "Estimation of Foreign Willingness to Pay United States Fishery Resources: Japanese Demand for Alaska Pollock," Land Economics, February, pp. 16-23.

FAO, Fish Utilization and Marketing Service, Fishery Industries Division. 1983. "Fishery Commodity Situation and Outlook 1983/83," FAO Fisheries Circular (760):39p. Rome.

Gordon, William G. 1984. "Long Range Objectives in Management." Presented at the Eighth Annual Seminar of the Center for Oceans Law and Policy, University of Virginia.

Hayes, Robert G. 1982. "Fisheries Trade: The Trade Establishment." In Proceedings of the International Seafood Trade Conference, pp. 331-340, Fairbanks, Alaska Sea Grant College Program.

Johnston, Richard S. 1984. "Status and Trends in Seafood Trade." Presented at the Eighth Annual Seminar of the Center for Oceans Law and Policy, University of Virginia.

Kaczynski, Vlad. 1983. "Market Aspects of the Joint Fishing Ventures in the Northeast Pacific and Alaska Waters." In Proceedings of the International Seafood Trade Conference, pp. 363-379, Fairbanks, Alaska Sea Grant College Program.

Kennedy, Peter. 1979. A Guide to Econometrics. Cambridge, Massachusetts: The MIT Press.

McCalla, Alex F. 1982. "Impact of Macroeconomic Policies Upon Agricultural Trade and International Agricultural Development." American Journal of Agricultural Economics 64(5):861-868.

Stokes, Robert L. 1981. "The New Approach to Foreign Fishing Allocations: An Economic Appraisal." Land Economics, November, pp. 568-582.

Wilson, James R. 1983. "Theoretical and Empirical Considerations of Worldwide Ocean Resource Zone Extensions and the Effects on Export Market Shares of Seafood." In Proceedings of the International Seafood Trade Conference, pp. 427-446, Fairbanks, Alaska Sea Grant College Program.

Appendix

A Diagrammatic Exposition of the Effects of Increased Availability of Fish on Trade

In Figure A-1, PP represents the production possibilities for two goods, F (fish) and G (other), in a two-good world, prior to extended fisheries jurisdiction, for a given country, say, the United States. (To abstract from the open-access phenomenon it is assumed that the fishery has been "rationalized." This begs one of the central questions of fisheries economics but does little damage to the argument. For further discussion see Anderson (126-140) and Wilson.) For diagrammatic simplicity is is assumed that the forms in which G and F are produced are the same as those in which they are consumed. Consumer preferences are represented by "community indifference curves," as exemplified by U_1, U_2, U_3. At relative prices given by the slope of MM, the U.S. produces at point X and consumes at point Y. That is, at this set of relative prices, the U.S. is willing to export OY units of F and import OX units of G. At different prices (different slopes of MM), the U.S. is willing to engage in different trades. In Figure A-2, this is expressed through "offer curves," which depict the U.S.'s willingness to trade at various relative prices (now given by the slopes of straight lines emanating from the origin). Thus, as before, at relative prices given by the slope of OM (which are equivalent to those given by the slope of MM in Figure A-1) the U.S. is willing to export OX units of F and import OY units of G. At lower relative prices of F (a steeper OM), the U.S. is willing to export less F. Indeed, at low enough prices of F the U.S. may switch to being an importer of F and exporter of G. Suppose a similar set of offer curves can be drawn for the rest of the world and that free market conditions prevail. In Figure A-3, the "dotted" lines are the offer curves for the rest of the world (ROW). They are assumed to differ from those of the U.S. because of different production possibilities, different preferences for F and G, or both. In the situation depicted, the U.S. imports OY' units of G from and exports OX' units of F to the rest of the world, in equilibrium.

Now suppose that, following the declaration of extended fisheries jurisdiction (efj), the production possibilities curve for the U.S. shifts to PP', as in Figure A-4. If this shift is such that, at given levels of F, the slope of PP' is greater than the slope of PP (representing a lower marginal cost for each level of F), the U.S. will be willing to export more F and import more G, at given relative prices than before efj.[1/] In Figure A-4, M'M' is drawn parallel to MM and tangent to PP'. Exports of F and imports of G increase from OX and OY to O'X" and O'Y", respectively. Thus, this particular outward shift in the production possibilities curve shifts the U.S. offer curves unambiguously. If there were no change in the offer curves of the rest of the world (an untenable assumption, made here only for expositional convenience. Relaxing it would strengthen, not weaken, the argument), this would lead to increased trade with the rest of the world, as demonstrated in Figure A-5, where, in the new equilibrium, the U.S. exports OX''' (greater than OX') of F and imports OY''' (greater than OY') of G. Thus, it appears that a fish exporting nation which experiences a shift in its production possibilities curve similar to that depicted in Figure A-4 is likely to increase its fish exports. Accordingly, world seafood trade increases.

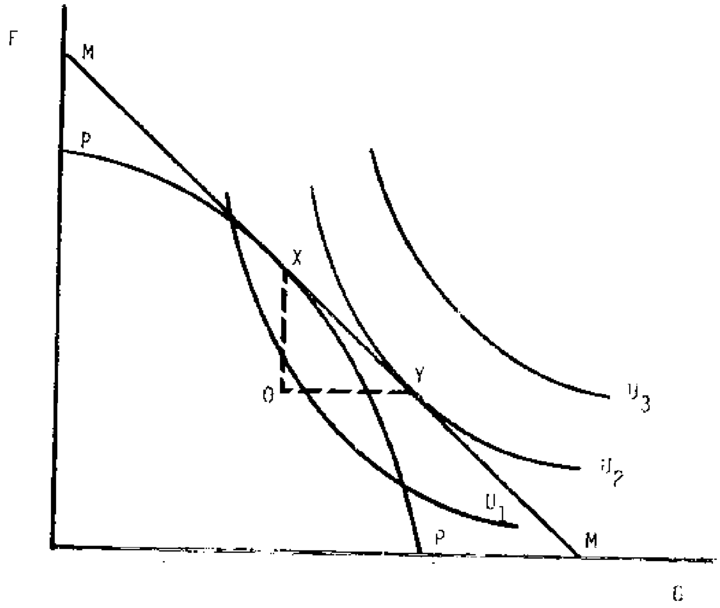

Figure A-1

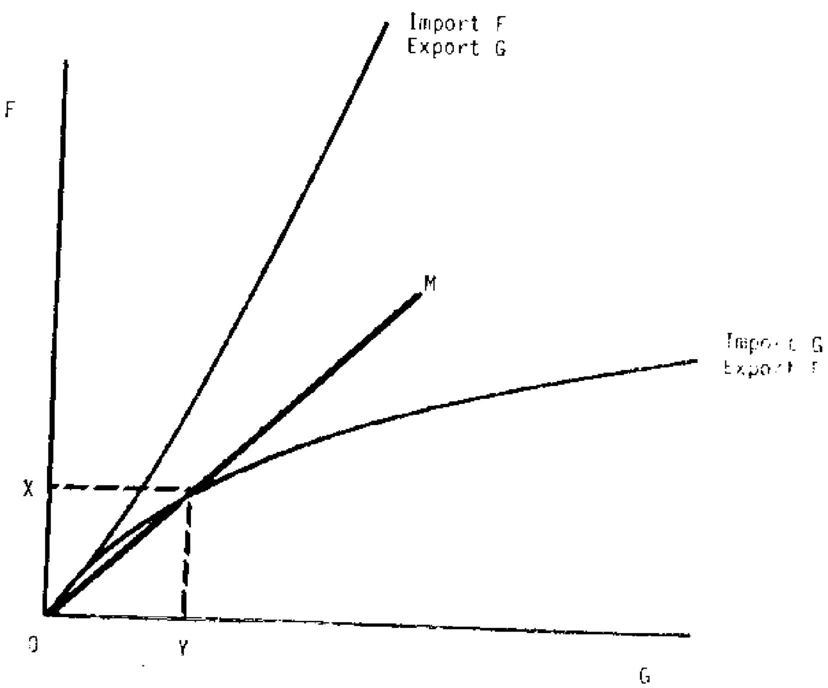

Figure A-2

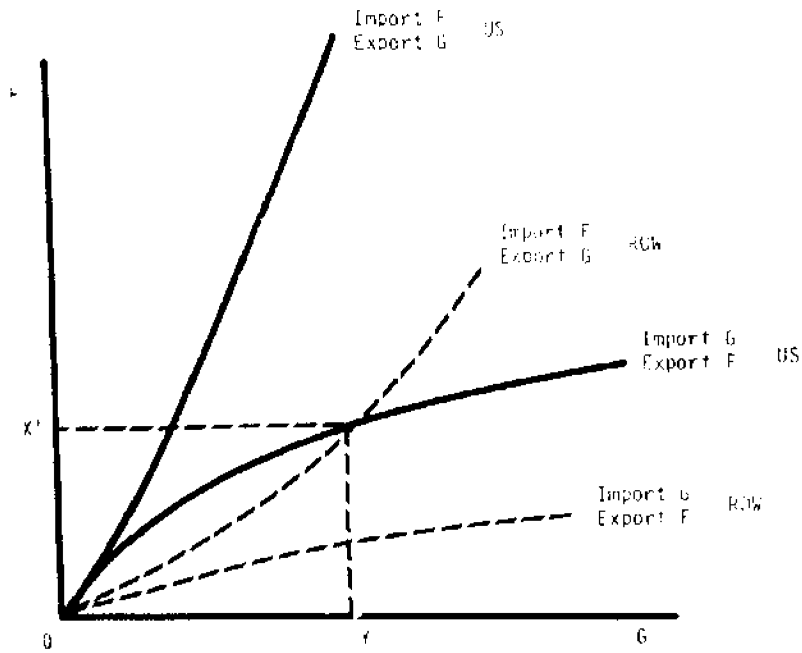

Figure A-3

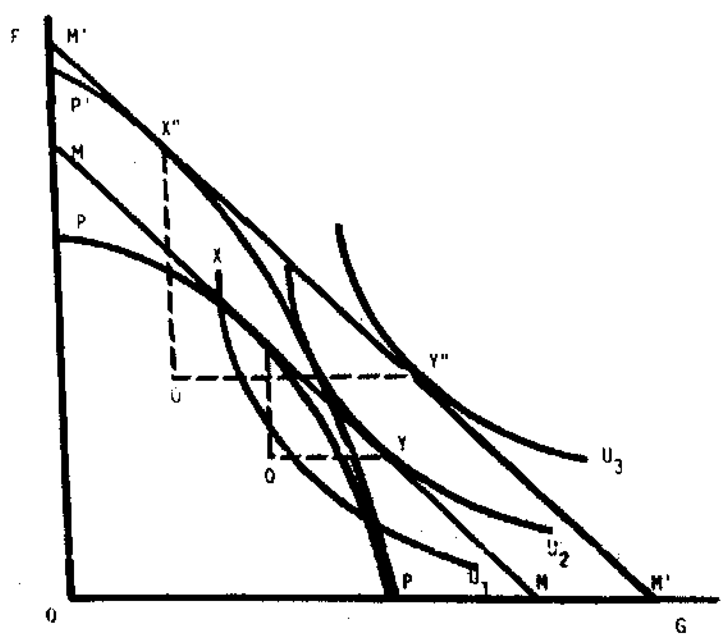

Figure A-4

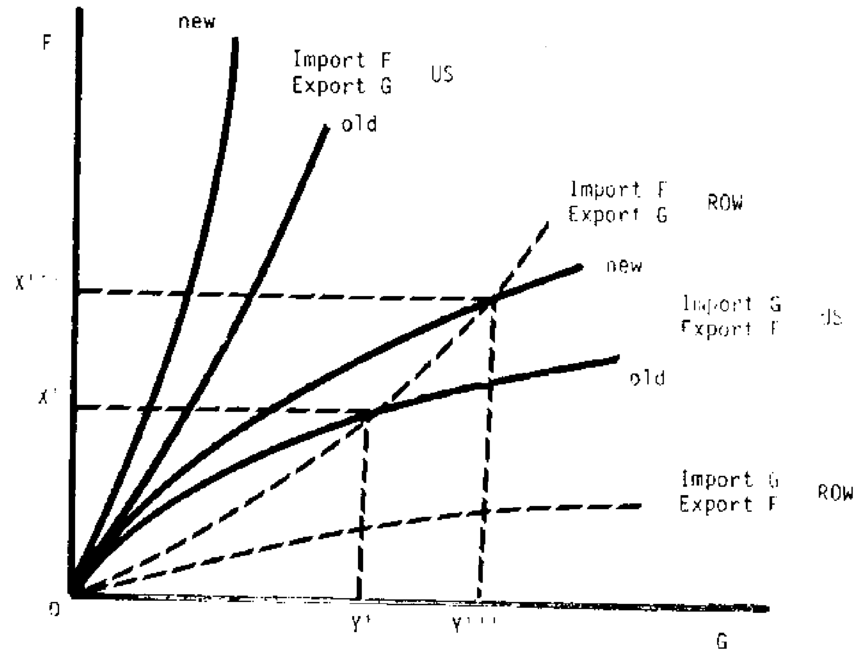

Figure A-5

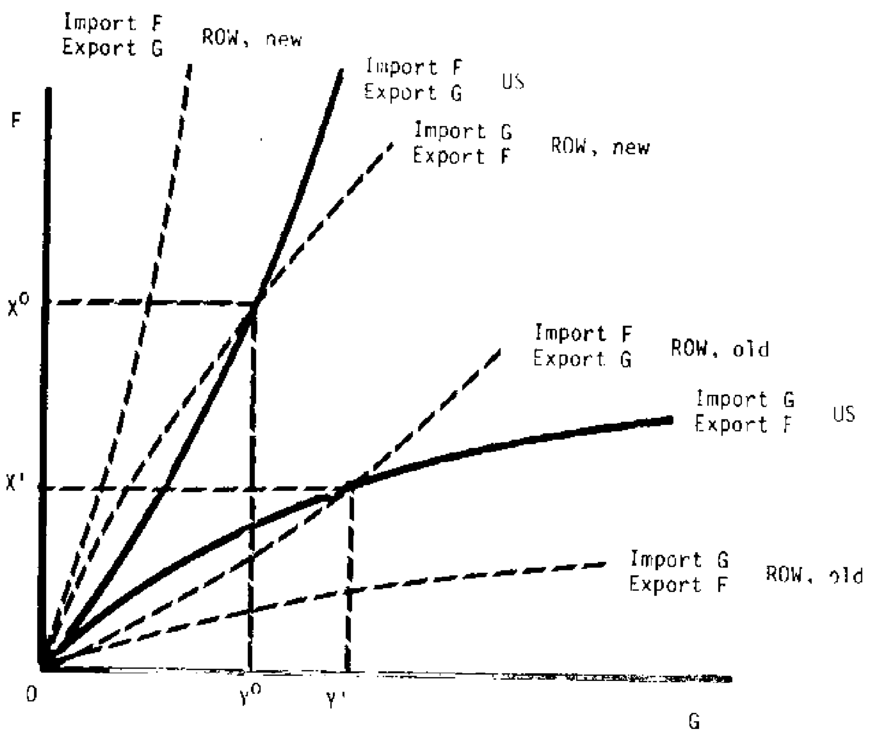

Figure A-6

Some useful extensions follow from this analysis:

1. A fish importing nation which experiences a shift in its production possibilities curve similar to that depicted in Figure A-4 is likely to decrease its imports of F (and decrease its exports of G). This would lead to a decrease in world trade. It is also possible, however, that such a country could become a fish exporting nation and, in the extreme, that this could lead to an increase in international seafood trade. This may lie behind the recent growth in world seafood trade in excess of the growth in landings, at least in part (see the discussion in the introduction to this paper). Such a situation is depicted in Figure A-6, where the offer curves of the F-importing "nation" (ROW), rather than those of the F-exporting nation, are assumed to shift with efj. The new offer curves could have a number of different configurations, leading to a variety of equilibrium trading situations. In the particular case depicted in Figure A-6, the U.S. has shifted from being an exporter of F (of OX') to being an importer of F (of OX°). Total world trade in fish has increased (from OX' to OX°) while, in this case, total world trade in G has decreased (from OY' to OY°).[2] Again, it is important to point out that this is only one of several results, the nature of which depends upon the characteristics of consumer preferences in the trading countries, the pre-efj production possibilities curves, and the nature and magnitude of the shift in the latter.

2. All bets are off if (a) F (and/or G) is an inferior good, (b) the shift in the production possibilities curve is such that the MC of F does not decline for all levels of F, or (c) both. In such cases, trade could increase, decrease, or remain the same. The issue, then, is an empirical one.

3. These are circumstances in which a shift in the production possibilities curve of the F-exporting nation is such that this country is worse off in the post-efj period than before. This is the case of immiserizing growth (see Batra, chapter 6) and is depicted in Figure A-7. Here, the post efj equilibrium terms of trade (specifically, the slope of M'M, and the slope of MM, both of which, in this diagram, are assumed to represent equilibrium terms of trade) represent a decrease in the relative price of F which is large enough to place this country on a lower community indifference curve.

   In Figure A-7, U_1 represents a lower level of community satisfaction than does U_2. In the words of one analyst, "It is possible for this deterioration in the terms of trade to be so large as to outweigh the physical increase in output and leave the country worse off than before" (Williamson, p. 284). It has been pointed out that this situation can be "corrected" by the imposition of an "optimum tariff," by the F-exporting country (Batra, Chacholiades). In the case of a fishery, however, there are other alternatives. If the fishery is unexploited, it may appear to be in the interest of the F-exporting country to forestall utilization of the resource. If the F-importing nations (who, in this case, would be made better off by encouraging exploitation) saw this as a foregone opportunity, they might be willing to "bribe" the exporter to increase its production (e.g., through subsidy programs, which is tantamount to offering improved terms of trade), or they might be willing to pay for the right to harvest the resource themselves.

4. In the case of an F-importing country, it is possible that, while an increase in its production possibilities would increase domestic well-being, allowing another country to exploit the resource, and charging for the right, would generate even greater domestic gains. This is especially likely in the case where the costs of exploitation by another nation are lower than those of the domestic country (As may already have been demonstrated by the presence of distant-water fleets in the waters now included in the domestic country's efj zone.). For example, the production possibilities curve may shift out even further in some sense, for other countries then for the country whose boundaries are increased by efj, if the former are given access to the efj waters. Payments for this right could take the form of a user fee (Stokes, Stephen Crutchfield), or a less direct payment, as exemplified by the U.S. "Fish and Chips" policy (Hayes). An analogous rationale may lie behind the plethora of joint venture arrangements now seen worldwide (Chen and Hueth, Kaczynski).

What seems to be clear is that, while existing models of international trade can provide some guidance in understanding the impacts of efj on seafood trade, the world's fisheries have some unique attributes which merit more detailed analytical and theoretical treatment.

Appendix Footnotes

1. This may not be the case if G has the properties of an inferior good.

2. The equilibrium terms of trade have changed also, with a decrease in the relative price of F.

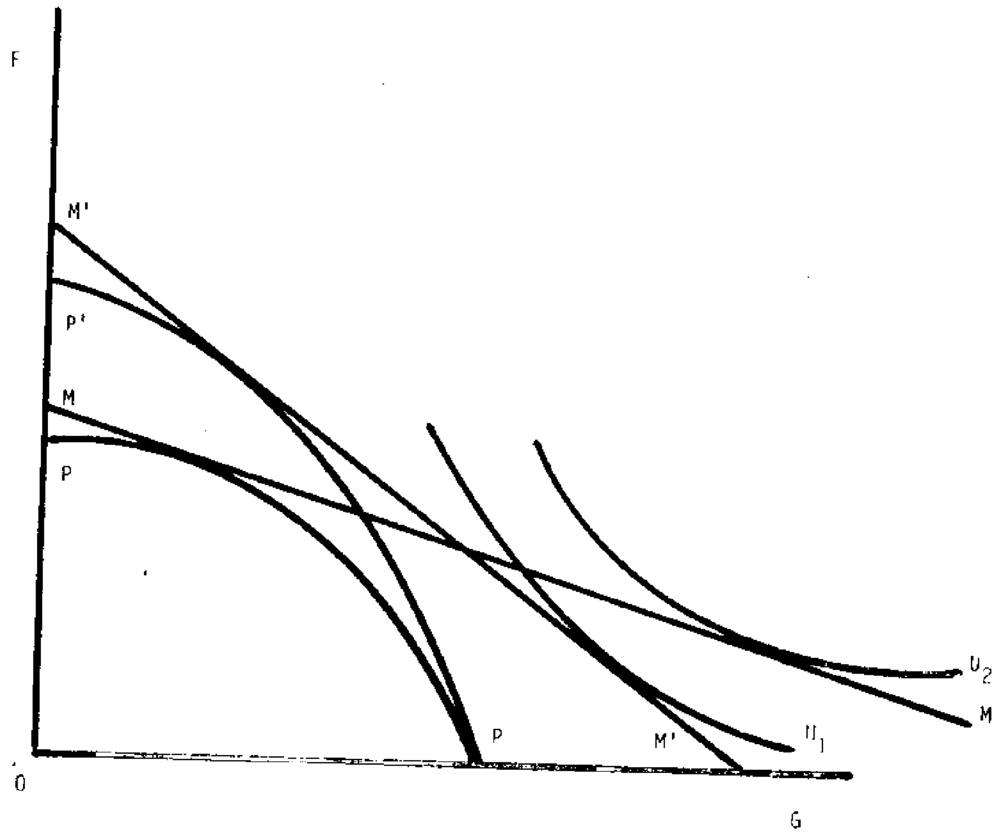

Figure A-7

Extended Jurisdiction, Factor Mobility and Seafood Trade

James R. Wilson
National Marine Fisheries Service
Juneau, Alaska, USA

Introduction

With passage of the Magnuson Fishery Conservation and Management Act (MFCMA), there has been considerable speculation on what the far-reaching impacts of implementing such a law might be in the United States. Of particular importance has been the possibility of positive trade effects resulting from the assertion of stronger property rights. The expectation has been that, with gradual removal of foreign fishing effort in the U.S. Fisheries Conservation Zone (FCZ), the trade avenues available to the United States would be more evident. However, recent written testimony by the Commerce Department, reports, "the decade past has been one of forced adjustment to new patterns in fishing and in trade" [International Trade Staff Report 84-3]. The report goes on to say that in 1971, fishery imports totalled just over 1 billion dollars, while exports totalled 139.245 million dollars. However, if joint ventures are ignored, an impressive export expansion appears to be slow in coming, and the year 1983 had the largest deficit on record for seafood trade (4 billion dollars), despite exports of just over 1 billion dollars. Table I lists the yearly trade accounts for the U.S. in fisheries products.

Table 1. The Yearly Trade Accounts for U.S. Fishery Products, 1971-1983, in Thousands of Dollars

Year	Imports	Exports	Deficit
1971	1,704,201	139,245	934,956
1972	1,494,411	157,888	1,336,523
1973	1,583,133	299,168	1,283,965
1974	1,710,878	262,132	1,448,746
1975	1,637,099	304,729	1,332,370
1976	2,332,345	384,690	1,947,655
1977	2,662,191	520,496	2,101,695
1978	3,076,564	905,534	2,171,030
1979	3,811,052	1,082,366	2,728,686
1980	3,648,082	1,006,154	2,641,928
1981	4,086,995	1,156,995	2,930,000
1982	4,467,013	1,045,303	3,421,710
1983	5,088,527	1,008,684	4,079,843

It was expected that external trade in seafood, in the long run, would be enhanced by the implementation of the MFCMA, all other events held constant. However, passage and implementation of the MFCMA was the culmination of activities which were essentially global in proportion. The passage and implementation of the MFCMA did not occur under a static world oceans regime. Rather, it occurred during the time when other countries had already changed their ocean jurisdiction or were in the process of making such a change.

This paper will argue that extended jurisdiction might affect the structure and performance of fishing industries worldwide, by altering the amount of one factor (ocean space) available to them. That is, one would expect a direct result of extended jurisdiction to be changes in the relative factor shares used in the production of fish. Indeed, for firms based in some countries which suffered a loss in available fishing area, the relative productivity of some of their inputs (those factors which had been used in distant water fishing) has declined. This was due to reduced access to ocean area.

The MFCMA was reasonably liberal in giving consideration to those foreign fishing nations experiencing hardships due to rapid decrease in prime fishing grounds. However, the obvious intent of MFCMA has been to minimize, and eventually to exclude foreign fishing involvement within 200 miles. In an apparent response to MFCMA, there have been some areas (specifically Alaska) which have experienced widespread foreign direct investment in processing. In addition, the fisheries management process in these areas is closely monitored and lobbied by foreign interests apparently prepared to go to great lengths to maintain their foreign directed allocations. Some other countries have taken advantage of a new type of cooperative fishing arrangement - joint ventures. All of these phenomena, which became increasingly obvious from the mid-1970s onward, strongly suggest that productive factors are being invested in countries which have experienced net gains in ocean resource zones. The process has been further accelerated by the recent "fish and chips" amendment to the MFCMA, since, now, allocations by the State Department to foreign fisheries are contingent on technology transfer and joint venture activity between foreign nations and U.S. firms. Also, relaxation of trade barriers to U.S. products is another "chip," which affects fish allocations.

A theoretical issue addressed in this paper is: Given the U.S. laws forbidding use of foreign-made hulls in domestic fisheries, it is expected for some fisheries, such as the groundfish fisrery in Alaska, that joint ventures will persist as an option to domestic directed groundfish fisheries because foreign hulls themselves are not easily traded.1/ In a sense, trade in seafood is expanding, but it is occurring within the context of production, which uses factors from different countries. For example, labor and capital are employed in a process which allows producers to take advantage of fishing grounds that would be closed, if some other process were used. Since the host country may not have the same labor-capital capabilities, they may be willing to hire these factors from outside. This trade of "effort" (productive factors for producing fish products) for raw product could arise from the inability of countries to sell physically mobile factors to the host country (the U.S., in cases presented here) for use in the production and trade expansion of fish products. The present situation contributes to the maintenance of the visiting country's seafood trade position over a more extended period of time. Within this paper, theoretical results will be presented which reinforce those observations described above. Further, the results will be derived under the assumption of an open access resource with one productive factor (ocean area) redistributed between two countries. In this analytical framework, a trade solution is possible, although it is not unique.

Given the above theoretical condition, it might well be asked whether empirical examples exist where extended jurisdiction has made a difference in the expanding/contracting export market shares of a country, and where the conditions under which such change could be observed. Models are then designed which explicitly account for arrangements such as joint ventures. Alternatively, commodities and conditions may be selected for which there is little interference from mobile factors. An empirical example of the latter type is presented for the Japanese export market shares of shrimp, prawns, and lobsters to the U.S. and Canada. An example of the former type is suggested for looking at the U.S. exports of fresh, chilled, and frozen finfish to Korea.

Mobile Factors and Joint Venture "Trade"

A brief review of the major results of general equilibrium trade models is helpful to provide a basis for later sections. For this discussion, two countries will be assumed, X and Y. Both country X and country Y are small, relative to the world. In each country, X and Y, two industries exist: fishing and the production of all other goods. The industries produce commodities F (fish) and G (goods). Peculiar conditions arising from common property, as well as production surfaces which are non-homogenous are ignored for the present. That is, both production surfaces for F and G are well behaved.2/ The two industries of each country (X or Y) possess the following functional form:

$$F = g(f_f(L_f,K_f),\ O,T) \qquad (1)$$

$$G = k(f_g(L_g,K_g),\ O,T) \qquad (2)$$

Each industry includes a "land" variable (O = ocean, T = terra firma), as well as the variables labor (L) and capital (K), which are combined in accordance with f_f and f_g to form a composite variable called effort, E. It is assumed for this analysis, that the production of fish is relatively more ocean intensive, and the production of other goods is relatively more land intensive. The immediate implication is that allocation of ocean to the production of fish is relatively more productive than is the uses of the ocean for the production of other goods. Later in the analysis, factor fixity in the "land" variable will be assumed (ocean and terra firma) within each country.

Two important cases exist where factor mobility with changing endowments might be considered. The first case occurs when the changing factor endowment increases the price of the output using the factor. If two countries, X and Y, are relatively large (able to affect world price), or if a two country world is assumed, mobile factors will either be traded or will enter into productive processes yielding the highest wage. This can be seen from the first order conditions of profit maximization:

$$p_f^x \, g'_{xe} = w_e^x \quad (3a)$$

$$p_f^y \, g'_{ye} = w_e^y \quad (3b)$$

As ocean area is redistributed from X to Y, P_f in X increases, while the price of fish in Y declines. However, the partial derivative, with respect to the composite input, effort, E, in (3a) decreases, and increases in (3b). If the factors comprising effort are physically mobile between countries, or can be traded on the open market, then for a reduction in X's endowment of ocean area and for an increase in Y's endowment, labor and capital will flow to country Y, if $w_e^y > w_e^x$. Additionally, if factors can be traded, then X will sell labor and capital to Y, until the marginal productivity of these two factors increases in country X. Factor prices will be equalized. However, if factors are physically mobile between countries, but not tradeable (in the sense that there are impediments to the transfer of ownership rights), then two likely results are the trade of F and G or the formation of a productive activity which takes advantage of the high output price in X and the high productivity of labor and capital in country Y, whichever has the lower transaction cost. These latter two cases have occurred on a regular basis as a result of worldwide claims on ocean space. Some countries have made new jurisdictional claims which have made it necessary for them to explore ways of combining these newly owned factors with other factors of production. However, these new jurisdictional claims have constrained other countries who had large fleets, and who had taken advantage of the fact that ocean rights were poorly defined.

However, it would be interesting to investigate other cases to determine whether factor movement is more generally observable, given some change in endowment. For example, will small countries experience the same factor movement phenomenon? Also, will common property considerations change the direction of factor movement or trade?

To address the first question of factor movement and small countries, a model was designed such that the effect of changes in endowments on the factor and output prices is 0. That is, if the endowments change, under the model assumptions listed here, there are no effects on the input prices. This is because of the combined assumptions of linear homogeneity and perfect competition in output markets, i.e., changes in quantities produced do not change output price. These results are well known in the international trade literature and are embodied in the factor-price equalization theorem, the Stolper-Samuelson theorem, and the Rybczynski theorem.[3/] A duality exists between the latter two theorems, under the assumption of linear homogeneous functions. This observation will be advantageous in developing further arguments, since, if the output price ratios are not assumed to be changing, then factor-price ratios will not change throughout the analysis. Further, factor-price ratios will remain equal between industries throughout the analysis.[4/] Given the assumption of constant relative factor prices, with the values of O and T constant, suppose the bracketed functions ff and f_g (Equations (1) and (2)) represent the amount of an intermediate product (call it effort E^*), which will be produced at a given (constant) factor-price ratio. In this case,

$$F = g(E_f^*, O^0, T^0), \quad (4)$$

$$G = k(E_g^*, O^0, T^0). \quad (5)$$

These are functions in one variable with parameterized T and O. A production possibilities frontier can be shown for F and G (Figure 1, Frame a). However, the relationship between E_g^* and G (with T and O constant) is a production function in one variable. Using the constraint condition that $E_g^* + E_f^* = E$, the function can be redefined as $G = k((E-E_f^*),O^0,T^0)$. Taking the inverse of the function would yield $E_f^* = k^{-1}(G,E,O^0,T^0)$. This function, then, is analogous to a production possibilities curve for effort in the fisheries (E_f^*) and goods (G).

If a linearly homogeneous utility function is assumed, the income consumption path for constant prices (world prices) is aG. This function is the solution of the condition;

$$\frac{f'_F(U)}{f'_G(U)} = \frac{P_f}{P_g} \quad (6)$$

where $f'_i(U)$ is the first derivative of utility with regard to F and G, respectively. In this small country, X, the world price, production points, and consumption points all happen to coincide at A, on production possibilities curve B. This is a no trade solution. With an autonomous decrease in the ocean area available, the production possibilities curve shifts down to D. However, world price has not

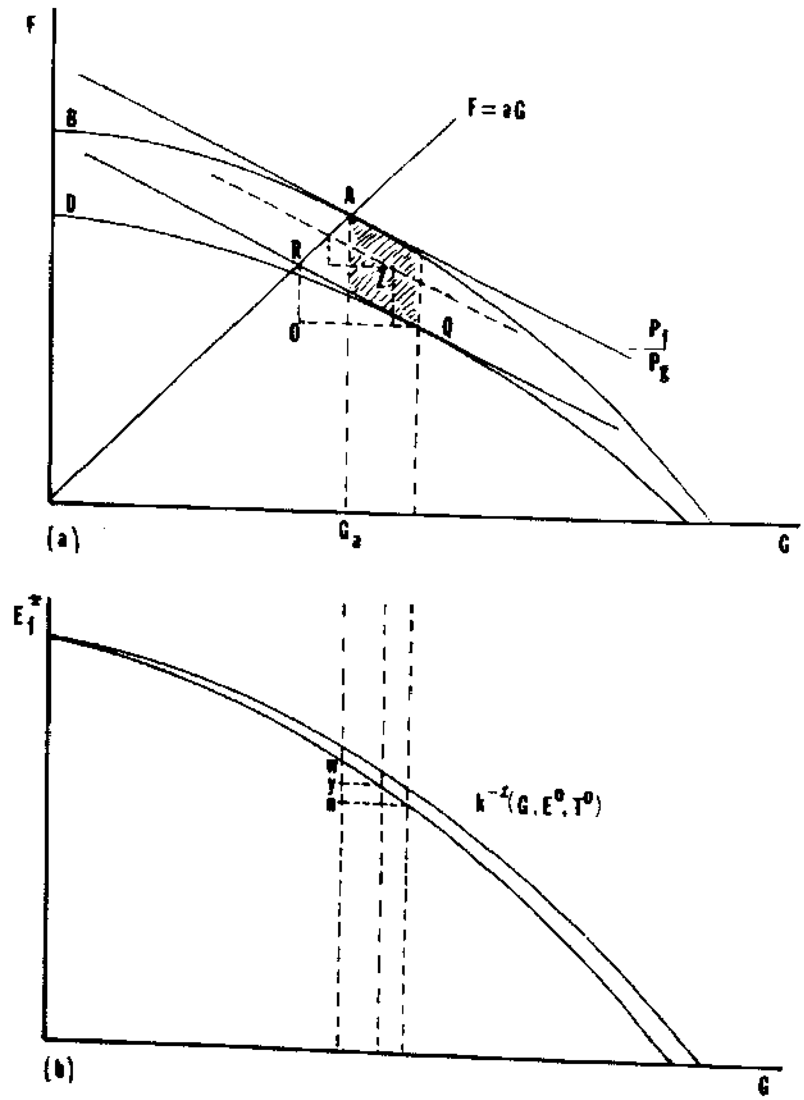

Figure 1. Changing Production Possibilities Curves Between Fish (F) and Goods (G) (Frame a); An Inverse Production Function of Effort (E) and (G) (Frame b).

changed. Under these conditions, the new production point is Q, the new consumption point is R, and G is traded for F. Specifically, OQ of G is traded for OR fish. Factor prices have been unchanged in the process, thereby satisfying the factor price equalization theorem. In addition, with the decrease in available ocean area, the production of fish is decreased rather than increased, and more G tends to be produced than F. This is the prediction of the Rybczynski theorem. The implication of this new equilibrium, where factors are immobile between countries, is that effort is taken out of production of fish and entered into the production of goods (Figure 1, frame b). These goods, in turn, can be used to buy fish.

However, what if some factors, such as effort, are physically mobile from country X to Y, such that X and Y can enter into an agreement where Y's resource is combined with X's physically mobile factors? Suppose, instead of production point Q, some production point, Z, within the shaded area was obtained, thus partially avoiding reduced catches in fish that both X and Y would experience if factors could not be combined between countries. A complete shift of X's production possibilities curve to B is unlikely, because the assumption has been made here that the fundamental change in ocean-rights will also affect the production possibilities of both countries. The amount WY of E_F^* would be given up for G production. However, the amount YU would be used in a new production process. In addition, Z is one point on some locus between A and Q made of tangencies between different production possibilities (corresponding to changes in host country ocean availability) and the fixed price ratio. In other words, a new productive process could be formed; call it $F_i = h(L_i, K_i, O_{iy})$, where ocean resources in country Y, (O_{iy}) are accessed. If O_j is the ocean area available under a given production process, where $F_j = g(L_j, K_j, O_j)$, then under factor-price equalization and the Rybczynski theorem (and under the assumed functional characteristics), trade could occur in effort and fish, as well as in goods and fish. This tendency would be especially strong if:

(1) It was more difficult or time consuming for effort to be used in G production than in fish production in country X;

(2) There is factor fixity among different uses in the "land" constraints (which include ocean area available for fishing, as well as the land variable).

With these assumptions, the results under factor-price equalization and the Rybczynski theorem follow. These results will be discussed in the next section. However, before this topic is left, several clarifications are needed. First, note the primary result is that consumption under the new property rights regime has increased when effort is allowed to be used in a new production process. Second, it is important to realize that country Y, which established the ocean property rights, will have production possibility curves moving in the opposite direction. However, with a new production process, their ability to secure fish will also be further enhanced. Therefore, this joint production process is mutually beneficial. This highly restricted model was used to give a simple demonstration of how trade in effort and fish might arise. The assumptions of linear homogeneity, while computationally attractive, are not totally generalizable to fisheries. The result of factor-price equalization and the Rybczynski theorem depend on a symmetrical bordered Hessian of comparative statics conditions from net revenue optimization. When functions which do not exhibit constant returns to scale are postulated (for example, a fisheries production surface), then trade solutions are less clear. Second, relative rates of capital movement between different processes may be an important factor in determining the occurrence of trade in effort and in fish. Costs of redesigning capital or reeducating labor for other processes would play a large part in determining direction of capital movement. Intermediate types of production, such as fishing or tendering in the host countries' Fisheries Conservation Zones (FCZ's), may be a relatively rapid method of factor deployment. A comparative statics analysis is shown in the next section for a three factor-three good economy under the assumption that the ocean factor does not enter into the production of goods, nor does land enter into the production of fish.

Comparative Statics Results

Comparative-statics solutions, which compose the basic arguments of the Rybczynski theorem, are developed in this section. The two objectives are to show, under assumptions of linear homogeneity and perfect competition in outputs:

(1) The Rybczynski theorem is upheld for the specified relationships between factor use and factor shares for three productive processes;

(2) The aberrations in relative prices caused by open access will change trade results, but the same basic process of effort movement to joint ventures will still take place under the stated assumptions.

To address the first point, assume there are three possible productive processes:

$$F_i = f_i\ (E_i,\ O_i), \qquad (7)$$

$$F_j = f_j\ (E_j,\ O_j), \qquad (8)$$

$$G = f_g\ (E_g,\ T_g). \qquad (9)$$

Equation (7) describes an activity similar to a joint venture, where O_i is the ocean area accessed under such a process. Equation (8) describes a fishing activity, which is essentially home-based, with O_j fixed. Equation (9) is the production of all other goods, with L_g being a land variable. Both values of F (F_i and F_j) are fish (or fish products). The endowment, "effort", is a composite of labor and capital, used in the same way as in standard fisheries economics theory. Land is not used in the production of fish. However, ocean space is used. Therefore, the constraints to this problem are:

$$E_i + E_j + E_g = E, \qquad (10)$$

$$T_g = T, \qquad (11)$$

$$O_i + O_j = O \qquad (12)$$

From the conditions of linear homogeneity, each production process can be expressed in terms of factor shares:

$$1 = f_i(a_{ei}, a_{oi}), \quad (13)$$

$$1 = f_j(a_{ej}, a_{oj}), \quad (14)$$

$$1 = f_g(a_{eg}, a_{tg}), \quad (15)$$

where a_{qx}, q = e, o, t and x = i, j, g is the respective factor divided by the dependent variable. There is also a set of prevailing prices, P_f and P_g (output prices), and imputed wages W_e, W_o and W_t embodied in the Lagrangian. Under a small country assumption, each country, X and Y perceives the same world prices for commodities.

The following objective function is obtained from a revenue maximization problem, with resource and unit isoquant constraints:

$$L = P_f\ (F_i + F_j) + P_gG + W_eE + W_tT + W_oO$$

$$- [F_i(W_e\ a_{ei} + W_oa_{oi}) + \lambda_i\ (1-f_i(a_{ei}, a_{oi}))] \quad (16)$$

$$- [F_j(W_e\ a_{ej} + W_oa_{oj}) + \lambda_j\ (1-f_j(a_{ej}, a_{oj}))] \quad (17)$$

$$- [G\ (W_e\ a_{eg} + W_ta_{tg}) + \lambda_g\ (1-f_g(a_{eg}, a_{tg}))]. \quad (18)$$

(Sections of the above equation are numbered separately for later reference.) Each submodel (16 through 18) of the maximum problem is a cost minimization problem, subject to the production constraint, with F_i, F_j, and G treated as parametric. The first partial derivatives of each sub-model (call them L_x, where x = i,j,g) are

$$\frac{\partial L_x}{\partial a_{qx}} = F_xW_q + \lambda_x \frac{\partial f_x}{\partial a_{qx}} = 0, \quad (19)$$

$$1 - f_x\ (a_{qx}, a_{qx}) = 0, \quad (20)$$

where q = e, o, t, and x = i, j, g. A simultaneous solution of each submodel yields optimal values, a^*_{qx}, which are themselves sole functions of the wages paid to the factors. However, as pointed out earlier, at the beginning of the analysis it was assumed factor prices did not change. Given the assumption of linear homogeneity and perfect competition in outputs, it is still true factor prices do not change, even if endowments do change. Therefore the a^*_{qx} are treated as constant. If the a^*_{qx} are placed into the constraints, given the model assumptions, the result is:

$$\begin{aligned} a^*_{ei}\ F_i + a^*_{ej}\ F_j + e^*_{eg}\ G &= E \\ a^*_{oi}\ F_i + a^*_{oj}\ F_j + 0 \quad &= O \\ 0 \quad + \quad 0 \quad + a^*_{tg}G &= T \end{aligned} \quad (21)$$

Attention is now turned to the change in the endowment of O, given the factor distribution that has been postulated. Note that, since O_j is postulated as fixed, a change in O is tantamount to a change in O_i. Therefore, the problem can be written as:

$$\begin{bmatrix} a^*_{ei} & a^*_{ej} & a^*_{eg} \\ a^*_{oi} & a^*_{oj} & \\ & & a^*_{tg} \end{bmatrix} \begin{bmatrix} \frac{\partial F_i}{\partial O} \\ \frac{\partial F_j}{\partial O} \\ \frac{\partial G}{\partial O} \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} \quad (22)$$

Solution by Cramer's Rule for the three unknowns yield:

$$\frac{\partial F_i}{\partial O} = \frac{-a^*_{ej}}{a^*_{ei}\,a^*_{oj} - a^*_{ej}\,a^*_{oi}} \qquad (23)$$

$$\frac{\partial F_j}{\partial O} = \frac{a^*_{ei}}{a^*_{ei}\,a^*_{oj} - a^*_{ej}\,a^*_{oi}} \qquad (24)$$

$$\frac{\partial G}{\partial O} = 0 \qquad (25)$$

Equations (23) and (24) are not determinate unless relative magnitudes can be assessed for a^*_{ei}, a^*_{ej}, a^*_{oi} and a^*_{oj}. One condition contributing to a positive flow of mobile factors, such as effort, into the i^{th} process ($\partial F_i/\partial O > 0$), would be if the factor share of effort in the production of fish products under the j^{th} process (the home-based fishery) is relatively great (effort intensive), compared to the i^{th} process. In addition, if the i^{th} process (joint venture fishing) is relatively more ocean intensive than the j^{th} process, then as the distribution of available ocean area changes, factors, such as effort, will try to flow out of the home-based or domestic fishery into the production of fish by joint ventures. Therefore, if equations (23) and (24) represent a situation such as Japan, who had wholly domestic near-shore and distant water fleets, the production in those ocean intensive distant water fleets decreased dramatically with the on-set of extended jurisdiction. By the same measure, the United States represented a situation where one of their factors, ocean, increased. Fish production also increased, mainly through reduced competition for resources. However, the factor, effort, for off-shore fishing was in very short supply in countries such as the United States, but was in plentiful supply in Japan. Effort was the most mobile and plentiful factor in Japan. The only remaining question to be resolved was the problem of access and compensation in the post-extended jurisdiction world. An important consideration is that most countries could not, for one reason or another, buy the effort components from those countries which had available supplies. The U.S., for example was, and still is, restricted by the Jones Act. Other countries simply did not have the currency to make such large purchases. The creation of joint ventures in the form of the purchase or barter of services of factors, both ocean and effort, became a solution to the problem of factor immobility.

The joint venture, then, could be expected to be organized around the mutual rental of factors. In the United States, those participating in joint ventures almost always engage in over-the-side sales to processing vessels. However, another settlement occurs between the representatives of each partner country. This settlement involves the apportionment of either proceeds from sales or the fish from the processing activity. Either of these forms of apportionment could be thought of as a rental payment for the use of ocean area (in Japan's case) and a rental payment for effort (in the case of the U.S.). Production of both countries would be increased through the trade of both effort and ocean services.

A simple example has been presented, which shows if the assumption about relative factor intensities between home-based and distant water operations can be made, then a redistribution of factors in favor of joint ventures will occur, even if world prices do not change with changing endowments. The example implies that even small countries which have no control over world prices, would be expected to engage in "trade" of mobile factors of production. Although a trade solution with all three productive processes is difficult to solve generally, a greater specificity of relationships between factor shares in different uses, will result in more definitive trade solutions. The effects of allowing factors to move between productive processes will be discussed in the following section.

Two questions which remain are:

(1) How reasonable is it to postulate the following?

$$a_{ei} < a_{ej},$$

$$a_{oj} < a_{oi}.$$

(2) What are the effects of the open access condition, where the world price of fish is relatively under-valued?

To address the first question, more detail is needed about each productive process. While requiring a significant amount of effort, distant water fisheries processes appear to be principally concerned with gaining access to fishing areas, from which raw products may be drawn. In other words, those fleets which would likely enter joint ventures tend to be directed at gaining access to large areas of highly productive oceans. This could mean joint ventures are using the ocean resource more intensively, relative to their use of effort. Alternatively, wholly domestic fisheries may not have the option of entering a joint venture fishery. With extended jurisdiction, domestic fisheries may be more effort-intensive, especially if fishing fleets are restricted to smaller, less productive areas. If these hypotheses are valid, then not only would country X experience effort movement into joint venture operations but, by the comparative statics results, would also experience a net gain of fish coming into the country (as does country Y). Country X's effort has been used, and fish has been and can be part of the settlement for the use of ocean and effort in the bi-national production process. In a sense, the joint venture circumvents a more traditional trade of goods for fish (Figure 2). As an example, the point Z of Figure 1 is placed on Figure 2, to conform with the comparative statics results. (The production possibilities curve upon which Z lies has not been drawn in Figure 2 to reduce clutter in the graphics.) It will be noticed from the comparative statics results (25) that, with a change in ocean area, G does not change. However, the results show that if the assumptions hold, the total production of F does increase. If the Engel curve, F = aG, represents the locus of tangencies between the preference map of a country and the boundary of an opportunity set of different incomes with a slope of $-P_f/P_g$, then trade will still occur in goods and fish.

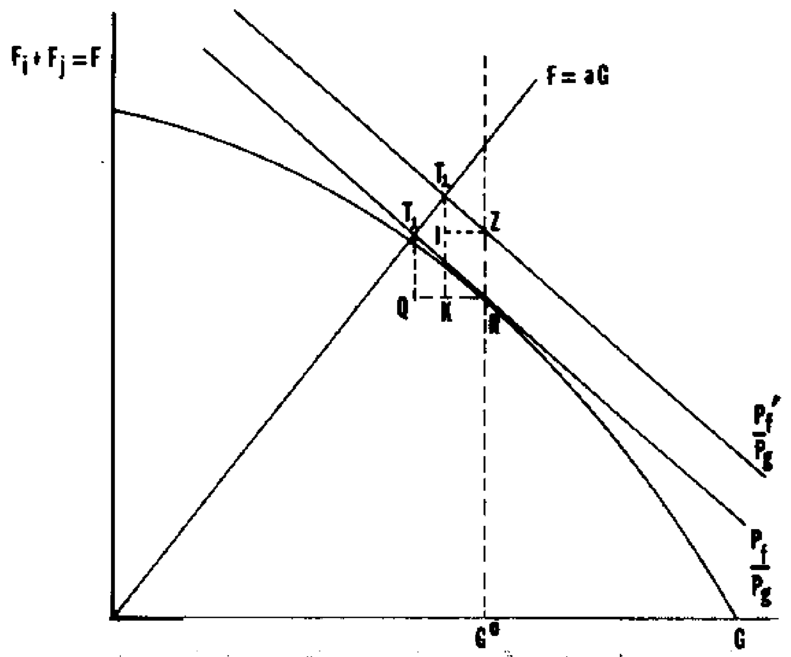

Figure 2. Production of Fish Through Joint Ventures, and the New Trade Solution.

Recall that the move from the pre-trade position R to that of Z took place through a trade of the services of productive factors. The diagram in Figure 2 most closely resembles what has occurred in Japan, that is, an augmentation of production possibilities. At the point Z, IZ (or RK) goods are given up for IT_2 of fish. This new trade solution is an improvement over the previous conditions of trade on the production possibilities curve. The amount QK of goods are retained by the country, which is better off than if trade of factor services did not occur (though not as well off as they might be with free access). Additionally, the other country (not shown in Figure 2), which has experienced similar production possibility gains, has been able to expand its production possibilities further than if trade of factors was not permitted. Therefore, both countries benefit from the rental of each other's factors after extended jurisdiction, and those rental payments may be made in fish or currency, whichever is the most advantageous medium of exchange.

The second question regarding relevance of price in the determination of trade results, when changes in factor endowments occur, is interesting. As Scott [1955] and later, Gould [1972] and Anderson [1977] have pointed out, the common property nature of fish resources of the oceans, both within each country and between countries, causes the effort expended in the fishery to be under-valued, relative to its potential value when combined with a resource endowment having strong property rights. This occurs because each individual fishermen, in the attainment of the individual firm equilibrium, causes the industry to be driven to the point where the average revenue of fish equals the average cost of fish. However, at this point, rents to the resource are dissipated through free entry. If a production function with a local maximum and regions, decreasing in their arguments, is assumed, the open access solution will have multiple equilibria, where average market costs equal average market revenue. Each of these equilibria represents a substantial divergence from the monopolistic solution (where marginal market costs equal average social revenue) or the state-run fishery solution (where marginal social costs equal average social revenue), suggested by Copes [1972]. This phenomenon of open access appears to be widespread in fisheries, and yields price ratios for fish and goods, which are not tangent to the production possibilities curve. Anderson's principal arguments will be used to show this result, except both production surfaces will still be assumed linearly homogeneous, as well as concave. For an economy producing G and E, where E is used in the procurement of fish (F) the following conditions hold:

$$\frac{dF}{dG} = \frac{dF}{dE}\frac{dE}{dG} . \qquad (26)$$

Equation (26) states that the slope of the production possibilities curve (PPC) for F and G is the product of the slope of the yield-effort relationship and the PPC for effort and goods, respectively. The change in total revenue with respect to a change in effort can be written as:

$$\frac{dE}{dG} = - \frac{P_g}{P_f\ (MPP_E^F)} , \qquad (27)$$

where P_g = price of G

P_f = price of F

MPP_E^F = marginal physical product of E in production of F.

Equation (27) states that, in equilibrium, the slope of the production possibilities curve for effort and goods should equal the price ratio of goods to fish, weighted by the inverse of the marginal physical product of effort in the production of fish. This is a well known marginal condition deriving from the satisfaction of first order conditions of revenue maximization. However, the same solution is not obtained for open access fisheries. The solution for open access is:

$$\frac{dE}{dG} = - \frac{P_g}{P_f\ (APP_E^F)} , \qquad (28)$$

where APP_E^F = average physical product.

For the same point on the production possibilities curve for E and G (and consequently for the PPC of E and F), the following relation holds in open access:

$$\frac{MPP_E^F}{MPP_E^G} = - \frac{P_g}{P_f} < \frac{APP_E^F}{MPP_E^G} = - \frac{P_g}{P_f} , \text{ or} \qquad (29)$$

$$\frac{MPP_E^F}{MPP_E^G} < \frac{P_g}{P_f} .$$

That is, in open access, the price ratio will always be greater than the slope of the production possibilities curve between goods and fish. The open access solution, therefore, changes the trade solution. In addition, the trade solution becomes indeterminate. However, the open access condition is interesting, because it has the potential for changing the trade solution in a number of ways. However, a determinate solution is not apparent, unless the more stringent assumptions made before are retained and unless an additional assumption is made; that for every point on the production possibilities curve (PPC) for F and G, there exists a price ratio steeper than the slope of the PPC at that point. Further, each price ratio associated with the PPC point is unique. Assuming the same linearly homogeneous utility function as before (so that the Engel curve aG can be produced), Figure 3 compares the trade solutions under open access fisheries with Pareto optimality in production. The dotted line represents the same Engle curve aG, and the line tangent to the PPC at R represents the Pareto optimal solution for production, where RQ goods are traded for QI fish. Suppose, however, this is an open access industry, where the true world price ratio is $(P_f/P_g)^*$. Figure 3 shows another Engel curve lying to the northwest of aG. In this particular case it has been drawn under the assumption that the slopes of the dotted price lines will equal the slope of the community indifference curve along this new locus. Where fish is considered a normal good, the economy in country X will import proportionally more fish for a unit of goods. If a productive activity which will enable X to produce at Z, the result (predictably) will be that $QQ'/T_1T_1' < II'/T_2T_2$. That is, as the quantity Z produced becomes larger, less goods are given up for fish. Country X would eventually find it advantageous to export fish itself if Z became large enough. However, counter-acting this trend is the fact that open access conditions appear to accelerate trade in fish; country X will tend to import more fish in a world with open access solutions, than if the world economy were Pareto efficient, *ceteris paribus*. Therefore, the open access solution in Figure 3 tends to obscure or play down the dampening trends joint ventures have on world trade of final products. Nevertheless, these trends are still evident, even appealing to the graphical solutions. The reader can verify that the amount of goods traded for fish becomes progressively smaller, as the point Z moves up the dotted line, if there are no changes in the relative slope of the price lines. Although this result is not too surprising, the combination of open access conditions plus factor mobility could be providing a situation where joint ventures and traditional trading patterns will persist, even though the fishery resources have been largely "rationalized" at the international level.

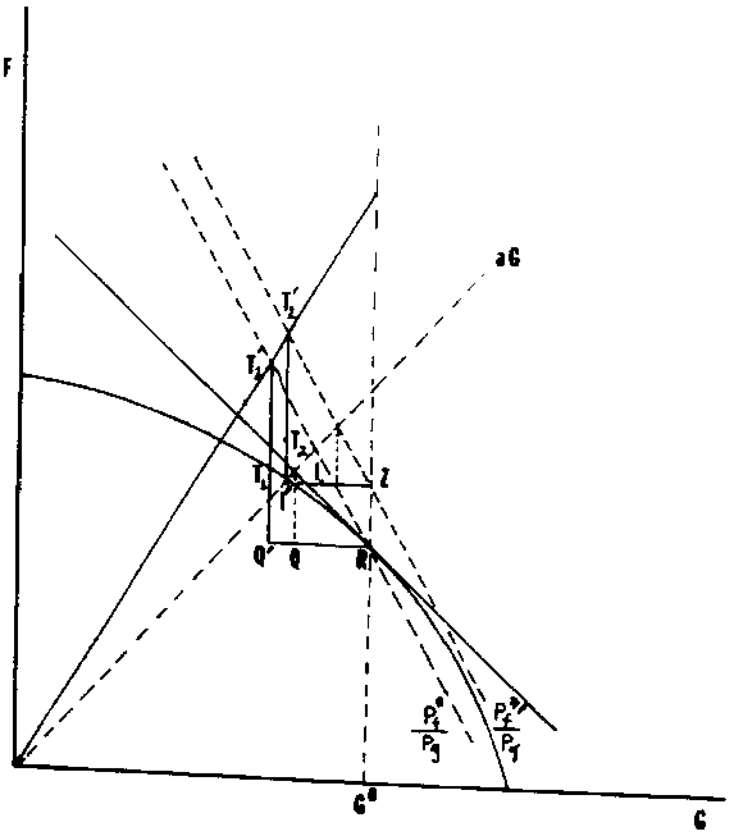

Figure 3. Comparisons of Open Access Versus Pareto Efficient Trade Solutions.

However, given the assumptions presented for deriving the comparative statics results for a change in ocean area, it has been shown that changes in factor endowments did not affect the prices paid for factors. Only world prices affect the prices paid to factors. Therefore, if world prices are held constant, factor prices will remain constant. As was discussed in the previous section, this is a result of the use of linear homogeneous functions and of assuming a small country, with no control over world price. Despite this restrictive assumption, it has been shown that physical factor mobility of effort and a means to effect the rental of productive factors, effort and ocean, will ensure movement of effort into that process which uses the ocean space factor most intensively. Again, by the factor price equalization theorem and the other assumptions made in this analysis, price changes need not be considered to show flow of factors. However, price changes will also cause the same flow of factors. This is the duality between the Stolper-Samuelson and Rybczynski theorems, referred to earlier. Finally, the model shown here is an example where the rental or barter of factor services is an effective alternative to the trade of factors, themselves. For example, a capital good can be sold or it can be rented out to another producer. Structural rigidities may preclude the sale of some capital goods to some countries. Then, the next best alternative may be to rent out the capital goods. However, rather than an explicit rental of the capital good, a joint production process could be formed. The factors are all paid out of the proceeds of the product. In this sense, trade has occurred, where effort has been exchanged for fish or currency. Although this may not be a surprising conclusion, it does pose some empirical problems for those performing trade analyses using data generated in the traditional manner. Most trades of fish generated from joint production processes never appear on a trade balance sheet. This may bias the analysis of the impacts of extended jurisdiction.

Empirical Analysis of Extended Jurisdiction Trade Effects With No Joint Ventures

The conditions under which extended jurisdiction occurs must be clearly specified, if its effect on trade of fish is to be understood. Additionally, the common property nature of the resource suggests that a unique or determinate trade solution, such as might be found under more restrictive assumptions, is not possible to derive. Two reasons exist for such a condition: (1) the shape of the production surface for fish is not usually thought of as linearly homogeneous; and (2) fish and the factors used to take fish are under-valued relative to the standard general equilibrium trade result. These considerations can either be explicitly modeled or implicitly controlled by carefully choosing cases to be analyzed by simple models. The latter approach was chosen, in a study on changes in Japanese export market shares to the U.S. and Canada, in the commodity group of shrimp, prawn, and lobster (SPL). These cases were specifically chosen for the following reasons:

(1) Japan has been hard hit by the trend of worldwide extended jurisdiction, from the standpoint of the magnitude of loss in access to fishing grounds.

(2) Shrimp, prawn, and lobster (SPL) products are generally considered luxury commodities by Japan, Canada, and the United States, and have wide consumer appeal. Therefore, fluctuating consumer effects are expected to be minimized.

(3) The fisheries dealing with SPL are, relatively speaking, inshore; well within the 200 mile limit. Also, all shrimp species are fully utilized by domestic fleets in the U.S. The inshore nature of these fisheries is generally a worldwide trait, related to the biology of the species.

(4) U.S. and Canadian trawling vessels and other methods of capture are well developed and may even be in over-supply. Therefore, little incentive exists for a trade in the various forms of effort between Japan, Canada, and the U.S. Furthermore, the Jones Act (a U.S. law) forbids fishing in U.S. waters and subsequent landing in U.S. ports, with foreign-made vessels.

(5) The U.S. is a major importer of SPL, as is Japan. Canadian imports are smaller, but this is probably related to Canada's population size, rather than differences in preference.

Japan's share in the import markets of Canada and the U.S. would be expected to fall between the years of 1959 to 1980, due largely to the worldwide trend in extended jurisdiction. The fall would be probable, even though markets for these commodities remained very strong during this time period.

The role of extended jurisdiction in the international trade of seafood has not been well studied. However, Lin et al. [1981] raise issues regarding the ramifications of extended management zones in the world community. A number of studies have been done using market shares analysis, in general. To study trade flows, direct or proxy measures of the import demand, and the price elasticities of that import demand are needed. Market shares approaches have been used to estimate the effects of price competition, and their use avoids the more difficult empirical problems that develop when specifying import demand functions. Studies by Hickman [1973, 1977] looked at changing trade patterns in the Pacific Basin countries between 1955 and 1975. Hickman's unaltered log-linear model is specified in the following manner:

$$Ln\alpha_{ijt} = a_{oij} + a_{1ij}Ln\,(P^x_{it}/P^m_{jt}) + a_{2ij}T + a_{3ij}Ln\alpha_{ijt-1} + v_{ijt}, \qquad (30)$$

where: α_{ijt} = the share of the exporting country i in the import market of a country j in year t, for all imports defined as:

$$X_{ijt}/\sum_{i=1}^{n}X_{ijt}$$

or, the ratio of the country i's exports to country j in year t (X_{ijt}) and the total exports to country j

a_{oij} = the intercept term

a_{1ij} = the short term elasticity of the market share with respect to price (expected sign is negative)

P^x_{it}/P^m_{jt} = the ratio of the export price for all goods of country i, based on F.O.B. price quotes, to an import price index in market j, defined as:

$$P^m_{jt} = \sum_{i=1}^{n}\alpha_{ijo}P^x_{it},$$

where α_{ijo} = share of the exporting country to input market in year 0

a_{2ij} = estimated trend growth rate (expected sign is positive or negative, depending on trade relations)

T = an index of time

a_{3ij} = estimated rate of response in market shares in year t to market shares in t-1 (expected sign is positive)

α_{ijt-1} = market shares of the previous period

v_{ijt} = error term

Hickman's model, used in 26 countries or country aggregates, yielded results which have considerable theoretical and empirical appeal. For example, signs on the elasticity measures, regardless of significance, were consistently negative, and the significance of the parameter estimates at 5 percent and 10 percent levels were common. Hickman included in his model the variable time, which, in this paper's model specifications, is not included. Also, Hickman's time index is designed to capture secular shifts in demand, but ignores determinants of supply.

Some supply determinant should be included in the export model for Japan, especially in the case of the fisheries for SPL. The time variable has been removed, and the variable AREA (the percentage of 1981 world jurisdictional claims in square nautical miles, by year) has been added to the model. In addition, the catch ratio of SPL between Japan and Canada, as well as the U.S., was included to account for short-term supply fluctuations.

The export-import price ratios are not strictly comparable between Hickman and the model specified in this study. Hickman weights the import market price by the share of the exporting country in year 0. This study computes the price ratio in the following manner:

$$\frac{P^*_{it}}{P^m_{jt}} = \frac{E_{ijt}\,\frac{\Sigma V_{it}}{\Sigma Q_{it}}}{\frac{\Sigma V_{jt} - V_{ijt}}{\Sigma Q_{jt} - Q_{ijt}}} \qquad (31)$$

where: V_i = the total value of exports of Japan of SPL, year t (1959-1980)

Q_i = the total quantity of exports of Japan of SPL, year t (1959-1980)

$(\Sigma V_{jt} - V_{ijt})$ = the total value of imports of SPL by Canada (U.S.), less the value of Japanese export to Canada (U.S., year t (1959-1980))

E_{ijt} = the exchange rate between Japan and the U.S. (1959-1980)

In this model specification of Japan's export market shares to the U.S. and Canada, the shares are developed in value terms (FOB), the catch is in metric tons, the variable AREA is substituted for time, and is in terms of percent (decimal fraction x 100), and the price ratio has been developed using U.S. currency in year t. All product forms of SPL were included in this analysis.

Model Tests. Actual specification of the export market shares model was a logistic, or logit, form. Unlike the Hickman model, the independent variables were unlogged. The logit form of this type is the familiar "S"-shaped function, common to such functions as the normal and t cumulative distributions, which are asymptotic at 0 and 1. It was felt that the unlogged form of the logit model was most likely to represent the actual function being estimated. Logistic-types of transformations have been used to investigate growth in the shares of particle board production [Oliveira and Buongiorno, 1977]. The logistic model has also been used in empirical work, where adoption of new technology has been felt to be time related. Another feature of logistic transformation is that it enables predicted share values, between 0 and 1, to be insured. Since this analysis involved estimation of a dependent variable, with relevant values between 0 and 1, a model which would consistently predict those values was considered important.

The dependent variable was transformed to logit form by dividing each observation of the dependent variable, JSHRUS (JSHRCAN) by 1 minus the variable; then taking the natural log of this index.

A simple logit transformation allows the model to be used as a predictive tool in cases where it is known the value of a dependent variable lies strictly between 0 and 1. If the problem is one of binary choice, then a simple transformation would be inappropriate.

The following independent variables (with a sample size of 21 years) for each country were regressed against the log of Japan's transformed export share to the U.S. (Canada), LJSHRUS (CAN):

LJSHRUS(-1) (CAN(-1)): The lagged (one year) logit index of Japanese export market share of shrimp, prawn, and lobster (SPL) in U.S. (Canada).

RATIOJUSA (CAN): Japanese export price of shrimp, prawn, and lobster (SPL) divided by the import price of SPL, without Japan's share included in the U.S. (Canada) (in dollars, U.S.).

AREA: The percentage of 1981 200 mile area claims of ocean held by countries as territorial or fisheries zones.

USCTHR, CNCTHR: The ratio of Japanese to U.S. (Canadian) catch of SPL.[5/]

DUM: A dummy variable, taking on the value of 0 for years 1959-1967 and 1 for years 1968 through 1980.

The dummy variable was included because, upon close inspection and corroboration from other sources, it appeared Japanese export trade statistics, either left fresh chilled and frozen products out of the early years or had aggregated them elsewhere. Both Fishery Statistics of the United States, as well as FAO production and export statistics, were consulted for several years in this time period and it was apparent Japan had an export trade in fresh/frozen SPL during this time period. However, composing Japan's trade picture for a commodity, which appeared never to have been reported would have been a nearly impossible task. To correctly specify Japan's market share in the U.S., Japan's total export of fresh, chilled, and frozen SPL would have to be inferred from import statistics of her trading partners.

Tests on the ordinary least squares (OLS) models for the U.S. revealed no heteroskedastic disturbances, using methods outlined by Glejser [1969] and Park [1966]. However, the Canadian model did exhibit some heteroskedasticity, caused by the variable JSHRCAN(-1). The parameter estimates for slope were obtained from the regression of JSHRCAN(-1) on the absolute value of the residuals. These were used in subsequent generalized least squares (GLS) estimation of the original model. In cases where heteroskedasticity was detected and corrected, the more efficient parameter estimates are presented in the results, along with the t-statistic. Since neither the R^2 of the original model nor of the transformed model are appropriate indicators of fit, the square of simple correlation between the efficiently fitted values of market shares and the observed values are presented as an approximate measure of goodness of fit, as suggested by Pindyck and Rubinfeld [1981]. The GLS transformation was made before testing for autocorrelated disturbances.

Tests for autocorrelation in both U.S. and Canadian models yielded ambiguous results, since inflated Durbin-Watson statistics occur as a result of using the Durbin-Watson test on models with lagged endogenous variables. Attempts to use the Durbin h-test, which is actually for large samples ($n > 30$), yielded equally ambiguous results. A large sample test, alternative to the h-test, shows no autocorrelation, but the prescription is suspect due to the small sample size (21 observations). For this reason, both models were corrected using GLS estimation techniques, outlined by Beach and MacKinnon [1978]. The corrected models are shown for each country in Table 2. The uncorrected models are not presented, since estimates were inefficient. A maximum likelihood technique, used to search for a generalized least squared weight ρ, was used to correct for autocorrelation.

Table 2. Models of Japan's Export Market Share Response in Shrimps, Prawns and Lobsters; GLS Estimation.

Part I. United States

LJSHRUS = -4.81 + 1.489 DUM -0.3035 RATIOJUSA + 0.3986 LJSHRUS (-1)
(-2.161)**(2.170)**(-.254) (2.313)**

-0.0038 AREA + 2.956 USCTHR
(-.756) (1.393)*

R^2 = .61; F(5,15) = 4.64**; Obs. = 21;
DURBIN WATSON = 1.7173

Part II. Canada

LJSHRCAN = -4.64 - 0.562 DUM -0.1045 RATIOJCAN + 0.4861 LJSHRCAN (-1)
(-1.423)(-.921) (-.065) (2.152)**

-0.0119 AREA + .7493 CNCTHR
(-0.6998) (1.099)

R^2 = .58; F(5,15) = 4.19**; OBS. = 21;
DURBIN WATSON = 2.0603

Simple Correlations

		(1)	(2)	(3)	(4)	(5)	(6)
(1)	LJSHRUS	1					
(2)	DUM	.33	1				
(3)	RATIOJUSA	-.38	-.19	1			
(4)	LJSHRUS (-1)	.40	.07	-.28	1		
(5)	AREA	-.16	.25	-.13	.14	1	
(6)	USCTHR	-.09	-.73	.01	.04	-.45	1
(1)	LJSCHRCAN	1					
(2)	DUM	-.33	1				
(3)	RATIOJCAN	-.26	-.05	1			
(4)	LJSHRCAN (-1)	.61	-.32	-.16	1		
(5)	AREA	-.37	.25	-.24	-.14	1	
(6)	USCTHR	-.06	-.34	.83	.03	-.55	1

* and ** indicates significance at 90% and at 95% respectively.

It should be emphasized that the poor quality of data available for analyses such as this made even these meager results interesting, in their own right. Also, the direction of effect (i.e., the sign) on AREA is robust through all transformations and throughout the analysis. Consequently, a one-tailed test could be done, and if 70 percent was an acceptable level of certainty, the parameter estimate would be significant. It would be insignificant at confidence levels greater than 70 percent. One observation made in response to both Canadian and U.S. models, is the role of AREA as an explanatory variable in these models. Despite the efficiently estimated parameters (the magnitudes of which did not appreciably change after using GLS, as expected), both models still had multicollinearity, although it was not at high levels. Interestingly, the simple correlations between area and the dependent variables of the two models reveal that area explains about 37 percent of the variation in LJSHRCAN, but only about 16 percent in the U.S. model. Yet the catch ratio, which explains less than AREA, is relatively highly correlated with AREA. This relationship between catch rate, AREA, and the dependent variables is the topic of further discussion in the next section. The t-values for AREA suggest a fairly weak variable if a two-tailed test is used. In addition, simple correlations suggest the catch ratio and AREA is strongly negatively correlated. For each model, the catch ratios capture an important dimension of the market shares issue. The hypothesis is, relative catches determine the amount of emphasis placed on external trade in a year. Both models suggest the ratio of Japanese catch to the importing country's catch is positively related to the movement of market shares. That is, as the ratio becomes smaller (either Japanese catch experiences relative declines or the importing country's catch experiences relative increases), the export market share declines. As would be expected, the lagged shares variable captures a substantial amount of the variation, suggesting market development and presence in the U.S. and Canada, by Japan, has been somewhat stable.

Both the U.S. and Canada models represent a hybrid of demand and supply relationships. Because of significant data constraints associated with well specified structural forms, estimation of a reduced form was hoped to yield a model which would correctly predict the market shares response, given changing exogenous variables. However, there is still considerable variation in market shares, which remains unexplained by both models.

Work by Lin et al. [1981] on shrimp in Pacific Rim countries, states that data problems encountered in making models, such as these, operable, were very large and were not completely overcome in their work either. The necessity of incorporating an inventory function and less aggregated data, over longer periods of time, has been voiced by many economists, including Lin. This need must presently go unfilled, since little of this type of data exists.

Johnston [1984] has argued strongly that other trends were occurring in the world which could make extended jurisdiction effects negligible, by comparison. One such possible variable could be changes in international monetary policy. Since these monetary policy changes are thought to have dramatically affected the world economy, especially in world agriculture, it is possible the same fluctuations are occurring in seafood trade.

An Analysis of Extended Jurisdiction Trade Effects With Joint Ventures

The previous section investigated an example where no joint ventures would be expected to arise, even though extended jurisdiction took place. Now consider a case where the U.S., which gained a substantial amount of ocean resources, does not display the type of export expansion expected with Korea. Korea, however, has expanded their fisheries, in spite of extended jurisdiction. The same model form was used as in the Japanese export models, except the dummy variable was not included, because Korea had no major problems with inconsistent reporting, except in 1968 and earlier. Apparently, earlier than 1968, reports were more aggregated and did not record trace amounts of trade. Therefore, the first observation was assigned an arbitrary shares value of .01. This would appear reasonable, since trace shipments could have been made during this time period and not recorded. Additionally, corroborating trade statistics suggest sporadic trade occurred with the U.S. prior to 1968. It is possible, then, some trade could have taken place in the intervening year.

The following model variables (sample size = 13) were included in the study of U.S. export shares to Korea:

LUSSHRK = The logit index of the U.S. export market shares of fresh, chilled and frozen fish (excluding salmon and ornamental fish) is defined as:

$$\log \frac{USSHRK}{1-USSHRK}$$

RATUSK = The price ratio between weighted average price of total Korean imports divided by the average price net of U.S. exports. Its composition is identical to that of Japan's export market share.

LAGESK = The lagged logit index of market shares.

HARRAT, JVHRAT = The ratio of total catch between the U.S. and Korea. The value of JVHRAT includes the catch taken by joint ventures. The catch does not include salmonoids, crustaceans, mollusks, or ornamental fish.

NAREA = The percentage of 1981 ocean area under extended jurisdiction.

Until 1979, when the Fish and Chips policy began, U.S. exports to Korea were sporadic and declining, while the Korean catch (relative to the U.S. catch of the same commodity) was expanding. Since Korea has been aggressive, world-wide, with regard to fisheries agreements, it is not surprising extended jurisdiction trends have had a limited effect on Korea. Although data on Korean trade are limited, a presentation of general effects from different treatments of joint ventures on model results are in Table 3. First, observe that the models, on the whole, appear to give fairly stable results, with respect to the relative importance of variables within each model. That is, none of the variables made a complete switch from being insignificant to being significant, with different model specifications. This lack of change is because the joint venture data covers only from 1978 to 1981. Also, the Fish and Chips policy, which began in 1979, may be making data interpretations of these latter years ambiguous, since the adoption of this policy could be causing Korea to engage in more imports than they normally might. However, incorporation of joint venture data caused some large changes of individual variables between models. For example, the lagged market share index LAGESK, which should have been positive (and was highly significant in the U.S./Canada share models), was not at all significant in Table 2 and also had the wrong sign in Part I of the table. When joint ventures were treated, first as Korean catch, and then as U.S. exports, LAGESK did exhibit expected (positive) signs. Despite substantial improvements in standard error of the estimate, however, the parameter for LAGESK never became significant. This was also the case for the two other variables (RATUSK and NAREA), which were insignificant at the test levels. However, each of these two variables, contributed more in terms of explaining variation in market shares than did LAGESK. The coefficient for HARRAT, the harvest ratio between the U.S. and Korea, had minor changes and a slight decline in significance.

Table 3. Market Shares Models for U.S. Exports of Fresh, Chilled and Frozen Fish, Excluding Salmon and Ornamental Fish, to Korea: Corrected for Heteroskedasticity and Autocorrelation.

Part I. With U.S.-Korea Joint Venture Catch Not Included

$$LUSSHRK = \underset{(-3.099)^{**}}{-3.749} - \underset{(-1.000)}{0.517}\ RATUSK - \underset{(0.2187\times10^{-4})}{0.520\times10^{-5}}\ LAGESK + \underset{(4.313)^{**}}{4.784}\ HARRAT$$

$$+ \underset{(0.609)}{0.0063}\ NAREA$$

R^2 = .63; F(4,8) = 3.34*; OBS = 13; DURBIN WATSON = 2.1171

Part II. With Joint Venture Catches Included With Korean Catch

$$LUSSHRK = \underset{(-3.080)^{**}}{-3.73064} - \underset{(-1.021)}{0.529}\ RATUSK + \underset{(0.01633)}{0.00390}\ LAGESK + \underset{(4.2952)^{**}}{4.295}\ JVHRAT$$

$$+ \underset{(0.6466)}{.00670}\ NAREA$$

R^2 = .62; F(4,8) = 3.30*; OBS = 13; DURBIN WATSON = 2.1138

Part III. With Joint Venture Catch as a U.S. Export

$$\text{LUSSHRK} = \underset{(-3.284)^{**}}{-3.71871} - \underset{(-1.079)}{0.559}\ \text{RATUSK} + \underset{(0.1147)}{0.0208}\ \text{LAGESK} + \underset{(3.637)^{**}}{4.853}\ \text{HARRAT}$$

$$+ \underset{(0.7901)}{0.00748}\ \text{NAREA}$$

R^2 = .63; F(4,8) = 3.33*; OBS = 13; DURBIN WATSON = 2.1089

* and ** indicates significance at the 90% and 95% levels, respectively.

Note the market shares relationships and their signs are exact analogues of one another, between Table 2 and 3. For example, the coefficient for NAREA is positive in the U.S. export model, since some export activity has been attributable to the U.S. gaining ocean area, relative to Korea. Japan, on the other hand, lost ocean area access to other countries. Hence, Japan experienced declines in market shares for increases in ocean area, under extended jurisdiction. The harvest ratios are analogous between the models, with the catch of the importing country forming the denominator. Therefore, the positive sign reflects the observation that as the relative catch of the importing country increases, the less inclined either country will be to engage in trade.

In the Korean models, a weaker negative relationship existed between HARRAT and NAREA (-.317), but a much stronger simple correlation between NAREA and the price ratio RATUSK (.502) was present. The latter relationship may be causing inefficient estimates of either HARRAT or RATUSK. Due to the limited data available, these models should be cautiously interpreted. However, it is interesting that relative harvest rates appear to play a vital role in one model and not in another. Note also that, although the model in Part III of Table 3 is biased in its representation of U.S. export market shares, it is still true the U.S. is a major exporter, even when assuming joint ventures are exports. (If U.S. joint ventures are considered exports, a more correct assessment would be to include all of Korea's world-wide joint venture activities as imports.) Therefore, the direction of change in the models is not a bias, and is an indication that the role of extended jurisdiction under different definitions of "trade" could change substantially.

One final issue concerns the differences between the general form of market shares model used in this paper, and that of other authors. The main difference in the models is in the logit formulations. Price elasticities, which are obtained from the Hickman model, are no longer so easily derived. The general form of the unlogged model is:

$$S = \frac{1}{1 + y_{t-1}^{-\alpha}\ e^{-(a-b_1x_1+\ldots+b_nx_n)}}\,, \qquad (32)$$

where $y_{t-1} = \dfrac{S_{t-1}}{1 - S_{t-1}}$.

If x_1 is the price ratio between the two countries, then the elasticity of market shares with respect to price would be:

$$\frac{\partial S}{\partial x_1}\frac{x_1}{S} = \frac{-b_1x_1}{1 + y_{t-1}^{\alpha}\ e^{(a-bx+\ldots+bx)}}\,. \qquad (33)$$

The relationships between variables in the linearized model also hold for the unlogged model. For example, suppose the shares in this time period (t-1) were increased. The likely effect on future shares can be seen by noting that as S_{t-1} becomes large, y_{t-1} also becomes large. However, as y_{t-1} increases, the value of the right hand of the denominator in (32) becomes very small, so S approaches 1. Conversely, negative values of parameters in the exponent of e tend to make S small. Therefore, the signs on the regression results correctly indicate the direction S will take for a change in the variables.

Summary and Conclusion

Many of the results of each empirical analysis are what would be expected, since specific cases were chosen to isolate the trade effects of extended jurisdiction. However, despite consistent results, both in terms of sign and level of significance, none of the results could be considered conclusive evidence that extended jurisdiction has a direct effect on market shares. What is conclusive is where there is a fairly strong negative relationship between harvest ratios and extended jurisdiction, there is also some diminution of harvest ratio's explanatory power in the models. Where harvest ratios were very strong, as in the Korean models, extended jurisdiction made less of an impact than in those cases where harvest ratios were not strong. When an arbitrary definition was made, calling joint ventures transactions "exports" (Table 3, Part III), the impact of extended jurisdiction was somewhat more pronounced.

The lagged share response is important in modeling the consistency and stability of Japanese export markets, but was not in the Korean models. Although the price ratio is insignificant, this result is not inconsistent with other work in this field:

> In most cases, the price of shrimp was found to be statistically insignificant in both import demand and world supply function...joint ventures and shipment contracts may be among the factors that hinder, to some degree, the movements of supply in response to changes in price. The failure of including an inventory function due to data insufficiency might be another major cause of this result [Lin et al., 1981].

Apart from data availability, the issue of data quality and accuracy of reporting should be mentioned. There were numerous cases where trade data could not be corroborated or where groups of commodities either appeared to be missing or aggregated under other commodity headings. This undoubtedly has contributed to some of the variation in the model. Additionally, this study did not investigate the impacts of world monetary policy, and did not control for these occurrences except through incorporation of the exchange rate.

It is important to note there is a consistent relationship between the AREA variable and export market share of the commodities (Japan) investigated. For those who gained ocean area (the U.S.), the relationship was positive; for those who lost, the relationship was negative. However, it has been shown the relative catch rates between countries sometimes play a major role in determining export markets. Further, those countries who have lost, but who have cultivated their access to ocean area, may actually be less affected than those who have not been as aggressive. There may be other commodities and/or countries which would initially appear to have been hurt by extended jurisdiction, but have actually been unaffected or even assisted by this trend.

In conclusion, this analysis did succeed in showing relative catch rates, as they have been affected by extended jurisdiction, can have substantial impact on export market shares. This is especially so in cases where aggressive negotiations have taken place to obtain rights to fish. Joint ventures are but one example of where some rights have been conferred upon guest countries. However, what is interesting about joint ventures is their quasi-trade approach to the problem of resource access. This is what was theoretically alluded to at the beginning of the paper. Those countries which have gained access through joint ventures or through some other methods are less likely to be affected by extended jurisdiction. The subsequent trade can be a barter of effort and expertise in exchange for fish. Such a barter scheme is theoretically plausible and the empirical work in this paper suggests such activity could be occurring. However, it is perhaps best to close with a more tangible observation:

> The Japan fishery has just learned that a Soviet-Mauritania joint venture has agreed to charter 34 Soviet vessels through the end of 1985. Charterage will be paid by giving a percentage of the catch to the Soviets...[Atkinson, 1984].

Thanks to R.S. Johnston, R. Bruce Rettig, R.A. Oliveira, Mike V. Martin, and Melissa Wilson for review and technical editing. Thanks also to Lorraine Jacobs and Chris Stone for typing.

Endnotes

1/ In communication with industry and government sources, it was learned that provisions of the Jones Act have been waived in some cases.

2/ By well-behaved, we mean: (1) each industry has a large number of identical small firms, and (2) the industry production factors are assumed to be linear homogenous, such that, for each industry, $F^j(tL_j,tK_j) = tf^j(L_j,K_j) = ty_j$, where t = a constant, L_j = labor, K_j = capital, j = industries 1 or 2. This type of function can be expressed in terms of the input-output coefficients by letting $t = 1/y_j$, and is completely described by the unit isoquant. For details on the properties of this function see Silberberg [431-465, 1978].

3/ For a succinct discussion on the duality between these two theorems, see Silberberg [1978].

4/ A necessary condition for this to occur is linear homogeneity in both industries.

5/ The inclusion of these variables has been criticized by some, because it begs the comparative advantage question. The model seeks to explain Japan's trade activities with the United States and Canada in the face of extended jurisdiction. These variables are still of interest, because with changing property rights, it is expected this ratio will change; thus, giving an indication of change in comparative advantage.

Literature Cited

Anderson, Lee G. 1977. The Economics of Fisheries Management. Johns-Hopkins Press, Baltimore.

Atkinson, William. 1984. News Item from Bill Atkinson's News Report. (Translation from Japanese Trade Journals).

Beach, Charles M. and James G. MacKinnon. 1978. "A Maximum Likelihood Procedure for Regression With Autocorrelated Errors," Econometrica 46:51-58.

Buongiorno, Joseph and Ronald A. Oliveira. 1977. "Growth of the Particle Board Share of Production of Wood-Based Panels in Industrialized Countries," Canadian Journal of Forest Research 7:383-391.

Canada. Annual Exports and Imports of Commodity by Country, Annual: Department of Statistics, Canada.

Copes, Parzival. 1972. "Factor Rents, Sole Ownership, and the Optimum Level of Fisheries Exploitation," Manchester School of Economics and Social Studies 41(June):145-163.

Glejser, H. 1969. "A New Test for Heteroscedasticity," Journal of the American Statistical Association 64(325):316-323.

Gould, J.R. 1972. "Externalities, Factor Proportions, and the Level of Exploitation of Free Assess Resources," Economica 39(November):383-402.

Hickman, B.G. and L.J. Lau. 1973. "Elasticities of Substitution and Export Demands in a World Trade Model," European Economic Review 4:347-380.

Hickman, B.G., Yoshimi Kuroda, and L.J. Lau. 1977. "The Pacific Basin in World Trade, Part III: An Analysis of Changing Trade Patterns, 1955-1975." National Bureau of Economic Research, Inc., 36 p. + Appendix.

Japan. Annual Fisheries Statistics of Japan. Japanese Ministry of Agriculture and Fisheries.

Japan. Monthly, Annually. Exports of Commodity by Commodity. Japanese Ministry of Finance and Japan Tariff Association.

Johnston, Richard S. 1984. "Extended Fisheries Jurisdiction and U.S. Food Trade." Working paper, photocopy, 12 p.

Lin, Biing-Hwan, Rebecca J. Lent, and Richard S. Johnston. 1981. "Trade and Investment in Fish Products Among Pacific Area Countries," unpublished manuscript. 58 p.

National Marine Fisheries Service. 1984. United States Imports of Fishery Products. Testimony submitted at the May 17, 1984 hearing before the House Subcommittee on Fisheries. Unnumbered manuscript. 37 p.

Park, R.E. 1966. "Estimation With Heteroskedastic Error Terms," Econometrica 34(4):888.

Scott, Anthony. 1955. "The Fishery: The Objectives of Sole Ownership," The Journal of Political Economy 63(April):116-124.

Silberberg, Eugene. 1978. The Structure of Economics: A Mathematical Analysis. McGraw-Hill, New York.

United States. 1981. Limits in the Seas; National Claims to Maritime Jurisdictions. Department of State, Washington, DC. 117 p.

United States. Annual. Imports (General and Consumption) Commodity by Country. U.S. Bureau of the Census.

Changing Structure of Fisheries and Seafood Markets

Situation and Prospects in the West European Market for Shrimp

Rolf Lasch
Institut für Landwirtschaftliche Marktforschung der Bundesforschungsanstalt für Landwirtschaft Braunschweig-Völkenrode (FAL)
Braunschweig, Federal Republic of Germany

1. Species and Product Forms in World Trade

In world trade a wide range of species of shrimp[1)] in different product forms are handled. Rackowe[2)] has summarized the commercially important species in three basic groups:

1. cold water species, which inhabit the North and Northeast Atlantic and the North Pacific,
2. warm water species, which inhabit tropical coastal areas, e.g. the Indo-Pacific, the Western Indian Ocean, the Western and Eastern Atlantic and the Eastern Pacific and
3. fresh water species, which live in rivers and lakes, principally in tropical areas.

Table 1. Commercially Important Species

Species Group	Origin	Common Name	Scientific Name
Coldwater	North Atlantic North Pacific	Northern prawn	Pandalus borealis
	North-East Atlantic	Common shrimp	Crangon crangon
Warmwater (Tropical)	Indo-Pacific	Green tiger shrimp	Penaeus semisulcatus
		Banana prawn	Penaeus merguiensis
		Indian white prawn	Penaeus indicus
		Giant tiger prawn	Penaeus monodon
		Kuruma prawn	Penaeus japonicus
		Fleshy prawn	Penaeus orientalis
		Western King prawn	Penaeus latisulcatus
		Brown tiger prawn	Penaeus esculentus
	Western Indian Ocean	Indian white prawn	Penaeus indicus
		Giant tiger prawn	Penaeus monodon
		Green tiger prawn	Penaeus semisulcatus
	Eastern Atlantic	Southern pink shrimp	Penaeus notialis
	Western Atlantic	Northern white shrimp	Penaeus setiferus
		Northern pink shrimp	Penaeus duoarum
		Southern pink shrimp	Penaeus notialis
		Northern brown shrimp	Penaeus aztecus
		Southern brown shrimp	Penaeus subtilis
		Southern white shrimp	Penaeus schmitti
		Redspotted shrimp	Penaeus brasiliensis
	Eastern Pacific	Yellowleg shrimp	Penaeus californiensis
		Whiteleg shrimp	Penaeus vannamei
		Blue shrimp	Penaeus stylirostris
		Crystal shrimp	Penaeus brevirostis
		Western white shrimp	Penaeus occidentalis
Freshwater	Indo-Pacific	Giant river prawn	Macrobrachium rosenbergii

Source: Rackowe, Robin; The International Market for Shrimp, ADB/FAO Infofish Market Studies, Vol. 3, March 1983.

The cold water shrimp are preferred in the West European market and represent a large part of European shrimp production. In the USA and Japan warm water shrimp enjoy the major part of the shrimp market.

In world trade shrimp are normally handled frozen, mostly raw and some cooked. Canned shrimp chiefly consist of small sizes, peeled and pre-cooked. Live and fresh shrimp will be sold only in limited areas close to ports.

Shrimp are processed in different product forms:

- headless, shell-on — is the primary form of trade
- whole, head-on — is the form preferred in the Southern European markets
- peeled deveined (P&D) or peeled undeveined (PUD) — i.e. head, shell and tail are stripped off the meat and vein is removed or not
- breaded — i.e. prepared in P&D form, battered, breading and frozen
- battered — are P&D shrimp immersed in batter and frozen
- cooked — are whole head-on or headless shell-on shrimp, peeled and cooked, frozen or canned

Shrimp are sold by size, expressed as count per lb or kg. The major part of world trade in shrimp is in frozen product form. In Europe head-on, headless shell-on and peeled forms are all in use. Canned shrimp and specialties have only limited markets.

2. Supply Situation in the West European Market

With landings of approximately 1.7 million tons (1974: 1.3 million tons) shrimp account for only a limited proportion of world fish landings (1982: 76.8 million tons).[3] However, they play because of their high price for a much more important role in particular production countries and in world fish trade.

In 1982 approximately 55 percent of shrimp landings were in the Pacific. In the North East Atlantic area there were only about 125,000 tons landed, although Western Europe after the USA and Japan is the most important market.

The catches in the North East Atlantic include in particular northern prawns (lat: pandalis borealis) at a level of 71,925 tons (1982) of which Norway with a catch of 50,841 tons took the predominant part.

In addition, common shrimp (lat: crangon crangon) with catches of 51,248 tons (1982) have a special importance in the North East Atlantic catches including the North Sea. Among Western European catching nations the Federal Republic of Germany with 15,522 tons of common shrimp has the greatest weight.

According to FAO statistics the landings of shrimp in the EEC countries have only declined marginally to 52,834 tons in 1982 from 53,406 tons in 1974.

Table 2. Landings of Shrimp in European Countries

	1974	1982
	tons	tons
Belgium/Lux.	1,652	2,225
Denmark	1,475	10,207
France	2,768	2,709
Germany (FRG)	28,656	19,834
Ireland	20	142
Italy	9,424	8,801
Netherland	7,525	7,325
UK	1,886	1,591
EEC (9)	53,406	52,834
Greenland	10,243	40,670
Faeroe Islands	2,023	4,637
Norway	26,481	51,679
Spain	32,325	15,792
	124,478	165,612

Source: FAO, Yearbook of Fishery Statistics, Catches and Landings, 1974-1982, Rome.

However, Denmark has shown a substantial increase in landings from 1,475 tons to 10,207 tons while in Germany the landings have fallen from 28,656 tons to 19,834 tons predominantly common shrimp. Also it should be noted that in the earlier years a substantial part of German shrimp landings was used as animal feed while today the total catch is used for human consumption. In the other EEC countries no substantial changes in volume of landings are to be noted. Landings of shrimp, especially northern prawns increased in the Northern European countries of Norway from 26,481 tons to 51,679 tons, Greenland from 10,243 tons to 40,[illegible] tons and the Faeroe Islands from 2,023 tons to 4,[illegible] tons. Because of the close political relationships between the last two countries and Denmark the internal EEC trade through the Danish "motherland" has been particularly influenced.

In contrast, the Spanish catches (1982: 15,792 tons) which for the most part were caught in West African waters play an important role only in the South European market.

Trade Developments in the EEC Countries

An analysis of the foreign trade of the Community in fresh and frozen shrimp products in the years 1974 and 1982 shows clearly the suction effects of the Common Market.

Table 3. Imports of Shrimp and Shrimp Products into the EEC[1)]

	1974		1982	
	tons	million US-$	tons	million US-$
Total	49,111	161.0	134,607	597.7
thereof from:				
Intra EEC	13,528	35.6	41,656	170.3
Extra EEC	35,583	125.4	92,951	427.4
Denmark	2,103	5.7	15,888	57.9
Netherland	6,529	18.3	11,709	47.8
Germany (FRG)	2,982	5.7	6,877	23.9
Greenland	3,199	15.9	22,895	76.0
Faeroe Islands	321	0.3	7,802	16.9
Iceland	456	1.5	2,743	16.7
Norway	2,213	7.6	7,895	59.7
Senegal	2,952	10.9	4,144	25.3
Cuba	680	2.1	4,184	28.6
India	2,489	7.0	5,641	27.2
Bangladesh	431	1.7	4,224	25.8
Thailand	437	1.3	9,001	35.0
China	1,350	6.3	1,563	14.2
Malaysia	6,622	17.6	6,129	39.9
Pakistan	1,916	5.9	2,151	8.8

1) 1974 - 9 EEC countries, 1982 - 10 EEC countries.

Source: EUROSTAT, Analytical Tables of Foreign Trade, NIMEXE 1974-1982.

Table 4. Exports of Shrimp and Shrimp Products from the EEC[1)]

	1974		1982	
	tons	million US-$	tons	million US-$
Total	16,496	46.5	64,578	261.6
thereof to:				
Intra EEC	12,636	34.5	48,562	194.7
Extra EEC	3,860	11.5	16,006	66.9

1) 1974 - 9 EEC countries, 1982 - 10 EEC countries.

Source: EUROSTAT, Analytical Tables of Foreign Trade, NIMEXE 1974-1982.

While in the year 1974 49,111 tons of shrimp with a value of US-$161.0 million were imported into the Community, the volume increased in the year 1982 to 134,677 tons, that is almost threefold. The value rose almost fourfold to a total of US-$597.7 million.

But within these imports there were structural changes. For example, fresh and frozen shrimp in the year 1974 at 23,557 tons of a value of $63.1 million accounted for about 48 percent (49 percent in value) of imports. In 1982, 89,876 tons of fresh and frozen shrimp of a value of $342.8 million were imported with a market share of 67 percent by volume and 57 percent by value.

In contrast, the growth rate in imports of processed shrimp from 25,554 tons (1974) to 44,801 tons in 1982 was markedly smaller. The proportion by volume was reduced from 52 percent (1974) to 33 percent in 1982. The value of imported processed shrimp products decreased from 61 percent to 43 percent in the same period.

As stated before, these figures demonstrate the particular importance of frozen shrimp, raw and often headless shell-on in international trade. In the future, however, a relative shift from marketing shrimp in fresh or frozen raw headless form to processing and marketing a frozen breaded and frozen peeled and deveined product, as has developed in the US market, is to be expected.

Also there is increasing trade within the EEC but an analysis of the structure of total imports of shrimp, between internal and external EEC-trade, shows clearly that as a result of the increasing market demand accompanied by stagnating landings the market must be supplied from outside the Community.

Greenland has an important share of the increasing total imports of the EEC. Its deliveries had risen from 3,199 tons (1974) to 22,895 tons in 1982 and the value at $76.0 million is the greatest.

In value terms Norway with exports of 7,895 tons and a value of $59.7 million, of which processed products have a much higher proportion, takes second place.

In contrast to Norway, Greenland supplies primarily frozen shrimp (18,083 tons / 79 percent). Among the Northern European countries, Iceland should be noted with deliveries of 2,743 tons and an export value of $16.7 million in 1982. The market supply within the EEC for shrimp is increasingly affected by deliveries from South East Asian areas including India, Bangladesh, Thailand, China and Malaysia.

Presently, Thailand is the most important source with 9,001 tons ($35.0 million) followed by Malaysia with 6,129 tons ($39.9 million), India with 5,641 tons ($27.2 million), Bangladesh with 4,224 tons ($25.8 million) and the People's Republic of China with 1,563 tons ($14.2 million).

It should be noted that Thailand and also Malaysia predominantly supply processed shrimp while the imports from India, Bangladesh and China are almost completely in the form of frozen shrimp.

Among African suppliers Senegal plays the most important role with deliveries of 4,144 tons worth $25.3 million. Cuba has shown a noticeable growth in exports to the EEC since 1974, which at that time were only 680 tons ($2.1 million). This has increased to 4,184 tons with a value of $28.6 million in the year 1982 of which approximately half were in frozen and half in processed form.

As with Greenland and the Faeroe Islands, other non-EEC countries supplying the market often have special trade relations with individual EEC countries, e.g. in 1982 not less than 79 percent of the Greenland and Faeroese exports of a level of 24,211 tons were supplies to the EEC through Denmark while Senegal and Gabon delivered the greatest proportion (over 90 percent) of their supplies to France. Of the Indian exports to the Community in 1982 about three quarters were supplies to Great Britain while the dominant proportion of the exports from Thailand and Cuba go to the French market.

The strong demand of the French market for shrimp influenced also internal Community trade. Denmark with 5,253 tons (15 percent of the total) and the Netherlands with 4,958 tons (14 percent of the total) were the most important suppliers among the member states.

Furthermore, the Netherlands are the leading transit center for trade to other EEC countries. Dutch traders handle a substantial volume of sales in other West European markets.

Between 1974 and 1982 total apparent consumption of shrimp in the important EEC countries increased by 43 percent from 86,021 tons to 122,864 tons. The total and per capita shrimp consumption are shown in Table 5.

The apparent per capita consumption in Denmark at 1.42 kg per head is highest followed by Belgium/Luxemburg at 0.89 kg, France at 0.64 kg and the Netherlands at 0.62 kg. In the lower half among EEC countries are the Federal Republic of Germany with a consumption of 0.39 kg per head, Great Britain with 0.37 kg and Italy with 0.34 kg.

This description of consumption in product weight terms is somewhat misleading as it is derived from international trade statistics in which the weight of frozen shrimp and that of shrimp products are summarized.

Table 5. Apparent Consumption of Shrimp and Shrimp Products (tons)

	1974					1982				
	Landings	Imports	Exports	Apparent Consumption	Per Capita kg/head	Landings	Imports	Exports	Apparent Consumption	Per Capita kg/head
Belgium/Lux.	1,652	4,299	290	5,661	0.56	2,225	8,737	1,903	9,059	0.89
Denmark	1,475	5,513	2,737	4,251	0.84	10.207	27,407	30,354	7,260	1.42
France	2,768	13,322	1,118	14,972	0.29	2,709	35,743	3,963	34,489	0.64
Germany (FRG)	28,656	3,036	2,676	29,016	0.47	19,834	10,180	5,778	24,236	0.39
Italy	9,424	929	982	9,371	0.17	8,801	10,611	244	19,168	0.34
Netherlands	7,525	5,733	6,775	6,483	0.48	7,325	13,983	12,510	8,798	0.62
UK	1,886	16,139	1,839	16,186	0.29	1,591	27,550	8,296	20,845	0.37
				85,940					123,855	

As Dutch and Danish companies are specialized in processing imported whole or headless shrimp for re-export as processed products import and export data are not totally comparable. In view of this, the Dutch and Danish consumption figures appear too high.

In volume terms France (34,489 tons), the Federal Republic of Germany (24,236 tons), United Kingdom (20,845 tons) and Italy (19,168 tons) are the most important markets within the EEC because of their population. However, as Germany[4] and Italy are to a substantial degree supplied from domestic landings, France and Great Britain remain as the most important import markets in Western Europe.

Outlook

In the case of shrimp, increased per capita consumption has been associated with increasing rates of exports to the EEC. This rapid growth has been due primarily to two factors. First, shrimp resources have been developed at an increasing rate in several areas of the world. Secondly, the EEC market has been able to absorb growing imports at high price levels.

Like prices of other seafood, the price level of shrimp has tended to increase both in nominal and in real prices over time.

But the demand for shrimp will depend on the state of economy, changes in consumer income and prices of substitute products.

In the recent years, shrimp consumption was influenced by economic stagnation in the EEC and weakening currencies against the US-dollar. The strong dollar will have caused deviations in trade mainly to the US market. These movements in exchange rates encouraged the exports to the USA, e.g. Norwegian export sales increased fourfold during 1983.

Extremely good catches of cold water shrimp in the North-East-Atlantic led to a new record in Norwegian shrimp production in 1983. With a haul of 76,473 tons, up 48 percent on that of 1982, shrimp are now second only to cod in value in the Norwegian total catch. In July 1984, Norway stopped its shrimp fleet because further big catches put pressure on stocks and threatened to flood the markets. Shrimp landings have been too large for the capacity of the processing plants.[5]

But other Nordic countries continued to contribute their share to the growing supply. In Iceland, the catchings of deepwater shrimp which are not under some form of protection jumped from 9,150 tons in 1982 to 13,091 tons in 1983. And in the first five months of 1984, the catch totalled 7,731 tons, up from 4,026 tons in the same period of the previous year.[6]

Therefore, the supply outlook for 1984 of cold water shrimp from the Nordic countries is still bright.

Despite wide fluctuations in individual countries and in landings from year to year, world shrimp catches increased steadily in the 70s. But looking at the markets over the next ten years, Rackowe[7] predicted that no substantial increases are expected, because traditional fishing grounds for shrimp have reached a level of full exploitation. Landings will probably remain at about present levels and increases will come only from shrimp aquaculture.

World demand for shrimp will continue to grow and producers could have difficulties in meeting market requirements.

The improved economic conditions on the US market and the high value of the dollar make this market particularly attractive for the Asiatic and also for the North European suppliers. In addition, the

Japanese demand for shrimp is also expected to increase. In any case a partial substitution with new products on the very price-sensitive market and also on that of the USA cannot be ruled out.

The markets for surimi-type shellfish product show already large growth rates and these products have been exported to the USA in rapidly increasing quantities. These new products represent one of the most successful product innovations on the US-seafood market.

Without doubt, the European market is also capable of absorbing additional quantities of shrimp because per capita consumption in Europe is still small by comparison with the USA.

But the European market consists of several countries, each with its special requirements with regard to types of products.

In the Northern regions consumers have a traditional preference for cold water shrimp but tropical species are steadily gaining acceptance in these markets in recent years. In UK and in Germany practically all types and sizes are in demand. The countries of Southern Europe (Spain, Italy, France) prefer tropical shrimp principally in head-on form. In France also substantial quantities of cold water shrimp are consumed.

Because domestic landings are relatively stagnant in the EEC countries it is estimated that the growing consumption will have to come from increasing imports. This includes species and product forms not presently popular in Western Europe.

Although the extremely good catches of cold water shrimp depress the market for tropical shrimp, at present, the increasing popularity of warm water species should encourage Asian exporters to give further attention to the West European market.

But considering the effects on demand of the incident of food poisoning in the Netherlands, in which 14 people died, caused by shrimp from South East Asia, consistently good quality must be the business philosophy of the shrimp trade.

Footnotes

1) In Western Europe small-sized shrimp are often called prawns.

2) Rackowe, Robin; The International Markets for Shrimp, ADB/FAO Infofish Market Studies, Vol. 3, March 1983.

3) FAO, Yearbook of Fishery Statistics, Catches and Landings. Vol. 54, 1982.

4) From the German landings a significant part is exported through the Netherlands to the French market.

5) Fishing News International, Vol. 23, No. 7, July 1984, Heighway Publications Ltd., London.

6) Fishing News International, Vol. 23, No. 7, July 1984, Heighway Publications Ltd., London.

7) Rackowe, Robin; The International Market for Shrimp, ADB/FAO Infofish Market Studies, Vol. 3, March 1983.

A Model of World Trade in Fish Products

Ulrich Sommer
Institut für Landwirtschaftliche Marktforschung der Bundesforschungsanstalt
für Landwirtschaft Braunschweig-Völkenrode (FAL)
Braunschweig, Federal Republic of Germany

Introduction

In recent years the volume of world trade in fish and fish products has increased considerably. The reason for this trade expansion which is attributable to greater supply as well as growing demand for high quality products, is the establishment of 200 seamiles fishing zones and the overfishing of much main consumption fish stocks. The main demand centres are the rich Western European and North American countries and those countries having a short coastline. There are many countries in Western Europe with both of these features as may be seen in the import development since 1970.

Besides the Western European and North American trade areas there are some other but less important trade concentrations e.g. the trade within the East-asiatic area and between the United States and the South American countries.

The data of world trade in fisheries are available in the form of trade statistics for some product groups and the whole trade, respectively. They have a high degree of aggregation and within this product aggregation there are changes in products and quality levels between different years. This is why an ambitious econometric model should not be used. But to discuss the trade development not only by absolute or relative trade flows but by figures which enable one to draw quickly a parallel between all trade relations within one matrix and within several years, information theory is used in the analysis of world trade in fish and fish products.

1 Information Theory and International Trade

Difficulties in making quantitative analysis grow with the size of the geographical area that is to be included in a model. These difficulties result not only from many different factors influencing the direction, dimension and composition of the trade flows but also from the unsatisfactory nature of the statistical data in regard to objective, spatial and temporal delimitation. However, to derive comparable conclusions within one trade matrix and over a time period, one should try to formulate characteristic properties in the form of one figure. One method to do this is by means of the information theory which is established in the forefront of the empirical quantitative analysis of international trade (Bihn, 1967, p. 12).

1.1 Some Definitions of Information Theory

Information theory defines the information content of a definite and reliable message as a function of the probability that the event would take place before the message came in (Theil, 1967, p. 3). The higher the probability of the event realization is the smaller is the information content of the message. This connection between the probability p and the information of the realization of the message h(p) can be described by a decreasing function (Shannon, 1948, p. 380).

$$h(p) = \log \frac{1}{p} = -\log p$$

To have an idea of the information content before the message is received, the entropy i.e. the expected information content is computed in the following manner.

Let the probability that one message comes in be p_1 and that it is not realized be p_2. Conditionally the sum of p_1 and p_2 must be 1. The entropy (H) is the sum of the information contents weighted with the corresponding probabilities.

$$H = p_1\,h(p_1) + p_2\,h(p_2)$$
$$= p_1 \log \frac{1}{p_1} + p_2 \log \frac{1}{p_2}$$
$$= \sum_i p_i \log \frac{1}{p_i} \quad (i = 1,2)$$

The information theory can be used only if the probabilities p_i add up to one

$$\sum_i p_i = 1 \qquad (i = 1,2,3,\ldots,m)$$

If there are two sets of probabilities, which are connected with each other in a two-dimensional matrix, bivariate information theory has to be applied.

The two marginal distributions X_i and X_j, which are stochastically independent from each other, and the bivariate distribution X_{ij} have to fulfil the condition that the sum of the probabilities that the messages come in is one. For each distribution the weighted average information content can be computed as follows:

$$H(p_{i.}) = \sum_i p_i \log \frac{1}{p_i} \qquad (i = 1,2,3,\ldots,m)$$
$$H(p_{.j}) = \sum_j p_j \log \frac{1}{p_j} \qquad (j = 1,2,3,\ldots,n)$$
$$H(p_{ij}) = \sum_{ij} p_{ij} \log \frac{1}{p_{ij}} \qquad \begin{matrix}(i = 1,2,3,\ldots,m)\\(j = 1,2,3,\ldots,n)\end{matrix}$$

The relationship between these three entropies is the so called "mutual information" $\log \frac{p_{ij}}{p_{i.}p_{.j}}$. This term is a measure for the difference between the independence level $p_{i.}p_{.j}$ and the realization of the message X_{ij} which has the probability p_{ij} (Theil, 1972, p. 125).

The mutual information is a value measuring the difference from the independence level for two specific messages. For the whole matrix system this is done by the entropy of the mutual information

$$H = \sum_{ij}\sum p_{ij} \log \frac{p_{ij}}{p_{i.}p_{.j}}$$

The value for this entropy is zero if there is stochastic independence between $X_{i.}$ and $X_{.j}$. It is non-negative and growing as the system moves away from independence (Theil, 1967, p. 34).

1.2 Application of Information Theory to a Trade Matrix

The transformation of an absolute trade matrix to a relative one similar to a probability distribution enables the application of information theory, because in the matrix system the two marginal sets and the interior values, respectively, add up to one

$$\bar{X}_{i.} = \frac{X_{i.}}{X_{..}} \;;\; \bar{X}_{.j} = \frac{X_{.j}}{X_{..}} \;;\; \bar{X}_{ij} = \frac{X_{ij}}{X_{..}}$$
$$\sum_i \bar{X}_{i.} = 1 \;;\; \sum_j \bar{X}_{.j} = 1 \;;\; \sum_{ij} \bar{X}_{ij} = 1$$

$X_{i.}$ = total export of country i
$X_{.j}$ = total import of country j

X_{ij} = trade flow from i to j

$X_{..}$ = world trade ($\sum_i X_{i.}$ or $\sum_j X_{.j}$)

The mutual information of this system $\log \frac{\bar{X}_{ij}}{\bar{X}_{i.} X_{.j}}$ can be defined as an aggregated coefficient of all trade activities. It is positive if the given trade flow is greater than the independence pattern implies and negative in the opposite case. Moreover the development over time of the individual mutual information values enables a relatively quick survey of the development of the trade flows within the whole time system (Theil, 1967, p. 363/364).

The method discussed can also be applied to the projection of bilateral trade flows (Uribe, Theil and de Leeuw, 1966). But this application should be limited to shortterm projections because projections are done under the assumption of constant trade intensity of the basic matrix. Over a short period there are normally only marginal fluctuations regarding the factors regulating international trade.

There is one problem that must be solved in the application of information theory to trade projections. If the trade matrix ($\bar{X}_{ij}^{t+n}$) is projected by estimated total exports and imports ($\bar{X}_{i.}^{t+n}$ and $\bar{X}_{.j}^{t+n}$) and by the trade matrix of the base year ($\bar{X}_{ij}^{t}$), the sum of the projected relative trade flows does not add up to one. This problem can be solved by iteration of the entropy of the mutual information (Sommer, 1974, p. 113 ff. and the cited literature).

2 World Trade in Fish Products

The value of the import trade in total fish products has increased from 1970 to 1982 six fold. This is due to nearly all product groups (table 1). The greatest expansion in volume as well as in value has happened in the trade in crustaceans and molluscs (fresh, frozen, salted and dried) but this is only marginally greater than the development regarding fresh and frozen fish. Only the trade in salted and dried fish shows decreasing tendencies in volume.

Regarding the geographical distribution of exports and imports there is an obvious concentration of both, imports and exports, and also of all product groups in the industrial countries in Europe, Asia and North America. However, growth rates mainly in exports are greater in South America, Africa and Oceania. It is assumed that this is a direct result of the expansion of the fishing industry in many of developing countries in these continents.

Since there are no world trade matrices published anywhere, the OECD publication "Trade by Commodities" is used as basis for the analysis of total world trade in fisheries in value. These trade matrices give a very good overview of world trade (total value) because total imports of OECD are nearly 85% of total world imports as published by FAO (Yearbook of Fishery Statistics) and the remaining world trade of 15% comes to a large extent from OECD countries too. Expecially Japan, Norway, Iceland and Spain export large quantities to African countries. Moreover Japan delivers to the Far East market and Canada and the United States export to the South American countries.

The matrices used in this paper are therefore compiled from OECD import and export statistics and total trade of Non-OECD countries has been taken from FAO yearbook of fishery statistics.

2.1 Total Trade in Fish Products (excluding Fishmeal) in Value from 1976 to 1981

World trade in fish products has doubled within the time period considered from 8020.9 million US-$ to 15 636.6 million US-$. Regarding the importing countries there is a strong concentration on the USA and Japan. These two countries import together nearly 40% of total world trade. However, whereas the import share of the USA is decreasing, the imports of Japan increased from 1976 to 1978 and show in 1981 a new rising tendency after a break in 1980. The model includes all EEC member countries separately to show trade flows between these countries and also between each EEC country and other exporters and importers. However if the EEC is regarded as one trade area it is by far the greatest importer. The import share has risen from 26% in 1976 to 31% in 1980; in 1981 however the share decreased to 27%. That means that in 1981 these three countries (USA, Japan, EEC) imported 70% of all fish products (in value). Regarding the exporting countries there is no similar concentration as on the import side. In 1981 the greatest exporter was Canada with 9% of world trade followed by the USA (8%) and Japan (6%). But if the world trade shares of the EEC countries are added up it can be seen that the EEC is also by far the greatest exporter with 15.5%.

2.2 Trade Intensity

Discussing a time series of trade matrices is very complicated because you can calculate four coefficients for each trade relationship between two countries (two import shares and two export shares).

Therefore in this report a method is used that allows the calculation of one abstract coefficient which is a composition both of import and export shares which is seen by decomposition of the coefficients

$$\alpha_{ij} = \frac{X_{ij}}{X_{.j}} : \frac{X_{i.}}{X_{..}}$$

$$\alpha_{ij} = \frac{X_{ij}}{X_{i.}} : \frac{X_{.j}}{X_{..}}$$

Besides these two equations illustrate that the trade intensity between two countries i and j, under the condition of a constant world trade share of total imports or total exports, is growing if the import or export share increase and vice versa. In other words the trade coefficients give a direct measure of the trade intensity between two countries with regard to total trade. As the total trade ($X_{..}$) is considered in the calculation, the trade intensities are fully comparable within one year and between several years. Thus the information theory on which the calculations are based gives the possibility to describe the interregional relations in one matrix.

As trade flows between 27 import regions and 31 export regions are analysed in the model it is impossible in this report to discuss all details. Therefore, only the most important and those where changes have happened are mentioned.

Regarding the trade intensities for Canada as an export country (table 2) it is obvious that the trade relations with the USA are the closest and that they are increasing since 1977. Moreover the principle of calculating the trade coefficients can be shown with Canadas export trade: Though Japan imports a larger volume from Canada than the UK does, the trade intensity of the UK is greater than that of Japan because total imports of each country and world trade have been included in the calculations.

The USA have expanded export trade by more than three fold and have intensified their trade relations with Japan, Australia and other countries in the Far East. However, the greatest trade intensity exists with Canada, but the capacity of the Canadian market is limited to some special high quality products because the degree of self sufficiency of Canada is very high and so trade relations with Canada are unlikely to expand. This is clearly to be seen in the development of the trade coefficients which have decreased from 12 (1976) to 8 (1981). As mentioned above imports of the USA have increased but the world trade share has decreased. The geographical distribution of the US trade flows can be interpreted as a diversification in fish demand. Supply of Canada, Norway, Iceland and Denmark might be substitutes for each other. Whereas the USA has intensified its trade with Canada it has reduced its trade with these European countries. By contrast trade with many countries in South East Asia has expanded. This should be the result of growing demand for products caught in these countries, mainly crustaceans and molluscs.

The Japanese market is mainly supplied by South East Asian countries but also from the USA. The growing trade coefficients for imports from the USA should be mainly influenced by a growing number of joint-venture agreements.

The trade intensities with the neighbouring countries, Australia, South Korea, Taiwan, India, PR China, Indonesia and Thailand were at a high level during all six years. They show an increasing tendency only in the trade with India and PR China, two countries with high production, which are able to supply the large Japanese consumer market that suffers under the limited catch possibilities as a result of the extension to 200 sea-miles in those catch regions where the large Japanese fishing fleet has operated.

The method used in this paper is very suitable to show the effect of the contribution of a trading community like the OECD or the EEC. Unfortunately in this report only trade data from 1976 to 1981 are available so that the effect of the community cannot be shown. This will be done in another study. But what can be seen is that all trade coefficients for trade relations between the EEC countries are very high and if one looks at the changes in the trade intensities for the exports of Greece the accession to the EEC in 1981 has been reflected in increased intensities between 1980 and 1981.

2.3 Trade Structure Analysis

Information theory has been used to calculate one coefficient showing the trade intensity in one factor. This has been done because it is impossible to quantify all reasons that are of significance for the flow development in such a matrix. This method is therefore a more descriptive method. In the following chapter changes in total trade of each country will be divided into a growth, a structural and a competitive component.

For this purpose the export ratio of country i($r_i^t = X_{i.}^t / X_{i.}^o$) is divided into the growth ratio of total world trade ($gw = X_{..}^t / X_{..}^o$) and the growth ratio of the export share ($ges = \bar{X}_{i.}^t / \bar{X}_{i.}^o$; $\bar{X}_{i.} = X_{i.} / X_{..}$)

Table 1: World Trade in Fish Products (Imports)

Product	1970	1972	1974	1976	1978	1980	1981	1982
	1 000 t							
Fish, fresh, frozen	2 000	2 334	2 754	2 655	3 348	4 166	4 287	4 306
Fish, salted, dried, smoked	498	497	387	388	356	423	411	384
Crustaceans and molluscs, salted, dried, smoked	493	676	754	933	1 028	1 109	1 129	1 128
Fish, canned[1]	606	660	732	820	823	970	1 013	907
Crustaceans and molluscs, canned[1]	102	112	126	145	160	170	180	193
	Mill. US $							
Fish, fresh, frozen	990	1 494	2 236	2 871	4 538	5 846	6 222	6 274
Fish, salted, dried, smoked	789	417	600	727	1 000	1 217	1 262	1 142
Crustaceans and molluscs, salted, dried, smoked	666	1 115	1 614	2 511	3 351	4 381	4 519	4 977
Fish, canned[1]	482	626	956	1 152	1 535	2 152	2 194	1 940
Crustaceans and molluscs, canned[1]	164	206	359	440	620	803	815	867
Total	2 591	3 859	5 765	7 701	11 044	14 399	15 012	15 200

1) Products and preparations, whether or not in airtight containers.

Source: FAO, Yearbook of Fishery Statistics.

Table 2: Trade coefficients

Countries	1976	1977	1978	1979	1980	1981
Exports from Canada						
USA	2.59	2.32	2.43	2.45	2.60	2.73
Japan	0.67	0.86	0.92	0.78	0.54	0.56
United Kingdom	1.02	1.16	1.02	1.16	1.86	1.75
Exports from USA						
Canada	12.03	9.89	7.43	7.33	9.76	8.11
Japan	1.08	1.80	2.22	2.00	2.06	2.19
Australia	1.09	1.23	1.63	1.40	1.85	1.70
Far East	0.89	1.25	1.20	0.98	2.37	3.32
Imports to USA						
Denmark	0.64	0.78	0.68	0.35	0.23	0.32
Iceland	2.06	2.36	2.07	2.25	1.75	1.55
Norway	0.61	0.70	0.70	0.44	0.44	0.42
Thailand	0.41	0.53	0.59	0.84	0.85	0.82
Taiwan	0.73	0.63	0.71	0.83	0.84	0.93
Other	1.06	1.10	1.27	1.24	1.32	1.38
Imports to Japan						
India	2.97	2.68	2.62	2.69	3.45	3.31
China PR	1.74	1.71	2.16	2.09	2.77	2.45
Korea Rep.	3.53	2.53	2.68	2.33	3.08	2.66
Taiwan	3.30	3.21	2.96	2.72	3.55	3.09
Indonesia	4.17	3.86	3.60	3.30	4.35	3.95
Thailand	2.89	2.31	2.00	1.84	1.99	1.94

$$r_i^t = \frac{X_{i.}^t}{X_{i.}^o} = \frac{X_{..}^t}{X_{..}^o} \cdot \frac{\bar{X}_{i.}^t}{\bar{X}_{i.}^o}$$

The growth ratio of the export share is divided into the competitive component (com) and the structural component (s). For this purpose each trade flow share ($\bar{X}_{ij} = X_{ij}/X_{..}$) is expanded by $X_{.j}/X_{.j}$.

$$\bar{X}_{ij} = \frac{X_{ij}}{X_{..}} \cdot \frac{X_{.j}}{X_{.j}} = \frac{X_{ij}}{X_{.j}} \cdot \frac{X_{.j}}{X_{..}} = a_{ij} \cdot b_{.j}$$

The competitive component attributes changes in the growth ratio of the export share (ges) of country i to changes in market shares (a_{ij}) and the structural component does it to changes in total import share of country $j(b_{.j})$.

Now we can write 'ges' as follows

$$ges = \frac{\bar{X}_{i.}^t}{\bar{X}_{i.}^o} = \frac{\Sigma a_{ij}^t b_{.j}^t}{\Sigma a_{ij}^o b_{.j}^t} \cdot \frac{\Sigma a_{ij}^o b_{.j}^t}{\Sigma a_{ij}^o b_{.j}^o} = com \cdot s$$

As the two indices are weighted by different quantities they are not directly comparable. Therefore, a transformation has to be made to get the same index for both components. Doing this transformation a correction factor appears which is the relative difference between the Paasche- and Laspeyres-index. This factor is influenced by each of the two components and grows with the difference between base year (o) and reporting year (t). Therefore a yearly correction of indices is made through which the value of the correction factor is minimized and lies near 1, so that it can be ignored (Henkner, 1971).

The importance of the competitive and structural component is judged in the literature in a different manner. But surely it is not wrong to say that the components give an overview of how the export advantages in the base year have been used or not. However, it is assumed that the supply or production elasticity, respectively, of the exporters is at least as large as the demand elasticity of the countries supplied.

2.4 Empirical Analysis of Competitive and Structural Development in the World Market for Fish

Dividing the export ratio in several components enables us to give an overview of the influence of a group of variables without knowledge of the direct influence of each of them.

2.4.1 Structural Component. This component shows under the assumption of constant market shares what the development of exports of one country would have been as a result of import demand changes only. Positive growth rates of the structural components imply that a country exports the largest share of its products into countries with import demand growth rates which lie above the average.

This relation is to be seen clearly in the development of the Canadian exports because they are strongly influenced by the trade flows to the USA (table 3). The share of world trade of the USA has decreased from 1976 to 1980. As Canada exports nearly 50% of its fish products to the USA this decreasing share of world trade leads to a decreasing structural component.

Another fairly good example is the Japanese export. Since 1977 Japan exports growing quantities to Nigeria and Lybia whereas the other relative trade flows do not show great changes. As the import growth of these two countries lies above the average of total world trade, this leads to an increasing structural component of Japanese exports.

2.4.2 Competitive Component. The competitive component gives information about changes in the market shares. The value of this component is an indication of the competitive position of one country - measured as market share - in total imports. It does not give information about the importance of this country in total world trade because competitive, structural, and growth components may have a different development. Only the product of structural and competitive components shows changes in the world trade share. In the discussion of changes in the competitive component all additional information of activities determining fish supply should be included to avoid misinterpretation.

From the countries mentioned in this report New Zealand has the highest growth in exports from 1976 to 1981. This could be realized by growing fish catches but it is based on an active trade policy because New Zealand has not automatically profited by exports into countries with growth rates above the total world trade. New Zealand has expanded its market share in many countries, for example Australia, several countries in the Far East but also in Europe (France, Italy).

Table 3: Exports of Fish Products, 1976-1981

1981 = 100

Year	Total exports p	Components[1] of export development: Growth gw	Structure s	Competition com
Canada				
1976	44.9	51.3	107.2	81.6
1977	56.1	59.7	107.6	91.6
1978	77.3	75.1	102.6	100.2
1979	91.9	92.0	103.1	95.7
1980	84.0	94.7	99.3	89.4
Japan				
1976	65.2	51.3	87.0	144.7
1977	68.7	59.7	83.5	137.6
1978	81.5	75.1	97.0	127.8
1979	71.7	92.0	87.9	94.0
1980	91.5	94.7	95.1	101.7
New Zealand				
1976	26.7	51.3	104.1	50.6
1977	31.2	59.7	104.4	50.0
1978	46.9	75.1	101.5	61.5
1979	69.5	92.0	94.9	79.6
1980	77.8	94.7	94.8	86.6
Greenland				
1976	30.0	51.3	87.7	66.7
1977	39.5	59.7	97.3	68.0
1978	42.4	75.1	95.8	58.9
1979	71.1	92.0	94.5	81.8
1980	97.8	94.7	107.0	96.5
Germany				
1976	66.0	51.3	99.7	129.1
1977	81.5	59.7	104.1	131.1
1978	93.3	75.1	105.5	117.8
1979	110.2	92.0	103.3	116.0
1980	116.1	94.7	113.4	108.1
Greece				
1976	72.3	51.3	91.2	154.6
1977	85.1	59.7	92.5	154.0
1978	88.6	75.1	99.9	118.2
1979	123.3	92.0	105.5	127.1
1980	115.9	94.7	109.6	111.6
Belgium				
1976	69.7	51.3	101.0	134.6
1977	77.5	59.7	101.2	128.2
1978	95.5	75.1	105.5	120.5
1979	111.3	92.0	106.4	113.0
1980	116.5	94.7	117.5	104.8

1) The Components are defined in the text.

In Greenland there are similar facts. Growing catches require great efforts to sell the fish in the world market. This has been achieved by increasing market shares in the trade with Denmark, France, Sweden and other OECD countries.

On the other side there are some countries like Germany, Greece and Belgium whose competitive components of trade are decreasing over the whole time period from 1976 to 1981. But for these countries it is difficult to conclude that this development is a direct consequence of a deteriorating competitive position, because fish catches in these countries are declining or have a very different structure within the period observed.

To analyse all the other countries in this paper for the present conference, time failed me but I am working on a larger study in which separate markets will also be analysed.

3 Summary

The objective of this paper was to present a method which enables us to give a quick overview of trade flow developments in a world trade matrix. This has been achieved by making use of information theory. Based on this method abstract trade coefficients have been calculated which are a direct measure for trade intensity. Furthermore the trade flow development has been divided into a structural and a competitive component. The interpretation of these components, however, is only possible if additional market information is available because this break-down of the two components supposes certain relationships in the field of trade activities of an export country and of supply-demand elasticities.

References

Bihn, W.R., Die informationstheoretische Messung von Struktursystemen des internationalen Handels. - Freiburg im Breisgau 1967.

FAO, Yearbook of Fishery Statistics. - Rom.

Henkner, K., Quantifizierung von Wettbewerbs- und Struktureffekten in der Exportentwicklung ausgewählter Industrienationen 1954 bis 1967. - DIW-Beiträge zur Strukturforschung, H. 15. Berlin 1971.

OECD, Foreign Trade by Commodities. - Paris.

Shannon, C.F., A Mathematical Theory of Communication. - Bell System Technical Journal, Vol. 27 (1948), p. 380 ff.

Sommer, U., Die Stellung der deutschen Seefischerei im Weltmarkt für Frostfisch. - Agrarwirtschaft, Sh. 55. Hannover 1974.

Theil, H., Economics and Information Theorie. - Studies in Mathematical and Managerial Economics, Vol. 14. Amsterdam, London 1967.

Uribe, P., C.G. de Leeuw and H. Theil, The Information Approach to the Prediction of Interregional Trade Flows. - The Review of Economic Studies, Vol. 33 (1966), Nr. 95, p. 210 ff.

Fisheries and Seafood Market Development

Non-Tariff Barriers to Trade in Fish and Fish Products With Special Reference to the EEC

Ian Scott
Nautilus Consultants
Marlborough, England

Abstract

This paper examines the nature and type of non-tariff barriers which may affect flows of world trade in fish and fishery products, together with their compatibility with the provisions of GATT. Finally, the principal NTBs utilised by the EEC are examined in greater detail.

I. Introduction

One of the ramifications of the change in the international fisheries regime has been the need and the opportunity to expand international trade.[1/] This expansion has been required in order to maintain the supply position of those countries who were "losers" in the allocation of fishing rights out to 200 miles, and to enable the "winners" to move towards a maximisation of the economic returns from their available resources. The subject of this paper is one factor which may inhibit the ability of an exporting country to penetrate a target market - Non-Tariff Barriers (NTBs). There are other factors to be taken into consideration when looking at the potential for trade. None of these are covered and no attempt is made to measure the relative importance of NTBs compared to such other factors. Examples of other constraints include the existence of tariff barriers or constraints in catching or production in the exporting country. Particular attention is paid to the EEC market, but this does not necessarily imply that EEC practices are more onerous or less onerous than those of other countries.

The paper first reviews the type and nature of NTBs and summarises the position of the General Agreement on Tariffs and Trade (GATT)[2/] with regard to the various practices. Coverage of the EEC details the overall size of the import market and provides an assessment of the most significant NTBs which may affect trade to the Community.

The basis of this paper is the work which was carried out for the National Marine Fisheries Service of the U.S. Department of Commerce.[3/] Analysis within the report has been expanded upon where required. This paper does not set out to deal explicitly with the problems of the U.S. exporter. Other countries covered in the NMFS study were Australia, Japan, Republic of Korea, Mexico, Venezuela, Brazil, Canada, Spain and Nigeria.

2. Non-Tariff Barriers

NTBs can take many shapes and forms reflecting government policies and public and private practices. Because NTBs are so wide bearing they can represent many problems to potential exporters wishing to expand their markets, but who remain unaware of possible hindrances. In order that this lack of knowledge may be countered to some extent by the provision of information, the FAO have issued a register of import regulations,[4/] and this information is regularly updated.

To take the fullest possible account of NTBs in a targeted market potential exporters need to be aware of such detail as the current balance-of-payments situation, the strength of the respective currencies in the world market, political climate especially with reference to imports and normal trading relationships. Such factors can be important parameters in deciding the success of an export venture, but individual companies may not have enough resources to take fully into account such factors.

NTBs can be ambiguous and difficult to legislate against. For example, one could take tastes and preferences in a country to be a NTB if the product of an exporting country is not favoured. Possibly the only means by which such a problem could be overcome would be to finance a sustained marketing programme - perhaps to the benefit of competitors in the market.

The imposition of NTBs can be immediate and effective. Perhaps the best example, although outside fisheries, of such a mechanism concerns the French routing video tape recorder (VTR) imports through an undermanned inland customs port. This had the desired effect of substantially reducing imports of VTRs, and the measure was withdrawn only after trade negotiations with the exporting country led to limits on import quantities.

Such NTBs as noted above can be regarded as abstract and informal, and they cover many facets of a nation's economy. The FAO register assesses the more formal regulations under a variety of headings. (i) Administrative; (ii) Technical; (iii) Import requirements; and (iv) Other regulations affecting imports.

(i) Administrative

Broadly speaking this heading covers licenses, foreign exchange, customs evaluation and import surcharges. Within GATT a code on licensing has been negotiated and it defines those procedures which are restrictive to international trade. The code's general approach is that licensing procedures shall be neutral in application and administered in a fair and equitable manner. The allocation of licenses should take account of the import performance of applicants in recent periods and new importers should be given consideration. Licenses should not have trade restrictions additional to those caused by quotas.

Import quotas are related to licensing and can have a substantial effect on the possibilities of exports to target markets, and as such can be used by the authorities to protect domestic producers by restricting supply. Japanese practices are perhaps the best example of how quotas can work.[3]

GATT Article XI proscribes all forms of prohibitions or restrictions other than duties, taxes or other charges, whether made effective through quotas, import or export licenses or other measures unless instigated to meet problems of standards, grading or marketing.

Import surcharges are proscribed in GATT Article III. Within the EEC, the German practice of levying VAT on the value of goods plus duty is, in essence, discriminating against imports, and thus contrary to GATT provisions.

(ii) Technical regulations

Stringent health standards for imported goods can be used in such a way as to be discriminatory against imports, e.g. there may be differential requirements over the level of mercury content allowed for domestic and imported goods. Standards covering product specifications, labelling, marketing and packaging can be detrimental to an exporter's efforts. This is particularly so when it is a small company which is trying to reduce the overhead cost of entering a targeted market. Stringent product specification standards can substantially increase the cost of producing for one particular market.

The GATT agreement on technical barriers to trade is designed to eliminate the use of standards and certification systems as impediments to international trade. Participants to the Code are required to use international standards with only limited accepted reasons for departure from such standards. Imports must be treated in the same way as domestic products, and disputes can be referred to a Committee of Technical Experts.

(iii) Import requirements

Import requirements are susceptible to use as a means of controlling or restricting imports by changing details at short notice. This type of barrier covers documentation, weights and measures, insurance, methods of quoting and payment. Extremely detailed requirements can make the physical task of importing so onerous as to make it not worthwhile for smaller companies.

The only part of GATT which refers to import requirements is Article VIII which dictates that fees for import documentation should only cover the costs of the services, and should not form indirect protection to domestic producers.

(iv) Other regulations

Two further principal mechanisms can affect trade.

Firstly, discriminatory licensing of traders can lead to distortions in international trade. For example in former years the Japanese quota for herring imports was allocated totally to the body representing the herring catchers, the Hokkaido Federation of Fisheries Co-operatives, in whose interest it was to restrict supply and therefore increase prices for their members. This was contrary to the terms of Article XIII of GATT.

Secondly, there is State trading. Article XVII of GATT says that there should be no discriminatory treatment on the part of state-trading enterprises, with any purchases made in accordance with purely commercial considerations.

In addition to the above it is useful to take into account two other possible forms of NTBs; subsidies and minimum import prices.

(i) Subsidies

Domestic subsidies can harm the trade of a third country either in total or to a target market by making domestic producers more competitive than they might otherwise have been, thus giving them a larger share of world export trade. Parties to the subsidies code of GATT agree to avoid domestic subsidies which result in injury to the domestic industry of another country or nullify or impair benefits accruing to that country; including tariff concessions which had previously been negotiated. Furthermore, subsidies should not be applied in a manner which results in a contracting party having more than an equitable share of the world exports in a particular product. In addition, export subsidies should not be granted in a manner which results in prices materially below those of other suppliers to a particular market.

(ii) Minimum import prices

Minimum import prices can restrict the ability of an exporting country to penetrate a market. This may happen firstly, because it loses a particular country possible cost advantages in production, and secondly, by spreading over a variety of genuses of the same species may lose the cheaper species their relative price advantage. If one asserts that minimum import prices are a charge on imports than they are not allowed by GATT. As previously stated, Article XI proscribes restrictions other than duties, taxes or other charges, while Article II provides that products included in bound schedules shall be exempt from all other duties and charges in excess of those imposed on the date of agreement.

3. Trade to Europe

The EEC consists of 10 member states whose fishing industries vary to a marked extent. On the demand side of the equation the markets of each country vary with different preferences for species, product forms and varieties. Although the eventual aim is to harmonise national measures to standards set by the EEC, this is by no means an easy task, and even when completed individual markets within the EEC will not form a microcosm of the whole. On the supply side, each country experienced differential effects from the change in fisheries regime, and the size and type of fleets differ markedly from country to country. The aims and aspirations of the fishermen in the individual member states also differ widely, as can be testified by the protracted negotiations over a reformulated Common Fisheries Policy. However, within the EEC as a whole there is a strong commitment to the fisherman, as to other primary producers, and the policies of the European Commission reflect this commitment.

The value of the EEC market to world trade is evident when one considers that in 1980 the total import value for all members was in excess of $4,500 million of fish and fish products for human consumption, and $630 million of fish meal and oil.

Two principal mechanisms which interfere with trade in fishery products to the EEC are the reference price system, which effectively sets minimum import prices, and the system of export refunds.

Under the reference price system the Commission of the EEC can suspend imports of produce at prices below reference price, and must state its response to imports if they enter member states at below reference price on three consecutive days. For some species, such as herring and tunny, the Commission's response is limited by prior trade agreements, to applying countervailing duties which would raise prices to reference levels.

It appears that the EEC fisherman has been afforded extra protection in recent years, with reference prices inflating more rapidly than guide prices (on which they are based) and withdrawal prices. In addition, in 1981, the reference price system was expanded so that ling and dogfish were added to the basic coverage. Furthermore, reference prices are fixed for all products covered irrespective of their presentation on import - thus coverage was expanded to include processed fish forms. This increased protection reflects EEC discretion to take into account producers' incomes and future supply and demand projections, whereas previously decisions were based on performance only.

For the U.S.A., Pacific cod exports to the EEC are militated against by the high reference price for cod fish as a whole - which is based on the value of Atlantic cod. Furthermore there has been discussion of extending reference price coverage to species not caught by fishermen of the member states, but which compete with EEC produce. By keeping the average price of traditional species high there is an invitation for import substitution which can only be kept in check by barriers to entry.

The NTB study poses the key question as to whether the reference price system operates as a charge on imports and not merely as a price below which the product cannot be imported. It can be argued that compliance with the reference price if borne by the seller is an additional charge contrary to Article II of GATT. Increases in reference prices vis-a-vis guide prices and greater coverage of the system are thus also against GATT provisions. Reference prices do not appear to be part of a government programme to control production, and thus do not gain exemption from the GATT provisions.

It should be noted at this stage that import suspensions have been rather infrequent in past years, which is indicative of a slowness in response on the part of the EEC in the years previous to 1981, and also the degree to which exporting companies conform to the required level of prices, or do not export at all.

The EEC has in the past set export refunds to enable economically important exports. This was particularly significant in relation to the sale of mackerel, in the main to west African countries, principally by Dutch and British interests. Such refunds allow the EEC to export mackerel at prices below what would otherwise be possible and in general below world price. The need to do this was due to competition from Soviet Bloc countries selling the same product into the same markets at prices substantially below what normal commercial practices would dictate. However, to the extent that such export refunds could stop the establishment of an export trade by other western countries they are not allowable under the provisions of GATT.

Whereas there are a host of regulations within EEC member states concerning administrative and technical regulations and import requirements,[4/] it is not believed that they substantially affect the ability of a third country to enter the market of a member state or discriminate against those third countries. For example, licensing for imports of fishery products is required by each of the member states but they are granted automatically as long as the import is not subject to some safeguard action. But the plethora of state aid given to the fishing industry by individual countries could be construed as an export subsidy dependent on the trade enduced and the effect of such trade on the other signatories to GATT.

4. Conclusion

The aim of this paper has been to outline the variety of factors which must be taken into consideration when examining the role and effect of NTBs. As such, this paper only represents a superficial examination, with the working of trade policy being a complicated issue which requires prolonged and detailed consideration.

To conclude it may be useful to encompass the thoughts of other people on trade issues.

In May, 1983, an OECD ministerial meeting[5/] agreed that as economic recovery proceeds then it provides favourable conditions which should be used to "reverse protectionist trends and to relax and dismantle progressively trade restricting and trade distorting domestic measures." So there is a need for the growing volume of fish trade to be brought under multilateral surveillance and submitted to multilaterally agreed rules, with perhaps joint action under UNCTAD and GATT to decide on and enforce concrete action to roll back protectionism. As Franco[6/] concludes in his paper "As regards non-tariff measures, an improved system of notification as is currently under consideration in most countries participating in multilateral trade agreements could result in a significant step towards a better knowledge of existing systems and a possible negotiation of their normative simplification or removal."

References

1. "OECD Work on International Trade in Fish and Fish Products", Paul Adam in "Proceedings of the International Seafood Trade Conference", Alaska Sea Grant Report No. 83-2.

2. "General Agreement on Tariffs and Trade", Volume 1, United Nations.

3. "A Study on the Impact of Non-Tariff Barriers to U.S. Trade in Fish and Fish Products", prepared for the U.S. Department of Commerce (Contract No. NA-81-SAC-00636), S.F.I.A., Joseph W. Slavin & Associates, ICF Inc., and P. Lance Graef, March 1983.

4. "Register of Import Regulations for Fish and Fish Products", F.A.O. GCP /INT/345/NOR.

5. "Proposals for Dismantling Protectionism", EFTA Bulletin, 1/84.

6. "International Trade in Fishery Products: Issues for Developing Countries", R. Franco in "Proceedings of the International Seafood Trade Conference", Alaska Sea Grant Report No. 83-2.

King Crab Trade and Exploitation: The Chilean Experien

Gustavo Montero and Frederick J. Smith
Department of Agricultural and Resource Economics
Oregon State University
USA

The growth and the more recent rapid decline of the Alaskan King crab industry has been well documentec Alaskan King crab production fell from a record high of 185 million pounds in 1980 to 34 million pounds in 1983. Alaskan King crab production continues to decline with season closures during 1983-84. Forecasts are for continued low production through the mid-1980s.

This rapid change in Alaskan crab production has had dramatic impacts upon world crab trade. Alaskan Tanner and Dungenness crab have become more important in world trade. Also Eastern Canada Tanner crab has entered the void left by the decline of Alaskan King Crab. Imitation king crab meat has found rapi acceptance as Alaskan King crab prices skyrocketed. United States consumption of this product is currently equivalent to 100 million pounds of live King crab.

King crab is not unique to Alaska. Industry scientists in Chile and the USA agree that Chilean King cr possesses the same organoleptic characteristics as the Alaskan King crab. Chilean King crab productior has increased steadily from about 856,000 lbs. in 1970 to 2,946,000 lbs. in 1982 (Table 1). While this is significantly less than former Alaskan production and imitation King crab meat production, it does represent a direct substitute for the fresh frozen Alaskan product.

In this paper we will share some of the production characteristics of the Chilean King crab and specul on the future of this product.

Table 1. Chilean King Crab Landings, 1970-1982 (tons)

Year	Landing
1970	428
1971	372
1972	391
1973	355
1974	511
1975	609
1976	1,028
1977	1,721
1978	1,908
1979	2,265
1980	1,351
1981	1,280
1982	1,473

Source: SERNAP

Biological Characteristics

The common Chilean name for King crab is Centolla. It is found from Chiloe (45 degrees south) to the of South America (55 degrees south). In the Atlantic, it is found from Camarones (44 degrees south) t the Beagle Channel, including the Falkland Islands. The crab is harvested from the beach to depths of 220 meters.

Average size at sexual maturity is 80 mm to 90 mm cephalothorax length, depending upon the geographic location. Spawning takes place within a 30 day period and in the Magellanes area this occurs from early December through the first week of January. Spawning is usually in water of less than 20 meters depth.

Tagging experiments indicate that the crab does not migrate far. The crab tends to aggregate when young, especially in shallow bays.

Net captured crab sizes vary from 50 mm to 180 mm cephalothorax length in males and 50 mm to 145 mm in females. There are significant differences in crab sizes between harvest areas. Much of this is attributed to the level of exploitation.

Production Characteristics

There are six types of boats used in the harvest of Chilean King crab. These range form small wooden boats of less than 7 meters length and oar powered, to 22 meter steel boats with hydraulics and a crew of 6 to 12.

Prior to 1980 crab were harvested with a net. This practice was outlawed in 1980 and since then the crab are harvested with a 160 cm x 60 cm x 47 cm trap. These traps are usually fished by hand and set in units of eight. The legal season is July 1 to January 30. Fishing is usually continuous during this period, depending upon market conditions. However, about 78 percent of the recent years landings have occurred between October and January (Table 2).

Table 2. King Crab Total Landings (tons) per Month, 1980-81 Season

	Month		Landing
1980:	July		21.4
	August		93.1
	September		151.7
	October		182.7
	November		288.4
	December		289.0
1981:	January		205.0
		Total	1,231.3

Production began in the early 1960s and was most important in the southernmost region, XII. More recently production has increased in regions XI and X. Production rose steadily to a high of 4.5 million pounds in 1979 and has varied around 2.7 million pounds since that time.

Chilean Exports

Chilean King crab exports increased from $4,600 during 1972 to $6,144,000 during 1982. Exports increased steadily from 1972 to 1979. Since 1979 exports have ranged from $2.2 million to $6 million (Figure 1).

Monthly 1979 through 1982 export data indicate that over 60% of the exports occur in the last quarter of each year (Figure 2). During 1979, 90% of the exports occurred during this time.

From 1977 to 1982, Europe was the most important Chilean King crab exports destination absorbing an average of 61% for that period. North America and the rest of South America were the other major exports destinations. However, there has been a steady increase in the exports proportion to North America. Most of the exports increase to North America are comprised of frozen product while Europe imports mostly canned product from Chile (Figures 3 and 4).

Product Form

King crab is exported as either frozen or canned. However, there are at least 6 different types of can packs and 9 frozen product forms. For example, the canned meat may be in brine, may be a pate, or may be white or mixed meat. The cans vary from 110 to 240 grams net weight packed 24 or 48 to the box. Frozen crab may be mixed meat, white meat, legs and claws, claws, meat with shell and whole shell. It may be frozen in 250 or 500 gram blocks and packed 18 or 36 to the box (Tables 3 and 4).

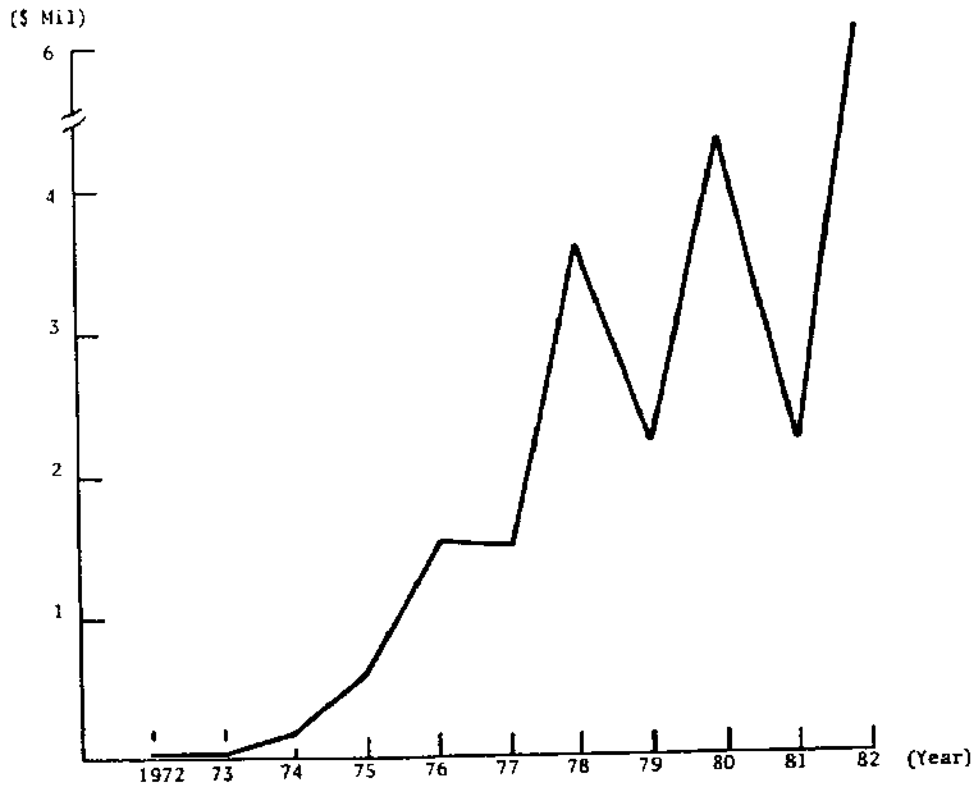

Figure 1. Chilean Exports of King Crab in $ (FOB) - 1972-82
Source: ODEPA and SUBSEP

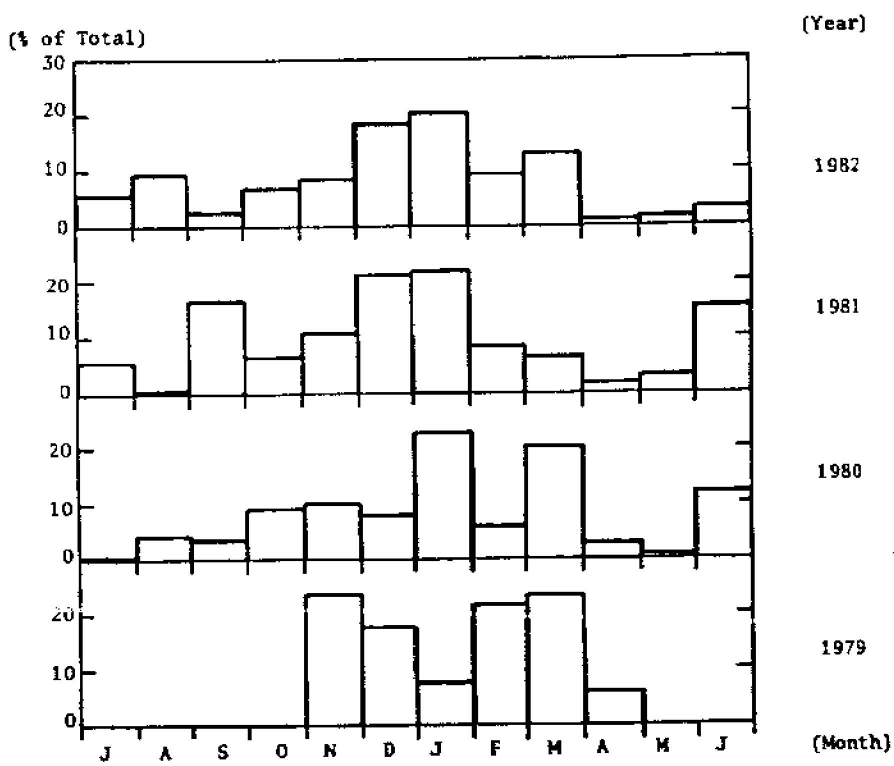

Figure 2. King Crab, Exports Seasonality
Source: ODEPA

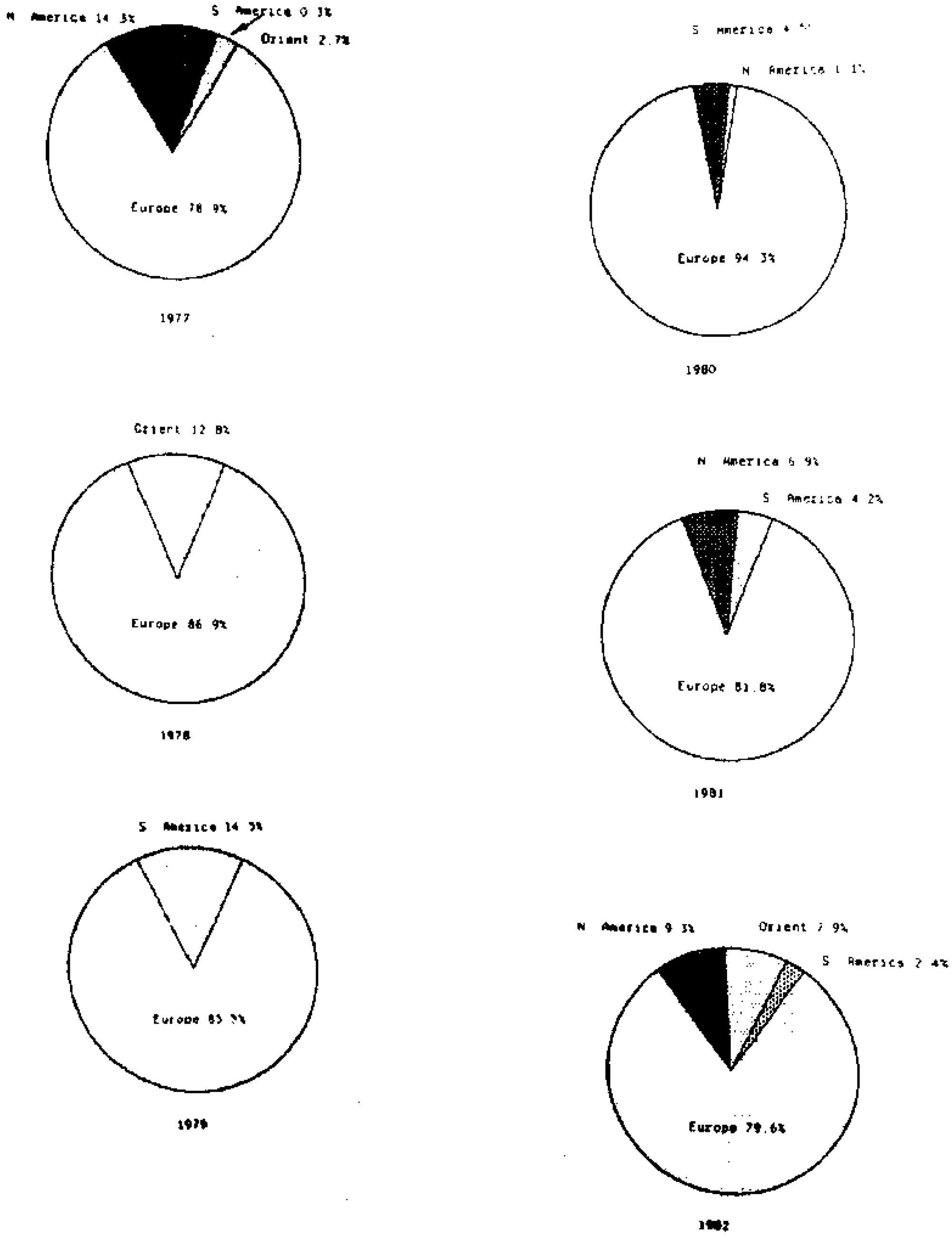

Figure 3. Canned Production - Market Share (Exports)

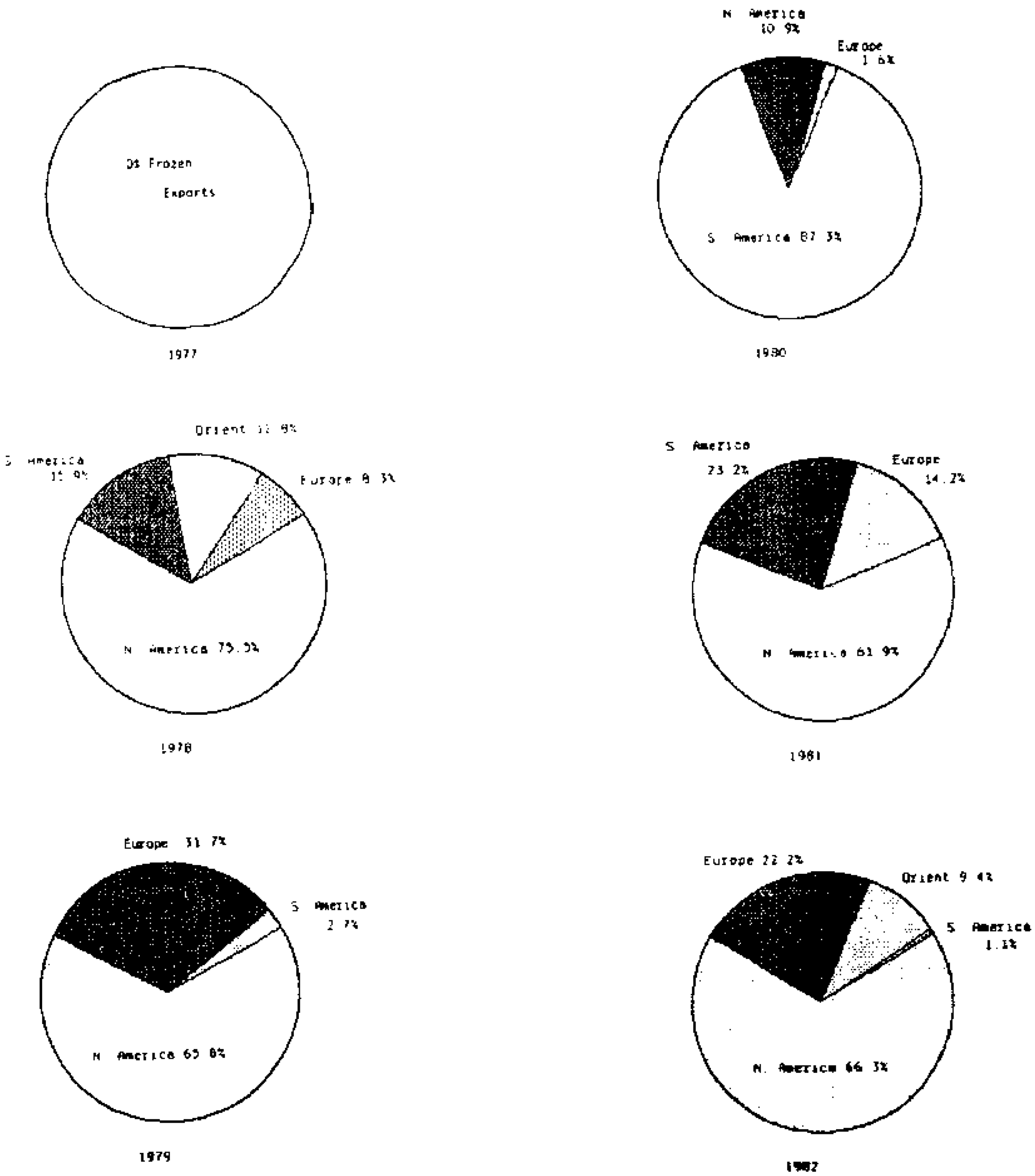

Figure 4. Frozen Products Market Share (Exports)

Table 3. Typical Canned King Crab Product Form Exported from Chile

Commodity	Type of Can	Weight GRS Net	Weight GRS Drained	Packaging	Box lg.
King Crab, in brine	Tin 307 x 113	180	130	24 x 180	4.3
King Crab, in brine	Alum 57	240	175	24 x 240	5.7
King Crab, pate	Alum 69	100	90	48 x 100	4.8
King Crab, pate	Alum 69	210	150	24 x 210	5.0
King Crab, white		110		48 x 110	5.2
King Crab, mix		110		24 x 2 x 110	5.2

Source: Pesquera Magallanes and Pesquera Cado de Hornos

Table 4. Typical Frozen King Crab Product Form Exported from Chile

Commodity	Type of Block	Packaging	Box (kg)
Frozen meat	500 gr.	18 x 500	9.0
Frozen meat	250 gr.	36 x 250	9.0
White meat	500 gr.	18 x 500	9.0
White meat	250 gr.	36 x 250	9.0
Cooked meat			10.7
Legs and claws			5.0
Claws			5.0
Meat with shell			27.0
Whole shell			27.0

Source: Pesquera Cabo de Hornos

From 1977 to 1982 the proportion of frozen to canned product changed dramatically. Frozen product increased from nearly 0% of the total in 1977 to nearly 90% in 1979, dropped back to about 6% in 1980 and was back up to about 75% in 1982 (Figure 5).

Marketing

Only small amounts of King crab is marketed domestically in Chile. The Chilean industry is dependent upon exports. In spite of this dependence, the Chilean industry has not developed product identity or differentiation. The export industry believes that there is confusion over their product. Chilean exporters attribute their generally lower product price to this confusion and not to differences in product composition or quality. During 1983, several Chilean exporters engaged marketing consultants to address this perceived problem and have solicited the assistance of Chilean Trade Promotion Bureaus in San Francisco and New York City.

Prior to 1979, there were few Chilean King crab companies, but they grew in size as production increased. After 1979, there has been an increase in the number of companies, as well as increases in size. However, production from these companies is far from steady, with several completely discontinuing production some years. This variation is not easily explained by variation in production. There have been severe domestic economic problems in Chile since 1979 and some companies have been unable to operate due to financial problems unrelated to King crab marketing.

There are about 9 companies that appear to be steady producers and exporters of King crab. Of these, 4 produce only frozen product and 2 produce only canned product.

Figure 5. Frozen Chilean King Crab Exported as a Proportion of Canned Exports
Source: ODEPA Statistics

Table 5. Chilean King Crab Industries, Season 1980-81 and Product Form Capabilities

Industry	Product: Canned	Product: Frozen
Pesquera 2 Oceanos		x
Pesquera Cabo de Hornos	x	x
Pesquera Baray		x
Pesquera Wagallanes	x	x
Pesquera Punta Mar		x
Coop. Pescadoes de T del Fuego	x	
Pesquera Polo Sur		x
Soc. Pesquera McLean	x	

Source: Instituto de la Patagonia

Conclusions

While the King crab industry is relatively new in Chile and much has to be learned about the population dynamics, there appears to be potential for increased and steady future production. The product is clearly a market substitute for Alaskan King crab, which has suffered a severe production decline during the past 3 years.

Chilean companies involved in the export of King crab products have experienced large variations in export volumes and product composition. Domestic economic factors have contributed to these companies difficulties. There is an effort to learn more about the export markets and to join with United States importing firms. Potentially this will increase product standardization and stabilize the Chilean product market.

In spite of improved crab production information, and improved market arrangements, the potential revival of the Alaskan King crab industry and possible economic instability in Chile will continue to cast an atmosphere of uncertainty over the Chilean King crab industry.

Development of a U.S. Surimi Industry

Sharon E. Gwinn
Alaska Fisheries Development Foundation
Anchorage, Alaska, USA

Despite its geographic isolation, Alaska has in recent history been a major participant in global economics, by virtue of its abundant natural resources. The far-reaching influence of Klondike gold and Prudoe Bay oil is about to be matched by a living, renewable marine resource, Alaska pollock. About $150 million worth of this small cousin of the cod, taken from Alaska waters each year, is the focal point of an international scramble for shares of a U.S. market exploding at more than 100 percent annual growth.

Surimi is a homogenized, white, flavorless protein paste, made by washing minced fish muscle in fresh water. Sold in frozen ten-kilogram blocks, it is the raw material base for hundreds of different food products, from shellfish analogs to imitation mushrooms. Two unique properties of surimi -- its ability to form a fine-textured gel at low temperatures, and its capacity for being restructured -- give the material unsurpassed versatility in the "architectural foods." Food scientists refer to these capabilities as "functional properties."

As we discuss the prospects for development of a U.S. surimi industry, it is essential to recognize surimi as a material, not a fish. Surimi can be produced from almost any fish species. Once the surimi is made, it is impossible to determine its original identity. In this characteristic lies the explanation for Alaska's strategy of using surimi as the key to the future of our fisheries.

The process for making surimi is illustrated in Figure 1. Round fish are headed and gutted, then minced in a deboner/meat separator. The minced flesh is washed and rinsed in fresh water, to remove blood, enzymes and other water-soluble proteins. A mechanical refining process removes any scales, bone particles or connective tissue from the washed mince. A screw/press dehydrator is then used to bring water content down to 75 to 77 percent. At this point the mince, with a consistency like that of mashed potatoes, is blended with small amounts of additives (sugar, sorbitol, polyphosphates) which will stabilize the protein and preserve its functional properties during freezing and cold storage. The secondary processor or kamoboko manufacturer will partially thaw the surimi and mix it with extenders, flavor and color to produce a finished product, as outlined in Figure 2.

The asterisks (*) on the diagram in Figure 1 mark important points. First, note that the surimi process requires large amounts of fresh water. Second, note the variety and quantity of by-products. Third, you can see that the final yield of surimi from round fish weight is a mere 22%.

The importance of recovering the value of by-products is obvious. It is presently unclear to what extent this is done in Japanese surimi plants. With surimi yields of 22%, it is also clear that unless by-products make a large contribution to the profit margin, the raw fish had better be very inexpensive. Though the processing of pollock at sea facilitates superior quality of surimi, the fresh water requirement is a severe and expensive limiting factor for offshore operations. It is often assumed that the need for higher quality surimi is responsible for the trend of Japanese industry toward increased surimi production at sea, but in light of these points, one wonders if the shift was made in order to reduce the price of the round fish.

Japan was the cradle and is still the primary domain of the surimi industry. Including the finished (kamoboko) products, the industry is worth more than $5 billion in transactions annually. This is one industry built by Japanese business, government and academia cooperatively, without benefit of any American innovations to copy.

What gives Alaska the audacity to attempt competing in this area? The answer is the Pacific pollock, a small, white-fleshed member of the cod family. This creature is so abundant that it comprises the

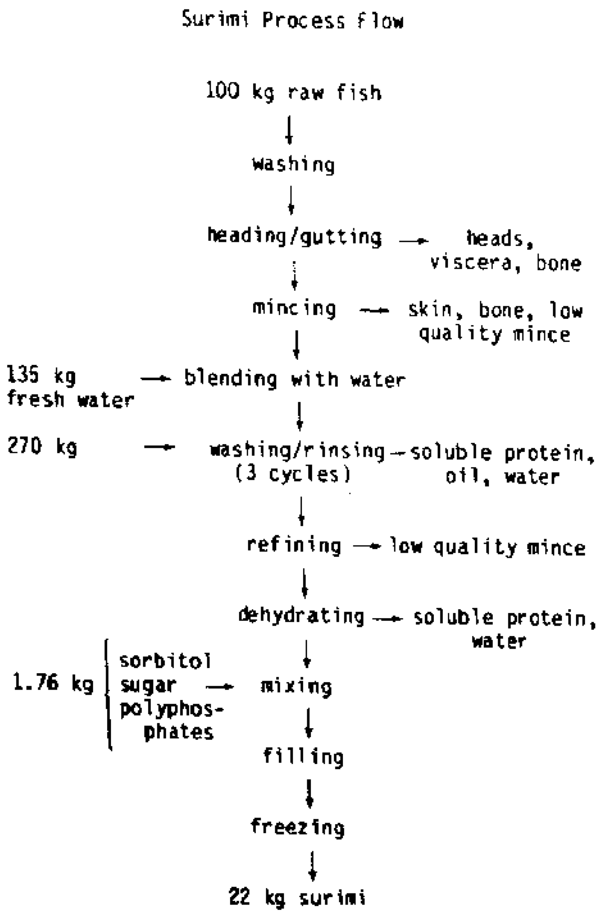

Figure 1. Surimi Production

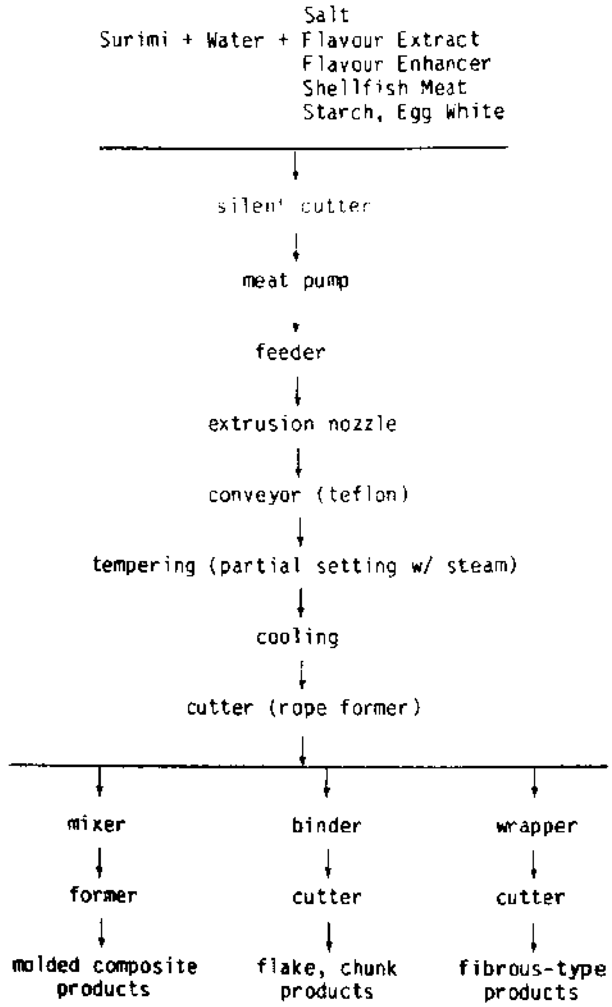

Figure 2. Kamoboko Production

largest single fishery biomass in the world; so dense as to provide catches of two tons a minute; and inexpensive enough ($90 per metric ton) to compensate for the low yield of the surimi process. By itself the Pacific pollock represents 75% of the growth potential for American fisheries within our Exclusive Economic Zone. It is too large an opportunity to ignore.

Every year more than three billion pounds (1.5 million tons) of pollock are harvested in U.S. waters off Alaska, almost entirely by foreign factory trawlers and floating processors. Largely through politically motivated negotiations, joint ventures now involve American fishermen in catching about 300,000 metric tons per year. No shore-based U.S. processors currently handle pollock on a commercial scale. A few U.S. factory trawlers process pollock when the more valuable groundfish species are unavailable.

The traditional approach to fishery development in Alaska has been the demonstration project. A team of progressive individuals with many years of experience in the seafood industry devises and tests out a combination of catching, handling and processing methods, in an effort to prove the huge groundfish resource can support economically viable U.S. businesses. This approach is suitable if one wishes to use fisheries development funds to support as many apparently good ideas as possible. However, it is not very effective if one's objective is to create opportunities for an industry.

It is easy to understand why the Alaska seafood industry would pursue fishery development goals by doing demonstration projects. Environmental and economic conditions place constraints on technical alternatives, so there are considerable uncertainties to be resolved in the practical sphere before we can even consider profitability. More significantly, a universal characteristic of Alaska's fisheries is that tremendous quantities of fish or shellfish must be handled at remote sites in very short periods of time. These conditions mandate that most of the industry's energy and expertise be production-oriented. Until recently, there has been no great need for marketing effort because we've been the proud possessors of most of the world's king crab and salmon, and could simply fill orders coming from the marketing firms, which are all located outside Alaska.

Now, the crash of the king crab fishery and increased salmon production in other countries force a review of priorities. Typically the progressive evolution of an industry involves a shift from production orientation toward market orientation. With the aid of external influences, Alaska Fisheries Development Foundation is trying to accelerate this transition.

Once we adopted a market-oriented perspective, our "pollock problem" was transformed into the "pollock opportunity." The huge Alaska pollock resource was to be the key to integrating our seafood industry into the U.S. food industry. This integration would give us a "foot in the door" toward creating diverse market opportunities that would, in turn, induce expansion of domestic processing capacity. Because of its functional properties and its versatility, surimi could give us the broadest selection of potential market opportunities of any of the product choices available from pollock.

The value of the Alaska pollock resource is no news to the Japanese. Pollock represents about 15 percent of the Japanese fish catch, and more than a third of their pollock catch comes from Alaska waters. Almost all of the Alaskan catch is made into surimi at sea.

Japanese production of frozen surimi began in 1960, in shore plants. That year's total pack was 250 metric tons. The first forays into making surimi at sea on large factory trawlers occurred in 1965. Figure 3 illustrates the general shape of the Japanese surimi industry in the 1980's. With about half of all surimi now being produced at sea, there is a continuing decline in the number of operating shore plants, which are concentrated on the island of Hokkaido. Comparing Figures 1 and 2, you can see that surimi is extended dramatically in making the finished kamoboko products. Much of this extension is accounted for by water, which surimi will absorb in great quantities without deleterious effects on the product's texture.

<u>Production</u>, metric tons

At Sea	% of Total	On Land	% of Total	Total	Year
192,264	63	114,393	37	306,657	1981
198,534	58	142,000	42	340,534	1982
208,110	55	168,887	45	376,997	1983
224,444	55	183,315	45	407,759	1984

<u>Imports</u>, 1981

About 27,000 mt cod surimi (origin USA, USSR), about 230 ¥/kg

About 8,000 mt non-pollock surimi (origin Taiwan, Hong Kong, Thailand), about 480 ¥/kg

<u>Exports</u>, to U.S.A., metric tons

1978	677
1979	681
1980	703
1981	829
1982	1,114
1983	1,709

(Other exports to Australia, Canada Europe. U.S.A. = at least 90% of total.)

Figure 3. The Surimi Industry in Japan

If Alaska is to develop a surimi industry of its own, Japan is the only obvious market for the material right now. Imports of surimi to Japan are restricted by quota, heavily regulated, and closely watched. Import quotas are administered by the Ministry of International Trade and Industry and the Ministry of Agriculture, Forestry and Fisheries.

Theoretically, a trading company or kamoboko manufacturer can simply request and receive an import allocation for any product allowed for in the 98 country quota. However, there is evidence that a surimi user who decides to purchase U.S. surimi runs the risk of being cut off from present Japanese supplies. Until there is a reliable, consistent supply of surimi available from the U.S., this is obviously a foolish and unlikely move.

If you examine the distribution channels for surimi in Japan, you'll discover that more than three quarters of the country's production is distributed through companies that are owned by or affiliated with one of the two largest Japanese fishing companies. These same companies operate joint ventures in Alaska, buying pollock at sea from American fishermen, and also have controlling interests in U.S. seafood processors operating Alaska shore plants. The possibility of exporting U.S. surimi to Japan has recently become a subject of the annual negotiations between Japanese and American seafood industry representatives. The negotiations are held to determine allocation levels for joint venture and foreign directed fishing operations, and to discuss the two sides' respective agendas for the future. In the case of the pollock fishery, the U.S. clearly does not hold a very strong hand. But the industry-to-industry negotiations provide, for the first time in many years, both a forum and a set of objectives on which fishermen and processors can work together as a concerted force. This cooperation is paramount in the development of a U.S. surimi industry.

A look at the Japanese kamoboko industry (Figure 4) gives us an idea of what might be in store for the future participants in the American market. "Kamoboko" is used here as a generic term for several classes of finished products made from surimi. In Japan, the classes are distinguished mainly by the cooking method used, which may be steaming, broiling, or frying. In addition to the myriad of products called "kamoboko," surimi is also used to make fish hams and sausages, usually placed in a separate group in published production statistics. Though all kinds of kamoboko products have been sold in ethnic markets in the U.S. for many years, it is the imitation crab products that have put the steep incline in America's consumption of surimi-based products over the last few years. The Japanese call these crab analogs "kanibo," "kanikama" or "kaniashi," and export sales figures will usually be found classified under the heading "other kamoboko." The surimi-based crab products wholesale in the U.S. for about $2 to $2.50 a pound.

Production, Thousands of metric tons

		1982	1983	% of total kamoboko
Fish cake (Kamoboko),	Steamed	352	347	35
	Broiled	188	195	20
	Fried	289	297	30
	Fish ham, sausage	95	98	10
	Imitation crab	36	44	5
	Total	960	981	100

Exports: Mostly to U.S.A., Australia, U.K., New Zealand

Year	U.S.A.	Total, mt	% to U.S.A.
1979	977		
1980	1,482		
1981	2,604	4,033	64
1982	7,332	9,330	78
1983	14,982	18,829	79
1984	15,650	18,906	82 (Jan.-July only)

Surimi-Based Products, Trends, % of total production

Year	Fish Cake	Sausage, Ham	Imitation Crab
1973	83.5	15.1	1.4
1980	88.2	9.8	2.0
1981	87.6	9.7	2.7
1983	85.5	9.9	4.5

Figure 4. The Kamoboko Industry in Japan

Only one American company, JAC Creative Foods in Los Angeles, makes crab analog products. Kibun U.S.A., an American subsidiary of the largest Japanese kamoboko manufacturer, has built plants in Redmond, Washington and Raleigh, North Carolina. The majority of the skyrocketing U.S. demand for these products is met by imports from an increasing number of Japanese as well as Korean producers.

A glance at Figure 5 will show how important the U.S. market for shellfish analogs is to the Japanese. These data are indicators of economic importance, but we must not forget that to Japan's largest fishing companies, the maintenance of market share for Japanese kamoboko in the U.S. is of strategic importance as well. As long as American companies can not compete effectively in that market, we will continue to give away the majority of the value of our pollock resource. The Japanese companies can continue to remind us that since we do not have the ability to process the fish, they are entitled to it. Even if all of our pollock were caught by U.S. vessels and made into surimi by U.S. processors, less than 15% of the total consumer value of that fish would be accruing to American businesses. What we need is an American market for American surimi.

Year	Imitation Crab Production, mt	Exports		% of Product Exported	% of Kamoboko Exports That is Imitation Crab
1978	16,615	340	(USA only)	2	?
1979	17,589	977	"		35
1980	18,037	1,482	"		85
1981	25,300	2,604	"		86
1982	36,000	9,330	(total)	26	92
1983	44,000	18,829	"	43	92

Figure 5. The Imitation Crab Market

If we imagine what the American market for surimi could look like, given the material's nutritional advantages, functional properties, and ability to mimic all kinds of textures, we can visualize a vast territory. As Jack Hice, the inventor of the fish stick, says, "The Universe is full of wonderful things, patiently waiting for our wits to grow sharper." Before our wits can be of any use to us, we must first draw a rough map of the territory. The list of U.S. food industry sectors in Figure 6 is a start.

shellfish analogs	chips, snack foods
formed fish products	bakery products
processed meats	pet food
flavor carriers, extracts	meat extenders
sauces	dietary foods
seasonings	canned meats
pasta	dairy product analogs
soups, stews	non-dairy desserts
sausage, smoked foods	frozen entrees
vegetable analogs	

Figure 6. Market Opportunities in the U.S. for Surimi

Each of these sectors is likely to interpret the virtues of surimi differently from the next. In a frankfurter, the surimi might be there to replace fat, bind water, carry flavor, or contribute texture. In a loaf of bread, it might be there as a protein fortifier. In a pasta, it might give just the right "mouthfeel" and provide essential amino acids without affecting the product's delicate flavor. The pric of surimi will, eventually, reflect the value of these contributions.

In some cases the material of choice might not be exactly surimi, but could be a washed minced fish, or even a "whole" mince, if the desire for a natural, unrefined muscle fiber is greater than the need for extended shelf life. Surimi is the "foot in the door" to the U.S. food industry. Once this versatile material makes the introductions, the creativity, efficiency and marketing skills of that industry can take over, and bring into the U.S. economy the full value of Alaska's pollock resource.

To get surimi in the door, there is a terrific amount of inertia to overcome. Production-oriented seafood producers are unaccustomed to the technology of mechanized continuous processing and skeptical about the profit margin in pollock. Food processing companies are unfamiliar with fish and doubtful of its marketing advantages. Cold storage and distribution systems for frozen foods in the U.S. are in many instances inadequate for proper preservation of fish. Though surimi-based crab consumption has now surpassed that of the "real thing," American consumers are not known for their attraction to seafood.

Fortunately, surimi's unique capabilities can negate most of the assumptions underlying this apparently hostile marketing environment. Looking beyond its use in shellfish analogs, we might easily envision surimi as an ingredient in lunch meats, frankfurters, soups and sauces, pet foods, products for special diets, and all manner of "imitation" or "entirely new" foods. The Alaska Fisheries Development Foundation wants to promote the development of a diverse market for surimi in the U.S., because diversity of markets translates into alternatives for producers, conveying to them the flexibility they need to stay in business and gain more economic stability. AFDF focuses on being a catalyst of market development, by reducing the cost of product development using surimi in American food companies. We provide surimi, technical assistance and consistent encouragement to companies who want to evaluate the possibilities of surimi as an ingredient that can enlarge their market or enhance their profitability.

The market now taking shape in the U.S. for this versatile food ingredient promises to be entirely different from the one based in Japan. The highly automated U.S. food industry will require a material that is not only available year round, but also produced to meet specifications (protein content, texture-forming capacity, water binding capacity, color, etc.) within a lot of surimi, and from one lot to the next, will often be even more important than gradations in quality. These purchasers of surimi will demand rigorous quantitative measures of all specifications of importance in their particular product, and will not pay for qualities they don't need. Surimi will have to compete with a full range of alternative protein ingredients, including mechanically deboned poultry, soy protein, egg albumin, casein, and wheat gluten.

Sweeping changes will occur in Alaska's seafood industry as a result of its introduction to the U.S. food business. Groundfish processing will become more mechanized and automated. Process control, cost accounting, statistical quality control and other technical subjects will assume true high priority. If U.S. seafood processors seize this new market opportunity successfully, the Alaska groundfish fishery could actually be domesticated.

To conclude, it is clear that a U.S. market for surimi will develop, and probably eventually match the proportions of the Japanese market. The only real question is whether it will be nurtured and owned by American businesses, or dominated by imported products and U.S. subsidiaries of foreign companies.

In closing, I would like to share a poem, written by an Alaska fisherman, that embodies the lighter side of this story.

SEA-LAMI

Oh! what dilemma the hogs and steers are facing
For now the flesh of fish is being stuffed in sausage casing!
Mixed in with the spices, no fin or scale is seen
And nutritional information states, it has the same protein.
So ingredients once rounded up by ropin' ridin' fellers
Are now coralled in nets pulled tight be fishin' boat propellers.
To the ultimate dismay of the hog sloppin' granger,
Who finds the oinkers' future in no small amount of danger.
What the heck has happed, have we all gone balmy?
Coining up new words; the latest one- SEA-LAMI.
Things will never be the same, it seems sorta phoney.
I can see it coming now. Can we stand- BAY-LONEY?

HARRISON SMITH
F/V SEA MINER

Seafood Trade Models

Modeling Issues Pertaining to Fisheries Managemei and Seafood Trac

Trevor Young
Department of Agricultural Economics
University of Manchester
England

It is sometimes argued (e.g. Pontecorvo, 1981) that in the fisheries economics area too much effort is expended in the construction of micro models and too little attention is given to macro analysis. Most applied work, the argument goes, is conducted at the level of a single fishery, instead of within a broader framework. In this short paper, I will attempt to categorise the work of fisheries economists according to the level of aggregation at which it is conducted, to raise some general issues confrontin model builders and to briefly address the micro vs. macro issue.

A Classification of Fisheries Economists' Models

As a number of authors have remarked, economics is best regarded as a tool-kit. Any classification of these tools is necessarily an arbitrary one but nevertheless the usual dichotomy of economic models int "micro" and "macro" seems overly restrictive in the present context. Instead I would prefer to denote three broad approaches to empirical work:[1/]

- (i) tools of a purely micro character
- (ii) tools of a mixed character
- (iii) tools of a purely macro character

Clearly the analytical tools are ranked in order of degree of aggregation and I will endeavour to catalogue empirical work in fisheries management and seafood trade accordingly.

(i) Tools of a purely micro character

Here the researcher is concerned with the analysis of decision making by a single agent - either by the individual consumer (although frequently neoclassical theory is extended, without modification, to the household) or by the firm. Studies of the former include, for example, the analysis of household budgets, product quality and labor supply decisions. Applied work at the firm level often deals with supply response and efficiency measurement, usually based on production, cost or profit functions and utilising cross-section or mixed periodicity data.

In the fisheries economics area, the literature falling within the purely micro category has been scant Studies conducted at the household or fishing vessel level include Colman and Young (1972), MAFF (1984) Sandiford (1984) and Opaluch and Bockstael (1984) but, outside these few examples, there has been very little research work of this type. The neglect of this class of analysis is to be regretted somewhat, since many of the current interesting questions concerning the marketing of fish products and fishermen response to market intervention may require the use of these tools.

(ii) Tools of a mixed character

The analytical tools in this class are macro in the sense of covering the whole economy but micro in th sense of maintaining the identity of individual markets and products. They could equally well be terme "market models" since much of this type of applied work concerns the analysis of demand or supply at th market level or the construction of complete structural models of individual commodity markets. In addition, however, the class would comprise input-output analysis, spatial equilibrium, general equilibrium and trade.

Most applied work on fisheries economics would seem to fall under this mixed character heading. Certainly most, if not all, of the bioeconomic models in the fishery management area, although often described as "micro" models,[2/] must be catalogued here since they are constructed at the level of a single fishery, not of a vessel. Moreoever, a number of structural models of individual fish markets have been constructed (e.g. Doll, 1972, Storey and Willis, 1978, Strand et al., 1981, Blomo et al., 1982, and Tsoa, 1982), and several studies of the demand for fish and fish products have been undertaken (e.g. Bell, 1978, Huppert, 1980, Crutchfield, 1982, DeVoretz, 1982). On the other hand, the use of input-output models and spatial equilibrium as analytical tools is rare in the fisheries economics area.[3/] A discussion of general equilibrium and trade in seafood products is given later in this paper.

(iii) Tools of a <u>purely macro</u> character

Macroeconomic models are constructed at the level of the national economy and address, *inter alia*, questions of output, inflation, growth and the balance of trade. It is often helpful to view macroeconomics as essentially a highly aggregated version of general equilibrium theory.

As fisheries economists, we are rarely dealing with pure macro issues. Macroeconomic variables may be important determinants of variations in fisheries markets; yet this macro connection is ignored in micro or market modeling. For example, if the researcher is trying to determine the opportunity cost of labor in the fishing industry, as, say, part of a project concerned with reducing fishing capacity, then it may be pertinent to explicitly recognise that the probability distribution of opportunities outside fishing will be tied to macro variables such as the regional unemployment rate and that job search will be affected accordingly. Perhaps the only area of modeling in which the interconnection between levels of aggregation is not neglected, is that of international trade. Namely, there have been a few studies which attempt to analyse the impact of exchange rate fluctuations or trade cycles on trade flows of individual products (e.g. Siegel, 1984).

In sum, although fisheries economists have at their disposal an impressive array of analytical tools, they have, for the most part, made use of only those of a "mixed" character in their empirical study of problems of fisheries management and seafood trade. This seems unnecessarily restrictive. However, as fisheries economists broaden the range of policy issues which they address, it is to be expected that the selection of analytical tools will also expand.

<u>Recent Developments and Concerns</u>

Over the last decade, a number of interesting developments and upheavals have taken place in the field of economic theory, and in particular, macroeconomics. Specifically, a great deal of attention has been given to the role of expectations and uncertainty, to non-competitive price formation, and to the phenomenon of disequilibrium.[4/] Indeed as Hey (1981) has pointed out, at the current time economic theory itself is very much in disequilibrium. These new concerns of economic theorists can be incorporated into models in the fisheries economics area and indeed some have been both at the macro and market levels of aggregation. For example, the first issue of <u>Marine Resource Economics</u> was devoted entirely to aspects of uncertainty and fisheries economics. There has also been a limited amount of work on disequilibrium (e.g. Bockstael, 1983) and this body of literature might expand as fisheries economists turn increasingly to the analysis of quotas. More generally, these theoretical developments have been viewed as a way of providing rigorous microfoundations to macroeconomics[5/] and it is to this question that I now turn.

Many would argue that a macroeconomic model or indeed a market model should not only provide an adequate explanation (or fit) of historical data but also it should be founded on sound economic reasoning, and in particular on rational economic behaviour. If the latter is absent, then we have merely a statistical relationship, not an economic one, and that relationship may be completely spurious. In other words, we would be dealing with correlation, without causality.

The importance of microfoundations has also been noted recently by Perry: "...if we take seriously the idea that agents' reactions may depend on their environment, a good set of micro underpinnings could inform our thinking about how to bring about desirable changes in agents' behaviour. It might provide some basis for answering whether and how the reactions of agents might change in a different stabilization policy regime. It might also provide some basis for designing and evaluating policies that are aimed more directly at changing the reactions of agents." (Perry, 1984, p. 402). Another view of microfoundations is that they offer a rationale for what appears on the right hand side of a macro or market level regression.

While these arguments for microfoundations have much appeal, a fundamental issue for the applied economist seems to get side-stepped, i.e. the question of consistent aggregation. An appeal to microfoundations may help in establishing the variables to be included in a macro regression but the precise form of the equation, in order to remain consistent with the micro function, is still a major concern. The conditions for consistent aggregation are invariably restrictive. The work on aggregation in the 1960s (e.g. Green, 1964) bears this out and more recent approaches to the problem (e.g. Lau, 1982) do not seem to be much more encouraging. In other words, there still remains a wide gap between theory and empirical practice.

Another hardy perennial among the modeling issues is the debate on whether partial equilibrium or general equilibrium is the appropriate approach in the study of international trade. The discussion here will be confined to those aspects which are relevant in the analysis of seafood trade.

Many empirical trade studies, particularly of individual fish products, are of a partial, ad hoc type. At one extreme, the external trade variable is assumed to be exogenous or explained as a residual in a sectoral model (e.g. Doll, 1972 and Storey and Willis, 1978). Perhaps a more illuminating approach is to specify individual behavioural equations, typically in the form of demand functions, although the export relation may sometimes appear as a supply-type relation, (e.g. Blomo et al., 1982 and Tsoa, 1982). Alternatively import and export share equations are estimated, again in a rather ad hoc manner, with the *ceteris paribus* assumption at least implicitly being made (e.g. Wilson, 1983 and Young, 1983). Given the data problems which often plague trade studies, these models seem to work quite well on the usual statistical criteria and it is likely that the partial approach will remain a popular choice among applied economists.

Some researchers, however, have sought to invoke the more elaborate paradigm known as general equilibrium as the basis for their trade models which have been either econometrically based or some adaptation of multi-sectoral planning models. A recent example of this approach is the model of the International Institute for Applied Systems Analysis (IIASA) and it might be informative to outline that model briefly.[6/] The IIASA model is a system of linked national agricultural sub-models covering the world food and agricultural system as part of the Food and Agriculture Program[7/] (FAP).

An important feature of this modeling exercise concerns the European Communities model, covering all EC countries, except Greece. The general equilibrium scheme is illustrated for two countries in Figure 1.

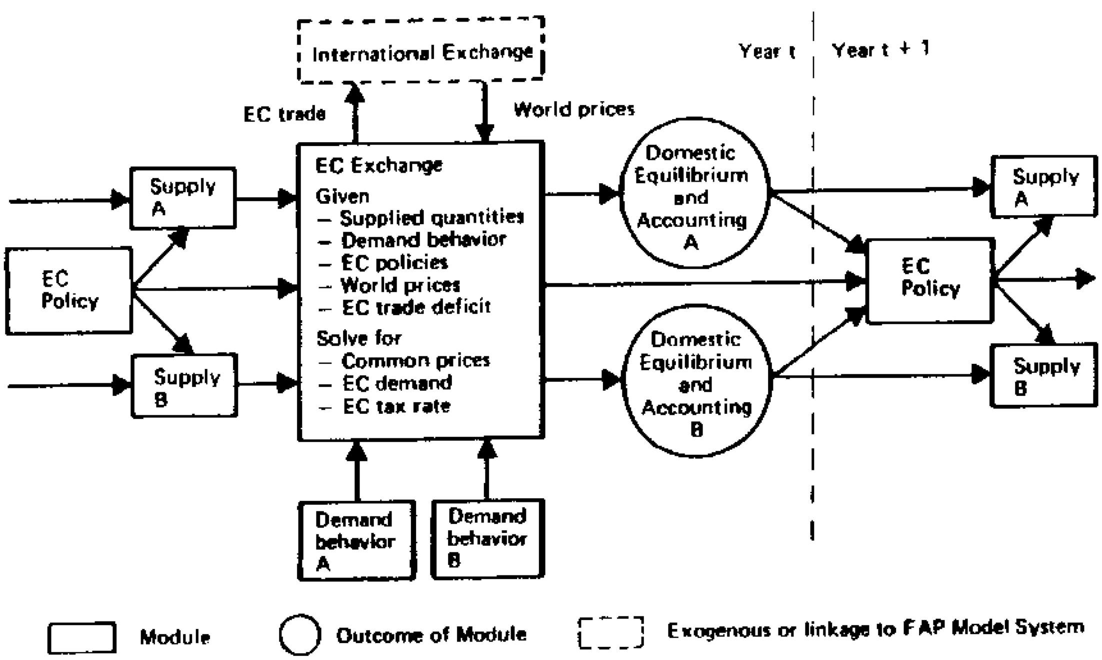

Figure 1. A Schematic Outline of the EC Model (simplified for two countries).

Under the Common Agricultural Policy, the EC nations first interact with each other and together they trade with other countries in the world market. In the exchange component illustrated, EC prices, demand and trade flows adjust, given total supplies and world market prices, until markets clear. The assumption of fixed world prices can be dropped when the EC sub-model is linked with the FAP system and the full system can be solved for equilibrium prices and trade flows under a variety of policy scenarios.

For present purposes the important feature of the IIASA system is its commodity coverage. Table 1 shows that the EC sub-model covers 15 commodities including "fish". However when this sub-model is linked to the global system, the number of commodities collapses to only 10 and the aggregate "fish" is combined with "pork, poultry and eggs". Indeed applied general equilibrium analysis, including that reported in Scarf and Shoven (1984), deals by necessity with broad commodity groups, often considerably more aggregated than in the IIASA scheme. A finely disaggregated system seems to be intractable.

Table 1. Commodities in EC Model and in FAP Model System

EC Commodity List	IIASA/FAP Commodity List
1. Wheat	1. Wheat
2. Coarse grain	2. Coarse grain
3. Rice	3. Rice
4. Bovine + ovine meat	4. Bovine + ovine meat
5. Dairy	5. Dairy
6. Pork, poultry, eggs 7. Fish	6. Other animals
8. Protein feed 9. Oilseeds	7. Protein feed
10. Sugar	
11. Fruit 12. Vegetables 13. Beverages and resid. other food	8. Other food + beverages
14. Nonfood agriculture	9. Nonfood agriculture
15. Nonagriculture	10. Nonagriculture

I would argue that although the analysis of trade in fish in total may prove useful for a number of purposes, our interest in that broad aggregate is somewhat limited. More often we are concerned with the changing composition of that trade in response to various policy and market stimuli or with trade flows in individual fish species, such as salmon or, yet more disaggregated, Atlantic salmon.

Even if it were computationally feasible, a full-blown general equilibrium approach in the fisheries economics area would rarely be merited, because the fishing industry does not account for the large percentage of national employment or of the total consumer budget in most countries.[8/] Even Frank Hahn, one of the most prominent defenders of general equilibrium, has stated: "The paradigm is of course of ambitious generality and for very many important purposes a much more modest Marshallian apparatus will do very well." (Hahn 1973, p. 41).

An alternative strategy,[9/] combining elements of the partial equilibrium and general equilibrium approaches, would be to restrict attention to a subset of markets which have a strong, direct bearing on the commodity of interest or which would be affected markedly by a contemplated policy change. The aim would be to make the subset as comprehensive as possible while keeping the system tractable. Having constructed the subset of markets, it may be treated as an economy in and of itself. In effect, we would have a restricted or constrained general equilibrium system. This approach may prove most useful when examining relatively broad policy questions such as extended fisheries jurisdiction. Nevertheless, as a general rule it may be argued that the more disaggregated the commodity in question or the more specific the policy under discussion, the more likely that a partial model will be perfectly adequate.

Micro vs. Macro Models

Having outlined the array of analytical tools available to the fisheries economist and some of the difficulties encountered with their implementation, the question arises: which tool is to be preferred? The question, however, may be readily dismissed. It is futile to debate whether a particular modelling methodology is a good one or a bad one; the worth of a tool depends entirely on the task to be performed or the problem posed. The complaint raised at the beginning of the paper, that empirical work in the fisheries economics area is not macro enough, is a criticism of the questions being asked, not of the way in which the answers are derived.

In the past much research in fisheries economics concerned the construction of bioeconomic models reflecting the underlying biological and economic relationships. The models developed were entirely appropriate to the determination of optimal harvesting solutions, the key point of interest. While no doubt this type of research will and should continue, it is also clear that recently many researchers are broadening their interests into a number of other areas, including modeling of fishermen's behaviour, policy analysis, marketing and international trade. As the fields of research expand, so too must the selection of analytical tools and perhaps even new techniques may be invented.

Footnotes

1. This classification broadly follows that of Reynolds (1971).

2. For example, see Hannesson (1978).

3. Examples of the use of input-output include King and Shellhammer (1982), Briggs et al. (1982) and Frost (1983). I have been unable to locate any studies which use spatial equilibrium analysis.

4. See for example Hey (1979, 1981) and Benassy (1982).

5. See for example, Weintaub (1979) and Benassy (1982).

6. Details of the IIASA approach are given in Parikh (1981) and Farber et al. (1984).

7. Thirty-eight countries are currently included in the FAP model system.

8. This may not be the case in a number of developing countries but there the overriding constraint is likely to be data availability.

9. See Just et al. (1982), Chapter 9.

References

Anderson, L.G. 1981. Economic Analysis for Fisheries Management Plans, Ann Arbor Science.

Bell, F.W. 1978. Food from the Sea: The Economics and Politics of Ocean Fisheries. Westview Press. Colorado.

Benassy, J-P. 1982. "Developments in Non-Walrasian Economics and the Microeconomic Foundations of Macroeconomics" in W. Hildenbrand (ed.) Advances in Economic Theory. Cambridge University Press.

Blomo, V.J., J.P. Nichols, W.C. Griffin and W.E. Grant. 1982. "Dynamic Modelling of the Eastern Gulf of Mexico Shrimp Industry". Amer.J. of Agric. Econ. 64: 475-482.

Bockstael, N.E. 1983. "Disequilibrium and Seafood Trade Modelling". Proceedings of the International Seafood Trade Conference. Anchorage.

Briggs, H., R. Townsend and J.A. Wilson. 1982. "An Input-Output Analysis of Maine's Fisheries". Department of Economics, University of Maine.

Colman, D.R. and T. Young. 1972. "Expenditure on Fish by Households in Great Britain". FERU White Fish Authority.

Crutchfield, S.R. 1982. "Estimation of Foreign Willingness-to-Pay for United States Fishery Resources: Japanese Demand for Pollock". Land Economics.

DeVoretz, D. 1982. "An Econometric Demand Model for Canadian Salmon". Can.J. of Agric. Econ. 30: 49-60.

Doll, J.P. 1972. "An Econometric Analysis of Shrimp Ex-Vessel Prices, 1950-1968". Amer.J. of Agric. Eco[n]. 54: 431-440.

Farber, U., K. Frohberg, E. Geyskers, C. Meghir and P. Pierani. 1984. "The IIASA Food and Agriculture Model for the EC: An Overview". WP-84-50 IIASA, Laxenburg.

Frost, H. 1983. "An Input-Output Table with Particular Reference to the Danish Fishing Industry". Proceedings of the International Seafood Trade Conference. Anchorage.

Green, H.A.J. 1964. Aggregation in Economic Analysis. Princeton University Press.

Hahn, F.H. 1973. On the Notion of Equilibrium in Economics An Inaugural Lecture. Cambridge University Press.

Hannesson, R. 1978. Economics of Fisheries: an Introduction. Universitetforlaget.

Hey, J.D. 1979. Uncertainty in Microeconomics. Oxford. Martin Robertson.

Hey, J.D. 1981. Economics in Disequilibrium. Oxford. Martin Robertson.

Huppert, D.D. 1980. "An Analysis of the United States Demand for Fish Meal". Fishery Bulletin. 78: 267-276.

Just, R.E., D.L. Hueth and A. Schmitz. 1982. Applied Welfare Economics and Public Policy. Prentice-Hall.

King, D.M. and K.L. Shellhammer. 1982. The California Interindustry Fisheries (CIF) Model: An Input-Output Analysis of California Fisheries and Seafood Industries". Working Paper P-T-6. Center of Marine Studies. San Diego State University.

Lau, L.J. 1982. "A Note on the Fundamental Theorem of Exact Aggregation". Economic Letters 9: 119-126.

Ministry of Agriculture, Fisheries and Food (MAFF). 1984. Household Food Consumption and Expenditure: Annual Report of the National Food Survey Committee. HMSO.

Opaluch, J.J. and N.E. Bockstael. 1984. "Behavioural Modelling and Fisheries Management". Marine Resource Economics 1: 105-115.

Parikh, K. and F. Rabar (eds.). 1981. Food for All in a Sustainable World: The IIASA Food and Agriculture Program. IIASA. Laxemburg.

Perry, G.L. 1984. "Reflections on Macroeconomics". Amer. Econ. Review 74: 401-407.

Pontecorvo, G. 1981. "Economic Analysis in Fishery Management Plans: Comment". In L.G. Anderson op cit.

Reynolds, L.G. 1971. The Three Worlds of Economics. Yale University Press.

Sandiford, F. 1984. "How Can We Manage to Keep Fishing?: An Analysis of Multiobjective Decision-Making for the Scottish Inshore Fishery". Paper delivered at the annual Agricultural Economics Society Conference. Cambridge.

Scarf, H.E. and J.B. Shoven (eds.). 1984. Applied General Equilibrium Analysis. Cambridge University Press.

Siegel, R. 1984. "U.S. Seafood Exports and the Exchange Rate". Proceedings of the Second Conference of the International Institute of Fisheries Economics and Trade, Christchurch, forthcoming.

Storey, D.A. and C.E. Willis. 1978. "An Econometric Analysis of Atlantic Sea Scallop Markets". J. of the Northeastern Agric. Econ. Council 7: 111-118.

Strand, I. Jr., J.E. Kirkley and K.E. McConnell. 1981. "Economic Analysis and the Management of Atlantic Surf Clams". In L.G. Anderson op cit.

Tsoa, E., W.E. Schrank and N. Roy. 1982. "U.S. Demand for Selected Groundfish Products, 1967-80". Amer.J. of Agric. Econ. 64: 483-489.

Weintraub, E.R. 1979. Microfoundations. Cambridge University Press.

Wilson, J.R. 1983. "Theoretical and Empirical Considerations of Worldwide Ocean Resource Zone Extensions and the Effects on Export Market Shares of Seafood". Proceedings of the International Seafood Trade Conference. Anchorage.

Young, T. 1983. "An Analysis of the Import Demand for Fish in the United Kingdom". Proceedings of the International Seafood Trade Conference. Anchorage.

An Econometric Analysis of Salmon Markets

Biing-Hwan Lin
Department of Economics
University of Alaska
USA

Introduction

Salmon accounts for a large portion of both the physical volume and ex-vessel value of the seafood harvest in the water of the Pacific coast (Wood, 1970). Due to this relative importance among fisheries and the distributional issues involving different user groups of salmon related resources (e.g., water and habitat), salmon has attracted considerable attention among (fishery) economists in the Pacific Northwest area. To date, numerous research efforts have been devoted to investigating salmon related issues, among them the attempt to identify and quantify the factors affecting the demand for salmon products. An inexhaustive list of previous demand studies includes Nash and Bell (1969), Waugh and Norton (1969), Wood (1970), Onuorah (1973), Johnston and Wood (1974), Wang (1976), Johnston and Wang (1977), Mayo (1978), Abraham (1979), Swartz (1979), and Devoretz (1982).

The usefulness of conducting a demand analysis is to obtain the empirical estimates of demand own-price, cross-price, and income elasticities. The use of these elasticities in drawing policy implications is discussed in the rest of this section.

In the past, the governments of Canada and the U.S. have spent millions of dollars in a variety of salmon enhancement programs aiming at increasing the stock and the harvest of salmon. Since the well being of salmon fishermen is one of the major public concerns in the salmon industry, an important issue that needs to be addressed is the impact of increased landings on the ex-vessel price and the total revenues received by the salmon industry.

Suppose curves D_d, D_f and D_t (as shown in Figure 1)[1/] are domestic, export, and total demand for Pacific salmon, respectively. The vertical line S represents the landings of salmon before the salmon enhancement programs.[2/] The equilibrium price of salmon is set at P. Od and Of are quantities consumed domestically and exported, respectively. The supply intersects the total demand at its inelastic portion, by construction. Thus an increase in landings (from S to S') due to enhancement programs will depress the ex-vessel price (from P to P') at a greater percentage (i.e., PP'/OP > SS'/OS) so that total revenues received by fishermen drop from PdSO to P'eS'O. However, it can be shown that an increase in landings will increase fishermen's revenues if landings intersect the total demand at the elastic portion, say point g. Thus this example illustrates the policy implications (i.e., if the salmon enhancement programs will increase or decrease fishermen's revenues) that can be drawn from the results of demand analyses.

One important issue which should be raised here is that the ignorance of either of the two markets (i.e., domestic and export markets) will hamper the emprirical results in two counts. First, the total demand (D_t) is more elastic than the two individual demands (D_d and D_f). Ignoring either one of the two markets will limit the usefulness of conducting such an analysis. Secondly, the empirical results will likely suffer from having a simultaneous equations bias. Unfortunately, most of previous demand studies have pursued this issue along the single equation framework.

This work is a result of research sponsored by the Oregon State University Sea Grant College Program and the University of Alaska Summer Small Grant Program. The author gratefully acknowledges Richard S. Johnston for his suggestions for improvement and presenting this paper for me. All remaining errors are the author's responsibility.

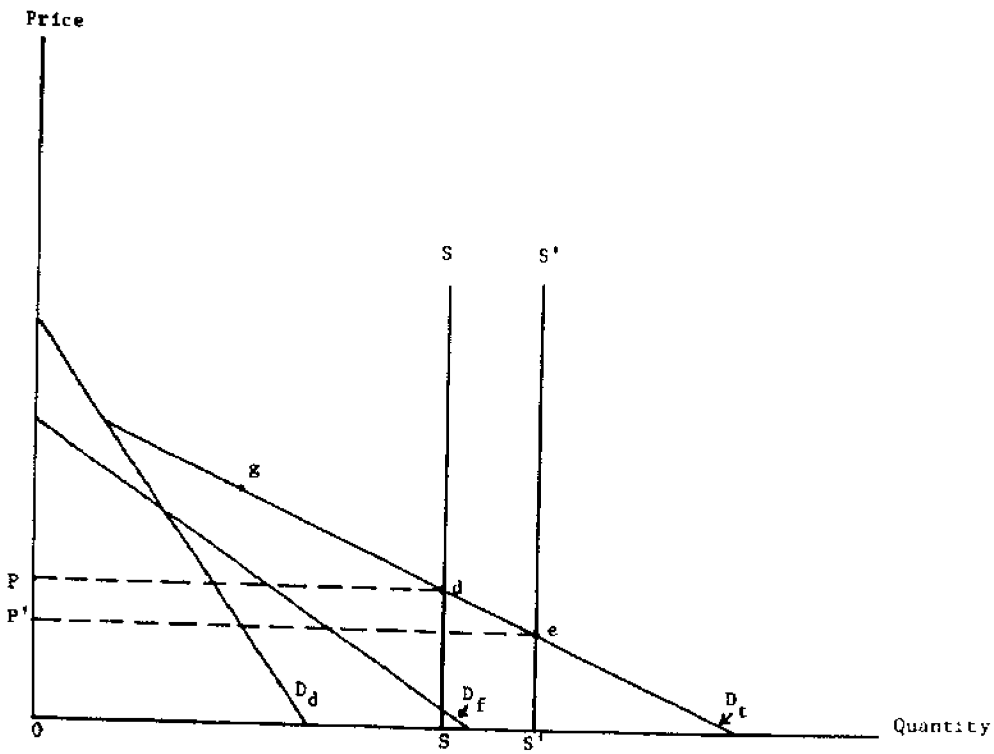

Figure 1. Impacts of Increased Salmon Landings on Fishermen's Revenues

The cross-price elasticity is another useful source of information which can be provided in a demand analysis. For example, canned tuna is considered as a substitute of canned salmon. The cross-price elasticity of canned tuna will indicate the spillover effect of changes in the tuna market on the salmon market. Therefore, if a change in tuna market is anticipated, we can predict the possible effect on the salmon market by examining the results obtained from a demand analysis.

Japan and Norway are competitors (both as consumers and suppliers) of North America in the international salmon markets. The inclusion of the production levels of both Japan and Norway in the market analysis will not only improve our understanding of the market but also enable the prediction of possible courses that the market will take when foreign production varies. This issue will receive more attention because several salmon producing countries have expressed an interest in duplicating the successful salmon farming practice in Norway. In the past, little attention has been paid to the issue of international competition.

The above discussion points out the research direction of this study. The main objective of this study is to improve our understanding of the factors affecting the Pacific salmon markets. To achieve this objective, two models have been estimated. The first model emphasizes the demand for Canadian canned salmon markets. Both export supply and export demand are estimated simultaneously by two-stage least squares and three-stage least squares. In the second model the Pacific (both Canada and the U.S.) salmon markets (both canned and noncanned) are decomposed into two sectors (supply and demand). The allocation of salmon into canned and noncanned product forms is formulated by applying the Nerlove expectations models (Labys, 1973) and estimated by seemingly unrelated regression techniques. Then the supplies of canned and noncanned salmon are treated as exogenous variables in the submodel in which the export supply and export demand for both products are estimated by three-stage least squares techniques.

An Econometric Analysis of the Canadian Canned Salmon Market

In the past, several studies have estimated the demand for Canadian canned salmon. None of these studies attempts to estimate domestic demand and export demand simultaneously. In a recent publication Devoretz (1982) stresses the need for disaggregating salmon into different species. However, the domestic demand and exports are aggregated into the wholesale demand which is then estimated by both ordinary least squares and two-stage least squares techniques. Because domestic demand and export demand are likely to be affected by different factors, it is likely that Devoretz's model can still be improved upon by estimating the domestic demand and export demand simultaneously in a system of equations.

The landings of salmon and the supply of canned salmon are assumed to be perfectly price inelastic. This assumption is usually made either explicitly or implicitly in the fishery literature. However, an attempt is made to investigate the process of allocating landings into different product forms in the second model.

Because Canadian canned salmon is consumed both domestically and abroad, an international trade model is specified which contains two behavioral equations (an export supply and an export demand) and one identity (quantity exported equal to quantity imported) as discussed in the next section.

Model specification and empirical results.

The results of the structural estimation with variable definition are summarized in Table 1. Data sources are summarized in Table 2. Each functional form (for the behavioral equations) is assumed to be multiplicative. The Canadian export supply is hypothesized to be negatively related to the real Canadian income level, and positively related to the real wholesale price of canned salmon, real wholesale price of poultry,[3/] and Canadian landings of salmon. Ideally, the real wholesale price of canned tuna should be treated as a demand shifter. The price of canned tuna is ignored for lack of data. The export demand for Canadian canned salmon is hypothesized to be negatively related to the real wholesale price of canned salmon, the U.S. production of canned salmon, and Japan's landings of salmon. The export demand is expected to be positively related to the real U.S. income level, the exchange value of the Canadian dollar in terms of the U.S. dollar, and the real wholesale price of canned tuna in the U.S. Finally, the quantity exported by Canada should be equal to the quantity imported by the rest of the world from Canada as specified in the identity equation.

Table 1. Structural Estimates and Variable Definition

I. The exchange variable is treated as an exogenous variable.

1. Canada's export supply of canned salmon:

$$\text{(2SLS) } CXQ = \underset{(4.39)}{6.21} + \underset{(1.41)}{2.40}CWP - \underset{(0.65)}{1.20}CY - \underset{(1.44)}{2.49}WPC + \underset{(0.98)}{0.84}PPC + \underset{(0.41)}{1.21}LC$$
PRMSE = 0.0352

$$\text{(3SLS) } CXQ = \underset{(4.28)}{8.00} + \underset{(1.39)}{1.87}CWP - \underset{(0.64)}{0.90}CY - \underset{(1.43)}{2.12}WPC + \underset{(0.97)}{0.91}PPC + \underset{(0.39)}{0.96}LC$$
PRMSE = 0.050

2. Canada's export demand for canned salmon:

$$\text{(2SLS) } CXQ = \underset{(8.0)}{28.4} - \underset{(2.09)}{2.68}CWP + \underset{(0.97)}{0.29}UY + \underset{(2.31)}{2.33}ER - \underset{(0.69)}{1.10}UCQ - \underset{(0.48)}{0.048}JL + \underset{(1.49)}{0.57}TP$$
PRMSE = 0.0343

$$\text{(3SLS) } CXQ = \underset{(7.7)}{25.2} - \underset{(2.0)}{2.45}CWP + \underset{(0.94)}{0.26}UY + \underset{(2.21)}{2.11}ER - \underset{(0.66)}{0.93}UCQ - \underset{(0.45)}{0.0024}JL + \underset{(1.44)}{0.30}TP$$
PRMSE = 0.0481

II. The exchange rate variable is excluded from the model specification.

1. Canada's export supply of canned salmon:

$$\text{(2SLS) } CXQ = \underset{(3.98)}{5.85} + \underset{(1.41)}{2.43}CWP - \underset{(0.43)}{1.30}CY - \underset{(1.41)}{2.43}WPC + \underset{(0.90)}{0.77}PPC + \underset{(0.39)}{1.24}LC$$
PRMSE = 0.0355

$$\text{(3SLS) } CXQ = \underset{(3.93)}{6.77} + \underset{(1.40)}{2.08}CWP - \underset{(0.43)}{1.17}CY - \underset{(1.40)}{2.08}WPC + \underset{(0.89)}{0.79}PPC + \underset{(0.38)}{1.07}LC$$
PRMSE = 0.0522

2. Canada's export demand for canned salmon:

$$\text{(2SLS) } CXQ = \underset{(8.4)}{29.9} - \underset{(2.07)}{3.31}CWP + \underset{(1.05)}{0.28}UY + \underset{(2.07)}{3.31}ER - \underset{(0.66)}{1.34}UCQ - \underset{(0.52)}{0.043}JL + \underset{(1.59)}{0.42}TP$$
PRMSE = 0.0347

$$\text{(3SLS) } CXQ = \underset{(8.2)}{26.8} - \underset{(2.02)}{3.07}CWP + \underset{(1.03)}{0.25}UY + \underset{(2.02)}{3.07}ER - \underset{(0.65)}{1.18}UCQ - \underset{(0.5)}{0.009}JL + \underset{(1.56)}{0.16}TP$$
PRMSE = 0.051

Note: numbers in parentheses are standard errors; coefficients are also elasticities; PRMSE denotes root-mean-squared percent error.

Jointly Determined Variables

CXQ: Canada's exports of canned salmon in thousand pounds.
CWP: Canada's wholesale price of canned salmon, cents per pound.

Predetermined Variables

CY: Canada's income level (million dollars) deflated by its wholesale price index.
WPC: Canada's wholesale price index, with 1979 and 1980 figures being estimated by a linear trend model.
PPC: Canada's poultry price index deflated by WPC.
LC: Canada's landings of salmon, in thousand pounds.
UY: U.S. income level (1000 million dollars) deflated by the U.S. wholesale price index.
ER: Units of Canadian dollar per unit of U.S. dollar, deflated by the U.S. wholesale price index.
UCQ: U.S. production of canned salmon in thousand pounds.
JL: Japan's landings of salmon.
TP: Real price of canned tuna in the U.S.

Table 2. Data Sources, 1952-1980

Variables[4/]	Sources
CQ, FQ, CWP, FWP, TP & NL	1. USDC, NMFS, Fishery Statistics of the U.S. Various issues.
	2. USDC, NMFS, Fisheries of the U.S., Various issues.
	3. Statistics Canada, Annual Statistical Review of Canadian Fisheries, Various issues.
CXQ & FXQ	1. USDC, Bureau of Census, U.S. Imports for Consumption, Various issues.
	2. ____, U.S. Exports for Consumption, Various issues.
	3. Trade of Canada: Export by Commodities, Various issues.
Y, Y', & ER	1. IMF, International Financial Statistics, Various issues.
	2. UN Monthly Bulletin of Statistics, Various issues.
CSP & FSP	1. USDA, Food Consumption: Sources of Data and Trends, 1909-63.
	2. USDA, Food Consumption and Expenditures, 1960-80.
	3. Agricultural Canada, Handbook of Food Expenditures, Prices, and Consumption, 1981.
JL & AL	1. FAO, Yearbook of Fisheries Statistics, Various issues.

The model is estimated by both two-stage least squares (2SLS) and three-stage least squares (3SLS) techniques using the annual data for the period of 1952-80. The reported low root-mean-squared percent errors (PRMSE) indicate that the model appears to fit well. All variables have the signs consistent with a priori theoretical expectations. Because the exchange rate variable and the price variable have similar coefficients in the export demand function, the hypothesis that the exchange rate variable and the price variable should be treated separately is refuted and the model is reestimated accordingly. Both 2SLS and 3SLS provide similar results (see Table 1) which are interpreted here.

Since the functional form is multiplicative, the estimates are also the elasticities. The price of canned salmon, income, and landings of salmon variables have the absolute elasticities greater than one in the export supply equation. By performing necessary manipulations it can be shown that the Canadian domestic demand for canned salmon is both price and income elastic.[5/] The finding that the landings variable has an elasticity greater than one is consistent with the fact that canned salmon accounts for a larger market compared to the noncanned market. The high price elasticity of the export demand is plausible, as the Canadian canned salmon exporters are competing with other suppliers from Japan and the U.S. in the international market. Given the empirical results, we can predict that an increase in the landings of salmon will increase the market value of the increased production in canned salmon at the wholesale level. Because the derived demand for the salmon at the ex-vessel level is not estimated here, it is impossible to measure the direct relationship between landings and fishermen's revenues. However, if the fishermen's revenues are assumed to be proportional to the wholesale values, it seems reasonable to conclude that fishermen as a whole are likely to increase their revenues from the salmon enhancement program.

An Econometric Analysis of the Pacific Salmon in North America

Both landings of salmon and the supply of canned salmon are assumed to be perfectly price inelastic in the previous model. This assumption has been made by all the previous empirical studies in this research area. The treatment of landings as an exogenous variable arises from the difficulties in justifying (empirically) that the present ex-vessel price can affect the present level of landings significantly. There are many factors (biological, climatical, political, regulatory, etc.) which can exert significant impacts on the stock and catch of salmon. Two recent articles by Clark and McCarl (1983) and McCarl and Rettig (1983) are presentations of our limited knowledge of the supply of salmon at the ex-vessel market.

The difficulties of specifying a supply function for salmon at the ex-vessel market are not overcome here. Nevertheless, an attempt is made to shed light on the process of allocating raw salmon into different product forms (canned and noncanned) by employing the Nerlove expectation models.

In the previous model and the present model total demand for salmon at the wholesale level is partitioned into domestic and export demand to remove a possible simultaneous equations bias. The present model differs from the previous studies in the level of aggregation. First, all five salmon species (chinook, coho, chum, pink, and sockeye) are aggregated. This is a necessary procedure, since the U.S. export data are available on a species basis for only a very short period of time. In addition, the high correlation among the ex-vessel prices of different species of salmon will certainly create multicollinearity problems if demand functions are specified for each species with prices of all five species being included in the model. Second, Canada and the U.S. are combined into one region (North America) and all importing countries of Pacific salmon from North America are grouped into the rest of the world (ROW) region. This type of aggregation has been suggested in the studies of international trade in agricultural commodities (e.g., Fletcher, Just, and Schmitz, 1977). The high correlation (0.9557) between the Canadian and the U.S. average ex-vessel prices suggests that salmon markets in these two countries are highly interdependent and hence supports this aggregation procedure.

Model specification

Canned and round and dressed salmon (fresh and frozen) are the major products processed from landings. The production of each salmon product depends on several factors, including the wholesale price, processing and marketing costs, and the ex-vessel price. These factors need to be predicted by processors or negotiated between processors and fishermen so that the desired production can be planned by processors before the opening of the salmon season.

Processing and marketing costs are assumed to be constant in order to simplify the analysis. The volume of landings is the major determinant of the ex-vessel price, when demand shifters remain constant. The present level of landings is thus used to represent the ex-vessel price. Since canned and noncanned salmon products are competing for supply in the ex-vessel market, wholesale prices or both products are included in each supply function. Based upon the above arguments, the desired production of canned salmon is hypothesized to be:

(1) $$CQ^* = a_0 + a_1CWP^* + a_2FWP^* + a_3NL + u_1$$

where an asterisk indicates the desired or expected level of variables; CQ is the production of canned salmon; CWP and FWP are wholesale prices of canned and noncanned salmon, respectively; NL denotes the landings of Pacific salmon from North America; u_1 is an independent, normally distributed random error term with a zero mean and constant variance.

Assume that production cannot change immediately in response to new economic conditions so as to reach the level planned for the same period. The following quantity adjustment is introduced.

(2) $$CQ - CQ_{-1} = k(CQ^* - CQ_{-1})$$

where -1 indicates a one year lag for all variables; k is the coefficient of adjustment speed and $0 < k < 1$.

Combining equations (1) and (2) leads to an equation in which the supply variable is represented in terms of its actual quantity.

(3) $$CQ = ka_0 + ka_1CWP^* + ka_2FWP^* + (1-k)CQ_{-1} + ka_3NL + u_1$$

The price variables are now the only variables left in the expectation form. Nerlove (1961) indicates that they can be removed by making certain assumptions regarding the manner in which processors form their price expectations. The simplest case is that of the naive expectations, where the current expected price is assumed to be equal to the previous actual price, i.e.,

(4) $$CWP^* = CWP_{-1} \text{ and } FWP^* = FWP_{-1}$$

Substituting equation (4) into equation (3) leads to the supply function being determined by the variables in actual values, i.e.,

(5) $$CQ = b_0 + b_1CWP_{-1} + b_2FWP_{-1} + b_3CQ_{-1} + b_4NL + u_1$$

where $b_0 = ka_0$, $b_1 = ka_1$, $b_2 = ka_2$, $b_3 = 1-k$, and $b_4 = ka_3$. The expected signs for the coefficients are $b_1 > 0$, $b_2 < 0$, $b_3 > 0$, and $b_4 > 0$. If the coefficient of the adjustment speed (k) is close to one b_3 will be close to zero. Similarly, the supply of noncanned salmon can be hypothesized to be:

(6) $$FQ = c_0 + c_1FWP_{-1} + c_2CWP_{-1} + c_3FQ_{-1} + c_4NL + u_2$$

It should be noted that equations (5) and (6) can be derived from different assumptions of quantity and price adjustment processes.[6/] The major discrepancy, due to the use of different assumptions to derive the same specification of the supply relationships, lies in the complexity of the error terms. Consequently, different estimators are employed.

The specification of the domestic demand and export demand for canned and noncanned salmon follows the previous model and can be expressed by equations (7), (8), (9), and (10), respectively.

(7) $$CDQ = d_0 + d_1 CWP + d_2 Y + d_3 TP + d_4 CSP + u_3$$

(8) $$CXQ = e_0 + e_1 CWP' + e_2 ER + e_3 Y' + e_4 JL + u_4$$

(9) $$FDQ = f_0 + f_1 FWP + f_2 Y + f_3 FSP + u_5$$

(10) $$FXQ = g_0 + g_1 FWP' + g_2 ER + g_3 Y' + g_4 AL + g_5 JL + u_6$$

where CDQ, CXQ, FDQ, and FXQ are the domestic and export demand for Pacific canned and noncanned salmon, respectively; CWP, CWP', FWP, and FWP' are the real wholesale prices of canned and noncanned salmon in U.S. dollars and foreign currency, respectively; Y and Y' are the real income levels for the North America region and the major importers of the Pacific salmon, respectively; CSP and FSP are the real prices of substitute or complementary goods with canned and noncanned salmon in North America, respectively; JL and AL are landings of salmon in Japan and of Atlantic salmon, respectively; ER is the exchange rate variable; u_i is the error term.

The model consists of six behavioral equations (5) - (10). To close the above model, four identity equations are needed. As specified in equations (11) and (12), supply of each salmon product equals the sum of domestic demand and export demand. Equations (13) and (14) are price identity equations.

(11) $$CQ = CDQ + CXQ,$$

(12) $$FQ = FDQ + FXQ,$$

(13) $$CWP*ER = CWP',$$

(14) $$FWP*ER = FWP'.$$

Estimation procedures and data sources.

To facilitate the discussion of estimation procedures and data sources, the model is restated here with the _a priori_ expected signs of the coefficients included.

1. Supply Functions:

(II.1) $$CQ = f(+CWP_{-1}, -FWP_{-1}, +CQ_{-1}, +NL)$$

(II.2) $$FQ = g(+FWP_{-1}, -CWP_{-1}, +FQ_{-1}, +NL)$$

2. Domestic Demand Functions:

(II.3) $$CDQ = h(-CWP, +Y, +TP, ?CSP)$$

(II.4) $$FDQ = i(-FWP, +Y, ?FSP)$$

3. Export Demand Functions:

(II.5) $$CXQ = j(-CWP', -ER, +Y', -JL)$$

(II.6) $$FXQ = k(-FWP', -ER, +Y', -JL, ?AL)$$

4. Identity Equations:

(II.7) $$CQ = CDQ + CXQ$$

(II.8) $$FQ = FDQ + FXQ$$

(II.9) $$CWP*ER = CWP'$$

(II.10) $$FWP*ER = FWP'$$

Estimation procedures. The above model actually consists of two submodels, one for canned salmon and the other for noncanned salmon. Within each submodel, supply is determined first and then feeds into the (quantity) identity equation in the system of simultaneous equations which contains two demand equations (domestic and export demand) and two identity equations. Therefore, it is a recursive submodel.

Because the error term in each supply equation may or may not be serially correlated by assumption, different estimators are employed. In the case when the error term is not correlated, the presence of a lagged endogenous variable (CQ_{-1} or FQ_{-1}) among the explanatory variables means that the error term is no longer uncorrelated with all the explanatory variables (Johnston, 1972). As a consequence, the ordinary least-squares (OLSQ) estimator will produce biased estimates in small samples. It has, however, been proved that the OLSQ estimator has the smallest mean squared error when compared to two other alternative estimators (Copes, 1966). For this reason, the OLSQ still seems the best estimator, provided that the error term is random.

While the error term in each supply equation may be serially uncorrelated, the error terms may be correlated across the two supply equations. This is because the landings of salmon are processed into either canned and noncanned salmon. Therefore, the two supply equations are estimated by the seemingly unrelated regression (SUR) technique.

As explained above, different expectations models will lead to the same specification of equations (II.1) and (II.2) with complicated error terms. Facing this issue, two additional estimators are employed. They are a generalized least-squares method with the Cochrane-Orcutt procedure (Labys, 1973) and an instrumental variable approach (Johnston, 1972).

Two systems of simultaneous equations for the demand sector are specified in this model. Due to the nature of the quantity identity equation, the behavioral equations can not assume the multiplicative functional form, if the reduced-form equations are to be derived with unique coefficients. They are assumed to be linear. These two simultaneous equations systems are combined and estimated by three-stage least squares (3SLS) to take into account the possible correlation between the error terms across systems.

Data sources and problems. Data used in this study are annual, covering the period from 1952 to 1980. Data sources are summarized in Table 2 (page 4).

The major data problem lies in lack of the production data for noncanned salmon in the U.S. The production of canned salmon is converted into live weight and then subtracted from the landings figure to derive the U.S. production of noncanned salmon. To produce a 48-pound (standard) case of canned salmon, depends on the species of fish being canned, as follows: chinook, 68 lbs.; coho and chum, 72 lbs.; sockeye, 70 lbs.; and pink, 78 lbs. (Johnston and Wood, 1973). Apparently, there are difficulties in using these conversion rates throughout the period 1952 to 1980, but it is the most convenient way of estimating the U.S. production of noncanned salmon.

Since the data on production of noncanned salmon in the U.S. are not available, it is difficult to calculate the wholesale price of noncanned salmon in the U.S. For this reason, the Canadian wholesale prices of canned and noncanned (round and dressed) salmon are converted into the U.S. dollar and used as endogenous price variables.

Because the whole world is partitioned into two regions (North America and ROW), a further explanation of the calculation of some variables (income and exchange rate) is in order. The ROW income variable (Y') is calculated by the following formula:

$$Y' = \sum_{i=1}^{n} (Y_{it}/Y_{io})*W_{it}$$

where n is the number of major importing countries of Pacific salmon; Y_{it} and Y_{io} are the ith country's income levels in years t and 1952, respectively; W_{it} is the ith country's share of the ROW's imports in year t. All income figures should be deflated by appropriate price indices (such as the wholesale price index of each country). Exchange rate variables are calculated similarly. That is,

$$ER = \sum_{i=1}^{n} (ER_{it}/ER_{io})*W_{it}$$ 7/

where ER_{it} and ER_{io} are the units of the ith country's currencies per unit of the U.S. dollar in year t and 1952, respectively.

Empirical results.

Three estimators are employed to estimate the supply equations. They are (1) seemingly unrelated regression (SUR), (2) generalized least-squares with the Cochrane-Orcutt procedure (GLS) and (3) the instrumental variable procedure (IV). SUR and GLS produce similar results but SUR performs better in terms of mean squared error. The IV procedure does not provide expected results. Therefore, only the SUR results are reported here, with t statistics in parentheses.

$$CQ = \underset{(.05)}{-20.5} - \underset{(3.50)}{1.35}FWP_{-1} + \underset{(2.03)}{0.85}CWP_{-1} + \underset{(0.60)}{0.045}CQ_{-1} + \underset{(9.20)}{0.55}NL$$

$$R^2 = 0.828$$

$$FQ = \underset{(.02)}{1.06} + \underset{(3.56)}{1.84}FWP_{-1} - \underset{(2.09)}{1.12}CWP_{-1} + \underset{(1.20)}{0.120}FQ_{-1} + \underset{(1.76)}{0.15}NL$$

$$R^2 = 0.858$$

The high R-squared statistics indicate a good goodness-of-fit for both equations. All the estimated coefficients have signs consistent with a priori theoretical expectations. The estimated coefficients of the price variables (FWP_{-1} and CWP_{-1}) in the noncanned salmon supply equation are bigger than those in the canned salmon supply equation. This result reflects the fact that it takes more raw salmon to produce canned salmon than noncanned salmon. The landings variable (NL) has a bigger coefficient in the canned salmon equation than that in the noncanned equation. This points out that the canned market is bigger than the noncanned market. The coefficients of lagged supply variables (CQ_{-1} and FQ_{-1}) are small and statistically insignificant, reflecting a high speed of adjustment in both sectors.

The two simultaneous equations models are estimated as a single system by three-stage least squares (3SLS). The results are summarized below, with standard errors in parentheses and elasticities in brackets.[8/]

$$CDQ = \underset{(53)}{130} - \underset{\substack{(0.60)\\ [1.13]}}{1.93}\,CWP - \underset{\substack{(0.13)\\ [1.22]}}{0.23}\,Y + \underset{\substack{(6.12)\\ [1.58]}}{15.31}\,TP - \underset{\substack{(0.74)\\ [0.81]}}{1.12}\,PPU + \underset{\substack{(1.27)\\ [1.84]}}{2.62}\,MPU$$

$$PRMSE = 0.251$$

$$CXQ = \underset{(55)}{64} - \underset{\substack{(0.18)\\ [0.32]}}{0.11}\,CWP' - \underset{(56)}{4.65}\,ER + \underset{(0.02)}{0.030}\,Y' - \underset{(0.04)}{0.078}\,JL$$

$$PRMSE = 0.709$$

$$FDQ = \underset{(48)}{8.5} - \underset{\substack{(0.75)\\ [0.96]}}{0.85}\,FWP + \underset{\substack{(0.096)\\ [0.97]}}{0.08}\,Y + \underset{\substack{(0.49)\\ [0.23]}}{0.137}\,PPU + \underset{\substack{(1.0)\\ [0.65]}}{0.398}\,MPU$$

$$PRMSE = 0.608$$

$$FXQ = \underset{(42.7)}{-16.8} - \underset{\substack{(0.137)\\ [0.24]}}{0.127}\,FWP' + \underset{(42)}{14.15}\,ER + \underset{(0.01)}{0.055}\,Y' - \underset{(0.032)}{0.028}\,JL + \underset{(0.448)}{0.72}\,AL$$

$$PRMSE = 5.463$$

Because R-squared statistics are not applicable with 3SLS (and 2SLS), root-mean-squared percent error (PRMSE) is used to evaluate the overall goodness-of-fit. In terms of the associated PRMSEs and standard errors, the domestic demand for canned salmon equation performs well but the export demand for noncanned salmon equation performs poorly. In general, most of the variables have signs in accordance with a priori expectations.

In the domestic demand for canned salmon equation, the price variable (CWP) has a negative coefficient and statistically significant at the 1% level, based on a one-sided asymptotic test. The own-price elasticity, calculated at the mean, is 1.13. The income variable has an unexpected sign. Similar findings have been reported in the previous studies when the quantity dependent model is specified. It should be noted that canned salmon is found to be a normal good in Canada as indicated in the previous model. Because the income variable may capture the effect of the change in consumer's tastes, it is still an open question if canned salmon is an inferior good in North America. Canned tuna appears to be a substitute good of canned salmon. The recent glut in the supply of canned tuna in the international market will have a sizable spillover effect on the canned salmon market. The empirical results also indicate that poultry (PPU) is a complementary good with canned salmon and beef (MPU) is found to be a substitute good of canned salmon.

All the estimated coefficients in the export demand for canned salmon equation have expected signs. As Japan's landings increase, the export demand for canned salmon decreases. A surge in the value of the U.S. dollar will, as expected, adversely affect the export demand for North American canned salmon.

Because the exchange rate variable in the export demand for noncanned salmon equation has a unexpected sign and it is statistically insignificant in both export demand equations, the exchange rate variable is excluded from the model specification in another experiment. The 3SLS results are summarized below.

$$CDQ = 132 - 2.03\ CWP - 0.22\ Y + 14.7\ TP - 1.12\ PPU + 2.70\ MPU$$
$$\quad (52)\ (0.58)\quad (0.13)\quad (6.02)\quad (0.72)\quad (1.25)$$
$$\quad [1.19]$$

$$CXQ = 60 - 0.131\ CWP' + 0.032\ Y' - 0.0775\ JL$$
$$\quad (13)\ (0.095)\quad (0.014)\quad (0.0371)$$
$$\quad [0.37]$$

$$FDQ = 5.5 - 0.991\ FWP + 0.094\ Y + 0.179\ PPU + 0.365\ MPU$$
$$\quad (48)\ (0.76)\quad (0.097)\quad (0.494)\quad (1.0)$$
$$\quad [1.13]$$

$$FXQ = -4.37 - 0.078\ FWP' + 0.052\ Y' - 0.026\ JL + 0.762\ AL$$
$$\quad (15)\ (0.094)\quad (0.005)\quad (0.03)\quad (0.043)$$
$$\quad [0.15]$$

Judging from the associated standard errors and estimated coefficients, the treatment of exchange rate variables as separate shifters is not supported in this study. In both experiments the demand for canned salmon appears to be more price-elastic than the demand for noncanned salmon. Together with the fact that it takes more raw salmon to produce canned than noncanned salmon, an increase in the landings of North American Pacific salmon should induce a bigger increase in the production of canned salmon, when the values of other predetermined variables remain constant. Therefore, it is believed that the recent glut in the supply of canned salmon will have a great impact on the salmon fishery. As indicated in the empirical results, Atlantic salmon appears to be a complementary good with Pacific salmon. However, the relationship between Atlantic and Pacific salmon is reversed in a separate experiment in which all monetary variables are expressed in logarithmic terms. A possible explanation is that the landings of Atlantic salmon have been relatively low until recent years. The relationship between these two species of salmon is, therefore, difficult to detect at the present time.

Summary and Suggestions for Future Research

Because salmon is one of the most valuable fishery resources of the Pacific coast, research in salmon markets has received considerable attention among fishery economists in the Pacific Northwest area. Although salmon products are traded heavily in the international markets, the international component has rarely been incorporated in the analysis of demand for salmon. As a result, the problems of model misspecification and simultaneous equations bias may be present in the previous studies. Therefore, the major objective of this research is to improve our understanding of the salmon markets by considering the international component explicitly.

Two international trade models are specified and estimated in this research. The first model emphasizes the Canadian canned salmon market. The empirical results indicate that the Canadian domestic demand for canned is both income elastic and price elastic. The finding of a positive income elasticity contradicts the previous findings in the literature. This raises an interesting question of whether the unexpected finding of canned salmon being an inferior good can be explained by the problems of model misspecification. Therefore, future research in this area is still warranted. The finding of a high price-elasticity is consistent with the previous findings and suggests that an increase in the production of canned salmon will increase its gross wholesale values. For the time being, it is difficult to predict if an increase in salmon landings will increase or decrease the ex-vessel values received by salmon fishermen. In order to examine the effect of increased landings on its ex-vessel values, markets of different levels (i.e., ex-vessel, wholesale, international, and retail) need to be modelled simultaneously. This is, of course, a challenging task for fishery economists to accomplish.

In view of the successful performance of the first model, a more complex model is formulated with two distinct characteristics. First, Canada and the U.S. are aggregated into one region called North America and the major importing countries of Pacific salmon from North America are grouped and called the rest of the world. Second, the model consists of two submodels, one for canned salmon and the other for noncanned (round and dressed) salmon. Each submodel is recursive and supply is determined first by applying the Nerlove expectation models. These two supply functions are estimated by the seemingly unrelated regression technique. After supplies being determined, domestic demand and export demand for both products are estimated as a system by three-stage least squares. The estimation of the two supply functions provides satisfactory results. The previous prices and the present landings are found to be the important factors in the production of the two products. The estimation of the demand for both products as a system, however, does not provide a good statistical fit. Two possible explanations are suggested here. First, a better model has yet to be specified. Secondly and most importantly, the data base for salmon markets is a rather weak. For example, the U.S. production and inventory data on noncanned salmon are not available. The Canadian inventory data on canned salmon are confidential and hence not available. One remedy to this data problem is to use the marketing year (June to June) data. An overview of the data base reveals that the Canadian data are superior to the U.S. data. Thus, it seems promising that the second model should be refined and applied to the Canadian market.

Footnotes

1. The figure is drawn for the purpose of illustration. It does not necessarily reflect the empirical results of the study.

2. This implies that salmon landings are perfectly price-inelastic, an assumption usually made in the demand analysis of fish products.

3. Previous studies found that poultry is a complementary good with salmon.

4. Because the functional form is multiplicative (log-linear), the income and the own-price elasticity of domestic demand can be derived from the estimated export supply equation. For example, taking the anti-logarithmic transformation of the fifth equation in Table 1, it can be obtained that

$$CXQ = e^{5.85}\ PPC^{0.77}\ LC^{1.24}\ (CWP/WPC)^{2.43}\ CY^{-1.3}$$

$$= A\ (CWP/WPC)^{2.43}\ CY^{-1.3}$$

where $A = e^{5.85}\ PPC^{0.77}\ LC^{1.24}$

Let CDQ and S denote the quantity of domestic disappearance and quantity supplied, respectively. Then CDQ = S - CXQ. The income and the own-price elasticity of domestic demand can be derived as

$$(\partial CDQ/\partial CY)\ (CY/CDQ) = 1.30\ A\ (CWP/WPC)^{2.43}\ CY^{-2.3}\ (CY/CDQ)$$

$$= 1.30\ [A(CWP/WPC)^{2.43}\ CY^{-1.3}]/CDQ$$

$$= 1.30\ CXQ/CDQ$$

Similarly, the own-price elasticity of domestic demand can be derived as

$$[\partial CDQ/\partial(CWP/WPC)]\ [(CWP/WPC/CDQ] = 2.43\ CXQ/CDQ$$

Therefore, given the estimate of the export supply equation and the ratio of the exports to the domestic disappearance, we can calculate the income and the own-price elasticities of domestic demand. For the period 1952 to 1980, the average of the ratio of the exports to the domestic disappearance is found to be close to 1.0.

5. The definitions of FWP, FQ, NL, FXQ, FSP, CSP, and AL are discussed in Table 2 on page 4.

6. For a detailed discussion, see Johnston (pp. 300-20, 1972) and Labys (pp. 39-42, 1973).

7. There are alternative ways of calculating the exchange rate variable. When there is only one dominant importing country in the market, the dominant country's currency can be used as the exchange rate variable. In the case of salmon markets, there are more than one important importing countries. Besides the specification adopted here, the principal component procedure can be used to come up with composite exchange variable. It is not clear which specification is better.

8. PPU and MPU are real prices of poultry and beef, respectively. Other variables are as defined previously. All elasticities are calculated at the mean values of the appropriate variables.

References

Abraham, Gideon. "Canadian Chum Salmon Export Market Study." M.S. thesis. Oregon State University, 1979.

Canada, Statistics Canada. Annual Statistical Review of Canadian Fisheries. Ottawa: Canadian Bureau of Statistics, Vol. 8-11.

Canada, Agriculture Canada. Handbook of Food Expenditures, Prices, and Consumption. Ottawa: Communication Branch, Agriculture Canada, 1981.

Canada, Trade of Canada: Export by Commodities. Ottawa: Canadian Bureau of Statistics. Various issues.

Clark, Jerry and Bruce A. McCarl. "An Investigation of the Relationship Between Oregon Coho Salmon (Oncorhynchus Kisutch) Hatchery Releases and Adult Production Utilizing Law of the Minimum Regression." Canadian J. of Fisheries and Aquatic Sciences 40(1983):516-23.

Copes, J.S. "Monte Carlo Results for Estimation in a Stable Markov Time Series." J. Royal Stat. Soc., Series A, 129(1966):110-16.

Devoretz, D. "An Econometric Demand Model for Canadian Salmon." Can. J. of Ag. Econ. 30(1982):49-59.

Fletcher, S.M., R.E. Just, and A. Schmitz. "The Impact of Exchange Rates and Other Factors on North American Wheat Export Demand." Working Paper No. 12. Giannini Foundation of Agricultural Economics. U-C Berkeley, 1977.

Food and Agricultural Organization of the United Nations. Yearbook of Fishery Statistics. Rome. Various issues.

International Monetary Fund. International Financial Statistics. Washington, D.C. Various issues.

Johnston, J. Econometric Methods. New York: McGraw Hill, 2nd ed. 1972.

Johnston, R.S., and D.H. Wang. "Markets for Canadian Salmon: An Economic Analysis of Market Demand." Canada, Fisheries and Marine Science. Department of Fisheries and Environment. 1977.

Johnston, R.S., and W.R. Wood. "Demand Analysis for Canned Red (Sockeye) at Wholesale." Oregon State University, Sea Grant Pub. No. ORESU-T-74-001. 36 pages.

Labys, W.C. Dynamic Commodity Model: Specification, Estimation and Simulation. Lexington Books, 1973.

Mayo, D.R. "An Econometric Analysis of the British Columbia Salmon Industry." Master Essay. University of British Columbia, Department of Economics, 1978.

McCarl, B.A. and R.B. Rettig. "Influence of Hatchery Smolt Releases and Adult Salmon Production and Its Availability." Canadian J. of Fisheries and Aquatic Sciences 40(1983):1880-86.

Nash, D.A. and F.W. Bell. "An Inventory of Demand Equations for Fishery Products." Working paper No. 10. Division of Econ. Res., Bureau of Comm. Fish., 1969.

Nerlove, M. "Time-Series Analysis of Agricultural Products." In E.O. Heady et al., editors, Agricultural Supply Foundations. Ames: Iowa State University Press, 1961.

Onuorah, M.C. "Foreign and Domestic Trade in Canned Salmon of the U.S. and Canada: the Effect on the Derived Demand of the Fishermen." M.S. thesis. Oregon State University, 1973.

Swartz, A.N. "The Pacific Coho Salmon Fishery: an Intraseasonal and Interregional Economic Analysis of the Ex-vessel Market." Ph.D. thesis. Oregon State University, 1979.

United Nation. Monthly Bulletin of Statistics. New York. Various issues.

U.S. Department of Agriculture. "U.S. Food Consumption: Sources of Data and Trends, 1909-63." ERS. Stat. Bull. No. 364, 1965.

________. "U.S. Food Consumption, Price, and Expenditures, 1960-80." ERS Stat. Bull. No. 672, 1981.

U.S. Department of Commerce, Bureau of Census. U.S. Imports for Consumption. Various issues.

________. U.S. Exports for Consumption. Various issues.

________. National Marine Fisheries Service. Fishery Statistics of the United States. Washington, D.C. Various issues.

________. Fisheries of the United States. Washington, D.C. Various issues.

Wang, D.H. "An Econometric Study of the Canadian Sockeye Salmon Market." Ph.D. thesis. Oregon State University, 1976.

Waugh, F.H. and V.J. Norton. "Some Analyses of Fish Prices." Working paper No. 32. ERS. U.S. Bureau of Comm. Fish., 1967.

Wood, W.R. "A Demand Analysis of Processed Salmon from the West Coast." Ph.D. thesis. Oregon State University, 1970.

Multinational Arrangements

Export Marketing Strategies for Fish and Fisheries Products: Lessons From International Tuna Joint Ventures in the Southwest Pacific

Karl C. Samples
Department of Agricultural and Resource Economics
University of Hawaii
USA

Introduction

Proliferation of exclusive fishing zones around the world has altered the flow and direction of international trade in seafood products. Trade flows have diminished in a number of instances. Reductions in United States (U.S.) demand for frozen groundfish imports is an example where increased resource endowment, combined with changes in relative prices, have reduced import incentives (Copes, 1980). Instances can also be found where fish, once transported to distant markets in the holds of foreign factory ships, are now consumed in the coastal country of origin.

For many coastal nations, however, ocean enclosure has triggered greater interest and activity in export marketing. An export orientation is sometimes induced by an excess supply situation in local markets for a fish product that is consumed in copious quantities abroad. Such is the case, for example, with squid in the U.S. and tuna in the southwest Pacific. Alternatively, requisite processing facilities may not be situated locally. Unprocessed fish or shellfish, such as trawl-caught pollack in the U.S., must be exported to foreign processors if they are to be sold at all. Existence of international price differentials, especially for luxury or specialty products, further encourages exportation. Added to economic comparative advantage incentives are the political goals of increased net foreign exchange earnings, export tax revenue creation and export-led economic growth (Johnson, 1973; Keesing, 1967).

As a result of strong export incentives, international seafood trade has on balance registered a net increase since the widespread appearance of fishery conservation zones during the mid to late 1970s. According to United Nations statistics, world exports of fish and fisheries products grew in terms of volume at an average annual rate of 4 percent over the years 1977 to 1981 (see Table 1). The nominal value of exports grew at 12 percent annually over the same period. More recently, however, this strong upward trend has reversed somewhat (Infofish, 1984).

Despite general trade expansion, efforts to sell seafood products abroad have repeatedly been hampered by export marketing inexperience, under-financing, processing constraints, and product distribution bottlenecks. Delivering a suitable product to foreign customers at the right time, in the correct order quantity, and at a competitive price can be a formidable task, especially for the uninitiated. At a minimum, a well-conceived export marketing plan is called for.

This paper addresses strategies for selling seafood products in foreign markets. The primary objective is to describe the role that international joint venture arrangements can play in facilitating this process. No attempt is made to differentiate the marketing role of joint ventures in industrialized, semi-industrial and non-industrial coastal nations. Space does not permit giving adequate attention to this subject even though joint venture marketing opportunities and activities are obviously influenced by the condition of a country's infrastructure and marketing resources. Furthermore, no clear distinction is made between selling edible and non-edible fisheries products.

The paper begins with an overview of some basic export marketing considerations. The dual purpose of this section is to point out how joint venture arrangements fit into an overall export marketing strategy, and to introduce some marketing terminology used throughout the paper. Readers already familiar with marketing management concepts may wish to direct their attention to the second section. Here the focus turns specifically on international joint venture arrangements. Three international joint ventures located in the southwest Pacific are analyzed in terms of their organization and scope of export marketing activities. Based on these case studies, lessons are drawn about the export marketing strengths and shortcomings of joint venture arrangements.

With target markets identified, decisions about product form and volume, pricing, distribution and promotion can provisionally be made. These constitute the mix of controllable marketing variables. Product form and volume determine processing and handling requirements. Price is usually subject to manipulation. Pricing affects total sales, profits and level of competition from new market entrants. Distribution and promotion decisions influence the type of customers served, total sales volume and marketing costs. Choice of a distribution system also has relevance for marketing management control and business risk (Rosenbloom, 1978).

Decisions on marketing mix have direct implications for what marketing services an exporter will be required to perform. For example, a decision to sell smoked cod direct to retailers in northern Europe means export marketing channel members must fulfill significant processing, storage, transportation and selling functions. Consigning raw cod to a foreign processor entails far less marketing responsibilities. Regardless of which specific services are performed, they must be provided at minimum possible cost if export markets are contestable. Firms with large volumes and wide export product lines have competitive cost advantages in this regard. For example, it is known that fixed costs associated with maintaining foreign sales outposts, conducting market research, and providing product transportation and storage services can be averaged over increased sales volume. In addition to economies of scale, fixed costs of export marketing can also be averaged over multiple product lines. Efficiencies realized by multiple product firms, or "economies of scope", have been modeled elsewhere by Panzar and Willig (1981) and also described by Bailey and Friedlaender (1982).

Goal definition and target market analysis leaves open the question of who will carry out the marketing plan. What is needed are participants with the technical know-how, marketing information sources, financial wherewithall, and business ambition to overcome export obstacles. Broadly speaking, three alternatives present themselves. First, locally owned and operated firms can assume full export responsibilities or work in cooperation with foreign middlemen. Alternatively, foreigners can wholly accomplish all exporting tasks. Thirdly, foreign and domestic firms can harmoniously link together in joint ventures to achieve commonly held marketing objectives.

Quite likely if public decision makers are concerned about seafood export expansion, domestic firms are either unwilling to engage in the activity, or are incapable. Perhaps increased interest could be sparked through a export training program, or a export market information dissemination program. Export subsidies in the forms of export tariff reductions, export loan programs, income tax concessions, infrastructure development projects and granting sole distributorship rights are routinely used to encourage additional exports by domestic firms.

Foreign firms may be in a better competitive position to supply needed export marketing resources. Foreign involvement can take the form of "fee fishing" arrangements. This effectively places all marketing responsibilities (and therefore marketing profits) in the hands of distant-water fishing organizations. Fee fishing arrangements are convenient in terms of low initial contracting costs and rapid start-up. They are relatively risk free from the point of view of island communities because limited demands are placed on locally supplied investment resources. Their effectiveness in accomplishing a host nation's long-term fisheries development objectives has been called into question (Kent, 1980; Aprieto, 1981; Martin et al., 1981). Other forms of direct foreign investment in seafood exporting activities have been documented for the U.S. (Sullivan and Huggellund, 1979) and southwest Pacific (Kent, 1980; Ridings, 1983). Based on these studies, the contribution of foreign-owned subsidiaries towards achieving a host nation's exports objectives appear to be mixed. Positive contributions include the opening of new markets by overcoming tariff and non-tariff barriers; introduction of improved processing, handling and transportation technology; and the injection of additional financial resources. On the negative side are factors such as retarded development of domestic marketing capabilities, increased demands on locally generated investment capital, transfer pricing and tax avoidance, and monopsonistic raw material procurement behavior. Gains and losses such as these seem to be characteristic of direct foreign investment impacts in general (see for example Chudson (1975) and Parry (1980)). In balance the social and economic impacts of direct foreign investment in fish export marketing activities are not well understood and deserves further study.

A third export avenue is to collaborate with foreign partners in joint export marketing ventures. The joint venture concept is a vague and broad one. There is no agreement on a general definition. Nevertheless, a consensus exists that a joint venture constitutes a formalized collaborative effort by any number of contributing members in a mutually beneficial, risk-sharing business partnership (Martin, et al., 1981; Kaczynski and LeVieil, 1980; Hamlisch, 1974; Friedman and Kalmanoff, 1981). Such associations arise because partners to the venture, acting independently, cannot efficiently achieve their business objectives. By approaching a project jointly, a synergistic combination of inputs takes place. The result is the production of commonly desired outputs at reduced total cost.

Rapid expansion of joint venture activity has been observed by Kaczynski (1981), Kaczynski and LeVieil (1980) and Crutchfield et al. (1975), among others. Reportedly, at least a doubling of the number of fishing joint ventures to over 500 occurred worldwide between 1970 and 1980 (Kaczynski, 1981). Today, joint ventures are globally distributed. They are involved with harvesting, processing, storage, transshipment and distribution of numerous fish species.

Table 1. Growth in World Fxports of Fish and Fisheries Products

Commodity Group	Quantity(a) 1977	1981	5 Year Average Growth	Value(b) 1977	1981	5 Year Average Growth
Fish: Fresh, Cnilled or Frozen	3,460	4,535	+6%	3,593	5,804	+12%
Fish: Dried, Salted or Smoked	441	537	+4%	739	1,399	+18%
Fish Products and Preparations	811	989	+4%	1,389	2,223	+12%
Crustaceans and Mollusks: Fresh, Frozen, Dried and Salted	834	1,082	+6%	2,370	4,120	+15%
Crustacean and Mollusk Products and Preparations	94	136	+9%	361	621	+14%
Oils and Fats	578	722	+5%	250	289	+ 3%
Meals, Solubles and Other Animal Feeds	2,043	1,945	-1%	874	926	+ 1%
Total	8,261	9,946	+4%	9,576	15,382	+12%

Source: United Nations Food and Agriculture Organization (FAO), 1979 Yearbook of Fisheries Statistics, Vol. (49); FAO 1983 Yearbook of Fisheries Statistics, Vol. (53).

Notes:

(a) Quantity = thousands of metric tons
(b) Value = thousands of $US.

Strategic Considerations in Export Marketing

Export marketing decision making begins with the identification of concrete export marketing objectives. Objectives serve as important benchmarks to measure the performance of a particular export endeavor. Goals usually differ between public and private planning agents. Government may seek to increase fishermen's wages or employment opportunities, earn foreign exchange, develop infrastructure, and so forth. A private firm generally has less altruistic goals. It may seek to diversify risk, stimulate profits, increase marketing share, or add to total sales volume. Although strategic planning to achieve public goals is emphasized in this paper, recognition has to be given to the fact that if exporting is to be undertaken by the private sector, private business objectives must be satisfied as well.

Aside from goal formulation, the export marketing environment needs appraisal (Kotler, 1984). Understanding the economic, political-legal and cultural environment of the exporting and potential importing countries is helpful in selecting trading partners and marketing mix variables. Important considerations include: fish raw material supply availability; current and forecasted demand for exportable products in potential markets; degree of competition from other exporting nations; existence of tariff and non-tariff barriers; political stability in target markets; and domestic and foreign monetary regulations.

Given a set of goals and marketing environment constraints, a ranking of potential export markets can occur. Although sales could conceivably be made worldwide, selecting one or a few export markets to target attention on may be advantageous for risk management and market coverage purposes (Ayal and Zif, 1979). Target markets usually are defined in terms of geographic and demographic dimensions. For example, a target market for canned tuna is middle-income urbanites in Canada and the United Kingdom. Cultural or political ties sometimes identify target markets. On other occasions, target markets are those where the bulk of consumption occurs (U.S. and Japan for tuna, for example).

Acquiring access to marketing skills of experienced transnational corporations is an incentive factor for host nations contemplating joint venture involvement. As Walmsley (1982) puts it, a joint venture is "a deliberate alliance of resources of two independent organizations in order to mutually improve their market growth potential (p. 4)." This view of joint ventures as exporting marketing institutions is commonly shared. For example, in arguing for increased Canadian involvement in joint ventures, Tomlinson and Brown (1979) state that joint ventures "provide virtually guaranteed access to markets -- and with costs which permit competitive price levels (p. 258)." Similarly, mention is made of the fact that joint ventures in the U.S. have created opportunities to harvest pollack, squid and other underutilized species where domestic markets are weak and/or domestic processing costs are excessively high (Kaczynski, 1979). Kaczynski (1984) argues further that the primary advantage of contractual "over-the-side" joint ventures in the U.S. is the export marketing services obtained from foreign partners. The existence of export market potential is an incentive to both parties. Crutchfield et al. (1975) point out that establishment of joint ventures is facilitated when a common shared goal of all participants is to exploit promising export markets.

Tuna Joint Ventures in the Southwest Pacific

Ridings (1983) identified seventeen tuna joint ventures active in the southwest Pacific. Out of this group, only eight are "international" joint ventures in the sense that participants are of different nationalities. The other nine are locally registered companies, wholly owned by foreign interests. Included in this latter group, for example, are the two canneries in American Samoa which are owned entirely by Van Camp and Starkist. Of the eight international joint ventures, all involved equity participation by Japanese firms. Local governments were active participants in half of the ventures. Case studies presented below concern joint venture operations in Fiji, the Solomon Islands and Vanuatu. Information on the operating characteristics of the ventures came from different sources, depending on the host country. Much of the detailed information about the Fiji joint venture came from personal interviews with venture participants and from public records. News articles and other secondary data sources provided information about the ventures in the Solomon Islands and Vanuatu.

Case I: The Pacific Fishing Company, Ltd., Fiji. Fiji's experience with joint ventures began in 1963 with the licensing of a fish freezing and transshipment company. The firm, Pacific Fishing Company, Ltd. (PAFCO), was organized as a joint venture between several Japanese firms and a small group of Fiji private investors. Equity ownership was largely subscribed to by three Japanese transnational firms. The major shareholder, C. Itoh and Co., Ltd. (Itohchu Shoji), owned 33.3 percent of the newly formed PAFCO. Nichiro Fishing Co., Ltd. (Nichiro Gyogyo) and Banno of Osaka both subscribed to 25 percent equity ownership. The remaining 16.7 percent equity ownership was subscribed to locally.

PAFCO operations commenced in 1964, serving as a freezing and cold storage facility for chartered Japanese, Korean and Taiwanese longlining tuna vessels. The major tuna species unloaded at PAFCO were albacore, yellowfin and bigeye. Under contract, the catch was sold to PAFCO, frozen or chilled, and then consigned to C. Itoh. Final destinations were markets in the U.S. and Japan. The impact of PAFCO operations on Fiji's export trade in fish products was phenomenal. In 1963, Fiji exported $US 20,000 in fish products. Within one year, this volume had increased to $US 214,000 (Table 2). Between 1964 and 1972, PAFCO exports grew to over $US 8 million.

In November of 1974, the government of Fiji and C. Itoh and Co., Ltd. (hereinafter referred to as C. Itoh) signed a ten year agreement that restructured ownership of PAFCO. The Government became part-owner in recognition of its granting PAFCO sole rights to process and export tuna caught in Fiji waters. The agreement stipulated that PAFCO would build a 60 MT/day tuna cannery and a fish meal plant according to a phased construction schedule. Since 1974, PAFCO has largely confined its activities to satisfying the following objectives: 1) to process and can tuna fish for local and overseas markets; 2) to purchase and sell raw fish, and 3) to sell supplies and equipment to fishing boats.

By far, the bulk of cannery output (90 percent) is sold as solid pack light meat to export markets in Commonwealth Nations including United Kingdom, Australia, New Zealand, and Canada. Special trade concessions granted to Fiji in the form of import tariff reductions have favored exportation to these markets as opposed to U.S. markets. PAFCO also sold approximately 6,000 cases of flake tuna in local markets under its Sunbell label in 1982. A small fraction of total landings are sold in frozen form (albacore, billfish, and mahimahi) to markets in Tokyo where it is eventually canned for export and for consumption by Japanese households (Kitson and Hostis, 1983). In addition, PAFCO sells dried fins from sharks landed incidentally by chartered vessels.

Gross turnover by PAFCO rose dramatically since large scale cannery operations commenced in 1976. Even with recent depressed tuna market conditions, sales were 730 percent higher in 1982 than during the pre-cannery days of 1974. Steady sales hikes are largely the result of successful market penetration and product positioning efforts by C. Itoh staff working for PAFCO. In 1980, PAFCO controlled an estimated 9 percent (2,566 MT) of the United Kingdom canned tuna import market. In 1981, it supplied 16 percent (1,599 MT) of Canadian canned tuna imports (Kitson and Hostis, 1983).

C. Itoh has assumed almost fully the management, export, domestic marketing and transshipment responsibilities of the PAFCO operation. This is a result of its expertise, provisions of the PAFCO agreement and its majority stockholder position. In terms of management, four out of six members of the

Table 2. Fiji's Exports of Fish and Fishery Products, 1958-81.

Year	Fresh and Frozen (MT)	Fresh and Frozen ($US)	Smoked, Dried or Salted (MT)	Smoked, Dried or Salted ($US)	Canned or Otherwise Preserved (MT)	Canned or Otherwise Preserved ($US)
1958	-(a)	3,000	-	-	-	-
1959	-	-	-	-	-	-
1960	-	-	-	-	-	-
1961	-	11,000	-	-	-	9,000
1962	-	13,000	-	-	a	12,000
1963	-	13,000	-	-	-	5,000
1964	-	207,000	-	-	-	7,000
1965	3,700	1,031,000	-	-	-	5,000
1966	6,200	1,955,000	-	-	-	5,000
1967	6,000	2,603,000	-	-	-	-
1968	5,500	2,140,000	-	-	-	-
1969	8,600	3,948,000	-	2,000	100	55,000
1970	7,900	4,791,000	-	20,000	400	324,000
1971	8,600	5,791,000	-	-	100	164,000
1972	10,800	8,280,000	-	-	-	12,000
1973	6,800	6,042,000	-	3,000	300	285,000
1974	3,600	3,172,000	100	184,000	600	600,000
1975	2,362	1,622,000	3	6,000	395	407,000
1976	2,362	1,479,000	17	53,000	456	1,117,000
1977	3,104	4,203,000	243	991,000	2,380	4,624,000
1978	4,297	6,285,000	76	432,000	4,075	10,424,000
1979	1,349	1,583,000	47	337,000	5,734	14,124,000
1980	3,583	7,282,000	57	441,000	3,561	10,741,000
1981(b)	3,583	7,282,000	57	441,000	5,440	16,328,000

Source: United Nations, Food and Agriculture Organization (FAO), 1963 Yearbook of Fisheries Statistics, Vol. 17; FAO 1964 Yearbook of Fisheries Statistics, Vol. 19; FAO 1965 Yearbook of Fisheries Statistics, Vol. 21; FAO 1969 Yearbook of Fisheries Statistics, Vol. 29; FAO 1972 Yearbook of Fisheries Statistics, Vol. 35; FAO 1974 Yearbook of Fisheries Statistics, Vol. 39; FAO 1977 Yearbook of Fisheries Statistics, Vol. 44; FAO 1978 Yearbook of Fisheries Statistics, Vol. 47; FAO 1981 Yearbook of Fisheries Statistics, Vol. 53.

Notes:

(a) "-" equals zero, nill or none reported.
(b) Preliminary

PAFCO Board of Directors are C. Itoh employees. Sales management is entrusted to the Managing Director, who resides in Japan and operates out of C. Itoh headquarters in Tokyo. Day to day management of PAFCO operations is the responsibility of a handful of C. Itoh employees who are positioned in top and middle-level management niches. Aside from providing key organizational and personnel management skills relating to raw material procurement and canning production, C. Itoh is largely responsible for marketing management. This includes making all decisions on product mix, production timing, markets to be penetrated and product distribution, gathering.

Performance of these services is facilitated by C. Itoh's massive size and its ability to achieve economies of scale and scope in product distribution. In 1983, C. Itoh's reported sales were $US 56.7 billion for a product line that extended from raw fish to microcomputers. The company reportedly maintains 85 branch offices outside of Japan (The Oriental Economist, 1984). This network serves as a market intelligence gathering and communication system. Market data is relayed to corporate headquarters, where it is in turn interpreted and disseminated back to trade outposts. Furthermore, the company has access to huge financial reserves, both internal and external, that are used to lubricate PAFCO trade flows by credit extension to buyers.

There are several ways that C. Itoh distributes PAFCO products. For private labeled canned tuna, it usually acts as a consignee, arranging transportation, insurance and storage. For this service, it receives a 2.5 to 3 percent commission. Often products consigned to C. Itoh are sold to C. Itoh subsidiaries such as C. Itoh of America, Inc. or C. Itoh of Vancouver, Ltd. Occasionally, C. Itoh will purchase canned tuna outright. This occurs when PAFCO cannot supply enough volume on its own to meet an order. C. Itoh will then purchase from several producers, including PAFCO, and assemble a large enough lot to fill the order quantity. Frozen albacore, bigeye, black marlin, white marlin, swordfish and Pacific marlin are often bought directly by C. Itoh and transported to Japan. In Japan, these items are either canned in C. Itoh's own cannery, or distributed to other processors. A similar trade occurs in dried sharks fin and skipjack loins.

Case II: Solomon-Taiyo, Ltd., Solomon Islands. The Solomon-Taiyo, Ltd. (STL) joint venture was licensed to operate in 1972, following fifteen months of tuna stock assessment by Taiyo Fishing Co., Ltd. (Taiyo Gyogyo). STL was structured as a joint venture between the government of what was then the British Protectorate of the Solomon Islands, and Taiyo Fishing Co., Ltd. (hereinafter referred to as Taiyo). The company was formed with $A 1,000,000 in authorized share capital, of which Taiyo eventually subscribed to 75 percent. The Government was allocated 25 percent in consideration of its granting STL exclusive rights to fish in Solomon Island territorial seas, and to export tuna and tuna products. The duration of the joint venture agreement was set at 10 years, subject to renewal. In 1981, the contract was revised to give the Government 50 percent equity, and was extended another 10 years (Meltzoff and LiPuma, 1983).

Under guidelines of the 1972 agreement, STL built a 600 MT cold storage facility, ice plant, brine freezer, 600 cases/day cannery and an arabushi plant at Tulugi. Taiyo provided long term loans to finance these shore based facilities that were completed in 1973. Skipjack tuna, harvested by chartered vessels, was the target species for processing and export. In 1976, a second freezing plant and cold storage plant began operations at Noro. Together with the Tulugi station, nearly 18,000 MT of skipjack were processed annually by 1978. This represented a dramatic increase from the zero catch levels which existed six years previously.

Under terms of the 1972 and 1981 agreements, Taiyo is granted exclusive rights to export tuna and tuna-like species, in all forms, from the Solomon Islands. The bulk of the fresh and frozen tuna exports shown in Table 3 is shipped to the Van Camp cannery in American Samoa. Canned light meat tuna is shipped to Great Britain, where STL tuna commanded 7.5 percent of the total canned tuna market in 1980 (Kitson and Hostis, 1984). The bulk is sold under private labels. Small amounts are also shipped to Japan where they are presumably reexported to the U.S. and markets in Europe. Dark meat tuna which is not exported is marketed locally using a separate marketing label. Arabushi, or smoked skipjack tuna loin is marketed exclusively in Japan.

Table 3. Solomon Islands' Exports of Fish and Fishery Products, 1971-81.

Year	Fresh, Frozen		Smoked, Dried, Salted		Canned or Otherwise Preserved	
	(MT)	($US)	(MT)	($US)	(MT)	($US)
1971	4,165	1,238,000	-(a)	-	-	-
1972	12,138	3,584,000	-	-	-	-
1973	5,091	1,539,000	-	-	-	-
1974	8,297	2,834,000	69	116,000	829	767,000
1975	3,647	1,271,000	162	319,000	891	1,188,000
1976	12,098	5,965,000	140	225,000	671	1,195,000
1977	9,773	6,375,000	106	388,000	670	1,520,000
1978	14,518	10,262,142	223	736,000	666	1,581,000
1979	21,918	15,255,601	142	438,000	761	1,906,000
1980	19,000	13,224,000	918	4,526,181	2,162	8,734,804
1981	23,246	16,179,216	848	4,179,427	2,060	7,048,290

Source: United Nations Food and Agriculture Organization (FAO), 1974 Yearbook of Fisheries Statistics, Vol. 39; FAO 1977 Yearbook of Fisheries Statistics, Vol. 44; FAO 1978 Yearbook of Fisheries Statistics, Vol. 47; FAO 1981 Yearbook of Fisheries Statistics, Vol. 53.

Notes:

(a) "-" equals zero, nill or none reported.

The willingness and ability of Taiyo to sell STL tuna rests in the multinational's immense size and intimate awareness of international fishery trade. Taiyo is fully diversified in all aspects of commercial fishing, from product harvesting to processing, transportation storage and wholesaling. It handles a wide range of fresh (crab, salmon, tuna, trout, etc.) and processed (dried, canned, smoked) fish products for human consumption and industrial uses. In the STL venture, Taiyo is largely responsible for the sizable growth in exports discussed previously. As in the case of PAFCO, all line executives in the company are Taiyo employees. Before the revised 1981 agreement, Taiyo also controlled the board of directors through its majority voting strength. This has since changed. Currently there are six board members of which the Government appoints three, including the chairman. In day to day operations, however, Taiyo employees make binding decisions concerning product quality, product mix, product shipping, and production timing (Meltzoff and LiPuma, 1983). By contrast, Taiyo is the sole exporting agent for STL products. For this basic marketing service, Taiyo receives a sales commission of 5 percent on canned tuna and 3 percent on frozen product.

<u>Case III: South Pacific Fishing Co., Vanuatu.</u> The South Pacific Fishing Co. (SPFC) was licensed to operate as a fishing, freezing and transshipment base for a fleet of about 20 tuna longliners back in 1954. Construction of a 1,300 MT freezing plant and 20 MT/day ice plant began two years later and actual operations commenced in 1957. The objectives of SPFC were: 1) to buy and sell frozen tuna; 2) to supply chartered fishing boats with fuel, oil, food, and fishing gear, and 3) to inspect and repair fishing boats. A detailed discussion of SPFC early operations is found in Leaney and Lea (1957) and Wilson (1966).

The company was structured as a joint venture between four companies. Included were two Japanese companies, Mitsui and Co., Ltd. (Mitsui Bussan Kaisha) and Taiheyo Suisan Daisha, a U.S. firm (Washington Fish and Oyster Company), and a local firm. Mitsui and Co., Ltd. (hereinafter referred to as Mitsui) was, and continues to be, the majority stockholder. Sometime around 1981, the government of Vanuatu was granted 10 percent ownership of the company in return for unspecified export tariff reductions.

Fishing and freezing activities expanded briskly. Within one year, Vanuatu (formally New Hebrides) had a million dollar export trade in fishery products. By 1968, exports of frozen yellowfin and albacore tuna had doubled (Table 4). Tuna exports reached a high during the tuna longline heydays of the early 1970s. During this time, the New Hebrides government was earning an estimated $US 400,000 annually in tuna export tariffs, a significant public revenue amount. A drop in exports occurred during 1981 because of an extended boycott. The bulk of tuna exports have historically been sold to buyers in the U.S. Wilson (1966) reported that Washington Fish and Oyster Company (the U.S. partner) was a regular buyer of frozen tuna. It is uncertain which U.S. canneries are currently purchasing Vanuatu tuna. A likely destination is Mitsui's Neptune cannery in Puerto Rico. Second quality tuna, along with dried sharksfin, is marketed by Mitsui in Japan.

Table 4. Vanuatu's Exports of Fish and Fishery Products, 1958-81.

Year	Fresh and Frozen (MT)	Fresh and Frozen ($US)(a)	Smoked, Dried or Salted (MT)	Smoked, Dried or Salted ($US)	Canned or Otherwise Preserved (MT)	Canned or Otherwise Preserved ($US)
1958	3,509	1,225,266	-(b)	-	-	-
1959	3,710	1,153,417	-	-	-	-
1960	4,133	1,180,366	-	-	-	-
1961	3,673	1,195,756	-	-	-	-
1962	4,289	1,501,110	-	-	-	-
1963	2,975	987,910	-	-	-	-
1964	2,873	984,061	-	-	-	-
1965	3,366	1,259,906	-	-	-	-
1966	6,564	3,068,936	-	-	-	-
1967	5,977	2,616,037	-	-	-	-
1968	6,627	3,075,351	-	-	-	-
1969	7,988	3,981,149	-	-	-	-
1970	9,216	5,986,478	-	-	-	-
1971	13,346	8,354,896	-	-	-	-
1972	15,598	11,527,755	-	-	-	-
1973	15,131	11,403,304	-	-	-	-
1974	9,824	8,175,276	-	-	-	-
1975	5,218	3,310,140	-	-	-	-
1976	6,091	6,663,132	-	-	-	-
1977	9,997	13,260,000	-	-	-	-
1978	9,182	13,161,692	-	-	-	-
1979	7,724	12,020,742	-	-	-	-
1980	8,300	15,255,715	-	-	-	-
1981	4,840	9,559,597	-	-	-	-

Source: Government of Vanuatu, Office of National Planning and Statistics. <u>Vanuatu Statistical Bulletin, 1982</u>.

Notes:

(a) Exchange rates used to calculate values in $US are as follows: 1958-1976 ($1.283 = 100 vatu); 1977 ($1.250 = 100 vatu); 1978 ($1.354 = 100 vatu); 1979 ($1.446 = 100 vatu); 1980 ($1.157 = 100 vatu); 1981 ($1.052 = 100 vatu.

(b) "-" equals zero, nill or none reported.

Mitsui and C. Itoh play similar export marketing management roles. Mitsui is a larger trading company than C. Itoh. In 1983, Mitsui reported annual sales of $US 64.3 billion and had 150 branch offices outside of Japan (The Oriental Economist, 1984). An estimated forty Mitsui employees reside in Vanuatu. In the marketing area, their responsibility is to schedule tuna purchases and sales, monitor prices, and provide technical guidance on freezing technology and product quality. Although SPFC is geared to produce a frozen tuna product, Mitsui has in the past experimented with fish smoking and drying. In the early 1960s, a small tuna smoking plant was built and 67 MT of smoked product was exported to Japan (Wilson, 1966). This operation probably would have continued but the factory was destroyed by fire. Mitsui has also recently been investigating the feasibility of using SPFC freezing facilities to export frozen beef that is produced locally.

Lessons Learned About Joint Venture Export Marketing

One yardstick for evaluating a joint venture's export marketing performance is how well the venture contributes to achieving fisheries development objectives. While professed development objectives differ between localities, it generally appears that southwest Pacific Island nations seek to: 1) increase export earnings from tuna sales; 2) increase the value-added to locally caught tuna, and 3) assimilate technical and business skills from foreign partners. Based on these evaluation criteria, the performance of individual joint ventures is mixed, depending on formal structures and participants. Nevertheless, some general lessons can be learned.

Lesson #1: foreign partners can contribute key export marketing management inputs. Firms such as Taiyo, C. Itoh and Mitsui bring many years of export marketing experience to host countries. They also come equipped with financing sources, established distribution systems, and political allies. Since all have previous experiences with fish processing and distribution, they have the capabilities to undertake activities ranging from collection and freezing of fish (in the round) for transshipment to U.S. or Japanese buyers, to the operation of smoking (arabushi and katsuobushi) plants and tuna canneries. In the cases of freezing and transshipment ventures, Japanese firms assume responsibility for: 1) purchases and maintenance of freezing equipment; 2) determining fish purchase and delivery schedules; and 3) contracting for export sales.

Lesson #2: joint ventures can export large quantities of fish and fisheries products. There is probably little disagreement that joint ventures have augmented Pacific Island gross export earnings. In all the cases discussed above, formalized agreements with Japanese transnationals over the past two to three decades have created entire export industries from nothing. Two factors have generally contributed to higher tuna export values: additional tuna thoughout and increased average value-added per ton of tuna landed. Whether canned or not, increased physical tuna throughput entails additional marketing responsibility. Either new export and domestic markets must be developed, or existing markets such as U.S. canneries in American Samoa must be further penetrated. Aside from simply selling more tuna and tuna by-products, joint ventures have tended to raise the value per ton of tuna landed. More sophisticated local processing is a key factor.

To what extent are Japanese transnational corporations responsible for higher gross value of tuna exports, and increased average value per metric ton of tuna landed? For Fiji, C. Itoh is largely responsible by reason of the fact that it retains almost complete control of marketing management decision-making. A similar situation reportedly exists in the Solomon-Taiyo joint venture (Meltzoff and LiPuma, 1983). Historically, it has been C. Itoh's and Taiyo's responsibility to select what type and how much canned and frozen tuna to produce, and where to distribute the product. Through affiliates in Japan, they have opened highly concentrated Japanese smoked and frozen tuna markets to Pacific island imports. With their business connections in Europe, they have assisted Fiji and the Solomon Islands obtain preferential trade access to EEC member countries under terms of the Lome Agreement. They have also managed to produce canned products of consistent quality and in sufficient quantity to satisfy stringent import requirements of large wholesale food distributors.

Although the PAFCO, STL and SPFC joint ventures have increased export earnings, it is uncertain whether their activities have increased net foreign exchange earnings. Canning, freezing, and smoking operations are import-intensive. Almost all inputs with the exception of factory labor, maintenance services, and raw tuna are imported. Imports include metal for cans, packing oils, fuel, paper, uniforms, ad infinitum.

Lesson #3: profitability and management training are potential weak points. Although information on company profits is proprietary, available evidence suggests that average annual profits for the STL and PAFCO ventures are very modest, perhaps zero. Meltzoff and LiPuma (1983) report that "The joint company has not, however, netted a profit during its first decade, incurring a serious setback in 1978 which forced STL to recapitalize to the extent of $US 4 million," (p. 55). Despite impressive gains in sales volume, PAFCO profits have also been low. In only two of the nine years that the Fiji government has participated in PAFCO have dividends been declared. Profitability of the SPFC is unknown. While low profits during start-up years are to be expected, it is suspected that STL may be paying excessively high prices for spare parts, machinery and expendable supplies purchased from Taiyo. Furthermore, there is concern that Taiyo is not striving to obtain top market prices for tuna it receives on consignment (Meltzoff and LiPuma, 1983). To control for this possibility, the 1981 revised STL agreement establishes an in-house marketing division to monitor Taiyo's pricing and distribution strategies.

Interpretation of the actual profit picture is confused, however, by the fact that participants routinely extract income from company activities in more direct ways. Japanese partners typically receive management fees, sales commissions, technical assistance fees, and loan interest payments. Government partners extract import and export duties. They also collect taxes on locally generated income. Since these charges are accounted for as costs of doing business, reported profits tend to be low even though partners are earning positive financial returns.

Consistent lack of attention paid to training local marketing managers is also a lesson to be learned, at least from the PAFCO and STL ventures. Training practices of the SPFC are uncertain. As noted in the case study of Fiji, Japanese expatriates occupy all senior level management posts. A similar situation prevails in the Solomon Islands where Japanese managers from Taiyo occupy all upper and middle-management positions. Since marketing decision making in these ventures is conducted entirely by employees of Japanese parent firms, there is little expectation that, in the short term, island nations can assume significant marketing responsibilities.

Lesson #4: control of joint venture marketing activity is a complex matter. As more marketing tasks are undertaken by foreign firms, a host nation's ability to control the marketing process and monitor sales performance diminishes. At least this has been the experience in Fiji and the Solomon Islands. Two reasons for this can be given. First, because the supply of firms capable of processing and selling large quantities of tuna is limited, suitable partners are in a position of strength to negotiate agreements that provide near full marketing autonomy. Secondly, the cost of monitoring day-to-day activities of joint venture partners can be high, and suitably trained local personnel may not be available. Through a combination of these factors, the problem arises of finding a balance between maintaining control over market management on the one hand, and utilizing the services of independent expatriate marketing experts to increase tuna harvesting rents, on the other.

Costs of achieving more marketing management control can be high. Marketing control can be "bought" in several ways including: 1) purchase of controlling equity interest in the venture; 2) negotiating contract terms which stipulate that local managers receive full training in marketing management, and employ these individuals as "watchdogs"; 3) conducting routine management audits to measure marketing performance of transnational corporations (done with the aid of paid consultants); and 4) terminating the joint venture agreement and contracting instead for specific marketing services to be performed on a competitive bid basis.

Conclusions

Export marketing of tuna products in the southwest Pacific has been facilitated by joint venture establishment. Based on experiences of Fiji, the Solomon Islands and Vanuatu, it appears that joint ventures can be flexible in terms of the size and scope of marketing activities undertaken. Japanese partners in these ventures have the requisite marketing skills to infiltrate new markets, and further penetrate existing tuna markets. Although export sales have grown significantly, Japanese management has not generally stimulated strong profit performance. Nor have the Japanese devoted serious attention to developing the marketing skills of local managers. Whether this is a peculiarity of Japanese partners, or all foreign joint venture partners, is not known.

Low profits and lack of attention to managerial training are two reasons why joint ventures are often viewed as stop-gap measures, to be abandoned when local skills are somehow sufficiently developed to permit complete local management. Political incentives to adopt this outlook may be great, especially in the Pacific where tuna is an economically and politically important commodity. A short term view of joint venture usefulness, however, ignores the fact that world markets for fish and fisheries products are highly competitive and volatile. Even the Japanese experts (Mitsui, Taiyo, C. Itoh) have lost millions of dollars playing the tuna marketing game (Kitson and Hostis, 1983). Whether it is in the best interests of coastal nations to undertake this risk, and try to develop capabilities to market their own fishery resources is not altogether certain. Perhaps, therefore, export marketing joint ventures should be viewed as more permanent arrangements, to be carefully guided and controlled so as to achieve export marketing objectives.

Acknowledgements

This research was supported in part by project PP/R-7, "International Joint Venture Arrangements and Commercial Fisheries Development in the Pacific Basin" which is funded by the University of Hawaii Sea Grant Program under Institutional Grant #NA81AA-D-0070 from NOAA, Office of Sea Grant, U.S. Department of Commerce. The author remains responsible for all errors and omissions.

References

Aprieto, V. 1981. Fishery Management and Extended Maritime Jurisdiction: The Philippines Tuna Fishery Situation. East-West Environment and Policy Institute Research Report No. 4, East West Center, Honolulu.

Ayal, I. and J. Zif. 1979. Market Expansion Strategies in Multinational Marketing. Journal of Marketing (43): 84-94.

Bailey, E. and A. Friedlaender. 1982. Market Structure and Multiproduct Industries. Journal of Economic Literature (20): 1024-1048.

Chudson, W.A. 1975. Multinational Enterprises in Developing Countries: Some Issues in the Manufacturing Sector. In P. Boarman and H. Schollhammer, Editors. Multinational Corporations and Governments: Business-Government Relations in an International Context. New York: Praeger Publishers.

Copes, P. 1980. British Columbia Fisheries and the 200-mile Limit: Perverse Effect for the Coastal State. Marine Policy (4): 205-214.

Crutchfield, J., R. Hamlish, G. Moore and C. Walker. 1975. Joint Ventures in Fisheries. FAO/NDP Indian Ocean Fishery Commission IOFC/DEV/75/37. Rome, Italy.

Friedman, W.G. and G. Kalmonoff, Editors. 1981. Joint International Business Ventures. New York, New York: Columbia University Press.

Government of Vanuatu, Office of Natural Planning and Statistics. 1982. Vanuatu Statistical Bulletin. Santos, Vanuatu.

Hamlisch, R. 1974. The Role of Joint Ventures in Establishing Fishery Industries, in R. Kreuzer, Editor. Fishery Products. Surrey, England: Fishing News (Books) Ltd.

Johnson, H.G. 1973. International Trade and Economic Development. In P. Streeten, Editor. Trade Strategies for Development. New York: John Wiley and Sons.

Kaczynski, W. 1979. Joint Venture in Fisheries Between Distant-Water and Developed Coastal Nations: An Economic View. Ocean Management (5): 39-48.

Kaczynski, V. 1981. International Joint Ventures in the North Pacific Fisheries. Paper presented at the 15th Annual Conference of the Law of the Sea Institute, Honolulu, Hawaii.

Kaczynski, V. 1984. Joint Ventures as an Export Market. Marine Policy 8(1): 16-29.

Kaczynski, V. and D. LeVeil. 1980. International Joint Ventures in World Fisheries: Their Distribution and Development. Washington Sea Grant. Technical Report WSG-80-2. Seattle, Washington.

Keesing, D.B. 1967. Outward-Looking Policies and Economic Development. The Economic Journal (77): 303-320.

Kent, G. 1980. The Politics of Pacific Island Fisheries. Boulder, Colorado: Westview Press.

Kitson, G. and D.L. Hostis. 1983. The Tuna Market. Asian Development Bank and FAO INFOFISH Market Studies Volume 2, Kuala Lumpur, Malaysia.

Kotler, P. 1984. Marketing Management. Englewood Cliffs, New Jersey: Prentice Hall, Inc.

Kotler, P. 1984. Marketing Management: Analysis Planning and Control. Fifth Edition. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Leaney, C. and D. Lea. 1967. Some Recent Changes in New Hebridean Trade. The Australian Geographer (10): 286-297.

Martin, G., Y. Matsuda, J. Bardach, S. Comitini, and S. Hardjolukito. 1981. A Strategic Goal Analysis of Options for Tuna Longline Joint Ventures in Southeast Asia: Indonesia-Japan Case Study, Research Report No. 3, East-West Environmental and Policy Institute, East-West Center, Honolulu, Hawaii.

Meltzoff, S. and E. LiPuma. 1983. A Japanese Fishing Joint Venture: Worker Experience and National Development in the Solomon Islands. International Center for Living Aquatic Resource Management. Technical Report 12, Manila, Philippines.

Panzar, J. and R. Willig. 1981. Economies of Scope. American Economic Review (71): 268-272.

Parry, T. 1980. The Multinational Enterprise: International Investment and Host-Country Impacts. Greenwich, Connecticut: JAI Press, Inc.

Ridings, P. 1983. Resource Use Arrangements in Southwest Pacific Fisheries. East-West Pacific Island Development Program Paper Series, East-West Center, Honolulu, Hawaii.

Rosenbloom, B. 1978. Marketing Channels: A Management View. Hinsdale, Illinois: Dryden Press.

Sullivan, J. and P. Huggelund. 1979. Foreign Investment in the U.S. Fishing Industry. Lexington, Massachusetts: D.C. Heath and Company.

The Oriental Economist. 1984. Japan Company Handbook. Tokyo: Dai Nippon Printing Co., Ltd.

Tomlinson, J. and P. Brown. 1979. Joint Ventures With Foreigners as a Method of Exploiting Canadian Fishery Resources Under Extended Fisheries Jurisdiction. Ocean Management (5): 251-261.

Tomlinson, J. and I. Vertinsky. 1975. International Joint ventures in Fishing and 200-Mile Economic Zones. Journal of Fisheries Research Board Canada (32): 2569-2579.

United Nations Food and Agriculture Organization (FAO). Annual. Yearbook of Fisheries Statistics. Fishery Information, Data and Statistics Division. Rome, Italy.

Walmsley, J. 1982. Handbook of International Joint Ventures. London: Graham and Trotman, Ltd.

Wilson, J. 1966. Economic Survey of New Hebrides. London: Her Majesty's Stationery Office.

Fisheries Management: Theory and Practice

Imperfect Competition and Transboundary Renewable Resources: The Implications for Fishery Control Policies

Susan M. Capalbo
National Center for Food and Agricultural Policy
Resources for the Future
Washington, DC, USA

Richard E. Howitt
Department of Agricultural Economics
University of California, Davis
USA

Abstract

This paper presents a nonlinear optimal control framework for modeling a renewable resource industry which is characterized by a competitive harvesting sector, a monopsonistic or oligopsonistic processing sector, and a transboundary resource stock. The model is comprised of three interrelated parts: the fisherman's supply relations, the biological growth and recruitment relations, and the wholesale demand relations. The empirical analysis pertains to the North Pacific Halibut fishery which is primarily a bilateral fishery (U.S. and Canada). The overall thrust of the results is toward strict conservation of the resource by the processors. This is achieved via the market price offered to fishermen.

I. Introduction

Over the past two decades increased attention has focused on analyzing the impacts of restricting use of and access to common property fishery resources. With the exception of Clark and Munro (1980) and Schworm (1983) the management models have focused on regulating the harvesting sector directly via management restrictions on the number of participants, catch levels, gear restrictions, season limitations fees, etc. Clearly, these regulatory techniques entail transaction costs and infringe on the economic 'freedom' of the participants.

Furthermore, the extent to which the benefits from restricted resource use at the harvesting level are passed on to consumer depends on the market structure of the processors and other intermediaries. Some of the problems associated with management policies aimed at the harvesting sector may be avoided and/or the magnitudes of the costs reduced by developing regulatory schemes that operate on the derived demand of the harvesting sector. This paper focuses, in part, on analyzing management schemes directed at the processors as a potential means of regulating the exploitation of this fishery.

A second focus of this paper is on the transboundary characteristic of the resource stock. National management schemes designed to foster sole ownership within each country will not succeed in achieving optimal utilization rates. Furthermore, the transboundary nature of the resource often hinders development of effective institutional frameworks for management and conservation.

In analyzing management schemes for transboundary renewable resources, consideration is given to the impacts of changes in harvest rates on future stocks (biological externalities) which in turn affect future supplies, and the price/quantity impacts on the product markets of trade among the harvesting countries. The theoretical constructs applicable to developing optimal utilization rates for transboundary resources are similar to those used in production economics and demand analysis. The biological externalities and common property characteristics further constrain the model and are reflected in the qualitative properties. For example, the marginal conditions for optimality in production require equality between marginal net revenues and marginal user costs, taking into account both the social and private costs of production and resource use. The marginal conditions for use of transboundary renewable resources are composed of both spatial (across individuals and countries) and time dimensions.

The overall objective of this paper is to provide a framework capable of assessing the economic and biological consequences associated with alternative policies for transboundary renewable resources.

We wish to acknowledge funding support from the National Marine Fisheries Service and Sea Grant Office.

From this framework are obtained both the quantitative and the qualitative conditions characterizing an optimal utilization path of the resource stock under the economic conditions stated above.

The specific objectives, as they relate to the empirical portion of the analysis, are:

(1) to construct a bioeconomic model which reflects the bilateral (U.S. and Canadian) interdependence for utilizing the North Pacific halibut resources; and

(2) using the results of the bioeconomic model, to determine and compare the quantities harvested and sold in the U.S. and Canada, and the relative market prices, under various policy alternatives and institutional arrangements.

The paper proceeds as follows: The specification of the biological and economic components of the policy model are discussed in Section II along with the qualitative properties of the model. Estimates of the parameters of the monopoly/monopsony model are given in Section III. A discussion of the implications of the results for fishery management policies is provided in the final section.

II. Theoretical Framework

The basis for developing the model described in this section is the premise that the benefits that should theoretically result from an optimal harvesting scheme for renewable resources may not be forthcoming to final consumers due to noncompetitive elements. The processor allocation model developed in this paper is a deterministic optimal control model consisting of a set of difference equations representing the "system" (the halibut industry) that is being controlled, a set of constraints and terminal conditions imposed on the variables of the system, and an objective function which quantitatively measures the performance of the model.

For the North Pacific halibut industry, the preliminary investigations into market structures indicate that imperfect competition occurs on the selling side of the product market and on the buying side of the factor market in both the U.S. and Canada. Therefore, the two submodels which comprise the processor allocation model are cast in a monopoly/monopsony mode.

The processor's problem is to maximize net returns from sales of the resource product over his entire planning horizon, subject to a downward sloping market demand and a supply constraint on the resource inputs. Since the processor is a monopolist he can choose the quantity to place on the market in period t (or alternatively, at what price to sell his output); and since he is also a monopsonist, he can decide what exvessel price to offer fishermen and at what rate to deplete the resource stock. If the processor knows the supply response functions of the fishermen, selecting an exvessel price is equivalent to selecting the quantity of fish he wants to purchase from the harvesters. On the product side, the processor is determining the optimal pricing over time, or alternatively, the optimal allocation between inventories and current sales.

The fishermen's control variables are the quantities of raw fish to sell to the processor in both countries. The solution to the fishermen's problem will be in terms of harvest rates as a function of the exvessel prices. The processors' control variables are the exvessel prices to offer fishermen and the quantities to place on the wholesale market in the current period. Control over the quantity of fish harvested can be exercised through the market mechanism.

Processor allocation model

The behavioral interactions for the monopsony/monopoly processor model are schematically represented in Figure 1. The exvessel supply responses (1A) and the wholesale demand relations (1B and 1C) are needed information for empirically implementing this model.

The processor allocation model used in the empirical application is comprised of submodels for the two countries. These submodels are interdependent with respect to supply responses of the fishermen in each country and with respect to the trade flows and market demands for the final products. The objective function reflects the joint maximization of net revenues to processors in both countries. The marginal conditions reflect the impact on the welfare to both countries of an exogenous change in either country's control variables.

The landings supplied to the U.S. and Canadian processors are determined by the relative exvessel prices offered by each processor, the level of the stock, and the costs involved in traveling to different ports. The level of processors' demand for raw fish is influenced by demand determinants for the final product and the processing and freezing costs.

On the product side, the total supply of halibut products consists of current production and holdover inventories. The levels of current production are determined by the sales of raw fish at the harvesting level. Given the available supply, the processor must then allocate this quantity between sales in the current period and sales in the next period.

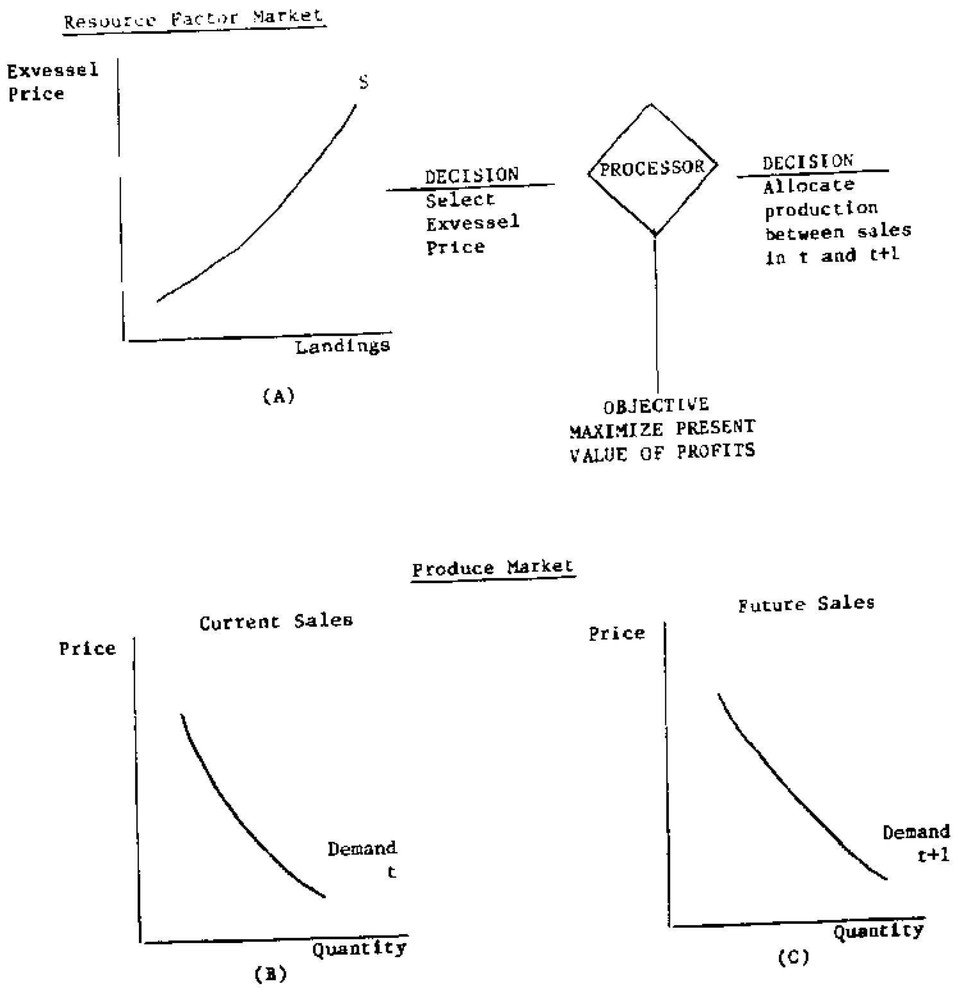

Figure 1. Allocation Decisions by a Monopsonistic/Monopolistic Processor

Inventory accumulation decisions for halibut products are important. Under open-access harvesting conditions, a competitive processor is uncertain as to the availability of fish to him in future time periods and therefore holds inventories of frozen fish products. A competitive processor would be unwilling to forego, entirely, purchases of raw fish which may not be consumed in the current period since his conservation efforts will be counteracted by other processors. In contrast, a monopsonistic processor has the choice of maintaining a supply of raw fish in the ocean, where it will grow over time, or in the freezer. His decision depends on the costs involved in the freezing operations and the costs associated with not having immediate access to products to fulfill unexpected changes in demand. These decisions are reflected in the marginal conditions for the optimization model.

In summary, the U.S. and Canadian processors are faced with the problem of simultaneously equating demand and supply in two markets--the exvessel or factor market and the wholesale/retail market. Processors need to offer an exvessel price so that the resulting quantities supplied by the fishermen fulfill the level of current sales and the level of inventories which maximize the processors' profits over time.

III. Empirical Analysis

The optimal control model is comprised of a set of wholesale demand relations, a set of fishermen's supply functions, a set of biological relations to describe the dynamics of the biomass, and a criterion function.

Since the available information on halibut consumption is insufficient for estimating retail demand functions, consumer preferences are assumed to be reflected in the derived demands facing the processors. Two assumptions are made with regards to the wholesale demand specifications. First, wholesalers do not significantly change the level of their inventories between periods. The quantity sold by processors in period t is approximately equal to the quantity purchased by consumers in period t. Second, competitive conditions exist at the wholesale and retail levels in both countries. The wholesale-retail margins reflect handling costs and not increased profits.

The U.S. retail demand is satisfied by U.S. processed halibut and exports from Canada; therefore both quantities enter directly into the U.S. processors' derived demand function. Canadian retail demand is met by Canadian production only.[1]

The derived demand facing U.S. and Canadian processors are specified in price dependent form as:

$$P_t^{Wu} = f_u(Q_t^{uu}, Q_t^{cu}, Y_t^u, Z_t^{Du}, w_t^u)$$

$$P_t^{Wc} = f_c(Q_t^{cc}, Y_t^c, Z_t^{Dc}, w_t^c)$$

where: P_t^{Wi} = wholesale price in country i, i = u, c

Q_t = quantity consumed in country i and processed in country j)

Y_t^i = consumer income in country i

Z_t^{Di} = exogenous demand determinants (retail level)

W_t^i = exogenous factors (wholesale level)

The fishermen's supply response functions are assumed to be based on profit maximizing behavior. These functions are not derived from a specific profit function, but are ad hoc specifications which reflect the theoretical properties of supply functions. Two underlying determinants of the supply responses are noted: the biomass effect, and the effects of the relative exvessel prices offered by U.S. and Canadian processors on the allocation of landings. Landings per unit of effort in any given period are variable. If effort levels are constant, the variability in landings is due primarily to variations in the size of the biomass. As the biomass increases, landings per unit of effort also increase; alternatively, to harvest a given quantity of fish, the amount of effort required is inversely related to the biomass level.

The delay-difference (D-D) model developed by Deriso (1981) is the basis for the biological component of the model. It features the mathematical simplicity of traditional stock-production models and the age-structure model for the halibut fishery, providing a model that can be used with limited data.

A D-D model applied to the halibut fishery can be specified as

$$B_{t+1} = (1+\rho)\ell S_t - \rho\ell^2\left(\frac{S_t}{B_t}\right)S_{t-1} + FB(S_{t+1-k})$$

where B_t = biomass of adult stock in year t;

S_t = the difference between the biomass of adult halibut and the setline catch, $B_t - C_t$;

C_t = setline catch of halibut;

ρ = biomass growth coefficient; $\rho \geq 0$. No units;

ℓ = annual natural survival fraction;

$FB(\cdot)$ = biomass of k year old progeny.

The base model criterion function is specified in terms of maximizing the present value of net returns to the U.S. and the Canadian processing sectors over the entire horizon. Net returns are defined as the difference between gross revenues and total costs. The level of returns to the U.S. processor is affected by the quantity of halibut exported from Canada to the U.S. Likewise, the value of Canadian exports are affected by the quantity placed on the U.S. market by the U.S. processing sector.

A summary of the model specification in functional form is given in Table 1.[2] Straightforward and analytical procedures of solving for the linear control rules would be applicable if the processor allocation model conformed to a linear quadratic specification. However, it is difficult to obtain an analytical understanding of the dynamics of the optimal policy when dealing with nonlinear models and nonquadratic criterion functions. The optimal control path cannot be stated as functions of the observed economic variables. Chow (1976, Chapter 12) discusses the feedback form of the solution to nonlinear deterministic systems. The implementability of this procedure depends on the degree of nonlinearity and the overall dimensions of the model.

A second approach is to solve the control problem numerically. Under an open-loop structure, the algorithm solves for all of the control vectors for all time periods, $u_1 \ldots u_T$, in each iteration. In essence, the method employed to solve the processor allocation model is an open-loop procedure; it first provides a linear approximation to the nonlinear model and then applies a gradient method for maximizing the criterion function. The numerical algorithm which is utilized in this research is MINOS/AUGMENTED.[3]

3.1 Wholesale Demand and Fishermen's Supply Functions

The wholesale demand and input supply relations, and the inventory identities can be initially considered as a system of equations which describe the halibut industry. Given the evidence that the halibut markets are not perfectly competitive, the product demand equations and the fishermen's supply responses constitute separate blocks in the system.

Since those equations need to be incorporated into the processor allocation model, it is important that the relationships are specified as succinctly as possible, but still retain desirable properties. Thus in the regression estimates that follow, the exogenous demand shifters relating to (Z_t^{Dc}, W_t^u, Z_t^{Du}, and W_t^c) have been omitted from the specifications. In general, this omission will result in biased estimates.

A second modification concerns the separation of the Canadian and U.S. quantity variables. Because of a strong collinearity between these two variables only the quantity which, a priori, has a negative effect on price is included. For any given Canadian production level, Q_t^{cc} has an inverse relationship to wholesale prices in Canada, while the quantity exported to the United States, Q_t^{cu}, should have a direct effect on wholesale prices in Canada. The Canadian derived demand function includes Q^{cc} in the specification but not Q_t^{cu}. For the United States, Q_t^{uu} and Q_t^{cu} are included in the demand specification.

Two specifications of derived demand relations were postulated. In the first specification, price in each country is a function of the quantity sold on the respective markets and the personal disposable income, while the second specification excludes the income variable from each relationship. Three indicators favored using the second specification, stronger t-statistics, no sizable difference in the standard errors and the absence of conclusive evidence of serial correlation. The results shown in Table 2 are utilized in the remainder of this study. Own-price elasticities calculated at the mean prices and quantities and at the 1976 prices and quantities, are reported in Table 3.

For both countries, the derived demands are price elastic when evaluated at the mean values and at the 1976 values, with the elasticities increasing almost threefold in 1976 from the values calculated at the means due to limited supplies. These elasticities are theoretically consistent: namely that a profit maximizing monopolist produces in the elastic region of the demand curve.

An initial examination of the exvessel price data revealed a high correlation between the exvessel prices offered by U.S. and Canadian processors. When the supply response equations were estimated using both the U.S. and Canadian exvessel prices, there were inconsistent signs and low t-statistics on the

Table 1

Summary of the Model Specification

Criterion Function:

$$\text{Max } N = \sum_t d_t \Big\{ Q_t^{uu} f_u(Q_t^{uu}, Q_t^{cu}, Y_t^u, Z_t^{Du}, W_t^u) + Q_t^{cc} f_c(Q_t^{cc}, Y_t^c, Z_t^{Dc}, W_t^c) + Q_t^{cu} f_u(Q_t^{uu}, Q_t^{cu}, Y_t^u, Z_t^{Du}, W_t^u) - Q_t^{uu}[a_t^u + r_t^u] - I_t^u m_t^u$$

$$- \phi P_t^u [g^{uu}(P_t^u, P_t^c, X_{t-1}^{uu}, B_t) + g^{cu}(P_t^u, P_t^c, X_{t-1}^{cu}, B_t)] - Q_t^{cc} a_t^c - Q_t^{cu}[a_t^c + r_t^c + t_t^{cu}] - I_t^c m_t^c$$

$$- \phi P_t^c [g^{cc}(P_t^u, P_t^c, X_{t-1}^{cc}, B_t) + g^{uc}(P_t^c, X_{t-1}^{uc}, B_t)]\Big\}$$

Subject to:

Biological Growth and Recruitment:

$$B_t = (1+\rho)\ell\,(B_{t-1} - C_{t-1}) - \rho\ell^2 \frac{(B_{t-1} - C_{t-1})(B_{t-2} - C_{t-2})}{B_{t-1}} + F_a(B_{t-6} - C_{t-6})$$

Fishermen's Supply Response:

$X_t^{uu} = g^{uu}(P_t^u, P_t^c, B_t)$

$X_t^{uc} = g^{uc}(P_t^u, P_t^c, B_t)$

$X_t^{cc} = g^{cc}(P_t^u, P_t^c, B_t)$

$X_t^{cu} = g^{cu}(P_t^u, P_t^c, B_t)$

Inventory Identities:

$I_t^u = I_{t-1}^u + \phi X_t^{uu} + \phi X_t^{cu} - Q_t^{uu}$

$I_t^c = I_{t-1}^c + \phi X_t^{cc} + \phi X_t^{uc} - Q_t^{cc} - Q_t^{cu}$

Identity for Total Catch:

$C_t = X_t^{uu} + X_t^{uc} + X_t^{cc} + X_t^{cu}$

and all variables are ≥ 0.

State Variables: B_t, X_t^{uu}, X_t^{uc}, X_t^{cc}, X_t^{cu}, I_t^u, I_t^c

Control Variables: P_t^u, P_t^c, Q_t^{uu}, Q_t^{cc}, Q_t^{cu}

Exogenous Variables: Y_t^u, Y_t^c, Z_t^{Du}, Z_t^{Dc}, W_t^u, W_t^c

Parameters: r_t^u, r_t^c, a_t^u, a_t^c, m_t^u, m_t^c, t_t^{cu}

Variable Definition

- N: discounted net revenues over planning horizon;
- d_t: discount factor;
- Q_t^{ij}: quantity sold by the processors in country i on the market in country j. i, j=United States (u), Canada (c);
- X_t^{ij}: quantity supplied by fishermen in country i to processors in country j;
- f_j: Wholesale derived demand in market j;
- Y_t^j: personal income in market j;
- Z_t^{Dj}: exogenous demand shifters (retail level) other than personal income;
- W_t^j: exogenous factors influencing demand at the wholesale level;
- a_t^i: processing costs per unit for processors in country i;
- r_t^i: transfer costs from i to the U.S. market;
- m_t^i: holding costs for processors in country i;
- ϕ: conversion factor from exvessel to wholesale poundage
- I_t^i: end-of-period holdings by processors in country i;
- P_t^i: exvessel price offered by processors in country i;
- B_t: biomass;
- t^{ij}: ad valorum duties, or tariffs, for products traded from i to j;
- C_t: setline catch;
- ρ: biological growth coefficient;
- ℓ: annual natural survival function.

Table 2. Derived Demand Equations: Wholesale Price as a Function of Wholesale Quantities, 1960-1977[a]
Estimation Technique: Seemingly Unrelated Regressions

Country	Dependent Variable	Constant	Quantity[b] U.S.	Quantity[b] Canada	Summary Statistics: Number of Observations	Summary Statistics: Standard Error of Equation	Summary Statistics: Durbin-Watson Statistic[c]
United States	$W_u P_t$	1.49 (12.63)	-.125 (-5.47)		18	.186	1.65
Canada	$W_c P_t$	.917 (15.39)		-.177 (-3.79)	18	.127	1.66

[a]t-values are shown in parentheses.

[b]The quantity variable for the U.S. corresponds to $(Q_t^{uu} + Q_t^{cu})$; the quantity variable for Canada corresponds to Q_t^{cc}.

[c]The Durbin-Watson statistic is computed from the OLS residuals.

Table 3. Own-Price Elasticity of Demand

	Using Mean Values	Using 1976 Values
United States	-1.48	- 4.89
Canada	-3.72	-10.57

parameter estimates for prices, concurrent with significant value of the F-statistic. This suggests that the separate influence of each price on the quantity supplied is weak, relative to the joint influence of prices.[4] Since increasing the size of the sample is impossible, only one of the price variables is included in each equation. In this regard we are committing a specification error by omitting a relevant variable, thereby biasing the estimates. However, the bias which may be introduced by specification errors is less serious than having inconsistent signs for the price coefficients and being unable to disentangle the effects of the U.S. and Canadian exvessel prices on the quantities supplied.

Two considerations are important in specifying the functional relationship. First, an increase in biomass should, ceteris paribus, shift the supply curve $(Q = f(p))$ to the left, since the marginal cost of catching a given quantity of fish is lower at higher biomass levels. Furthermore, for any given price, the rate of increase in the quantity harvested should be decreasing as biomass increases.

The second consideration concerns the effect of the exvessel price on the quantity supplied. Holding the biomass level constant, one would expect a direct relationship, with a positively sloped supply curve. But crowding externalities and marginally increasing costs of effort modify the supply response. To reflect these two considerations, the exvessel prices and the biomass variables enter nonlinearly in the input supply equations, $(P_t^u)^{\alpha_1}$ and $(B_t)^{\alpha_2}$:

$$X_t^{uu} = a_1(P_t^u)^{\alpha_1} + b_1(P_t^u)^{\alpha_1}(B_t)^{\alpha_2} + e_t^{uu}$$

$$X_t^{uc} = a_2(P_t^c)^{\alpha_1} + b_2(P_t^c)^{\alpha_1}(B_t)^{\alpha_2} + e_t^{uc}$$

$$X_t^{cc} = a_3(P_t^c)^{\alpha_1} + b_3(P_t^c)^{\alpha_1}(B_t)^{\alpha_2} + e_t^{cc}$$

$$X_t^{cu} = a_4(P_t^u)^{\alpha_1} + b_4(P_t^u)^{\alpha_1}(B_t)^{\alpha_2} + e_t^{cu}$$

where α_1, α_2 are between 0 and 1. And the error terms, are contemporaneously correlated.

This specification has two important characteristics. First, the price elasticity of supply is constant and equal to α_1. Secondly, in response to change in biomass level the supply curve does not shift in a parallel manner. At higher prices, a given biomass increase has a larger absolute effect on the quantities supplied than at the lower price levels.

Econometric Results. The values of α_1 and α_2 need to be determined before supply equations can be estimated using a two-stage estimation procedure. For each equation, the results from an ordinary least squares estimating procedure, for various values of α_1 and α_2 were compared. The best overall fit obtained for the four input supply responses was obtained when α_1 and α_2 were both equal to 0.5.

The input supply equations are estimated utilizing Zellner's method for seemingly unrelated equations because of the contemporaneous correlation of the error terms across the supply equations. The results of the input supply estimates, assuming that $\alpha_1 = \alpha_2 = 0.5$, are provided in Table 4.

The parameter estimates for both the price and the "price times biomass" variables are significant at the 1 percent level, and there is no indication of autocorrelation problems.

In the first equation, the quantity supplied by the U.S. fishermen to the U.S. processors, X_t^{uu}, is positively related to the exvessel price offered by the U.S. processors for biomass levels greater than 30.59 million pounds (MP). Biomass has a positive effect on the quantity supplied, although the magnitude of this effect is a direct function of the price level. The relative magnitudes of the impacts of these two variables in the current time period are:

$$\frac{\partial X_t^{uu}}{\partial P_t^u} = \frac{(3.560\sqrt{B_t} - 19.364)}{2\sqrt{P_t^u}} \quad \begin{matrix} > 0 \text{ for } B_t > 30.59 \\ \leq 0 \text{ for } B_t \leq 30.59 \end{matrix}$$

$$\frac{\partial X_t^{uu}}{\partial B_t} = \frac{(3.560\sqrt{P_t^u})}{2\sqrt{B_t}} > 0$$

As evident from the equations above, each impact depends on the level of biomass and the exvessel price.

The price elasticity of supply, ϵ_s^{uu}, is inelastic and constant (.50) at all combinations of price and biomass.

The elasticity of supply with respect to a change in biomass, ϵ_B^{uu}, exceeds 1.0 at all relevant price/biomass combinations (Table 5). It is interesting to note that at any given biomass level, ϵ_B^{uu} increases as the exvessel price increases. The responsiveness of X_t^{uu} to changes in the biomass levels and in the exvessel prices at various price/biomass combinations becomes crucial to understanding the short-term and long-term policy implications of various management schemes.

For the Canadian supply equations, the patterns of responses are similar to those exhibited by the quantity supplied by U.S. fishermen to U.S. processors. The econometric results indicate that the exvessel price offered is positively impacting X_t^{cc} and X_t^{cu} at biomass levels in excess of 34.49 MP, respectively.

The price elasticities of supply are inelastic and constant for both X_t^{cc} and X_t^{cu} at all price/biomass combinations. Furthermore, the elasticities of supply with respect to biomass changes are elastic. At high biomass levels (50.0 MP) the degree of elasticity also decreases.

In comparing the four input supply responses, the elasticities of supply with respect to changes in the biomass level are highly elastic, especially at biomass levels in the neighborhood of 40.0 MP. Of the four relationships, X_t^{uc} is most responsive to a change in biomass, and X_t^{uu} is the least responsive.

Table 4

Input Supply Equations: Quantity Harvested Related to Exvessel Price and Biomass Level, 1970-1977[a]

Estimation Technique: Seemingly Unrelated Regressions for Nonlinear Equations

Dependent Variable	Independent Variables: Price offered by U.S. processors $\sqrt{pu_t}$	Price offered by Canadian processors $\sqrt{pc_t}$	Price, Biomass Cross-Term $\sqrt{pu_t}$	$\sqrt{B_t}$	Summary Statistics: Number of Observations	Standard error of the equation	Durbin-Watson Statistics[b]
X_t^{uu}	-19.364 (-5.92)		3.560 (6.79)		8	.153	1.36
X_t^{uc}		-4.264 (-10.73)		.699 (10.98)	8	.018	1.56
X_t^{cc}		-28.896 (-9.14)		4.920 (9.71)	8	.148	2.14
X_t^{cu}	-18.250 (3.06)		3.056 (9.24)		8	.096	2.24

[a]Asymptotic t-statistics are shown in parentheses.
[b]The Durbin-Watson statistic is computed from the OLS residuals.

Table 5

Elasticities of Supply with Respect to Changes in Biomass, ϵ_B, at Selected Prices and Biomass Levels[a]

Price/Biomass Level	ϵ_B^{uu}	ϵ_B^{uc}	ϵ_B^{cc}	ϵ_B^{cu}
	Biomass Elasticities of Supply			
$.40/40.0 MP[b]	3.39	14.69	7.07	9.03
$.40/50.0 MP	2.17	3.67	2.95	3.23
$.50/40.0 MP	3.58	14.87	7.09	9.14
$.50/50.0 MP	2.18	3.68	2.96	3.23

[a]based on the following formulas:

$$\epsilon_B^{uu} = \frac{3.560\sqrt{P_t^u}\sqrt{B_t}}{2X_t^{uu}} \qquad \epsilon_B^{cc} = \frac{4.920\sqrt{P_t^c}\sqrt{B_t}}{2X_t^{cc}}$$

$$\epsilon_B^{uc} = \frac{.699\sqrt{P_t^c}\sqrt{B_t}}{2X_t^{uc}} \qquad \epsilon_B^{cu} = \frac{3.056\sqrt{P_t^u}\sqrt{B_t}}{2X_t^{cu}}$$

[b]Million pounds.

3.2 Growth/Recruitment Relation

The statistical estimation for the biological growth and recruitment relation was done by Deriso (1981). His results which are restated in Table 6 are based on the following equation:

$$B_{t+1} = 2 \cdot (\ell)(B_t - C_t) - (\ell^2)\frac{(B_t - C_t)}{B_t}(B_{t-1} - C_{t-1}) + (m)(\alpha)(\ell)(B_{t-5} - C_{t-5}) + \mu_t$$

where ℓ = annual natural survival fraction;
m = survival coefficient used as proxy for the affect of incidental catches;
α = transformed spawner-recruitment parameter;

and all the variables are as defined previously.

Table 6. Estimates for the Biological Growth and Recruitment Relations, for the Period 1929-1979

Parameter	Parameter Estimate	Standard Deviation
ℓ	0.833	0.023
m	.645	0.016
α	.105	0.031

Source: Deriso (1981), Table 2.

3.3 Processor Allocation Control Model

In this section the demand, supply, and growth relations are imbedded into the processor allocation control model to yield the optimal utilization rates for this resource when the processing sector is characterized by a monopsony/monopoly. This scenario is referred to as the Base Model. Errors due to misspecification of the Base Model, serial correlation, or other statistical problems in the regression estimations are carried over into the control model. Even more importantly, however, is the extension of the regression results beyond the range of data observations. A positive relationship between exvessel price and quantity supplied is also contingent upon the level of biomass exceeding a critical lower bound. Furthermore, at low exvessel prices for halibut, fishermen may divert their efforts to other species. Since the specifications utilized in this study do not account for these "unknown reactions," or structural shifts, bounds on the state and control variables are defined.

For global optimality, the necessary and sufficient conditions must hold over the entire domain for a solution to exist. The Lagrangian must be concave in both the states and controls; the constraints are linear in the states and controls; and the equations of motion are either concave or convex in the states and controls, and have non-zero costates.

The sufficient conditions for a global optimum are often violated when dealing with empirically-estimated objective functions. By restricting the constraint set to lie in a certain subspace in the domain, the objective function may be concave over that given region; and thus a global optimum obtained relative to the restricted subspace. When the processor allocation model was estimated without restrictions placed on the states and controls the model converged to a locally optimum stationary point.

The parameter estimates used in the Base Model are presented in Table 7. The sensitivity of the results of the Base Model to change in costs and tariffs is discussed in Capalbo (1982).

A time horizon of ten years is chosen to allow the effects of the dynamics of the bioeconomic model to be evident. As noted earlier, as the model horizon extends beyond the data period the likelihood that structural changes will alter the regression coefficients increases. Furthermore, since the processor allocation model is not updated during the solution algorithm, the value of projecting a 20- or 30- year policy without some feedback is questionable.

The controls are the exvessel prices and the wholesale quantities that maximize the discounted rents to the processing sectors. The optimal values of the control variables and the state variables in the final solution for the Base Model are presented in Table 8.

The exvessel prices, P_t^U and P_t^C, are set at the lower of \$.22 per pound. The optimal strategy for the processors, as determined by the model, is to buy the smallest quantity of landings that the model permits, thus allowing the biomass level to increase. At larger biomass levels, the fishermen are willing to supply larger quantities of fish at a given price. Because of the relative magnitudes of the effects on the quantity supplied associated with increases in prices and biomass levels, this behavior is

Table 7

Summary of the Parameter Values for the Base Model

Item	
Derived Demand Parameters (Source: Table 5.2)	**Regression Coefficients**
Price intercept, U.S. demand	1.49
Price intercept, Canadian demand	.917
Quantity coefficient, U.S. demand	- .125
Quantity coefficient, Canadian demand	- .177
Input Supply Parameters (Source: Table 5.3)	
Price coefficient for X_t^{uu}	-19.364
Price-biomass coefficient for X_t^{uu}	3.560
Price coefficient for X_t^{uc}	- 4.264
Price-biomass coefficient for X_t^{uc}	0.699
Price coefficient for X_t^{cc}	-28.896
Price-biomass coefficient for X_t^{cc}	4.920
Price coefficient for X_t^{cu}	-18.250
Price-biomass coefficient for X_t^{cu}	3.056
Biological Parameters (Source: Table 5.5)	**Parameters**
Annual natural survival parameter	0.833
Survival coefficient for incidental catches	0.645
Transformed spawner-recruitment parameter	0.105
Other Parameters	**Dollars Per Pound, Dressed Weight**
Processing costs, U.S.	0.12
Processing costs, Canada	0.12
Inventory holding costs, U.S.	0.10
Inventory holding costs, Canada	0.10
Transportation costs from processing facilities to Eastern United States and Canada	0.15
Tariffs on U.S. imports	0.00
Discount Rate, per annum	3.5

Table 8

Results for the Base Model with Exvessel Price Constrained to be $\geq$ \$.22

Time Period	State Variables							
	B_t	X_t^{uu}	X_t^{uc}	X_t^{cc}	X_t^{cu}	C_t	I_t^{u}	I_t^{c}
	million pounds							
1	37.276	1.114	0.006	0.534	0.203	1.858	0.000	0.000
2	38.098	1.226	0.028	0.638	0.299	2.242	0.000	0.000
3	38.664	1.303	0.043	0.795	0.365	2.506	0.000	0.000
4	38.934	1.338	0.051	0.844	0.396	2.628	0.000	0.000
5	39.091	1.359	0.054	0.872	0.413	2.700	0.000	0.000
6	39.142	1.366	0.056	0.882	0.419	2.724	0.000	0.000
7	39.177	1.370	0.056	0.889	0.424	2.740	0.000	0.000
8	39.224	1.377	0.058	0.897	0.429	2.762	0.000	0.000
9	39.283	1.385	0.059	0.908	0.436	2.789	0.000	0.000
10	39.343	1.393	0.061	0.919	0.442	2.816	0.000	0.000

Time Period	Control Variables							Shadow Prices						
	Q_t^{uu}	Q_t^{cc}	Q_t^{cu}	P_t^{u}	P_t^{c}	WP_t^{u}	WP_t^{c}	B_t (ρ_1)	X_t^{uu} (ρ_2)	X_t^{uc} (ρ_3)	X_t^{cc} (ρ_4)	X_t^{cu} (ρ_5)	I_t^{u} (ρ_6)	I_t^{c} (ρ_7)
	dollars per pounds													
1	1.647	0.355	0.255	0.220	0.220	1.252	0.854	0.169	0.523	0.523	0.523	0.523	0.547	0.547
2	1.525	0.349	0.368	0.220	0.220	1.253	0.855	0.866	0.170	0.170	0.170	0.170	0.529	0.523
3	1.667	0.457	0.381	0.220	0.220	1.234	0.836	0.765	0.156	0.156	0.156	0.156	0.476	0.476
4	1.734	0.508	0.386	0.220	0.220	1.225	0.827	0.678	0.159	0.159	0.159	0.159	0.444	0.444
5	1.773	0.537	0.390	0.220	0.220	1.219	0.822	0.593	0.167	0.167	0.167	0.167	0.420	0.420
6	1.785	0.547	0.391	0.220	0.220	1.218	0.820	0.507	0.179	0.179	0.179	0.179	0.402	0.402
7	1.794	0.553	0.392	0.220	0.220	1.217	0.819	0.411	0.199	0.199	0.199	0.199	0.386	0.386
8	1.805	0.562	0.393	0.220	0.220	1.215	0.817	0.306	0.226	0.226	0.226	0.226	0.370	0.370
9	1.821	0.573	0.394	0.220	0.220	1.213	0.815	0.194	0.267	0.267	0.267	0.267	0.355	0.355
10	1.835	0.585	0.395	0.220	0.220	1.211	0.813	0.086	0.339	0.339	0.339	0.339	0.339	0.339

rational. The benefits of restricting catch in period 1 is manifested through the larger levels of biomass made available in later periods, and the subsequently larger catches for the same exvessel price of \$.22 offered by the Canadian and U.S. processing sectors. The sum of the discounted processors' net returns are increased by foregoing production in the early periods. The exvessel prices in the final periods do not exceed the established lower limit on price. This implies that at the end of a ten-period horizon, the exvessel prices which equate the marginal revenue and the marginal input supply curves are still below \$.22 per pound. If the number of time periods were to be extended, it is anticipated that the prices in the final periods would eventually exceed the lower price bounds.

On the product side, the optimal time path for inventories is zero.[5] The initial level of hold-over inventories at the onset of the model, are immediately reduced to zero, implying that it is more costly to keep fish in the freezer than to hold them off-shore for future harvests.

Domestic utilization levels and exports from Canada to the U.S. are at positive levels for all time periods. Canadian processors sell approximately fifty percent of their production to domestic buyers, and export the remainder to the U.S. The time paths for the wholesale prices in the U.S. and Canada are also reported in Table 8. The price elasticity of demand exceeds 1.0 and the marginal revenue of sales in the U.S. is equal to the marginal revenue of sales in Canada, in each period.[6]

The values for the costates (or shadow prices) corresponding to the state variables for the Base Model are also reported in Table 8. The shadow price of biomass, ρ_1, measures the marginal value of the biomass constraint. The costate for biomass decreases over time as one would expect since later changes in biomass levels are less crucial to the system. The costates on the exvessel quantities supplied, $\rho_2(t)$ through $\rho_5(t)$, are equivalent in each period and increasing over time. The marginal valuations of the holdover inventories, $\rho_6(t)$ and $\rho_7(t)$, are also equivalent in each period, but have a decreasing value over time.

The impacts of exogenous changes in the processors' control variables can be traced through the model via the first order conditions for the Lagrangian formulation. In general, exvessel price changes will affect quantities supplied in the same period, as well as the quantities supplied in the future via the biomass growth/recruitment relation. Changes in the quantities processed affect the level of inventories and also the amount of raw product demanded by processors. Changes in the derived demand for fish may initiate a change in the exvessel prices offered to fishermen and thus set off the chain of effects involving exvessel prices.

3.4 Implications of the Empirical Results

Given the behavioral and biological assumptions, the results reported in this section are the optimal time paths for the state and control variables. Based on the results the following properties of the processor allocation model can be deduced. First the current biomass is low. The biomass increases as catch levels are reduced, and these higher biomass levels support larger sustained yields from this fishery. Within the context of the processor allocation model, the optimal paths for the states and the controls indicate that fishing levels and catches should be reduced to the lowest level. All results such as the quantities processed and sold, are determined so as to maximize processor returns, but always under the overriding goal to rebuild the biomass levels.

Second, the solution to the Base Model is not an interior solution. Since the supply responses and the demand functions are estimated over a given price/quantity range, it seems reasonable to restrict the model to operate within these ranges. There is no reason to believe that the estimated supply functions and demand relations would lead to global optimal solutions. Furthermore, the Base Model is unable to reach an equilibrium state in ten time periods primarily because of the biological growth relations. If the time horizon was extended, the system may reach an equilibrium state, although this is conditional upon the equations of motion for the state variables being robust enough to capture the steady-state conditions.

Finally, the results for the Base Model may be generalized to other fisheries also in disequilibrium. To only consider static relations for economic supply and demand, without incorporating the dynamic biological relationships into the input supply functions, is likely to yield misleading information to policy-makers.

Instability of the model was indicated by some of the eigen vectors of a linearization of the differential system around some specified points. However, the instabilities in the system may be controlled via the policy or control instruments. Since exvessel prices are one of our controls, it appears that lowering the exvessel prices may be a means for controlling the system. However, lower biomass levels are also associated with more stable conditions. In the processor-allocation model, lower exvessel prices, in effect, imply larger biomass levels. These observed effects of exvessel price and biomass levels on the stability of the differential system are evident in the results of the alternative policy scenarios. The formal tests for complete controllability and conditional controllability are satisfied.

IV. Summary and Conclusions

Biomass externalities and the transboundary nature of the resource stock have intensified the management conflicts in the North Pacific halibut industry. National management schemes that are designed to foster sole national ownership of the resource are unlikely to succeed in achieving optimal utilization rates. This study has explicitly considered the effects of harvest rates on future biomass levels and consequent shifts in the supply responses of the fishermen.

The primary objective of this study has been to provide a framework capable of assessing the economic and biological consequences associated with alternative policies for transboundary renewable resources. This objective has been successfully met by developing a theoretical bioeconomic model for the halibut industry, estimating this model, and then utilizing the estimates for policy analysis. More specifically, two segments of a dynamic system for the halibut industry were constructed and econometrically estimated. The first segment dealt with the fishermen's supply response functions. To capture the dynamics of the fisheries, the quantity supplied by the fishermen in the U.S. and Canada was related to both the exvessel prices and the biomass level. As the biomass level changed the marginal cost of catching a unit of fish also changed, and thus caused shifts in the fishermen's supply response behavior. Both the exvessel prices offered by processors in the U.S. and Canada and the biomass level are shown to be related in a nonlinear manner to the quantity supplied.

A second segment of the dynamic system dealing with the interdependence in the U.S. and Canadian product markets for halibut was also developed and estimated. The U.S. demand for halibut products is met by U.S. production and Canadian exports. The processing sectors in the two countries are depicted as imperfectly competitive. Each has a degree of market power over the quantity and prices at the exvessel and the wholesale levels. However, because of the trading between the two countries and because of the biomass externalities, the decisions by one sector to raise or lower prices, simultaneously affects the user groups in both countries.

A third segment of the dynamic system, the biological growth and recruitment relations of halibut, has also been discussed. The parameter estimates were obtained from a recent analysis by Deriso (1981). These three segments comprise the underlying dynamic system for the U.S. and Canadian halibut industry.

To assess the implications of alternative policy options, a nonlinear control model is developed. This model is based on the assumption that the processors are imperfectly competitive and the criterion function is in terms of maximizing net returns over time to the processing sectors. The necessary conditions for an optimal solution reflect both the direct and indirect impacts on the processors and fishermen. These impacts are due to the economic efficiency criteria of equating marginal revenues and marginal costs and to the biomass stock externalities which have been imbedded in the fishermen's supply responses. Changes in the supply response of fishermen in the U.S. in one period affect both the Canadian fishermen and U.S. fishermen in subsequent periods, as well as consumers and processors.

The results of estimating the nonlinear processor allocation control provide insight into the dynamics of the halibut industry. The preferred strategy from the processors' vantage point is to increase or "rebuild" the biomass levels by offering low exvessel prices to the fishermen. The immediate benefits to the processors, which are foregone in the earlier years because of smaller harvests, are outweighed by the benefits associated with a larger biomass level in the later periods. Again, the benefits from a larger biomass are traced through the shifts in the fishermen's supply responses over time.

Results from the processor allocation model support the concerns by management agencies that the current biomass levels are significantly below the maximum sustainable yield biomass level. It is beneficial to the processors to restrict initial catch levels by offering low exvessel prices, thus permitting growth in the halibut resource. These benefits are quantifiable because the biomass growth and recruitment relations are incorporated into the control model and because the biomass level enters directly into the fishermen's supply responses.

Further implications relate to the existence of imperfect competition at the processing level. That is, if the harvesting sector is fairly competitive but faces oligopsonistic processors, then from a management perspective, it may be easier to manage the fishery through the processing sector. This study has shown that if the processors are "sole owners" of the resource, they will conserve the stocks in a manner similar to regulatory agencies. Thus, the enforcement and regulating costs of imposing restrictions such as limited entry and catch quotas on the fishermen may be minimized in fisheries characterized by an oligopsonistic processing sector.

Footnotes

1. U.S. processed halibut exports to Canada are negligible.

2. A discussion and interpretation of the first order conditions can be found in Capalbo (1982).

3. This algorithm is discussed in detail in Capalbo (1982).

4. It is noted that large variances for the parameter coefficients may exist even without multicollinearity. The explanatory variables may have a small dispersion, or σ^2 may be large. The sample coefficient of correlation is a valid indicator of multicollinearity when there are only two independent variables.

5. Note that the hold-over inventories are annual inventories, carried over from one fishing season to the next, rather than monthly variations in stocks of frozen halibut.

6. The formulas for calculating the marginal revenues in the U.S. and Canada are:

$$MR_t^{US} = 1.49 - .250\,(Q_t^{uu} + Q_t^{cu}) - .12 - .15$$

$$MR_t^{CA} = .917 - .354(Q_t^{cc}) - .12$$

Bibliography

Anderson, L.G. 1975. "Optimum Economic Yield of an Internationally Utilized Common Property Resource," Fishery Bulletin 70:51-66.

Capalbo, S.M. 1982. "Bioeconomic Supply and Imperfect Competition: The Case of the North Pacific Halibut Industry," unpublished Ph.D. dissertation, University of California, Davis.

Chow, G.C. 1976. Analysis and Control of Dynamic Economic Systems, Wiley and Sons, New York.

Clark, C. 1976. Mathematical Bioeconomics: The Optimal Management of Renewable Resources, Wiley and Sons, New York.

Clark, C.W. and G.R. Munro. 1975. "The Economics of Fishing and Modern Capital Theory: A Simplified Approach," JEEM 2:92-106.

Clark, C.W. and G.R. Munro. 1980. "Fisheries and the Processing Sector: Some Implications for Management Policy," The Bell Journal of Economics 11(2).

Crutchfield, J.A. and A. Zellner. 1963. "Economic Aspects of the Pacific Halibut Fishery," U.S. Bureau of Commercial Fisheries, Fishery Industrial Research (1), pp. 1-173.

Crutchfield, J.A. 1980. "Regulations of the Pacific Halibut Fishery," unpublished paper, Institute for Marine Studies, University of Washington, Seattle.

Deriso, R.B. 1981. "Sources of Variability in a Delay-Difference Model: Application to Pacific Halibut," unpublished working paper, International Pacific Halibut Commission.

Gordon, H.S. 1954. "The Economic Theory of a Common Property Resource: The Fishery," Journal of Political Economy 62.

Munro, G.R. 1978. "The Optimal Management of Transboundary Renewable Resources," Resources Paper No. 18, Department of Economics, University of British Columbia.

Murtagh, B.A. and M.A. Saunders. 1976. "Nonlinear Programming for Large, Sparse Systems," Technical Report SOL 76-15, Systems Optimization Laboratory, Department of Operations Research, Stanford University, Stanford, California.

Murtagh, B.A. and M.A. Saunders. 1977. "MINOS, A Large-Scale Nonlinear Programming System (for problems with linear constraints)," User's Guide, Technical Report SOL 77-9, Systems Optimization Laboratory, Department of Operations Research, Stanford University, Stanford, California.

Murtagh, B.A. and M.A. Saunders. 1978. "Large-Scale Linearly Constrained Optimization," Mathematical Programming 14:41-72.

Murtagh, B.A. and M.A. Saunders. 1980. "The Implementation of Lagrangian-Based Algorithm for Sparse Nonlinear Constraints," Technical Report SOL 80-1, Systems Optimization Laboratory, Department of Operations Research, Stanford University, Stanford, California.

Schworm, W. 1983. "Monopsonistic Control of a Common Property Renewable Resource," Canadian Journal of Economics, XVI, No. 2, May.

Zellner, A. 1962. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," JASA 57:348-362.

Commercial Fisheries vs Aquaculture: Conflicts in the Northwest Salmon Fishery

James L. Anderson
Department of Resource Economics
University of Rhode Island
USA

James E. Wilen
Department of Agricultural Economics
University of California, Davis
USA

Introduction

Aquaculture technology may well prove to be one of the most significant factors in the world's salmon fisheries during the next several decades. At present, both public, private, and cooperative aquaculture facilities exist on the Pacific and Atlantic oceans. Public facilities have been particularly important in North America for the past two decades primarily as means of mitigating damages associated with salmon habitat losses. Along the Pacific Coast, for example, hatchery facilities have been constructed to replace spawning grounds lost to hydroelectric dams on rivers including the Fraser in British Columbia, the Columbia in Oregon, and the Sacramento in California. Similarly, Alaska has implemented enhancement programs in several areas in order to rebuild runs in historically-productive systems. While total public hatchery production is fairly low on the whole, its potential is perhaps better gauged by noting its role on a local scale. The supply from private aquaculture (ocean-caught and return to private facilities) represented approximately 30 percent of the total supply from coastal Oregon and Northern California (Anderson, 1983) in 1982, for example. In some areas of Alaska (e.g. in the Southeastern District of Lower Cook Inlet), aquacultured stocks contributed up to 88 percent.

Although public mitigation-oriented facilities are most prominent in North America, private profit-oriented facilities have been growing very rapidly elsewhere. Norway has led the industry in pen-rearing technology (enclosed raising from smolt to harvested adult) and Norweign-raised Atlantic salmon now successfully compete with Pacific-caught wild fish in the fresh fish markets of Europe, Japan and even the Pacific Northwest. In addition to pen-rearing salmon in North America smolts are also raised in hatcheries, released, and then harvested when they return from a maturation period in the open ocean, a practice referred to as salmon ranching. As yet, only the state of Oregon has allowed private profit-oriented salmon ranching although Washington state allows some subsistence-oriented salmon ranching by Native Indians and Alaska permits cooperative non-profit ranching.

What the future holds for aquaculture-produced fish in the Pacific is somewhat speculative at this point. What is apparent is that there is enormous untapped potential. In Alaska and British Columbia alone, for example, there are thousands of miles of bays and inlets suitable for pen-rearing and thousands more streams whose spawning capacities could be increased many-fold with hatchery facilities. Both regions have had on the drawing boards very large-scale cooperative enhancement programs totaling some 3/4 billion dollars. During the last two years, however, these programs have been put on hold and policymakers are now adopting a very cautious position towards expansion with new facilities. The caution has been echoed in Oregon with a moratorium on further development and in California with prohibition against artificially-reared fish other than for mitigation purposes.

Reasons for the current cooling of public support for aquaculture are many and varied. Some of the reasons are short run in that economic slowdowns in resource-based economies like Alaska and British Columbia have left little discretionary funding to embark on large programs, even if designed to be cooperatively financed once in operation. In addition, however, there has been considerable political resistance to private and cooperative aquaculture by fishermen themselves. While this may seem paradoxical at first (given that more fish would seem to mean larger harvest), there are some subtle reasons for such a position. One of the worries (also expressed by biologists) is that natural stocks might be extinguished in fisheries where fishermen are havesting on mixed stocks. Another worry is that natural stocks will somehow be outcompeted or otherwise adversely impacted by density dependent factors associated with any large increase in salmon releases. In addition, there is the very prevalent feeling among fishermen that they will lose political control over "their" salmon resources if new entrants with different objectives are allowed to participate. Finally, many fishermen feel that increased private aquaculture supply will have a substantial impact on prices.

The natural stock extinction problem is, in a sense, more relevant in cases where public enhancement is being used to rebuild a commercial fishery. The reasoning behind the worry runs as follows. In a mixed stock fishery (i.e. one where fishermen take an identical, policy-fixed proportion of recruits from both wild and hatchery stocks) benefits will be gained from hatchery-raising only to the extent that the exploitation rate can be higher to take advantage of the better recruit/spawner relationship made possible by the facility. But a higher exploitation rate on the mixed stock fishery will gradually eliminate the wild stocks. With private aquaculture, this problem can possibly be avoided since private facilities add to the exploitation rate after the commercial fishery. Hence the mixed stock commercial fishery may be managed on the fishing ground at a lower exploitation rate to preserve wild stocks and the excess recruits can be captured and sold out of the private hatchery facility.

With respect to the competition problem, there are indeed several potential points at which aquacultured and wild stocks may compete. The first place is in the river where smolts return to the ocean. If artificially reared smolts compete with naturally-spawned stocks en route to the ocean, then fishermen could conceivably be harmed. The second place is in the ocean when smolts return to mature and the same considerations apply as in the river stage. From the fishermen's point of view, however, whether they will actually be worse off is really not clear. This is because it is likely that the gains from returning aquacultured fish may more than compensate for the losses in natural fish.

We are left, then, with the issue of control over the salmon and, more broadly, the ocean and river resources. This issue is perhaps the more important one underlying debates between opponents and proponents of aquaculture. It is easy to understand, given the fragmentary nature of fishermen's coalitions and the contrasting big business (Weyerheauser, British Petroleum) nature of aquaculture, how such fears might arise. Nevertheless, the real issue is how substantial the conflict in positions really is. Are there, in fact, reasons why aquaculturists might want and promote different fisheries policies than the fishermen themselves? If the answer is no, then perhaps aquaculture and commercial fisheries can coexist. If there are substantial points of conflict, on the other hand, then we are likely to witness continued resistance and countermaneuvers over the short and intermediate term. In the long run, however, what probably counts most in this debate are the relative efficiencies of the two techniques. If Norway or Japan or any other country can successfully market aquacultured fish, the dominant producing natural-production entities like British Columbia and Alaska may have no choice but to, albeit reluctantly, entertain the prospect of artificially reared fish, either pen-reared, salmon ranched, or both. In a sense, what we may be witnessing here is no different from countless other situations in history whereby old methods are challenged by new ones. What makes this slightly more interesting is that policy is so pervasive in the challenged industry that it is unclear whether certain policies diminish or magnify the conflict.

In this paper we address, in both general and specific fashion, the potential conflict between traditional commercial fisheries and aquaculture. In the next section we outline a conceptual framework for analyzing points of conflict. This is followed by a discussion of an application of the model to the Oregon coho fishery. Section three discusses some empirical findings and section four compares some optimization/simulation exercises with the model. The final section offers a summary and concluding thoughts.

Points of Conflict Between Aquaculture and Wild-Stock Fisheries

At the heart of the question of whether commercial fisheries and aquaculture can coexist are issues of externalities. Externalities have been defined in different ways but they are best viewed in a general sense as linkages or points of feedback between decision makers in a system for which no market mechanisms exist. If there are no linkages or externalities between decision makers then we would expect no conflict over decisions and actions. As soon as we admit a link between decision makers, however, one group's pursuit of its goals may hamper the other from attaining its best position. Standard examples focus on polluter-pollutee links but the concept is broad enough to include a range of activities including heroin use, reckless driving and burping at the dinner table. In these and many other externality situations, society has invoked policies, laws, or customs to alter the amount of spillover impacts transmitted between decision makers.

In one sense, much of the political maneuvering by interest groups to exclude aquaculture in salmon has been based on claims that externalities exist between natural and artificial systems of raising and harvesting. The points of potential conflict have already been discussed and include competition in the river systems and ocean between fish, as well as conflict at the fishing stage over mixed stocks. Interestingly, there is nothing inherent about salmon aquaculture which makes these conflicts inevitable, i.e. in-river competition could be avoided by locating hatcheries on rivers without natural runs, ocean competition can be avoided by pen-rearing, and mixed stock problems can be minimized if fisheries are undertaken nearer to river mouths. Nevertheless, since much of the debate has focused on existing systems which do tend to involve some externalities, we will likewise focus our attention on these cases.

Figure 1 depicts points of interaction (i.e. potential externalities) between participants in a typical wild-stock fishery (perhaps also aided by public hatchery production) and the salmon-ranching form of aquaculture. As can be seen, aquaculture complicates an already-complicated system in a manner that makes even qualitative analysis ambiguous. For example, increased private aquaculture releases may (or may not) reduce natural returns due to instream or ocean density effects. The net effect may still be positive (or negative) at the terminal fishery. If the effect is positive and the program is large enough, prices may (or may not) fall enough to reduce profits, resulting in exit from the industry, relaxation of season length restrictions, etc. The point, however, is that it is not a priori clear how aquaculture activities should affect typical policies such as season length (or vice versa). Similarly, changes in public policy regarding public smolt releases and season length changes may or may not (through density effects again) reduce aquaculture returns as fishery profits rise, etc. Obviously, it is necessary to understand more about the quantitative interrelationships in order to better gauge who will gain and lose by various policies. In the next section we discuss some empirical results in a case study of the Oregon coho fishery.

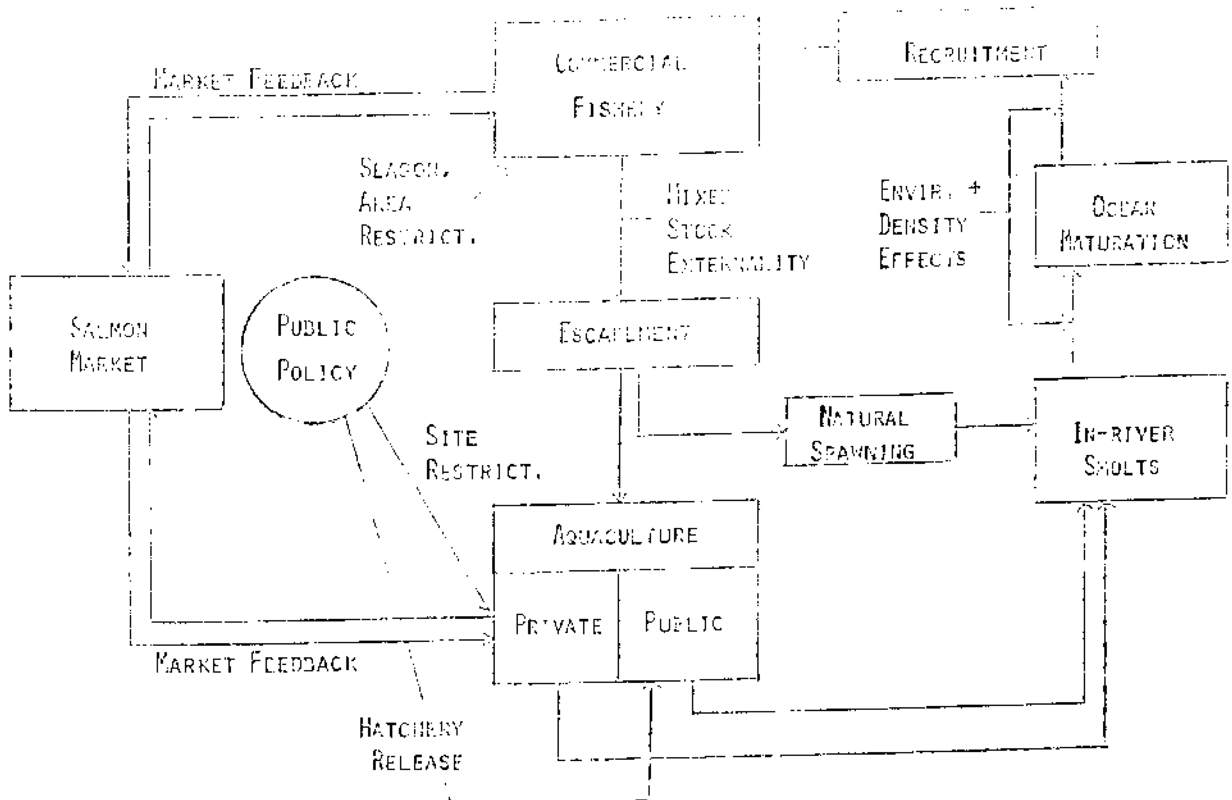

Figure 1. Interaction Between Aquaculture and Commercial Fisheries

A Model of Aquaculture-Natural Fishery Interaction

As discussed earlier, the state of Oregon is the only entity in North America which has allowed private salmon ranching for profit to develop. Releases of privately reared smolts increased from 88 thousand in 1974 to 231 thousand in 1982, a volume five times that of public hatchery releases. Of total troll and sport-caught coho in 1982 of 844,100 fish, an estimated 122,100 were from privately aquacultured stocks whereas another 165,000 returned to private facilities as harvest. One large firm (a subsidiary of Weyerhaeuser) is responsible for most of the production.

In the modeling effort presented here, we estimate the system depicted in Figure 1 by applying it to Oregon data and then use it to simulate impacts of some policies. In the interest of being brief, some of the details are skipped over in order to get to the conclusions. (Readers interested in more details are referred to the discussions in Anderson, 1983 and Anderson and Wilen, 1984.)

The system depicted in Figure 1 is composed of four subsystems; namely (1) the natural coho stock recruitment relationship, (2) the aquacultured smolt-release/return relationship, (3) the fishing production and effort dynamics relationships, and (4) the price or demand relationship. Data were gathered from various published and unpublished sources to estimate the four subsystems. The resulting equations are as follows:

Natural coho stock recruitment relationship

We characterized the population of natural coho salmon with a Beverton-Holt (1957) model of the form:

$$RN_{it} = ES_{i,t-n}/(\alpha_i+\beta_i ES_{i,t-n}) \qquad (1)$$

where

RN_{it} is the adult recruitment (10^3 fish) in area i, time t,

$ES_{i,t-n}$ is the escapement of parent stock (10^3 fish) in area i at time t-n, and

n is the generation length.

For coho salmon, n equals three years. [A more detailed coho life history can be found in ODFW, 1982.] Inverting both sides of equation (1) and multiplying by $ES_{i,t-n}$ yields the more easily estimated form:

$$ES_{i,t-n}/RN_{it} = \alpha_i + \beta_i ES_{i,t-n} \qquad (2)$$

The recruitment for a given year equals total stock which is approximated by the sum of: commercial ocean troll catch; open sport catch; net catch (if applicable); natural spawning escapement; and hatchery returns (obtained from WDF, 1982; ODFW, 1982; and PFMC, 1982). The portions of the stock derived from hatchery smolts were determined by the ratio of on-station and off-station hatchery returns to total escapement times total stock. The portion attributed to the naturally breeding population is the remainder of total stock.

The above stock-recruitment relationship was estimated using pooled time-series cross-section data from (1) the Washington coastal area, (2) Columbia River area, and (3) the Oregon/California coastal area. The intercept was restricted to be equal between regions, but the coefficient on parent stock was allowed to differ. In the results presented here, direct species interaction between aquacultured and natural fish stocks was ignored due to already-complex nature of the optimization problem (see, however, Anderson and Wilen, 1984).

The resulting equation used here is:

$$ES_{t-3}/RN_t = \underset{(2.55)}{.745} + \underset{(1.20)}{.00687}ES_{1,t-3} + \underset{(3.63)}{.00513}ES_{2,t-3} + \underset{(4.99)}{.00683}ES_{3,t-3} \qquad \begin{matrix} R^2 = .54 \\ \text{adj. } R^2 = .50 \\ \text{obs.} = 32 \end{matrix} \qquad (3)$$

The results indicate that net adult stock recruitment, $RN_t - ES_{t-3}$, increases with adult coho spawners, ES_{t-3}, and decreases as the density of the adult coho spawners increases.

Population dynamics of ocean released aquacultured salmon

A quadratic difference equation was used to represent the relationship between ocean smolt release and adult returns, given by

$$RH_{it} - SA_{it-1} = \gamma_i SA_{i,t-1} + \delta_i (SA_{i,t-1})^2 \qquad (4)$$

where

RH_{it} is the number of adult returns (10^3 fish) in area i, and

$SA_{i,t-1}$ is the amount of ocean released smolts (10^3 lbs.) in area i.

The equation can be modified by dividing both sides by $S_{i,t-1}$ which yields:

$$(RH_{i,t} - SA_{i,t-1})/SA_{i,t-1} = \gamma_i + \delta_{i,t-1} SA_{i,t-1} \qquad (5)$$

The estimates were done again using pooled time-series and cross-section data on public hatchery releases from (1) Washington coastal, (2) Columbia River, and (3) Oregon/California coastal areas (Cummings, and WDF various years). Since aquaculture has only been in operation since 1974, public hatchery production was used as a proxy. The estimated equation is:

$$(RH_t - SA_{t-1})/SA_{t-1} = \underset{(1.86)}{4.05} - \underset{(-1.39)}{.00159}SA_{1,t-1} - \underset{(-4.47)}{.00535}SA_{2,t-1} - \underset{(-3.73)}{.00238}SA_{3,t-1} \qquad \begin{matrix} R^2 = .47 \\ \text{adj. } R^2 = .42 \\ \text{obs.} = 39 \end{matrix} \qquad (6)$$

As with natural coho stock-recruitment relationship, the estimate of the intercept if restricted to be equal between cross-sections. The signs on the coefficients indicate that returning adults increase with smolt release but decrease with density of smolt release.

Fishery production and effort dynamics relationships

In order to estimate a fishery production function, we used the standard assumption that catch is a function of effort expended and fish stock. The simple functional form estimated was:

$$C_{it} = \theta_i E_{it} W_{it} = \theta_i EW_{it} \tag{7}$$

where

C_{it} is coho catch (10^3 fish) in area i and time t

E_{it} is effort (10^3 days fished) in area i and time t

W_{it} is coho stock (10^3 fish) in area i and time t

θ_i is the parameter to be estimated for area i, known as the catchability coefficient.

Since the best data on effort for the Northwest coast are those expended by the Washington troll fleet (WDF), we used data composed of days fished and catch by species in four coastal areas: the Grays Harbor area, the Quillayute area, the Cape Flattery area, and the Strait area. The data set was pooled with estimates corrected for auto correlation in the time series and correlation between cross-section (see Kementa, pp. 512-514), and the resulting equation is:

$$C_t = \underset{(13.36)}{.0135}\, EW_t \qquad R^2 = .89 \quad \text{adj. } R^2 = .89 \quad \text{obs.} = 36 \tag{8}$$

The estimated coefficient has the expected positive sign and is significant. Therefore, catch increases proportionately with coho stock and fishing effort.

The relationship constructed to represent the dynamics of fishing effort is basically a partial adjustment model for capital stock. Boat days fished are assumed to reflect the size and utilization of the existing capital stock. In addition, it is also assumed that fishermen will alter their capital stock directly as the real value of current catch or the season length changes. The functional form estimated is:

$$E_{it} = (1 - \theta_i)\, E_{i,t-1} + \theta_i \varepsilon_i SV_{it} \tag{9}$$

where

E_{it} and $E_{i,t-1}$ are the current and lagged number of days fished in area i, and

$SV_{i,t}$ is the current real exvessel value (1967 dollars) of total catch (coho, chinook, pink) multiplied by the total season length in area i. Value of total catch is equal to number of fish caught times pounds per fish times real price per pound.

θ_i, ε_i are adjustment parameters to be estimated.

The data on days fished used in the production function estimation are also used in this estimation. The annual catch of pink, coho and chinook, season lengths for each of the four regions and average annual weight of the fish by species were found in PFMC. The Oregon prices were used to calculate the value of catch (ODFW) since Washington exvessel prices were not available. These prices were deflated by the Consumer Price Index (CPI) to attain the real value of catch in 1967 dollars.

The results of the pooled estimation correcting the time-series auto-correlation, cross-section heteroskedasticity and cross-sectional correlation are

$$E_t = \underset{(11.33)}{.614}\, E_{t-1} + \underset{(6.82)}{.0001867}\, SV_t \qquad R^2 = .95 \quad \text{adj. } R^2 = .95 \quad \text{obs.} = 32 \tag{10}$$

Fishing effort increases with the real value of catch and season length as expected. The estimated adjustment coefficient, (1 - .614), is .386 indicating that effort adjusts 38.6 percent of the difference between current and desired effort in each period.

Demand relationship

Although various models have been estimated for canned and fresh salmon by other researchers, we chose a price dependent model based on the assumption that current price depends on current quantity and other current variables and also lagged variables. That is,

$$P_t = f(X_t, X_{t-1}, \ldots, X_{t-n}, Z_t, Z_{t-1}, \ldots, Z_{t-n}) \tag{11}$$

where

P_t = price in time t.

X_{t-j} = quantity demand in t-j, j = 0,...,n.

Z_{t-j} = other variables (i.e., income) in t-j, j = 0,...,n.

The lagged variables are proposed because of institutional structure in the coho market such as time needed to adjust contracts and the influence of inertia and habitual behavior on the part of fish buyers.

The particular form of the lag was assumed to be the familiar geometric lag. After making the usual transformation (Maddala), the resulting equation used in estimation is:

$$PC_t = \omega(1-\sigma) + \sigma PC_{t-1} + \beta_1 C_t + \beta_2 PI_t + \beta_3 Y_t + v_t \tag{12}$$

where

PC_t, PC_{t-1} is the U.S. real exvessel price of coho salmon in t and t-1, respectively (1967 dollars),

C_t is the U.S. coho landings in t (10^3 pounds),

PI_t is the meat, poultry and fish price index divided by one hundredth of the CPI (Base year 1967),

Y_t is the real disposable income for the U.S. in t (1967 dollars x 10^6),

σ is the parameter which measures the rate of decay, and

$v_t = u_t - u_{t-1}$.

With this model, there are autocorrelated errors and the lagged variable PC_{t-1} is not independent of v_t. This means the ordinary least squares estimates are biased and inconsistent. The appropriate estimation technique is generalized least squares which yields unbiased, efficient and consistent estimates of the parameters.

Annual data (1950-1981) for: the average annual domestic nominal and real prices of coho; the meat, poultry and fish price index (MPFI); the Consumer Price Index (CPI); real disposable income; and the United States landings of coho were obtained from U.S. Department of Commerce (various years). The estimated lagged linear demand function is:

$$\underset{}{PC_t} = \underset{(-2.45)}{-358} + \underset{(2.33)}{.377\,PC_{t-1}} - \underset{(-2.21)}{.00000266C_t} + \underset{(2.84)}{.00393PI_t} + \underset{(3.82)}{.00408\,Y_t} \qquad R^2 = .85,\ \text{adj. } R^2 = .82,\ \text{obs.} = 31 \tag{13}$$

The parameter estimates have the expected sign and all are significant at the 0.5 level.

The results indicate that the aggregate short-run price elasticity of demand for coho is -3.62 at the means. Other studies of the demand for salmonid species have found elasticities in a range from -3.94 to -9.68 for fresh/frozen product (DeVoretz, Quierolo and Johnston, Swartz) and from -1.47 to -12.92 for canned salmon (DeVoretz, Wang). Most of these studies are at the wholesale, not the exvessel, level. One would expect the elasticity to be somewhat lower at the exvessel level than at wholesale.

The estimated short-run income elasticity was 2.63 at the means. The income elasticities estimated by DeVoretz range from 1.17 to 9.80. The short-run cross-price elasticity of demand for coho was found to be 4.35 at the means.

Optimization/Simulation Results

The above estimated subsystems were combined in an optimization/simulation model in order to evaluate various interrelationships between private aquaculture, public aquaculture, and the commercial fishery. For the results presented here, we analyzed three different scenarios. In the first base case scenario, we assumed that public policies are chosen to maximize the profits of commercial fishermen, given the estimated recruitment relationships for natural and aquacultured coho, the catch production relationships and effort dynamics, and the demand relationship. The second case examines optimal policies for the aquaculturist and the third case examines a jointly optimal solution.

In the base case, we simulated a scenario which has fishermen as the principal group of concern in the coho fishery. Both public and private hatchery releases were fixed at current levels and then a time path of effort (fishing days) was chosen using a non-linear programming algorithm to maximize the present value of fishermen profits. The results are presented in Table 1 and Figures 2 and 3. (See Appendix for variable definitions and acronyms.) Qualitatively, the optimal (present-value maximizing) policy follows patterns suggested by standard capital-theoretic work in fisheries economics; namely an initial investment phase in which harvests are kept low and escapement is increased, followed by a harvesting phase near the sustainable yield associated with the new higher stock levels. (There is also a disinvestment phase in our results due to the necessity of choosing a terminal stock level in a finite horizon problem.) Overall, the optimal policy solutions for this simulation thus mirror the "catenary turnpike" properties discussed for example, in Clark, 1976; Clark and Munro, 1975; and Wilen, 1984.

Of particular interest are the steady state or longer-term ramifications suggested by the model. Although we have not run these simulations out over extended periods, the results presented here are sufficient to gauge the long run tendencies. Table 2 compares, for example, the ranges associated with the stock size, fishing effort, catch and escapement for different discount rate and cost assumptions. Again, as theory would suggest, as the discount rate increases, the optimal solution tends towards a smaller stock level and consequent smaller recruitment (catch plus escapement).

Of equal interest are some of the other price variables associated with the optimal policy simulation presented in Table 1. For example, the variables λ, ρ_{RN}, and ρ_{PC} are dynamic Lagrange multipliers associated with the production function, the natural coho fish stock (RN) and the price of coho (PC) respectively. These yield the marginal value to the objective function of marginal changes in the constraints. For example, $\rho_{RN,t}$ measures the increase which could be gained (in 1967 present value dollars) if the coho stock could be increased by a unit in time period t. The variable increases during the investment phase when extra units of stock have high payoffs and then decreases as the terminal time is approached. The value of ρ_{PC} reflects a similar pattern.

As a comparison case to the commercial fishery optimization problem, we examined a second scenario where the aquaculture firms are assumed to optimize their returns by choosing a smolt release policy. Our findings here are particularly revealing because they illustrate precisely the types of potential policy conflicts alluded to earlier. In particular, under current conditions, aquaculturists appear to be "bound up" by the activities of the open access commercial fisheries. For example, under the assumption that public hatchery releases and season length restrictions are held at current levels, the profit maximizing private smolt release policy is actually one which does not even utilize the fifteen periods alloted in our base case runs. As Table 3 shows, the aquaculture industry initially follows a pattern (much like the optimal "investment" policies discussed above for the commercial fishery) which builds up the run sizes of aquacultured fish. However, since fishermen harvest these mixed stocks and also respond to increased profits through entry, they ultimately (in this scenario) increase effort and harvest rates on aquacultured fish to the point where the aquaculture industry is effectively driven out of business. Note that this is the opposite of the more typically-voiced fear regarding fishing in mixed stocks; in this case it is the artificial stocks that are driven to (economic) extinction by mixed stock harvesting.

From the point of view of the aquaculturist, the above scenario is one which is not "controllable" in the sense that feasible choices don't admit a wide range of outcomes. For example, if (for some reason) the aquaculturists wished to stimulate commercial fishing effort, smolt releases could be increased but the density effects together with the small proportion of aquacultured fish in the total would severely constrain the potential impact. On the other hand, if they wish to decrease effort, again the small proportion of aquaculture in the total limits the potential. What is needed (again from the perspective of the aquaculturists) is some method of reducing commercial effort on the mixed stocks and hence on aquacultured stocks. Our calculations in this simulation show, in fact, how much a marginal decrease in season length would be worth to the aquaculture industry. The last column in Table 3 expresses the loss (in 10^6 present value dollars) associated with a unit (in 10^2 days) increase in the season length above 105 days in that year along the optimal path. As can be seen, the cost of the margin is as high as $9,300 per day and this represents an externality cost associated with the commercial fishery operating on the mixed stock.

An interesting question in the spirit of our externality framework is what season length the aquaculture industry would choose to allow if they were to control fisheries policy. A bit of reflection suggests an obvious answer; namely that aquaculturists would prefer fishing effort on their own stocks to be zero since everything taken by fishermen is lost to aquaculture. Suppose, however, that fishermen agree to a reduction in their season length if they are compensated for the loss with a payment of, for example, $10,000 per day for every day reduction below 105 days. In effect this is allowing the aquaculture sector to cinoebsate the commercial fishermen to reduce their externality - producing behavior - much like a pollution reduction bribe in a two party externality problem. Table 4 and Figure 4 show the results for this scenario. Two things are important. First, from the point of view of the aquaculture

Table 1. Commercial Fishery Profit Maximization
(r = .05; KE_t = 110 \$(1967)/day; CHI_t = 1.4 x 10^6 coho equivalents)
Present Value of Profit = 18.74 x 10^6 1967 dollars

Year	State RN	Exogenous RH	Exogenous RAH	Control E	Endogenous YC	Endogenous C	Endogenous FS	State PC	λ	μ_{RN}	μ_{PC}
1980	.528	.179	.078	.0585	1.72	.619	.165	3.24	3.24	.730	.151
1981	.477	.205	.231	.0	0	.0	.913	3.37	3.59	2.49	.401
1982	.680	.105	.185	.0	0	.0	.818	3.48	3.31	2.54	1.06
1983	.738	.2	.1	.0035	.116	.049	.99	3.58	3.07	2.53	2.55
1984	1.19	.2	.1	.0496	1.93	.998	.49	3.65	2.96	2.47	2.55
1985	1.26	.2	.1	.0524	2.09	1.10	.46	3.73	2.88	2.46	2.42
1986	1.27	.2	.1	.0533	2.13	1.13	.44	3.83	2.82	2.45	2.19
1987	1.15	.2	.1	.0512	1.97	1.00	.45	3.94	2.76	2.43	2.10
1988	1.13	.2	.1	.0516	1.97	.996	.43	4.05	2.70	2.42	2.02
1989	1.12	.2	.1	.0519	1.98	.995	.43	4.16	2.65	2.44	1.97
1990	1.12	.2	.1	.0527	2.01	1.01	.41	4.27	2.59	2.40	1.96
1991	1.11	.2	.1	.0532	2.02	1.01	.40	4.39	2.53	2.37	2.08
1992	1.11	.2	.1	.0664	2.51	1.26	.15	4.50	2.47	.68	1.80
1993	1.10	.2	.1	.0663	2.50	1.25	.15	4.62	2.42	.70	1.76
1994	1.09	.2	.1	.0663	2.49	1.24	.15	4.74	2.37	.72	.78
1995	.75										
1996	.75										
1997	.75										

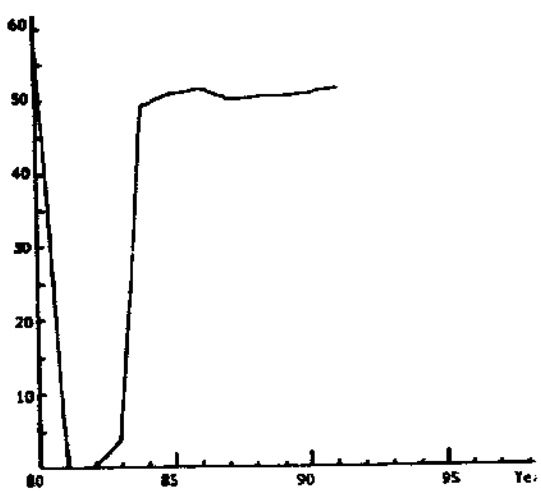

Figure 2. Fishing Effort for Profit Maximizing Ocean Fishery (10^3 troll days)

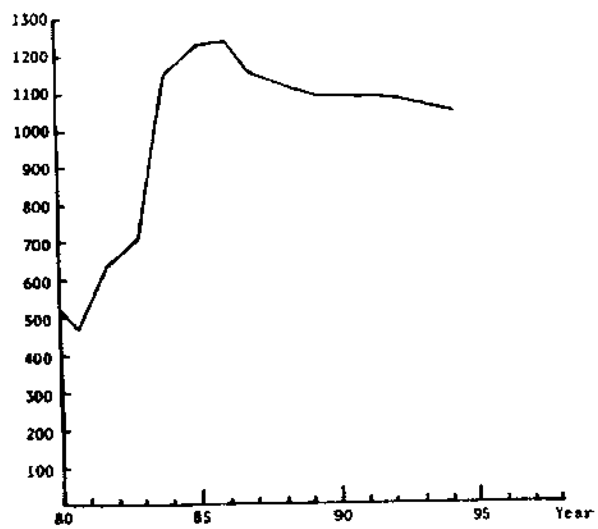

Figure 3. Natural Coho Recruitment for Profit Maximizing Ocean Fishery (10^3 fish)

Table 2. Summary of Long-Run Optimally Managed Coho Fishing

Real Discount Rate	Real Cost per Unit Effort (1967 \$/troll day)	Natural Coho Stock (10^3 fish)	Troll Equiv. Fishing Effort (10^3 days)	Coho Catch (10^3 fish)	Coho Escapement: Natural, Public, Private (10^3 fish)
.10	110	1050-1060	54.5-54.9	1010-1030	350-370
.05	110	1080-1090	53.2-53.7	1000-1020	390-410
.00	110	1110-1120	51.3-51.8	995-1000	440-460
.00	0	830-835	61.3-61.8	948-953	195-200

Table 3. Aquaculture Profit Maximization
(KS_t = .825 \$(1967)/lb.; Density Coef. = -2.36; CHI_t = 1.4 x 10^6 coho equiv.; r = .05; constant season)
Present Value of Profit = 1.55 x 10^6 1967 dollars

Year	State RN	Exo. RH	State RAH	State E	Endogenous YC	Endogenous C	Endogenous ES	Endogenous FP	Control SAP	Exo. S	State PC	λ	ρ_{RN}	ρ_{RAH}	ρ_{PC}	RG_S
1980	.528	.178	.078	.0585	1.72	.62	.16	.016	.063	1.15	3.24	.0	-.47	.68	-.29	
1981	.477	.205	.079	.0487	1.42	.50	.26	.027	.135	1.12	3.34	-.48	-.43	.93	-.28	-.61
1982	.680	.105	.147	.0412	1.30	.52	.41	.065	.164	1.05	3.45	-.60	-.40	1.08	-.28	-.74
1983	.738	.2	.167	.0362	1.225	.54	.57	.085	.180	1.05	3.55	-.70	-.37	1.16	-.29	-.82
1984	.878	.2	.176	.0332	1.19	.56	.69	.097	.186	1.05	3.65	-.76	-.34	1.17	-.29	-.87
1985	1.076	.2	.180	.0320	1.23	.63	.83	.102	.191	1.05	3.78	-.79	-.31	1.16	-.28	-.93
1986	1.136	.2	.182	.0318	1.25	.65	.87	.104	.192	1.05	3.84	-.76	-.28	1.12	-.26	-.91
1987	1.196	.2	.183	.0326	1.31	.69	.89	.102	.190	1.05	3.95	-.70	-.23	1.05	-.23	-.89
1988	1.242	.2	.182	.0344	1.40	.75	.87	.097	.186	1.05	4.05	-.62	-.17	.96	-.19	-.84
1989	1.253	.2	.180	.0371	1.52	.82	.81	.090	.178	1.05	4.16	-.52	-.11	.85	-.15	-.75
1990	1.259	.2	.175	.0408	1.67	.90	.73	.079	.163	1.05	4.27	-.40	-.05	.72	-.11	-.64
1991	1.258	.2	.166	.0457	1.86	1.00	.62	.064	.135	1.05	4.39	-.28	.0	.57	-.06	-.50
1992	1.247	.2	.147	.0518	2.09	1.11	.48	.044	.080	1.05	4.51	-.16	.0	.40	-.02	-.33
1993	1.228	.2	.097	.0589	2.33	1.21	.32	.020	.0	1.05	4.63	-.07	.0	.24	.0	-.14
1994	1.194	.2	.0	.0659	2.49	1.24	.15	.0	–	1.05	4.75	.0	.0	0	.0	.0
1995	1.134															
1996	1.020															
1997	.800															

Table 4. Aquaculture Profit Maximization: Season Control Cost 10,000 \$(1967)/Day Less Than 105
(KS_t = .825 \$(1967)/lb.; Density Coef. = -2.36; CHI_t = 1.4 x 10^6 coho equiv.; r = .05)
Present Value of Profit = 1.86 x 10^6 1967 dollars

Year	State RN	Exo. RH	State RAH	State E	Endogenous YC	Endogenous C	Endogenous ES	Endogenous EP	Control SAP	Control S	State PC	λ	ρ_{RH}	ρ_{RAH}	ρ_{PC}
1980	.528	.178	.078	.0585	1.72	.62	.164	.016	.082	1.15	3.24	.0	-.42	.81	-.28
1981	.477	.205	.099	.0480	1.41	.51	.271	.035	.143	1.12	3.35	-.50	-.35	1.07	-.26
1982	.680	.105	.152	.0404	1.28	.51	.427	.069	.171	1.05	3.45	-.64	-.25	1.25	-.23
1983	.738	.2	.171	.0356	1.21	.53	.579	.089	.192	1.05	3.55	-.72	-.23	1.43	-.17
1984	.889	.2	.182	.0315	1.14	.54	.731	.105	.210	.97	3.65	-.70	-.22	1.65	-.11
1985	1.082	.2	.191	.0270	1.05	.54	.933	.121	.220	.81	3.75	-.60	-.20	1.75	-.08
1986	1.140	.2	.195	.0236	.935	.49	1.04	.133	.226	.81	3.86	-.65	-.20	1.82	-.07
1987	1.207	.2	.197	.0211	.856	.46	1.14	.141	.231	.81	3.97	-.67	-.19	1.86	-.06
1988	1.264	.2	.199	.0194	.801	.44	1.22	.147	.233	.82	4.07	-.69	-.19	1.84	-.06
1989	1.284	.2	.199	.0186	.862	.42	1.26	.149	.234	.86	4.19	-.72	-.18	1.79	-.07
1990	1.300	.2	.200	.0189	.741	.43	1.37	.149	.233	.92	4.30	-.71	-.13	1.67	-.07
1991	1.311	.2	.199	.0208	.875	.48	1.23	.143	.230	1.00	4.42	-.66	-.08	1.51	-.06
1992	1.315	.2	.198	.0246	1.03	.57	1.14	.132	.225	1.05	4.53	-.53	.0	1.34	-.03
1993	1.316	.2	.197	.0248	1.25	.57	1.14	.118	.216	1.05	4.65	-.33	.0	1.13	.0
1994	1.312	.2	.193	.0369	1.55	.85	.855	.097		1.05	4.77	-.15	.0	0	.0
1995	1.302														
1996	1.286														
1997	1.256														

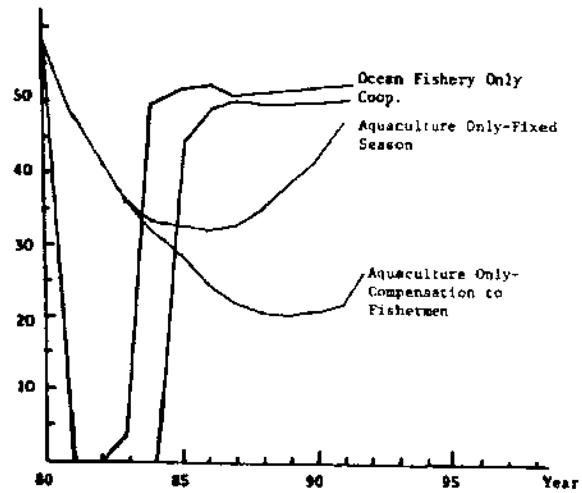

Figure 4. Fishing Effort Coop. vs. Ocean Fishery Only (10^3 troll days)

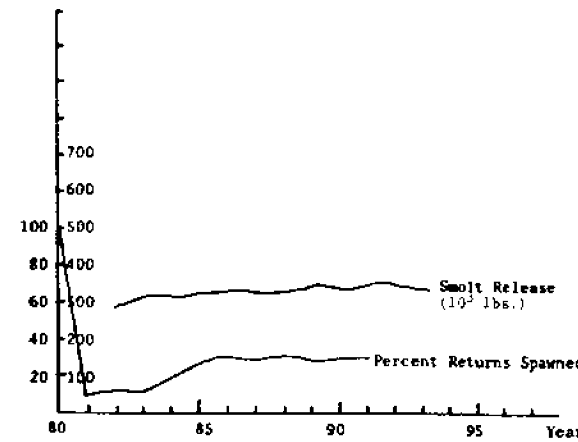

Figure 5. Smolt Release and Percent of Returning Adults Spawned Under Cooperative Management

Table 5. Cooperative Commercial Fishery/Aquaculture Profit Maximization
(KE_t = 110.0 \$(1967)/day; KBS_t = 10.0 \$(1967)/adult spawned; Density Coef. = -2.36;
$CHI_t = 1.4 \times 10^6$ coho equiv.; r = .05)
Present Value of Profit = 21.40×10^6 1967 dollars

Year	State RN	Exo. RH	State RAH	Control E	Endogenous YC	C	ES	EP	Control B	Endo SBP	State PC	λ	ρ_{RN}	ρ_{RAH}	ρ_{PC}
1980	.528	.179	.078	.0585	1.72	.62	.164	.016	1.0		3.24	3.24	.571	3.09	.449
1981	.477	.205	.231	.0010	.0316	.012	.90	.228	.081		3.37	3.20	2.19	2.98	.582
1982	.680	.105	.185	.0010	.0331	.013	.96	.182	.10	.192	3.48	3.14	2.33	2.90	1.07
1983	.738	.1	.185	.0010	.0327	.014	1.01	.182	.10	.222	3.58	3.07	2.36	2.83	2.39
1984	1.189	.1	.196	.0442	1.72	.89	.60	.079	.24	.218	3.65	2.96	2.29	2.77	2.45
1985	1.259	.1	.196	.0487	1.94	1.02	.54	.067	.28	.218	3.74	2.88	2.29	2.72	2.36
1986	1.273	.1	.197	.0505	2.02	1.07	.50	.063	.30	.228	3.83	2.82	2.27	2.66	2.17
1987	1.193	.1	.197	.0490	1.91	.99	.50	.067	.29	.225	3.94	2.76	2.27	2.60	2.07
1988	1.168	.1	.198	.0494	1.91	.98	.49	.066	.29	.227	4.05	2.71	2.27	2.54	1.98
1989	1.154	.1	.198	.0490	1.89	.96	.49	.067	.29	.233	4.16	2.64	2.40	2.47	1.95
1990	1.153	.1	.198	.0501	1.93	.98	.47	.064	.30	.230	4.27	2.59	2.36	2.41	1.97
1991	1.144	.1	.199	.0507	1.95	.99	.45	.063	.31	.233	4.39	2.53	2.32	2.37	2.13
1992	1.144	.1	.199	.0667	2.56	1.30	.14	.020	.80	.230	4.50	2.47	.54	1.33	1.86
1993	1.133	.1	.199	.0666	2.46	1.29	.14	.020	-	.234	4.62	2.42	.57	0	1.32
1994	1.124	.1	.200	.0665	2.36	1.26	.16	.020	-	.192	4.74	2.37	.59	0	.077
1995	.750														
1996	.750														
1997	.750														

industry, their destiny is now "controllable" in the sense that it is possible to stay in business indefinitely and achieve a steady-state smolt release plan. This requires that season length be reduced to a level near 80 days, at which level the aquaculturist can release slightly over 230,000 smolts (about 25% above the previous scenario). Second, even with a relatively stiff payment made for reducing commercial fishing effort, the present value of the aquaculturists profits in this new scenario are higher than in the first scenario. This is the case, of course, precisely because of the cost of the 105 day minimum season on the aquaculturists. By controlling season length, aquaculturists are able to undertake a more flexible smolt release policy which is more profitable even after the charge is paid.

As a final scenario, we ran a simulation in which it is assumed that fishermen and aquaculturists cooperatively manage both ventures to maximize joint profits. This scenario is not necessarily unrealistic; Alaska currently has several cooperatively operated hatcheries and it is an effective institutional mechanism for internalizing externalities and eliminating the conflicts between decision units.

Table 5 and Figures 4 and 5 reveal the optimal joint profit maximizing solution. As one would expect, the optimal cooperative policy lies somewhere between those already examined. Fishing effort is initially reduced to a minimum to let natural stocks recover and aquacultured stocks are likewise increased as fast as possible. When the steady-state path is reached, it is characterized by a higher level of the natural and aquacultured stocks and of recruitment. Commercial catch is lower because ocean caught fish have a lower shadow value than their counterparts from aquaculture facilities.

Summary and Conclusions

As discussed in the opening section, aquaculture has the potential to be a very important force in salmon fisheries over the next several decades. Most large-production countries have untapped potential but only a few operating facilities (general public) whereas Norway and other smaller producers appear poised to challenge these dominant forces in the market with large expansions in private aquaculture.

For various reasons, there has been considerable resistance to private salmon aquaculture in North America. Part of the resistance is due, very simply, to fears over possible increased competition in the market place, fears over the big-business nature of aquaculture, and fears over potential loss in political control. Where reasoned argument takes place publicly, the discussion often centers on the externalities which would be suffered by commercial fisheries as a result of growth in aquaculture.

This paper presents some analysis of these points of interaction in the one region in North America where private aquaculture has come into conflict with commercial fisheries. Statistical analysis presented here and elsewhere (see Anderson, 1983 and Anderson and Wilen, 1984) suggests some evidence of density-dependent interaction between hatchery production and natural production, but it appears that crowding in the rivers and at hatchery release points during the smolt phase is far more important than ocean impacts. What are probably most important, however, are mixed stock effects associated with commercial fishing on aquacultured stocks. Our analysis shows that policies directed at controlling commercial efforts can spell success or failure for aquaculture as well as the commercial fishery. Table 6 below summarizes present values associated with several scenarios examined here.

Table 6. Present Values of Simulated Policies

	Scenario	Policy	Present Value (10^6 1967 $)	
			Commercial Fishery	Aquaculture
A	Commercial Fishery Maximization	Effort Unconstrained and Chosen Optimally	18.74	NA
B	Aquaculture Maximizes Profits	105 Day Season; Smolt Release Chosen Optimally	15.23	1.55
C	Aquaculture Maximizes Profits	Smolt Release and Season Optimally Selected; Payment for Reduction	10.45	1.86
D	Cooperative Optimization	Smolt Release and Effort Chosen to Maximize Joint Profits	21.40	

These values are useful in putting some bounds on what is at stake in the aquaculture controversy in Oregon. Two things are evident from these results. First, it is obvious how important policy is to both industries. Season length and natural escapement policies are particularly critical and public hatchery releases also play a role. Second, the inefficiencies associated with the current regulatory structure are large in absolute magnitude and even large relative to losses which might occur as a result of some loss of control to aquaculturists.

Currently the principal control exercised in Pacific Coast salmon fisheries consists of season length changes (and area restrictions). The management structure has basically evolved into one in which capacity changes (fostered by higher abundance, prices, etc.) are met by season length changes which preserve some target escapement levels. Thus scenario A, in which effort is chosen optimally to maximize present values, is not even close to the real base case. In fact, even case B is overly optimistic as a base case for fishermen since aquacultured fish are added to the returns from the natural stocks. Over the horizon examined, for example, privately aquacultured recruits range between 15 and 23 percent of total recruits and hence total commercial catch. As a rough guess, then, if about 18% of the commercial fishery's profits are associated with private aquaculture, its no-aquaculture base case present value profits would actually be around 12.49×10^6 1967 dollars. If escapement policies are not able to restore natural stocks to higher levels as fast as this scenario assumes, present values would be even lower.

In sum, then, with no private aquaculture and continuation of past escapement policies, the present value of commercial fishing profits would be lower than 12.99 million dollars and probably lower than 10.0 million 1967 dollars. If the fishery were totally controlled by the aquaculture industry but with some side payments for excessive season length reductions, fishermen could conceivably be slightly better off and aquaculture profits would be around 2 million dollars (case C). With a reasonably gradual (four or five cycle) build up in natural stocks coupled with a fixed season and profit maximizing smolt release by aquaculture (case B) fishermen could realize over fifteen million dollars, about 18% of which is due to aquaculture. Finally, if the fishing industry could ever agree to bite the bullet and engage in a rapid buildup of natural stocks by closing the fishery for two cycles, a present value close to 19 million without aquaculture could be realized and over 21 million in a cooperative institutional arrangement.

Perhaps more interesting than these quantitative comparisons is the light shed on the conflicts between aquaculture and commercial fisheries mentioned earlier. What we have shown is that there are (obviously) points of conflict between the two groups. We have focused on the mixed stock problem, in particular, and have shown that the aquaculture industry needs to reduce season length below current levels to be able to even initiate a sustained industry. On face this is cause for fishermen to be wary of aquaculture growth. Paradoxically, however, if the aquaculture industry were successful in influencing policy to support their objectives, fishermen could also be better off in the long run if they were either compensated for season reductions or if they were allowed to increase effort after artificial stocks were built up. This is the case because there are very large gains to be made by reducing effort in the short run and building up natural stocks at the same time. Thus in the final analysis, the goals of these two groups (though different) may support the same policies (assuming mechanisms for cooperation/compensation can be devised) and the conflict may not be as serious as has been believed.

Appendix

Table 1A. Definition of Variables and Associated Assumptions Used in the Control Problems

RN_t is the recruitment of natural coho in year t (10^6 fish).

RH_t is the exogenously determined recruitment of public aquaculture coho in year t (10^6 fish).

RAH_t is the recruitment of private aquaculture coho in year t (10^6 fish).

CHI_t is the proxy stock of chinook in year t (10^6 coho equivalents). This variable is exogenous and is held constant at 1.4×10^6 coho equivalents. The coho equivalent is determined by chinook stock proxy times the average ratio of chinook/coho weight ratio times the average chinook/coho per pound price ratio. The average chinook stock (1971-1982) is assumed to be approximated by average catch of Oregon coastal, Crescent City, Eureka and Fort Bragg, chinook which is 0.500×10^6 fish (PFMC, 1983). The constant stock proxy was assumed to be representative since the chinook stocks have been relatively stable over the last decade. The average 1971-1982 chinook/coho weight ratio is approximately 2.0; the average 1971-1982 chinook/coho per pound ratio is 1.4 (PFMC, 1982).

E_t is the fishing effort in year t (10^6 days fished).

PC_t is the real price of coho in year t (1967 dollars/pound).

S_t is the season length in year t (10^2 days). It is assumed that Oregon/Northern California regional season for 1980-1982 is an average of total mean season length north of Cape Falcon and south of Cape Falcon.

C_t is the coho catch in year t (10^6 fish). $C_t = 13.5\ E_t(RN_t + RH_t + RAH_t)$.

YC_t is the coho equivalent catch in year t (10^6 fish). YC_t is endogenously determined by the fishery production relationship:

$YC_t = 13.5\ E_t\ (RN_t + RH_t + RAH_t + CHI_t)$.

ES_t is the escapement of adult coho (natural, public aquaculture and private aquaculture) in year t (10^6 fish). It is endogenously determined by:

$ES_t = RN_t + RH_t + RAH_t - C_t$.

EP_t is the escapement of adult coho to private aquaculture sites (10^6 fish). EP_t is endogenously determined by:

$EP_t = RAH_t - 13.5\ E_t\ RAH_t$.

SAP_{t-1} is the private smolts purchased for release in year t-1 (10^6 pounds).

KAP_{t-1} is the real cost per unit of smolt released in year t-1 (1967 dollars/pound). It is assumed that there are 16.5 smolts per pound. The cost used was 0.825 1967 dollars/pound (2.25 1981 dollars/pound), this is equivalent to 0.05 1967 dollars/smolt (0.136 1981 dollars/smolt).

r is the real discount rate and is assumed to be 0.05 per annum.

References

Anderson, J.S. "Bioeconomics Interaction Between Aquaculture and the Common Property Fishery with Application to Northwest Salmon Resources," Ph.D. thesis, University of California, Davis. 1983.

Anderson, J.L. and J.E. Wilen. "Estimating the Population Dynamics of Coho Salmon Using Pooled Time Series and Cross Section Data," Canadian Journal of Fisheries and Aquatic Sciences (forthcoming).

Beverton, R.J.H., S.J. Holt. On the Dynamics of Exploited Fish Populations. Ministry of Agriculture, Fisheries and Food. London. Fisheries Investigations Series, Vol. 2, No. 19, 1957.

California Department of Fish and Game. Files. 1982.

Clark, C. Mathematical Bioeconomics: The Optimal Management of Renewable Resources. Wiley-Interscience, (1976).

Clark, C. and G.R. Munro. "Economics of Fishing and Modern Capital Theory: A Simplified Approach," Journal of Environmental Economics and Management, Vol. 2, (1975), pp. 92-106.

Cummings, T. Edwin. "Private Salmon Hatcheries in Oregon." Oregon Department of Fisheries and Wildlife. Portland, Oregon. 1983.

DeVoretz, D. "An Econometric Demand Model for Canadian Salmon." Canadian Journal of Agricultural Economics, Vol. 30, No. 1, (1982), pp. 49-60.

Gilbert, Richard J. "Dominant Firm Pricing Policy in a Market for an Exhaustible Resource." The Bell Journal of Economics, Vol. 9, No. 2, (Autumn 1978), pp. 385-395.

Intriligator, Michael D. Econometric Models, Techniques and Applications. Prentice-Hall Inc., Englewood Cliffs, New Jersey. 1978.

Kmenta, J. Elements of Econometrics. The MacMillan Co. New York. 1971.

Maddala, G.S. Econometrics. McGraw-Hill Co. New York. 1977.

Murtagh, B.A., M.A. Saunders. Minos, A Large-Scale Nonlinear Programming System (for problems with linear constraints): User's Guide. Technical Report SOL 77-9. Department of Operations Research, Stanford University. Stanford, California. 1977.

Murtagh, B.A., M.A. Saunders. Implementation of a Lagrangian-Based Algorithm for Sparse Nonlinear Constraints. Technical Report SOL 80-1. Systems Optimization Laboratory, Department of Operations Research, Stanford University. Stanford, California. 1980a.

Murtagh, B.A., M.A. Saunders. MINOS/AUGMENTED: User's Guide. Technical Report SOL 80-14. Systems Operations Laboratory, Department of Operations Research, Stanford University. Stanford, California. 1980b.

Oregon Department of Fish and Wildlife. Files. Newport, Oregon. October 1982.

Oregon Department of Fish and Wildlife. Computer printouts of salmon statistics. Newport, Oregon. July 1982.

Oregon Department of Fish and Wildlife. Computer printouts on salmon prices, 1978-81. Portland, Oregon. 1982.

Oregon Department of Fish and Wildlife. Comprehensive Plan for Production and Management of Oregon's Anadromous Salmon and Trout: Part II. Coho Salmon Plan. Portland, Oregon. 1982.

Pacific Fishery Management Council. Proposed Plan for Managing the 1982 Salmon Fisheries Off the Coast of California, Oregon and Washington. Portland, Oregon. 1982.

Pacific Fishery Management Council. Proposed Plan for Managing the 1983 Salmon Fisheries Off the Coasts of California, Oregon and Washington. Portland, Oregon. 1983.

Queirolo, Lewis E., Richard S. Johnston. Market Analysis of Domestically Produced Rainbow Trout and the Impact of the Introduction of Pan-Size Salmon. Publication No. ORESU-T-79-004. Oregon State University Sea Grant Program. Corvallis, Oregon. 1977.

Ricker, W.E. "Stock and Recruitment." J. of Fish. Res. Board Canada 11:559-623. 1954.

Stokes, Robert L. "The Economics of Salmon Ranching." Land Economics 38(4) (1982): pp. 464-471.

Swartz, A. Nelson. "The Pacific Coho Salmon Fishery: An Intraseasonal and Interregional Economic Analysis of the Exvessel Market," Ph.D. thesis, Oregon State University. 1979.

Thorpe, J.E. "The Development of Salmon Culture Towards Ranching." In: Salmon Ranching. Ed. J.E. Thorpe. Academic Press. New York. 1981.

United States Department of Commerce, Bureau of Census. Various years. Statistical Abstract of the United States. Washington, D.C.

United States Department of Commerce, Oceanic and Atmospheric Administration, National Marine Fisheries Service. Various years. Current Fishery Statistics. Washington, D.C.

Washington Department of Fisheries. Computer printouts. October 1982.

Washington Department of Fisheries. Files. October 1982

Washington Department of Fisheries. Fishery Statistics Report. Olympia, Washington. Various years.

Wilen, J.E. "Bioeconomics and Optimal Use of Natural Populations." In A.V. Kreese and J.L. Sweeney (eds.), Handbook of Natural Resource and Energy Economics. North-Holland Publishing Company (forthcoming).

Wright, Samuel G. Status of Washington's Commercial Troll Salmon Fishery in the Mid-1970's. Washington Department of Fisheries, Technical Report No. 21. Olympia, Washington. 1976.