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Managing Alaska Groundfish: Current Problems and Management Alternatives

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I. Introduction

Groundfish stocks in the Gulf of Alaska (GOA) and the Bering Sea and Aleutian Islands (BSAI) present U.S. fishery managers with a dilemma: they offer huge potential economic rewards, and they present unusually complex management problems. Recent U.S. fishery policy has promoted domestic fishery development as a means of capturing benefits from the potential $2 billion (processed value) groundfish industry in the 200-mile Exclusive Economic Zone (EEZ) off Alaska. This "Americanization" policy assigns highest priority to U.S. fishing in quota allocations, and it creates incentives for foreign nations to assist in developing the U.S. fishery. Given the recent expansion of the U.S. groundfish industry, the policy can be considered a substantial success. However, a large U.S. trawl fishery may damage traditional fisheries for other high-valued fish and shellfish stocks off Alaska. Also, continued rapid growth in fishing capacity threatens to create the usual problems of overcapitalization: much reduced profitability, short and disorderly fishing seasons, and intense pressure on conservation agencies to slacken fishing regulations. These problem areas create difficult challenges for the fishery management system.

Traditional domestic fisheries off Alaska specialize on high-priced fish, such as salmon, roe herring, pink shrimp, halibut, sablefish, and king and tanner crab. As recently as 1980, low-priced groundfish (e.g., pollock, Pacific cod, flounders, and rockfishes) accounted for less than 1% of the landed fish value in Alaska. During the past decade, a large number of small, coastal vessels, of the traditional owner-operator type, have routinely landed small quantities of high quality groundfish in various fishing ports of Southeast Alaska and around the Gulf of Alaska. Alaska Department of Fish and Game statistics for 1985, for example, indicate that close to 700 vessels using longline, hand troll, and power troll gear landed about 8,400 metric tons (exvessel value of $8 million) of sablefish, rockfish, pacific cod, and other saltwater finfish.

Before 1976, U.S. groundfish management actions were limited to controlling incidental catches of salmon, king crab, and halibut by foreign fisherman. Several bilateral agreements with Japan and the Soviet Union negotiated in the 1960s and early 1970s included prohibitions on foreign trawling in areas and seasons of unacceptable incidental catches or of direct conflicts with U.S. fishermen.[1] To obtain foreign cooperation, the U.S. allowed foreign fleets to fish, or to engage in provisioning or loading operations in the U.S. contiguous zone (12-mile zone).

With the enactment of the Fishery Conservation and Management Act of 1976, later changed to Magnuson Fishery Conservation and Management Act (MFCMA), U.S. sovereignty in the EEZ permitted more comprehensive regulation of foreign and domestic fishing. Fishery management plans developed by the North Pacific Fishery Management Council (NPFMC) have established a framework for setting annual harvest quotas, allocating quotas among foreign and domestic fishermen, allocating harvests among areas and gear types, reserving and later releasing harvest quotas, and adjusting in-season quotas and allocations. The management plans also regulate trawl catches of prohibited species (halibut, tanner crab, king crab, salmon) by setting limits on such catches and by closing certain areas to trawl fishing.

The MFCMA permits foreign fishing in the U.S. zone to the extent that the fish would not be harvested by domestic fishing, and requires that catch available to foreign fishing be allocated among nations based upon such criteria as adherence to fishing regulations, contributions to scientific research on fish stocks in the EEZ, and the extent to which the foreign nations foster the growth of U.S. fishery. Starting in 1978, and more strongly after amendment to the MFCMA in 1980, the Department of State tied foreign fishing privileges in the EEZ to market access and trade policy. Nations that impose tariff or non-tariff barriers to importation of U.S. fish products were given low priority in allocations of allowable foreign catch. Moreover, the so-called "Fish and Chips" policy, provided larger allocations to foreign nations that assisted in developing the U.S. industry through joint ventures, transfer of technology, or agreements to purchase U.S. processed fishery products (National Marine Fisheries Service (NMFS), 1985).

In addition to the national, pro-development fishery policy, the availability of many capable fishing vessels and an advantageous world market situation for frozen cod blocks and fillets spurred the development of the groundfish fishery. Scores of vessels originally built as combination crabber/trawlers for the king and tanner crab fishery off Alaska were suddenly looking for alternative fisheries when the crab fishery "crashed" in the early 1980s. In the BSAI, for example, the crab fishery peaked with 377 vessels landing 237 million pounds (all species) worth $144 million exvessel in 1980. The total harvest dropped to 134 million pounds ($98 million) in 1981 and 67 million pounds ($93 million) in 1982. As the crab fishery continued to decline over the following three years, many vessel owners became eager to experiment with alternate fisheries, including groundfish off the west coast and Alaska.

World prices for high-volume groundfish products, such as frozen fillets and blocks, rose steadily but unspectacularly through the 1970s and early 1980s. According to NMFS Operation Price Watch data (reported in an unpublished paper by Lewis Queirollo and Joseph Terry) the nominal retail price for the U.S. cod market rose from about $1.08/lb in 1973 to $2.37/lb in 1985. After correcting for inflation using the Consumer Price Index, this represented a slight drop in real domestic price for cod. Prices for other frozen groundfish products followed suit. During 1986, however, a sharp decline in Atlantic cod production caused a supply shortfall and an abrupt rise in frozen cod prices. The price per pound for a standard layer/shatter-pack of 3-5 oz. Alaska pollock fillets rose from $.85 in early 1986 to $1.50 in early 1987. This price rise was clearly attenuating by the end of 1987, but the overall effect on profits and investment prospects in the groundfish industry was highly encouraging.

A third factor was the decline in the international exchange rate for the dollar. During 1985 through 1987, the Japanese yen/U.S. dollar exchange rate fell from 255 to 146 yen/$. Even with steady internal Japanese prices for surimi, fillets and headed-gutted groundfish, U.S. groundfish operators able to deal in the Japanese market could experience significantly increased profits opportunities.

The several economic inducements noted above spurred growth in the U.S. fishery in two distinct stages. The first stage involves joint ventures with U.S. fishing vessels delivering to foreign at-sea fish processors. Many of the U.S. trawl vessels acting as catchers came from the king crab fleet. By 1986, around 125 U.S. joint venture vessels caught 1.4 million metric tons of groundfish, and the U.S. catch exceeded the foreign catch in the EEZ off Alaska for the first time. The joint venture fishing fleet is now capable of taking the full sustainable yield of most groundfish stocks that can be efficiently caught by trawl gear.

The second stage, expansion of groundfish processing capacity, is proceeding rapidly but is currently far behind domestic fishing capacity. The Arctic Trawler, outfitted to produce frozen cod fillets, initiated the U.S. factory trawl fleet in 1980.[2] Once the profitability of domestic at-sea groundfish processing was proven, more and more firms launched new or converted factory trawlers. The reported 1986 harvest by U.S. factory trawlers exceeded 80,000 metric tons. In 1987, at least twenty-five domestic factory trawlers and motherships, ranging in size from about 120 to 335 feet in length, are currently operating or in final stages of preparation for operating in Alaskan waters. In addition, thirty or so coastal trawl vessels are delivering to new groundfish processing facilities in coastal ports, such as Kodiak, Sand Point, Akutan, and Dutch Harbor, Alaska. It is likely that both shore-based plants and at-sea processors will continue expanding while the joint venture catches will decline somewhat.

As noted earlier, the domestic fishery expanded in response to high groundfish product prices and to priority treatment for U.S. fishing in quota allocations. Record high groundfish prices were caused mainly by shortages of north Atlantic cod during the last few years. As the shortages are alleviated prices will decline. In fact, prices for frozen cod and pollock fell about 20 percent in late 1987. The pace of future growth in the groundfish industry will depend upon continued high worldwide demand for frozen groundfish products, access to Asian markets for frozen headed and gutted fish, access to the Japanese market for surimi, and a growing U.S. consumer demand for frozen fillets, blocks, and surimi-based products.

The surprisingly rapid growth in U.S. fishing and processing capacity has spawned some concern that continuation of the current management regime will encourage too much investment in fishing capacity. Overcapitalization of the fishing fleet may ultimately trigger a well-known list of fishery ills: shortened fishing seasons, increased discard of prohibited species, and reduced economic returns from the fishery. Further, with continued free access to other Alaska fisheries, excess fishing capacity leaving the groundfish fishery could crowd into the crab, herring, and halibut fisheries.

An additional problem is a potentially serious degradation in fishery information. Foreign and joint venture catches are routinely monitored at sea by U.S. observers aboard processing ships. The foreign observer program is funded by fees charged foreign fishing nations. A comparable program for domestic processing vessels, catcher vessels, and catcher/processors is not in effect, and it seems highly unlikely that a domestic observer program approaching the 95% coverage obtained in the foreign fishery will be implemented soon. Without systematic at-sea sampling to determine species and size composition of trawl catches, to check prohibited species incidental catch rates and to monitor compliance with other regulations, the effectiveness of the harvest quota system may become suspect.

In response to various emerging management problems, the NPFMC recently announced its intention to develop and adopt a limited access system for the sablefish longline fishery, to consider adopting a possible cut-off date for further entry to the groundfish fishery, and to initiate a study of alternative limited access systems for groundfish. The Council has also established special committees to investigate and make recommendations regarding prohibited species catch regulations and domestic observer programs. The urgency of developing comprehensive and effective management approaches to all aspects of groundfish management increases as U.S. investment in the fishery proceeds at a rapid pace.

The purpose of this study is to review the current problems in the fishery, to sort through the various regulatory options, and to analyze the advantages of various feasible approaches. Any evaluation of modified regulations must be based upon an accurate perception of the current fishery status, management regime, and policy objectives. To fill this need, the following section of this report provides a synopsis of the state of the groundfish fishery and of the current management regulations. Section III delineates some criteria for evaluating a new management system. The subsequent sections discuss the use of conventional fishery regulations, and the elements of limited access systems. The final section of the report sums up the findings and makes various recommendation on the design of future groundfish management measures.

Endnotes to Section I

1. See R.A. Fredin (1987) for an extensive history of groundfish regulation in Alaskan waters.
2. Trans-Pacific Seafoods' Arctic Trawler was originally built under a Federal fishery development program. The 296-foot freezer trawler and a sister ship (originally named the Sea Freeze Atlantic and Sea Freeze Pacific) were built at great expense and launched with much ballyhoo in 1968. This experiment was ahead of its time, as both ships proved unprofitable, and it failed to usher in the promised era of large-scale American groundfish trawling. Ironically, both sister ships have now been re-converted by private owners to fulfill their original tasks. The Arctic Trawler is undergoing still another conversion and will emerge as a surimi trawler.

II. An Overview of the Fishery

Size of the Fishery

Groundfish stocks in the Gulf of Alaska, Bering Sea, and Aleutian Islands (Figures 1 and 2) are among the largest and most valuable food fish resources in U.S. waters. During the past twenty years, annual groundfish harvests from Bering sea and Aleutian Island stocks ranged from 1 million to slightly over 2 million metric tons, while harvests from the Gulf of Alaska stocks have ranged from 78 thousand to 357 thousand metric tons (Figures 3 and 4). During 1984 through 1986 total harvests averaged 1.9 million metric tons per year in all areas combined. To place this in perspective, groundfish harvests from the U.S. zone represent about 27 percent of the total harvested throughout the north Pacific and Bering Sea (including FAO Zones 67 and 61), and are about 3 percent of the world food fish harvest (FAO, 1987).

As a percentage of total harvest, walleye pollock is the predominant species in both the BSAI and GOA (Figures 5 and 6). The next largest annual harvests in BSAI are for yellowfin sole, Pacific cod, other flatfish, and Atka mackerel. Following pollock in the GOA are Pacific cod and sablefish. Based upon recent unprocessed fish prices (ex-vessel and joint venture prices) the value of Alaska groundfish averaged about $256 million during 1984 to 1986. The value of processed products depends upon species and product category (e.g fresh fillets, headed and gutted fish, fillets in "shatter-packs," frozen blocks, roe, and surimi), product yields (i.e., pounds of product made per pound of raw fish), and product prices. Based upon prices, product yields, and distributions of fish to product categories reported in various publications and in interviews with groundfish industry participants, the total estimated product value from 1984 to 1986 was almost $1.4 billion per year.[1]

If the 1988 Acceptable Biological Catch (ABC) of each species were caught and sold at equivalent prices, the unprocessed market value would grow to $617 million (Table 1), and the potential processed product value (Table 2) could be over $2 billion. This total product value would be achieved only if: (a) all stocks abundances and market prices hold up to current levels, and (b) the domestic fishery is geared up to produce these harvest levels. Due to low stock abundances, or low market demands, or restrictive groundfish regulations (e.g., restrictive quotas or by-catch limits) annual harvests of some groundfish species have not been near the estimated long-term sustainable yields.

Stocks not being harvested near estimated MSY levels include Pacific cod (both BSAI and GOA stocks), and various flatfish species in GOA. Pacific cod catches in the Bering Sea averaged twice the estimated MSY during 1984-86 on the strength of two very large year classes spawned in 1977 and 1978. In the Gulf of Alaska, Pacific cod have been harvested well below sustainable yields. The NPFMC has designated a level of Optimum Yield (OY) that is only half the estimated

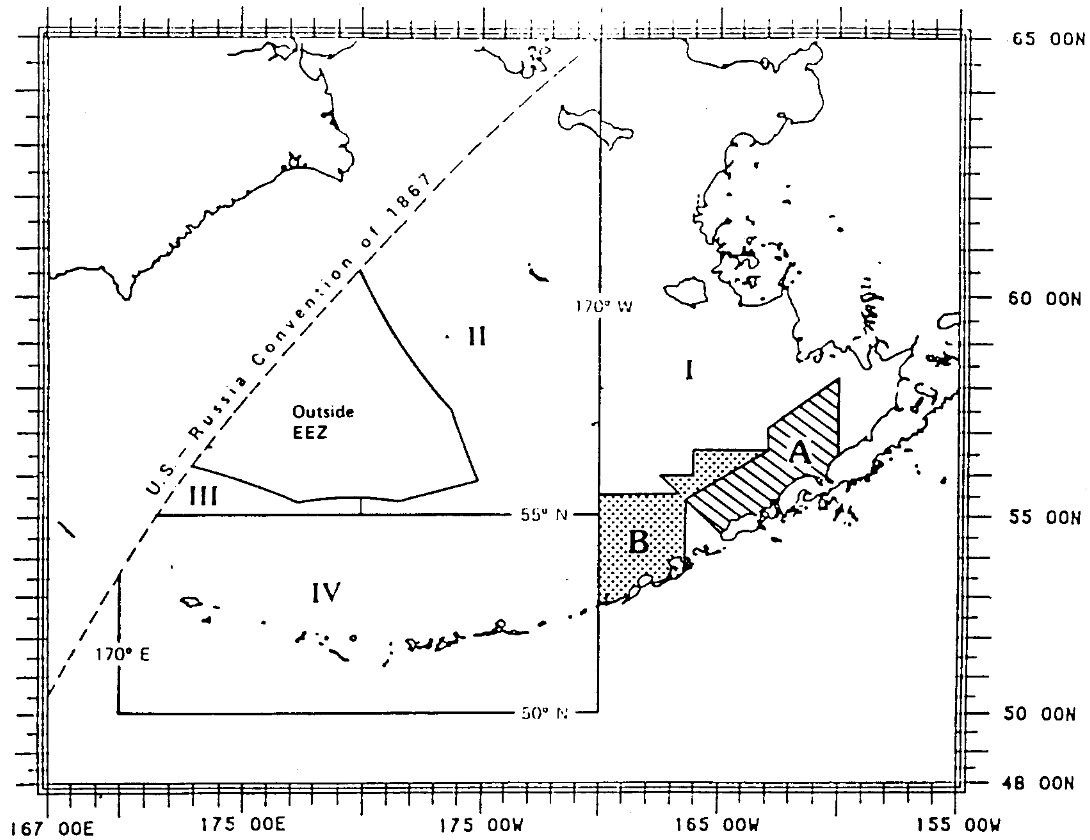

Figure 1. Statistical zones and special fishing areas in the Bering Sea and Aleutian Islands.

MSY, ostensibly to protect sablefish; and the Total Allowable Level of Foreign Fishing (TALFF) has been drastically reduced by arbitrarily allocating most of the quotas to domestic fishing. Pacific ocean perch stocks have been chronically overfished since the 1960s, when distant water fishing fleets from the Soviet block fished them very hard. Flatfish stocks in GOA are lightly fished due to lack of market demand for some species (e.g., Arrowtooth flounder), and because the harvest quotas for these species have been kept intentionally low to reduce the bycatch mortality of Pacific halibut.

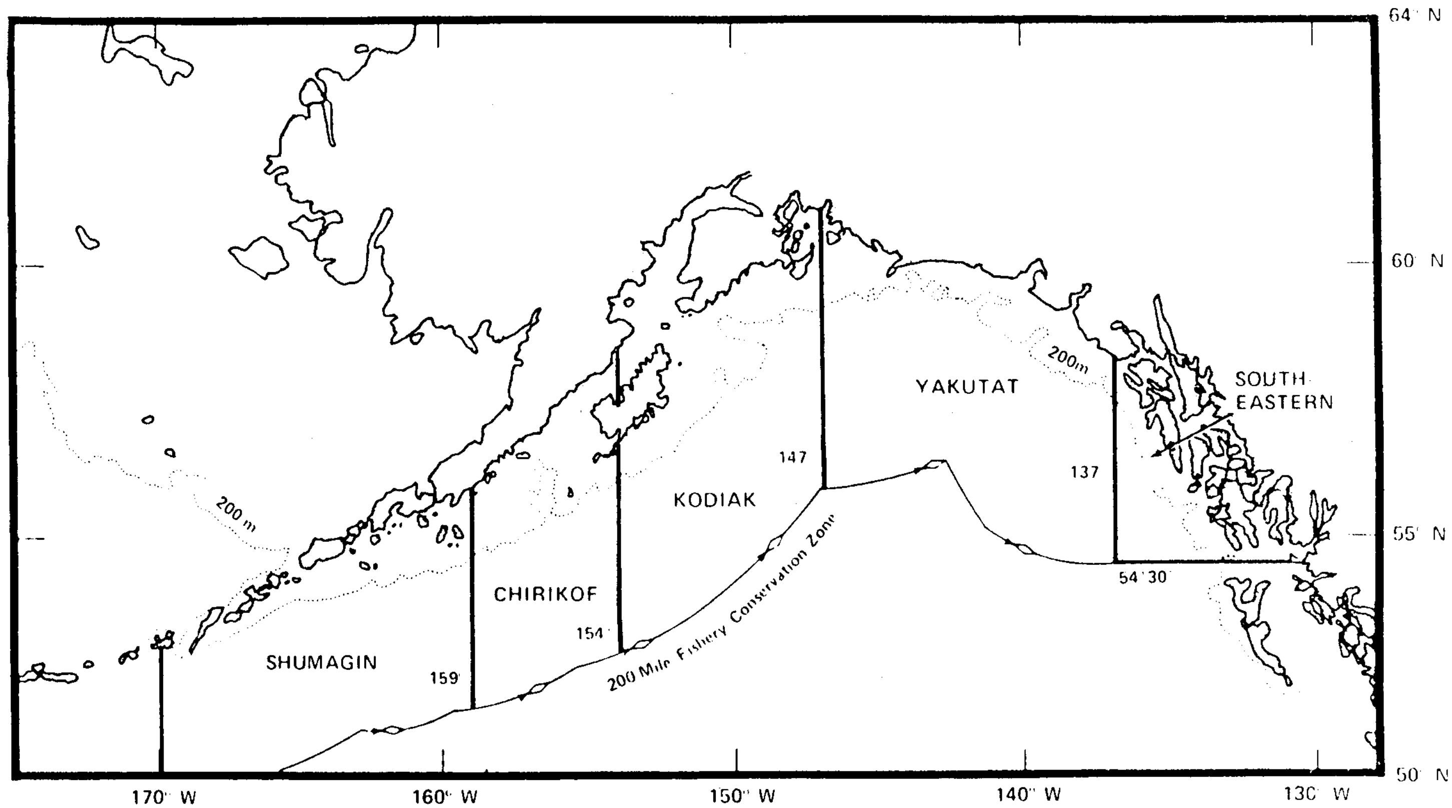

Figure 2. Statistical areas in the Exclusive Economic Zone in the Gulf of Alaska.

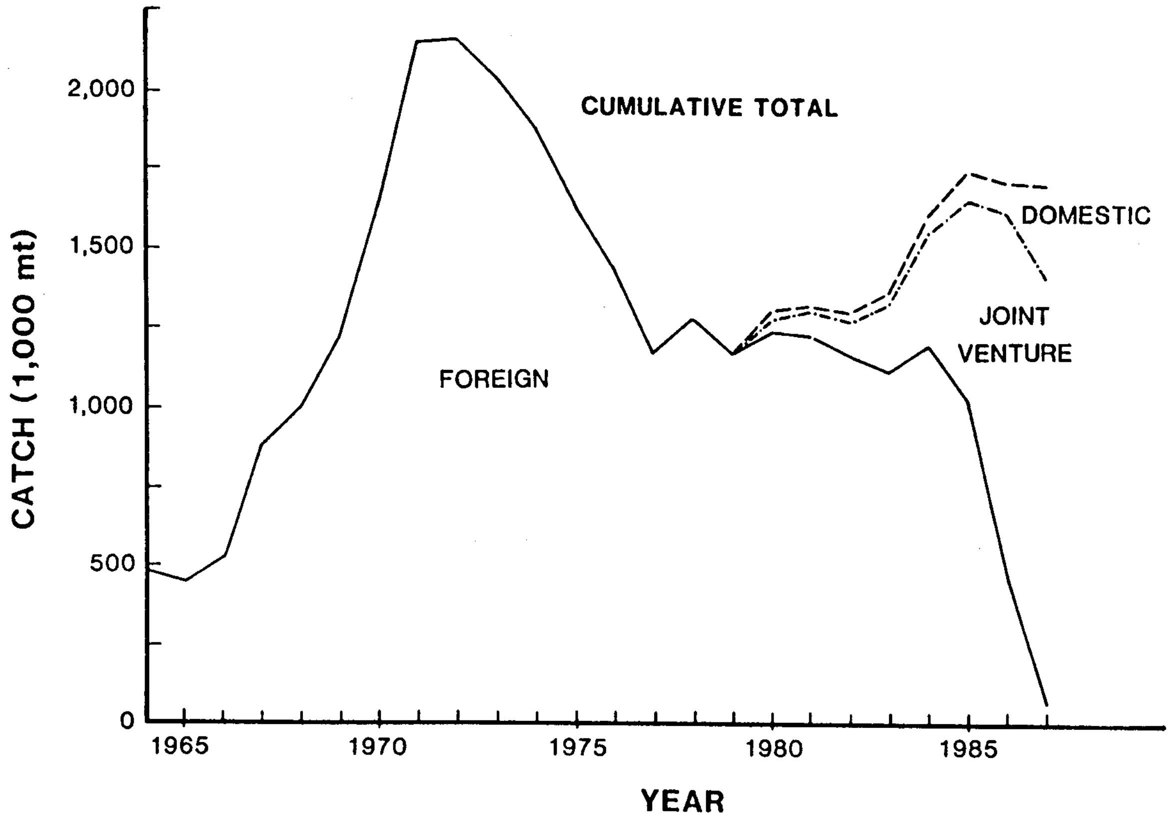

Figure 3. Annual groundfish harvests in the Bering Sea and Aleutian Islands.

Sources: Bakkala, R. G. and J. W. Balsiger, eds. (1987); Berger, J. D., J. E. Smoker and K. A. King (1986); and Smoker, J. E., personal communication.

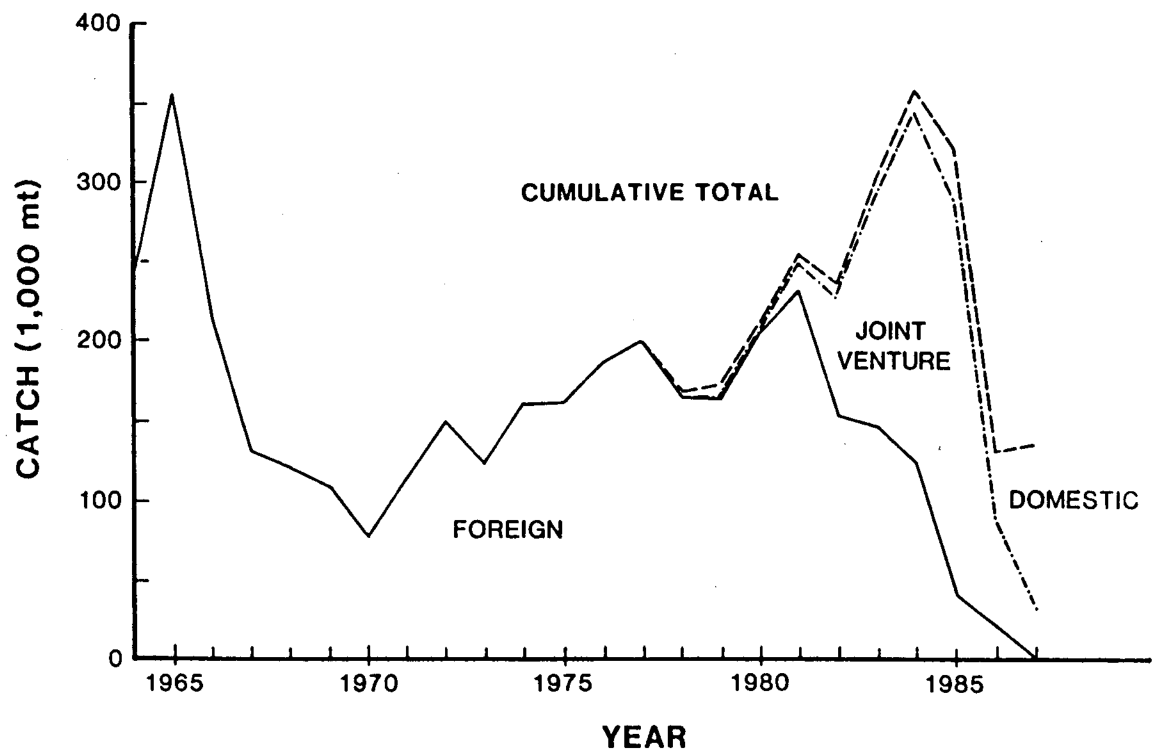

Figure 4. Annual groundfish harvests in the Gulf of Alaska.

Source: Major, R. L., ed. (1986); Smoker, J. E., personal communication.

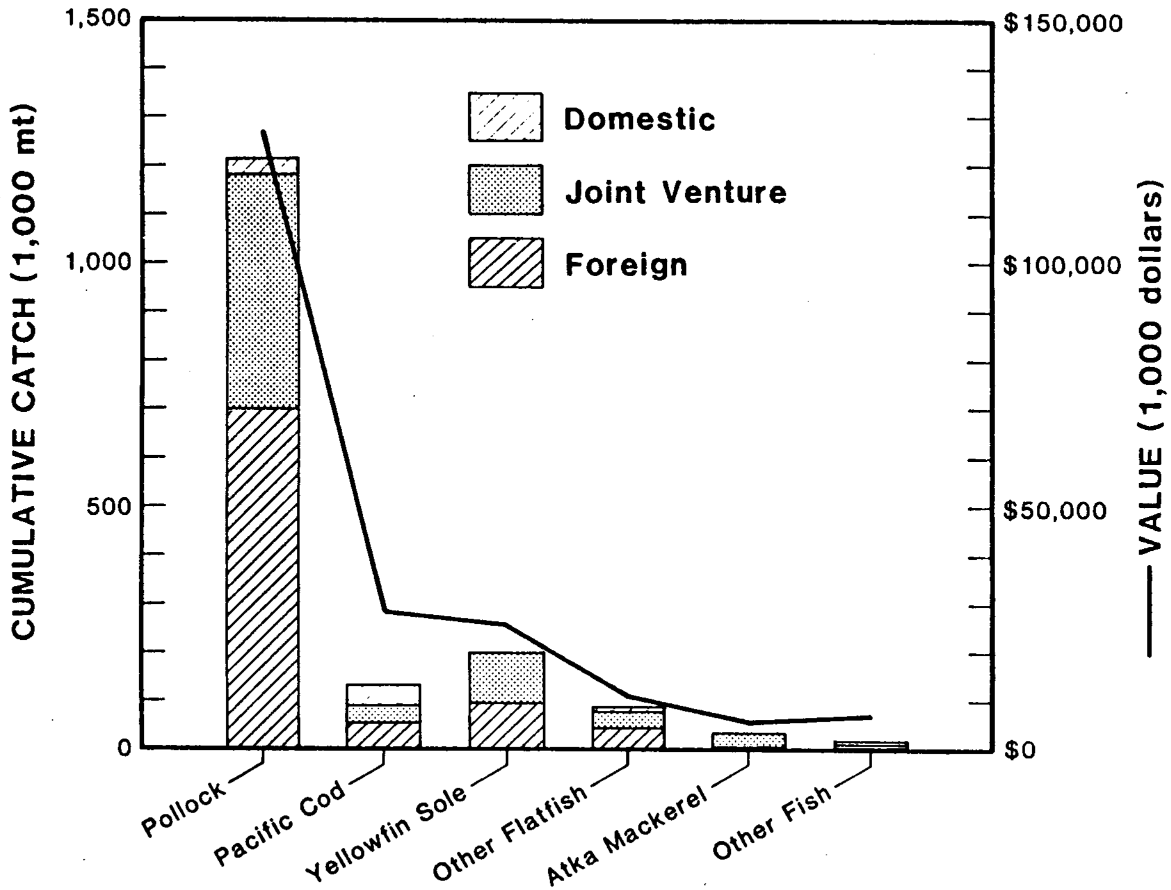

Figure 5. Average annual harvests, 1983-1985, and estimated exvessel value in the Bering Sea and Aleutian Islands.

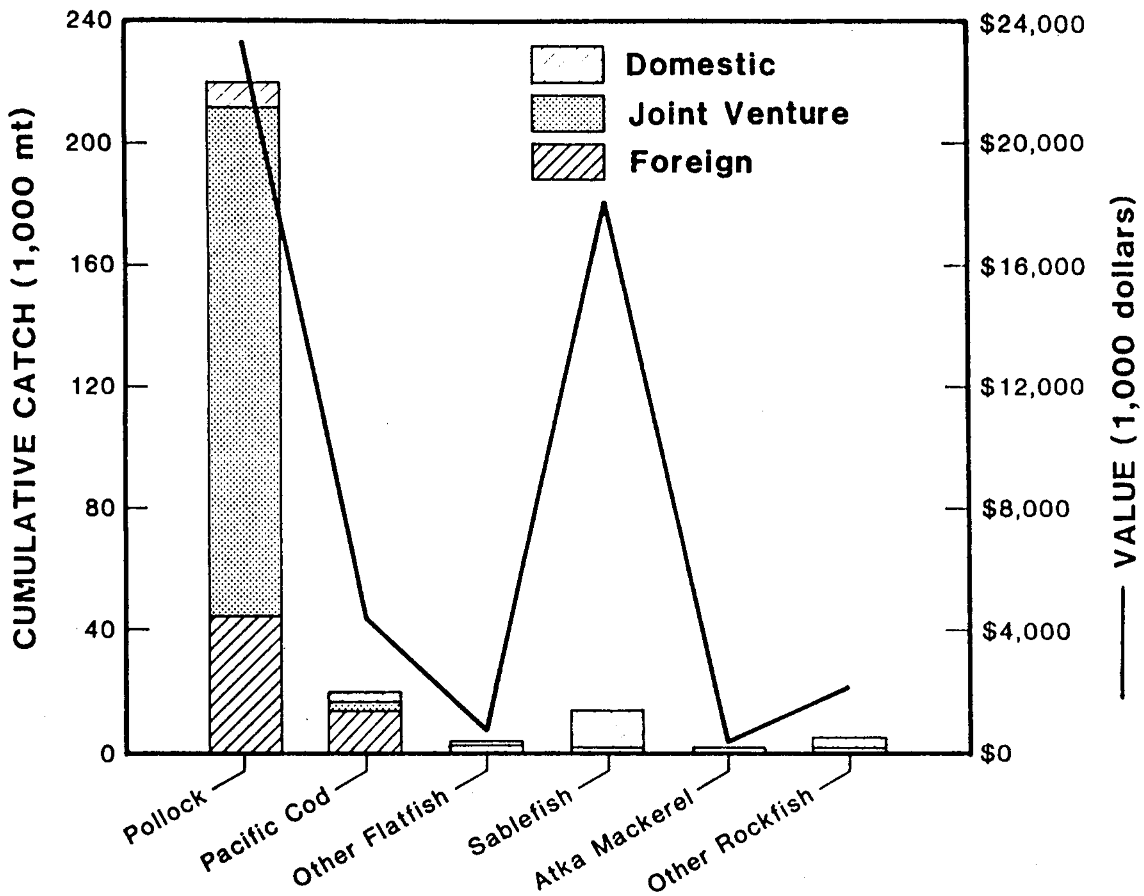

Figure 6. Average annual harvests, 1983-1985, and estimated exvessel value in the Gulf of Alaska.

Table 1. Acceptable biological catch (ABC) for groundfish species in the eastern Bering Sea, Aleutians, and Gulf of Alaska, 1988. Estimated value of unprocessed fish, assuming full utilization of ABC, and prices equal average of exvessel Alaska price and joint venture price.

	ABC's Bering Sea & Aleutians	ABC's ABC's Gulf of Alaska	Total ABC's	Average unprocessed fish price	Estimated value of unprocessed fish
	metric tons				$1,000's
Pollock	1,660,000	225,000	1,885,000	$ 105.2	$198,231
Pacific cod	385,300	125,000	510,300	222.4	113,473
YF Sole	254,000	19,410	273,410	134.0	36,637
Grlnd Turbot	14,100	0	14,100	166.0	2,341
A-T Flounder	109,500	416,151	525,651	134.0	70,437
Rock Sole	183,885	117,416	301,302	159.2	47,980
AK Plaice	81,246	0	81,246	134.0	10,887
Flathead Sole	59,736	79,385	139,120	172.0	23,932
Misc Flat	7,033	135,337	142,370	134.0	19,078
Sablefish	12,200	35,000	47,200	1,322.4	62,417
P-O-P	22,600	3,300	25,900	319.6	8,277
Rockfish	1,500	16,800	18,300	491.5	8,994
Atka Mack.	21,000	0	21,000	151.0	3,171
Thornyhead	0	3,750	3,750	714.7	2,680
Other Spec.	54,000	10,312	64,312	130.9	8,418
Totals	2,866,100	1,186,862	4,052,962		$616,955

Sources: (1) Summary for Industry Meeting, Extracted from Resource Assessment Document for Groundfish in the Bering Sea-Aleutian Islands as Assessed in 1987 and estimated Acceptable Biological Catch levels for 1988. December 3, 1987.
(2) Summary for Industry Meeting, extracted from Gulf of Alaska Groundfish Plan Team, Resource Assessment Document for Groundfish in the Gulf of Alaska. November 20, 1987.
(3) Prices are averaged from PACFIN reports for 1986 and joint venture prices reported by NMFS Alaska Regional Office.

Management Under the MFCMA[2]

Two fishery management plans have been implemented to regulate fishing in the Gulf of Alaska and Bering Sea/Aleutians through a detailed set of conventional fishery regulations. The main features of these plans are as follows:

1. Optimum Yield (OY) and Total Allowable Catches (TAC): Each plan establishes a range for the OY for all groundfish species. In BSAI the range is 1.4 to 2.0 million metric tons, and in the GOA it is 116 to 800 thousand metric tons. The TAC for each species is determined each year based upon annual resource assessments; the TACs are adjusted so that the total for all species falls within the OY range.

Table 2. Estimated maximum annual value of groundfish products from harvest of Alaska groundfish.

	ABCs for combined BSAI & GOA	Average product value per mt	Percent of ABC utilized	Estimated total product value ($1,000's)
Pollock	1,885,000	478.84	100.00%	$902,620
Pacific cod	510,300	822.32	100.00%	419,632
YF Sole	273,410	828.94	100.00%	226,640
Grlnd Turbot	14,100	1,884.95	100.00%	26,578
A-T Flounder	525,651	440.92	10.00%	23,177
Rock Sole	301,302	828.94	100.00%	249,760
AK Plaice	81,246	828.94	10.00%	3,582
Flathead Sole	139,120	828.94	100.00%	115,322
Misc Flat	142,370	828.94	50.00%	55,320
Sablefish	47,200	1,886.33	100.00%	89,035
P-O-P	25,900	1,242.30	100.00%	32,176
Rockfish	18,300	1,242.30	100.00%	22,734
Atka Mack.	21,000	661.39	100.00%	13,889
Thornyhead	3,750	1,242.30	100.00%	4,659
Other Spec.	64,312	661.39	50.00%	21,268
Totals	4,052,962			$2,206,391

Sources: Values per ton of harvested fish are based upon market prices for surimi, roe, shatter-pack fillets, headed and gutted frozen fish, and blocks; assumed distribution of raw fish to product categories; product yields derived from published documents and personal communications with industry members; and assumed partial utilization of arrowtooth flounder, Alaska plaice, miscellaneous flatfish and other species. Details of the calculation are available from the author on request.

2. Reserves and allocations: In BSAI 15% of each TAC is reserved, while none of the TAC in GOA is currently held in reserve. The non-reserved TACs are split between domestic annual harvest (DAH) and total allowable level of foreign fishing (TALFF) by allocating first to DAH all that the domestic fishing fleet is expected to harvest. The DAH is split between fishing for domestic processors (DAP) and joint venture processors (JVP), with domestic processors getting as much as they need before any TAC is allocated to JVP.
3. Season closures: The Alaska Regional Director of NMFS announces a closure for any species fishery when the directed (target) catch for that species to date plus expected incidental catch in fisheries for other species over the balance of the year reaches the TAC. When it is determined that the TAC is reached, the species is declared to be a prohibited species for the remainder of the year.
4. Prohibited species: Halibut, tanner crab, king crab, and salmon, as well as any species whose TAC has been reached, are considered prohibited species for trawl gear. These

species must be returned to the sea as soon after capture as practicable, and all fishermen are required to minimize their catches of prohibited species. The BSAI regulations directly establish prohibited species catch (PSC) limits, while the GOA regulations authorize the Regional Director to set PSC limits. For example, in Zone A of the BSAI (Figure 1) the limits are 80,000 tanner crab and 135,000 red king crab. For the entire BSAI the halibut PSC is 825,000 fish. When a PSC limit is reached, the bottom trawl fishery for yellowfin sole and "other flatfish" in Zone A is closed for the remainder of the year. After the PSC limit for halibut in the GOA is reached, the Regional Director prohibits fishing with trawl gear other than off-bottom trawls.

5. In-season adjustments: Both of the plans provide ample opportunity for the Regional Director to modify TACs, PSCs, closures, gear requirements, and allocations among DAP, JVP, and TALFF during the year. A series of specific considerations must justify these adjustments.
6. Time and area closures: In the Bering Sea the "Bristol Bay pot sanctuary" (area B, Figure 1) is closed to trawling, except that a portion of the area is open to trawl vessels participating in a special data-gathering program designed to measure incidental catch of prohibited species. Also, the "Winter halibut savings area" is closed to trawl vessels not having U.S. observers during December 1 through May 31 each year. In the GOA, directed fishing for sablefish with hook and line gear is closed from January 1 to March 31. Finally, four prime halibut fishing areas around Kodiak Island are closed to bottom trawling during all or part of the year. There have been other closures for foreign and domestic fishing not described here.
7. Gear limitations and allocations: Only trawls, hook and line gear, and fish pots are permitted to fish groundfish in the Gulf of Alaska; and fish pots are being phased out of the Gulf entirely by 1989. Sablefish is allocated primarily to hook and line gear fishing (80 percent in the central and western Gulf, and 95 percent in the eastern Gulf).
8. Observers: All vessels fishing in the EEZ of the Gulf of Alaska must take an observer on board when so requested by the Regional Director.

The foregoing regulations are reviewed and revised annually by the North Pacific Fishery Management Council and Department of Commerce to meet continually changing resource and economic conditions. The procedures for establishing annual TACs and PSCs, and the in-season adjustment mechanisms provide great flexibility in the regulations and assign a great deal of latitude to the Regional Director. This permits the Regional Director to respond to resource emergencies or other perceived problems in a relatively short time. In practice, the NPFMC is consulted before any significant management actions are taken.

Conservation under the Management Plans

The multispecies Optimum Yields for BSAI and GOA, acting as overall groundfish harvest limits, are set at levels less than the sum of the MSYs for all species. Maintaining the OY at this moderate level forces the individual species quotas to be, at least on average, less than estimated annual biological yields. This does not, however, prevent overfishing of individual stocks or sub-stocks. TACs for Pacific cod and flatfish in the GOA have been set at low levels (relative to estimated MSYs) to control incidental catches of king crab and halibut and to retard the joint venture fishery. Even though stock dynamics depend upon exogenous natural fluctuations (e.g., in recruitment) and inter-species linkages (e.g., predation, and competition for food) as well as fishing mortality, this conservative approach to annual quotas provides substantial protection to the groundfish stocks managed by the FMPs.

As noted earlier, some non-target species in groundfish fisheries support extremely important commercial fisheries. As documented in the provisional foreign fishery observer data report (Clancy and Nelson, 1987), the joint venture vessels in the Bering Sea caught 262,200 king crab, 5,652,400 tanner crab, 602,200 halibut, and 20,700 salmon during 1986. Similarly, foreign fisheries caught 22,000 king crab; 1,518,000 tanner crab; 286,200 halibut; and 1,800 salmon. In each case, these catches are discarded with some mortality. Incidental catch regulations reflect conservation efforts for halibut, salmon, king crab, and tanner crab and indirect efforts to allocate economic benefits among the target fishing fleets.

Because discarding fish involves fishing mortality without fish landings, greater discards generally lead to lower stock sizes and allowable catches. For example, the International North Pacific Halibut Commission adjusts its annual harvest quota down by about 10 million pounds due to the incidental catch mortality. Some critics of the prohibited species policy note that the discard of unintentionally and unavoidably caught fish and crabs does not promote conservation of those species nor does it increase the economic benefits from the fishery. The opposing view notes that prohibited species status prevents potential targeting on these species by groundfish fleets, and prohibition is necessary to maintain species allocations based upon historical shares and to achieve optimum yield. Also, where incidental catches are predominantly small, fast-growing fish, the surviving discards will grow to make a valuable contribution to the target fishery. This latter view is strongly held by halibut managers. The extensive use of time and area closures, and the unusually low TACs for flatfish and cod in the Gulf of Alaska are partly a reflection of the prohibited species approach.

Fleet Size, Processing Capacity and Overcapitalization

The rapid expansion of joint venture and domestic catch during the past seven years reflects the growth in fishing and processing capacity. The number of commercial fishing vessels receiving groundfish permits from NMFS's Alaska Regional Office has grown rapidly in every gear category (Figure 7).[3] From 1981 to 1987 the total number of groundfish permits grew from 199 to 1640, numbers of trawl gear permits grew from 54 to 197, and number of longline gear permits grew from 148 to 1435. Continuation of this trend will lead to excess capacity, or overcapitalization, in the fishing fleet.

Processing capacity is currently split between foreign and domestic. Overall, groundfish processing capacity is clearly greater than necessary, as evidenced by the early closure of the joint venture pollock fishery. Domestic processing capacity for species other than the traditional halibut and sablefish, however, is capable of handling only a fraction of the total groundfish caught. From the standpoint of U.S. policy which seeks economic development of the domestic industry, excessive multinational capacity for Alaska groundfish is not a concern.

An assessment of domestic groundfish capacity must distinguish between the separate trawl and longline fisheries, and it must recognize that at sea processing and fishing capacity are intimately linked in the factory trawl fishery. The halibut/sablefish longline fishery is a mature fishery which has already experienced widespread overcapitalization. Evidence for overcapitalization in the longline fishery is unambiguous. Between 1975 and 1986 the number of halibut fishing vessels grew by fifty percent, while the catching power per vessel at least doubled because of the switch from "J" hooks to circle hooks. Even though the halibut fishery is well managed for stock conservation, and annual halibut quotas remain at high levels, the fishing seasons are drastically reduced in length. In southeastern Alaska, the season length has dropped from 123 days in 1976 to three or four fishing days in 1986-87. In some areas halibut fishing was limited to twenty-four hour and twelve-hour openings, a practice that makes the fishery unsafe at times, and provides insufficient time for all fish to be properly dressed before being landed. Single day fishing capacity now exceeds the halibut quota in some areas, and the Director of the International Pacific Halibut Commission is prepared to recommend that trip limits be imposed upon halibut longliners.[4]

With short halibut seasons and high prices offered for sablefish, longline fishermen (especially those with vessels larger than 60 feet or so in length) increasingly diversify by switching to sablefish after halibut seasons are closed. The number of sablefish vessels grew by a factor of 7 from 1976 to 1987, with most of the growth coming after 1984. In the East Yakutat area the longline season lasted a full six months in 1984. It lasted only from April 1 to April 9 in 1987, despite the fact that the catch quota had been increased by fifty percent since 1984.

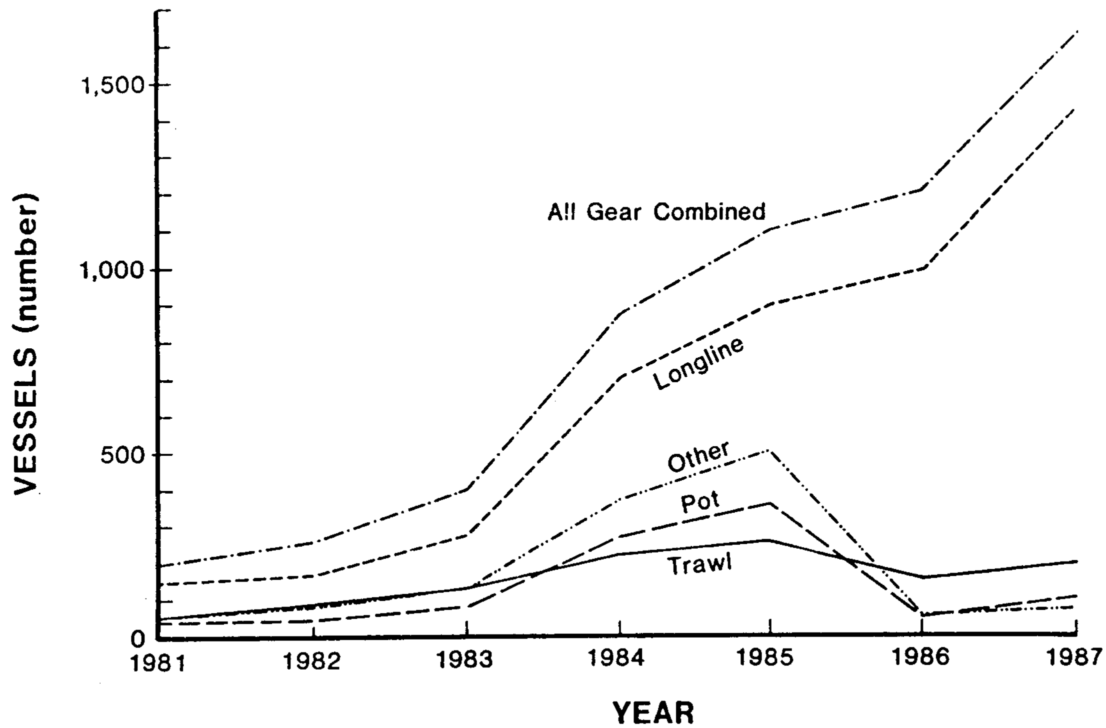

Figure 7. Number of groundfish permits issued by the National Marine Fisheries Service, Alaska Regional Office, Juneau.

As the domestic trawl fishery continues to expand, the evidence of excessive fishing capacity is emerging, but its effects are not yet strongly felt by major participants in the fishery. Shortened fishing seasons are one symptom. In the Bering Sea joint venture fishery, for example, the growing catch and fleet size has been accompanied by a progressively shorter season. During 1985 the JV harvest had reached 41 percent of its annual total by the end of April. During the comparable period of 1987, the catch reached 61 percent of the total, and the Bering Sea pollock quota had been reached before mid-June. Shorter fishing seasons in the joint venture fishery indicate that competition for pollock allocations has drawn excessive catching and processing capacity into the fishery. As noted above, most of the at-sea processing capacity is aboard foreign processing vessels. As U.S. processors begin to take a bigger share of the pollock, Pacific cod, and flatfish quotas, the same tendency to overcapacity may afflict the Americanized fishery.

While the existence of excess fishing capacity can be inferred from the progressively shorter fishing seasons, direct assessment of optimum capitalization for a fully domestic fishing and processing would be a more useful planning tool. This task is complicated by the technical diversity in fishing and processing operations, and because the capacity consistent with economic criteria depends upon fishing costs, catch rates, processing yields and costs, and the underlying biological constraints. All the factors determining the economic profitability of the fishery, in other words, need to be incorporated in the assessment of fishing capacity.

A practical approach to estimating optimal capacity must extrapolate from recent past experience and will invoke numerous simplifying assumptions. One method for doing this is the linear programming technique recently applied to multispecies groundfish fisheries on the Pacific coast (Huppert and Squires, 1987). Briefly, this is a mathematical method which finds the optimal (1) number of vessels, and (2) deployment of these vessels over areas and species. Optimal is defined as the maximum net economic return (total value of fish product minus cost of catching and processing) from the fishery, given the harvest quota constraints. The technique is called linear programming, because the objective is linear (a simple sum of profits from all segments of the fleet) and the constraints are linear (the sum of catches from all vessels must be less than or equal to the total allowable catch for each species).

The Appendix to this report contains a thorough description of a linear programming model developed for the Bering Sea and Aleutian Islands fishery. The model calculates the optimum fleet of factory trawlers and mothership operations for harvesting ABCs of pollock, Pacific cod, yellowfin sole, sablefish, Atka mackerel, other flatfish, rockfish, and other groundfish. Five classes of fishing operation are included; small, medium and large factory trawlers, small and large motherships.[5] Given the harvest quota constraints, the linear program selects the number of vessels in each class, and the deployment of those vessels (defined as assignments of available fishing and processing days among areas and target fishing strategies), to maximize net economic benefit from the fishery.

Fishing and processing costs, catch rates, and prices assumed for the calculation are discussed in the Appendix. Biological constraints on total annual harvests are represented by the recently recommended ABCs for 1988. Using these basic assumptions, the optimum fleet for Bering Sea and Aleutian Islands groundfish would contain 3 medium factory trawlers, 21 large factory trawlers, and 6 fillet motherships, and 3 large surimi motherships. Between 44 and 50 catcher vessels would supply the motherships. The projected total economic profit (over and above an assumed 10 percent return on capital investment) from this operation would be around $124 million per year, representing the total fish product value minus costs of harvesting and processing at-sea.

The optimum fleet estimated from this base calculation is surprisingly small considering that 140 motherships participated in the Bering Sea joint venture fishery in 1986 (Clancy and Nelson, 1987). One reason for this incongruity is that joint venture motherships fished an average of only 70 days in 1986, while full capacity utilization is assumed to be 265 fishing days per year for motherships. Also, an unknown fraction of the motherships operating in 1986 may have been smaller than the 460-foot motherships included in the model. Medium factory trawlers are assumed to be capable of fishing 260 days per year, but similar trawlers in the foreign fishery in 1986 fished an average of only about 40 days. Thus, a full-time factory trawler/mothership fleet operating at capacity in the Bering sea need not be nearly as large as recent foreign fleets.

Another surprise is that small freezer trawlers were not a significant part of the optimum fleet. In recent years, small freezer trawlers, used for producing headed and gutted fish and pollock/cod fillets, were a major component of the growing domestic trawler fleet. Three reasons for the divergence between model results and actual economic development patterns are apparent. First, the model does not include a financial constraint to reflect the difficulty fishing companies may have in raising the substantial capital needed for larger ships. Second, many of the small trawlers are designed to operate in the Gulf of Alaska fisheries where large scale pollock processing is less important than in the BSAI. Third, the economic returns predicted by the model presumes, as noted above, that an efficiently planned fleet operates during the entire fishing season. Under the existing "Olympic system" (i.e., open access competition), no rational investor would make this assumption, and the actual pattern of investments will reflect this reality.

A variety of practical considerations can be inserted into the economic model by changing the constraints, or by modifying assumed cost, price, or product yield rates. Some of these changes are examined in the Appendix. For example, an optimum fleet with large motherships excluded, would consist primarily of large factory trawlers generating a total net economic return of $97.8 million per year ($26.3 million less than the base calculations). Other calculations show that the trawl fleet would become largely unprofitable with 20 percent lower fish prices, and that aggregate fleet profits could increase to $281 million per year if prices rise by 20 percent.

These computations are useful guides to efficient fleet size, and they estimate the potential economic return which is likely to be squandered by overcapitalization under open access. Although the existing domestic catcher/processor fleet is not too large by this standard, there are currently far more than the requisite catcher vessels in the joint venture fishery. And, under the existing management system the fleet cannot be expected to stop growing when it reaches the optimum size.

Current Management Problems

Several problems in the Alaska groundfish system are apparent from the above discussion. It is increasingly evident that rapid growth in the domestic fishing fleet will soon prevent the United States from achieving economic efficiency objectives. Accompanying that growth, extensive waste of incidentally caught and discarded crab and halibut will be a concern. Until an adequate domestic observer program is established, the decreasing volume of catch sampling and fishery monitoring that attends the Americanization of the fishery is a threat to the credibility of scientific stock assessments. With little prospect of additional Federal funding from general tax revenues for regulation and monitoring, the Council's inability to collect resource rents from commercial harvesters may curtail necessary management and research activities. Evaluation of new management approaches for dealing with the emerging fishery problems requires careful consideration of objectives of public fishery management.

Notes to Section II

1. Prices, product yields, and allocations of harvested quantities among product categories for this computation are the same as those assumed for the optimum fleet calculations described in the Appendix to this report.
2. The descriptions of the management system and associated regulations are derived from recent versions of the two plans (NPFMC, 1984, 1986), the 1987 Gulf of Alaska groundfish regulations, and a draft of the Bering Sea and Aleutian Islands Area regulations (Code of Federal Regulations, Title 50, Parts 672 and 675).
3. These permits are required of all vessels fishing for groundfish in the EEZ. They are provided to all applicants, and are used for monitoring and record-keeping. They do not limit the entry of vessels to the fishery.
4. See the <u>Opinion</u> in the November, 1987 issue of Pacific Fishing magazine (p. 154).
5. The absence of shoreside processing plants from the model represents a data deficiency, not a finding that shoreside processing in Dutch Harbor, Akutan, Kodiak, and other areas cannot handle a significant portion of the groundfish in the Bering Sea.

III. Objectives

To choose a rational course of action requires knowledge of options, prediction of consequences, and awareness of objectives. Because they derive from conflicting interests and ideologies among fishery management agencies and industry groups, stated fishery management objectives are frequently overlapping, vague, or contradictory. To evaluate management options logically, it is necessary to choose a limited number of objectives. Such a choice requires rejection of some objectives; hence, a diminished attention to the interests of someone. Because this report is concerned with the overall performance of the commercial fisheries, and not with particular commercial interests, it will focus on broad, public policy objectives. The management objectives adopted here are distilled from the Magnuson Fishery Conservation and Management Act (MFCMA), the North Pacific Fishery Management Council's "Comprehensive Fishery Management Goals," management plans developed for groundfish fisheries, and other public expressions of resource management policy.

Fish Stock Conservation

A first criterion is that fish stocks be maintained at levels that permit large annual harvests and prevent overfishing. Past and current efforts by NMFS and NPFMC have emphasized annual yield estimates based upon scientific assessments fish abundance and research on key biological parameters. Fishery regulations include quotas to assure that annual harvest remain within acceptable bounds. Because the current regulations and any foreseeable modified regulations are likely to assure conservation of the major fish stocks, this report does not critically examine nor recommend modifications to the procedures adopted for assessing stock abundances and determining sustainable yields.

Because fish stocks fluctuate, a long run sustainable yield concept, like MSY, is inappropriate for assigning annual allowable catches. The Allowable Biological Catch (ABC) concept is a more flexible guide to annual quotas as it recognizes the fact that fish stocks vary, sometimes erratically, through time.[1] The Scientific and Statistical Committee (SSC) of the NPFMC has adopted a pragmatic definition which makes ABC a quantity that is above or below MSY as the underlying fish stock is greater or smaller than the level needed to sustain MSY. Multiplying the MSY fishing mortality rate times the current biomass provides a useful rule-of-thumb for calculating the appropriate quantity. The ABCs have not been calculated based upon the SSC's new definition as of yet. The management Teams have used similar approaches, some involving application of constant rates of exploitation to stock biomass. Whatever formal mechanism is used, annual adjustment of harvest levels is demanded of a management program under this resource conservation criterion.

While existing FMPs appear capable of conserving fish stocks, ambiguities and uncertainties regarding stocks and biological productivities may diminish the effectiveness of the conservation effort. For example, pollock populations in the Bering sea may sub-divide into several "stocks."[2] Different, but equally plausible, delineations of stock boundaries will lead to different estimates of potential yield in the EEZ. This source of ambiguity in scientific guidance on annual allowable catches adds to the substantial uncertainty in stock abundance due to wide variances in statistical estimates. Another problem is unknown volume of discards. Lack of information on quantities of fish discarded at sea poses a problem for stock assessment based on catch-per-effort. Unless on-site monitoring or accurate extrapolation from samples provide estimates of discard mortality, fishing mortality will be under-estimated. This latter is not a significant problem for stock assessments so long as fish stocks are monitored through fishery-independent surveys.

Economic Benefits

Economic benefits are commonly measured as the fishery's contribution to net income; that is, value of fishery products minus cost of production. The product value is expressed as the value to consumers, and the costs include all costs from harvesting, through processing and distribution, to retail marketing. Obtaining maximum economic benefits from a fishery depends upon several inter-related sub-objectives: (1) economic efficiency in harvesting and processing of fish; (2) producing and marketing an optimum mix of seafood products; (3) assuring product quality; and (4) technical innovation and productivity improvement through time in both harvesting and processing. These objectives, common to economic appraisals of industry performance throughout the economy, are achieved largely through private competition in fish product markets. Fishery management deals almost exclusively with sub-objective (1), which is not achieved through private competitive processes so long as the fish stocks remain open access resources.

It is useful to decompose the economic efficiency criterion further. First, efficient production requires a fleet of fishing vessels having sufficient capacity to harvest those fish worth harvesting on a cost-effective seasonal schedule. Because catch rates vary, and annual allowable catches fluctuate, the ideal harvest capacity will be capable of taking somewhat more than the average annual total allowable catches. Second, fish processing capacity should be matched to overall harvest capacity and it should be designed to produce the most valuable mix of products. Third, the cost of collecting scientific information, assessing fish stocks, monitoring catches and fishing effort, and enforcing fishing regulation should not be excessive. While optimal enforcement and monitoring effort cannot be precisely defined, specific features of the fishery management system should be evaluated for cost as well as resource conservation consequences.

In practice economic benefits from efficient production can be calculated at a regional, a national, or an international level of aggregation. While a national accounting stance is consistent with the National Standards of the MFCMA, regional interest groups will not be equally served by a national benefits objective. Maximizing national benefits may conflict with regional economic objectives whenever efficient production requires a shift in regional concentrations of economic activity.[3] When economic activity declines in a region, this normally results in reduced income to owners of immobile assets (land, buildings, harbors, etc.) for which demand has fallen. Thus, leaders of communities threatened with a loss of economic base (due to private business decisions, government regulations or whatever) will oppose a shift in economic activity even if the shift is consistent with maximizing benefits to the nation. In an important way, therefore, the national economic benefits objective may conflict with a regional economic objective.

Maintaining Flexibility

This objective overlaps both of the previous objectives, but is important enough to be stated separately. The recent history of fishing in Alaska provides abundant evidence that biological and economic changes can occur rapidly and unpredictably. To remain profitable over the long term, fishing firms must be adaptable to changing resources and markets. Diversification of fishing operations may be a part of this flexibility. Combination vessels are constructed with the expectation that during their useful lives they may be transferred among several distinct fisheries. A good example is the king crab/trawler combination. A substantial portion of the 125-vessel joint venture midwater trawl fleet came from the king crab fishery. Fishery regulations may preserve opportunities for fishing businesses to adapt and change as conditions change.

A similar objective is to design flexibility into key management procedures. New information, or developments in technology, may make established catch quotas or allocations illogical at a later date. For example, managers may need to designate a fish species as prohibited catch, while reserving the option to remove that designation when necessary. It should be possible to combine or separate individual species in quota regulations as appropriate for given circumstances. To maintain flexibility, managers should avoid getting boxed into a specific allocation of fish to narrowly defined gear groups or seasons or areas.

An Equitable Distribution of Fishery Benefits

Any set of management regulations will result in a distinct distribution of economic benefits. No generally accepted notion of fair and equitable treatment is available for judging equity of a given distribution among user groups or between resource users and the public at large. Nevertheless, there are specific approaches to equity that provide some logical guidance.

Fairness may be gauged either by outcomes (e.g., number of fish caught or income earned) or by processes (e.g., fair competition, or rules for entry). For example, judging on the basis of outcomes, it may be deemed unfair for a single fisherman or fishing company to harvest a preponderance of the catch, or to earn a preponderance of the profit. On the other hand, judging on the basis of process, a particular share may be fair or unfair depending upon whether the management system gives everyone an opportunity to harvest or earn profit. Where the outcome is the result of fair competition, and shares correlate with skill and planning, even a grossly unequal division of benefits may be considered equitable. To be useful guides to policy, notions of equity cannot be left ambiguous or fuzzy. Successful application of this criterion requires conscious adoption of explicit standards.

One standard is the prohibition of specific objectionable practices. For example, the MFCMA prohibits discriminating among U.S. citizens based upon State of residence. Equity may also require that any single fishing firm be prevented from dominating a fishery. These would be minimum standards for any regulation.

In evaluating a regulatory change, another useful approach to achieving equity is to avoid creating economic "losers" (e.g., anyone whose resource access or income-earning ability is significantly diminished).[4] Where fish catch is a reasonable proxy for benefits, approximate equity among user groups may be attained by maintaining catch shares. In a fishery that is developing as rapidly as the north Pacific groundfish fishery, however, simple guides, like past shares, need to be augmented to deal with change. Equity could be judged by fair process: concepts such as fair compensation,[5] or equal access to resources, or the fairness of the competition in which fish or economic benefits are obtained. Equity in dealing with user groups will be especially poignant issue in developing limited access programs, where government is seen as directly involved in the distribution of benefits.

As noted in the discussion of economic benefits, a management action that improves overall economic benefits can cause a loss in economic benefits in one location while increasing benefits in another location. Inter-regional shifts in economic benefits represent a most difficult problem for the "no losers" standard of equity. Because regional shifts in fishing and processing activity accompany almost any management action (especially limiting access), a strict version of the no losers criterion will prevent any action. A weaker version of the standard, such as "no significant uncompensated losers," is consistent with actual management practice.

Another question of equity concerns the division of costs and benefits between the commercial fishery and the public at large. On this subject, the President of the American Fisheries Society recently stated

> "It is a commonly accepted concept that those who use our resources should be charged a fair rate of rent to pay the cost for management, research, rehabilitation, and enhancement of the resource. Our present system of open entry fisheries and low-to-no user fees . . . causes the consumer to pay a higher price for a lower quality product. The loser is the owner of the resource, the public."[6]

The standard that firms should pay for using public resources is applied in some circumstances and not in others. Royalties paid by oil producers on Alaska's north slope, for example, represent an acceptable transfer of wealth from oil companies to the public. Timber sales from national forests are similar, but are sometimes made "below cost." Public irrigation projects in arid western States rarely, if ever, charge full costs to water recipients. There is no precedent for charging resource management costs to marine fisheries. Consequently, public resource policy is clearly inconsistent regarding distribution of benefits and costs between resource users and taxpayers.

The MFCMA establishes the national ownership and authority for managing fishery resources in the Exclusive Economic Zone (EEZ), but it is ambiguous regarding the extent to which users should pay for taking fish.[7] The law does not designate what share of the fishery benefits should accrue to the general public versus the fishing industry. Hence, the distribution of benefits between public and private interests warrants careful examination in developing management alternatives.

Optimum Yield

The MCFMA defines optimum yield (OY) as the quantity of fish prescribed on the basis of MSY as modified by any relevant economic, social, or ecological factor. An alternate definition of OY is the annual harvest that produces the largest benefits to the nation as a whole. This concept is not separate from the foregoing objectives; it incorporates all those other elements. OY involves a balancing of various objectives or criteria. For example, neither maximizing catch nor maximizing economic return would necessarily optimize the fishery. An optimum yield is the best balance of conservation, economic benefit, equity and flexibility.

Conclusion

In summary, groundfish management should be evaluated with respect to (1) fish stock conservation, (2) level of net economic benefits, (3) flexibility for management and private industry actions, and (4) equity in distributing economic benefits. If these objectives are adequately addressed, the "optimum yield" standard will be readily accomplished as well. Constraints on achievement of these objectives include political and administrative feasibility, consistency with national fishery policy, and scientific knowledge. Rational formulation of management regulations requires selection from among the feasible alternatives based upon the management objectives. While this rational model of decision-making is often attacked as unrealistic in detail, it provides a useful framework for examining improvements in the groundfish management regime.

Endnotes to Section III

1. The crash in king crab abundance in the early 1980s, the unanticipated resurgence in Pacific halibut in recent years, and the pollock disappearance from the Shelikof Strait two years ago provide ready examples of rapidly changing stocks.

2. It is currently unclear, for example, whether the pollock in the Bering sea between U.S. and Soviet 200-mile zones (the so-called "donut hole") belongs to the stock inhabiting the U.S. zone.

3. Program analysts recognize the economic importance, hence political importance, of "secondary benefits," regional increases in employment and income beyond those occurring in the primary industry. These secondary benefits tend to be balanced by equivalent losses elsewhere. Income-producing primary production activities, like fishing, will attract both support industries (ship repair, gear suppliers, fuel docks, grocery stores, etc.) and businesses related to use of the primary output (i.e., fish processors, brokers, cold storage facilities, shipping companies, etc.). Wherever the fish harvesting industry locates, these ancillary activities will also concentrate. As long as this is somewhere in the nation, the national economic benefits are essentially independent of location.

   Conflicts arise, however, when a region seeks to increase its secondary benefits at the expense of another region by, for example, moving a fishing fleet from one port to another. If the new port is better located and results in lower shipping or vessel transportation costs, then greater national economic benefits (measured by the reduced costs) will accompany the shift of the fleet to a new location. Local businesses and landowners in the new location are likely to gain economic benefits from shifting the fleet to their neighborhood even if there are no net national economic benefits. The business community at the old location will lose approximately an equal amount. Thus each region will want to establish the primary industry in their region regardless of whether their's is the best location.

   To a large extent, regional rivalries over location of economic activities amount to contests for secondary benefits that cancel out in the aggregate (i.e., it is a zero-sum game). Transfers of wealth through competition for industries are not justified by the national economic criterion. Such transfers of wealth may be justified on other grounds, such as a need to maintain incomes in isolated communities. This aspect of economic benefits falls within the equity objective discussed below.

4. The "no losers" criterion is equivalent to the concept of "Pareto optimality." A particular allocation of resources is termed optimal only if no one can be made better off without making someone else worse off. When applied to a change in allocation, this implies that at least one person is made better off while no one is worse off. This is clearly a very weak criterion in that everyone may be badly off even with an optimal allocation. The strength of this concept is that it requires no explicit weighing of different individual's welfare.

5. The question of what constitutes fair compensation for loss of property, for personal injury, and for taking of rights or privileges has long been a subject of judicial action. Courts make decisions in specific cases. But we do not expect these settlements to provide useful guidance to fairness in compensating fishermen for management actions that harm them. Fair compensation can be technically defined as an amount of money sufficiently large to satisfy the recipient (e.g., an amount equal to income lost). Whether the recipient is actually entitled to this compensation depends upon the property rights, or rules of access, prevalent in the fishery. Generally speaking, fishermen do not have rights to income from fish resource, and they cannot sue for compensation of losses attributed to management actions. It is conceivable, however, that a limited access system could establish such rights.

6. S.A. Moberly. 1977. President's Corner. Fisheries. 12(5):39. The concern over fish quality and price in this statement is not especially pertinent to Alaska groundfish. Most of the

groundfish products are of increasingly high quality and consumer prices have not been raised due to excessive competition in the fishery.

7. In a detailed legal interpretation of the MFCMA, W. T. Burke (1977) concludes that the Act does not prevent the collection of substantial taxes and fees from fishermen. Most other interpretations, including that of the General Counsel for the National Marine Fisheries Service, focus on the statement in section 304(d) of the Act that requires fees charged for fishing permits not to exceed the administrative costs incurred in issuing the permits. This statement suggests no rent can be collected by the Federal government.

IV. Conventional Regulations

All the regulations currently used in Alaska groundfish management can be classified as "conventional." They restrict the commercial fisherman's choice of fishing gear, timing, area or species. Conventional regulations work to defeat the consequences of open competition for fish; they do not alter the institutions and property rights arrangements that make commercial profit incentives conflict with resource conservation. These regulations, in effect, treat symptoms rather than fundamental causes of conservation failures in the fishery.

Treatment of symptoms can be effective; and conventional regulations are frequently successful in maintaining fish abundance. Assuming that groundfish management must continue to rely heavily upon conventional regulations, it is important to consider modifications that may help to more fully achieve fishery management objectives. The regulatory options discussed below include some likely candidates for change. In light of the declining foreign fishery, only regulations applied to domestic fishing operations (joint venture, factory trawler, and shoreside delivery) are considered.

Regional Division of Species Quotas

Quotas are subdivided to protect sub-stocks, to extend fishing seasons, and to allocate harvest shares among fishing fleets or processing plants in various locations. Similarly, multiple season openings and closures in a given area can spread the harvest over different fishing fleets, and they can help to separate in time various incompatible uses of the fishing grounds. As noted in Section II above, the current Groundfish FMPs include a wide variety of techniques of this sort. For example:

1. Quotas are completely separated between Bering Sea and Gulf of Alaska. This is both an administrative division (the two FMPs require separate harvest quotas) and a division of biologically separate populations.
2. In the Gulf of Alaska the target quotas for sablefish are allocated into Southeastern, central and western sub-areas.

Where there are separable stocks of fish, in the sense that one stock is largely unaffected by level of harvest on other stocks, the corresponding separation of harvest quotas facilitates maximizing overall average annual yields. This addresses the fish stock conservation objective, while it does not interfere with achievement of economic benefits and equity. No further sub-divisions are proposed or recommended by this report.

Allocation of Quotas among Gear Types

Two main reasons for prohibiting a particular gear or restricting catch by gear type are (1) to increase the total physical yield from a stock and (2) to establish by regulation the distribution of economic benefits among groups of fishermen. The physical yield objective is exemplified in the prohibition of trawl gear in the halibut fishery, and by the special fishing grounds and seasons reserved for non-trawl fishing. The second motive is evident in the Gulf of Alaska groundfish regulations that divide up sablefish quotas among longline, trawl, and pot gear.

Incidental and Prohibited Species Catch Regulations

Prohibited species catch limits play an important role in regulating the groundfish fishery, because (1) they represent an administrative procedure for separating fisheries by gear type, and (2) they provide a mechanism for allowing multi-species fisheries to continue after one species' harvest quota has been reached. As noted in Section II, trawlers are prohibited from retaining high-valued species like halibut, king and tanner crab, and salmon. Also, after a particular groundfish species quota is exhausted in any regulated area, that species becomes a prohibited species during the remainder of the year in that area.

A significant problem encountered under the existing prohibited species regulation, is that substantial portions of the incidental harvests are discarded dead. This clearly reduces the economic benefits from what they would be if fishing methods did not capture prohibited species. To eliminate the mortality of discarded fish is not technically possible, however, so the economic objective requires establishing a method of balancing benefits of prohibiting landings with costs of discarding. A second problem is that when large volumes of discards are not recorded, uncertainty regarding fishing mortality rates reduces the accuracy of the stock assessments and annual biological yield estimates.

In the case of halibut and sablefish, for example, the extremely short halibut season induces fishermen to discard essentially all species except halibut during halibut fishing. Similarly, as the sablefish fishing season was shortened to a few days, the fishermen specialized in landing only sablefish while discarding all other species (including the prohibited halibut). Requiring fishermen to land single species during each specialized season is generally inefficient and wasteful. Fortunately, the longline fishermen are often able to target with fair precision, thus limiting the total mortality due to discards.

One promising modification to the prohibited species regulation, proposed by a NPFMC member, would reallocate some of the species quotas from the target fishery to non-target fisheries. Instead of discarding all halibut during the sablefish season, for example, one could allow halibut to be landed as a proportion of sablefish landings (10% of sablefish, for example). A different proportion for halibut might be permitted in Pacific cod landings. Given the allowable incidental catch, the managers could calculate the quantity of halibut likely to be landed in the sablefish and/or cod fishery. This quantity would then be subtracted from the target halibut quota during the open halibut season. Extension of this concept to other species and gear types could be pursued.

If incidental harvests legalized by this procedure would otherwise have been discarded dead, the total harvest will be increased and clear economic gains can be enjoyed. Also, where two species can be caught by the same gear in the same area, the overall costs of catching both together will generally be lower than costs of catching the two separately. If harvests can be increased while overall fishing costs are decreased, the economic efficiency gains from this approach can be substantial. The potential economic gain must be weighed against the possibility that legalization of landings by a new gear, or in combination with a another species, may induce fishermen to modify fishing tactics such that total discards actually increase.

Regardless of the potential for overall economic gains, the re-allocation of high-priced species like halibut and sablefish from intense, directed fishing seasons, to multispecies fisheries will meet substantial opposition. The change to multispecies fishing would disadvantage those fishermen whose fishing strategies are well adapted only to the short, intense, single-species fishing season.

Analysis of the options here is difficult due to well known problems in data gathering. Solid evidence regarding discards, and, more importantly, prospective discards under hypothetical conditions, are not available. Consequently it is not possible to determine whether potential cost savings and harvest increases through multispecies fishing will be significant.

Limit the Catch per Trip

The so-called "trip limit" is intended to reduce the rate of harvest (landings per week) during an open fishing season in order to increase the length of the season. The tactic can be successfully applied to shore-based fishing if the fishing vessels are unable to increase the frequency of trips to compensate for reduced catch per trip. Trip limits are not used in Alaskan groundfish fisheries yet, but the Director of the International Pacific Halibut Commission has expressed an interest in using trip limits in the future. Examination of the experience with trip limits on the west coast should prove instructive.

In response to the Pacific Fishery Management Council's 30,000 pound trip limit on widow rockfish, many trawlers reduced fishing trip length and increased trip frequency. The Council responded by limiting the allowable trip frequency to once per week. When the trip limit was reduced to 20,000 pounds, some of the larger midwater trawl vessels could no longer cover operating costs. To redress this unequal impact three options were offered each fishing vessel: a once per week limit of 20,000 pounds; a once per two week limit of 40,000 pounds; and a twice per week limit of 10,000 pounds.

Trip limit regulation has been fairly successful in spreading out widow rockfish harvests over a longer period of time, an effect that purportedly helps to sustain rockfish fillet markets and to improve the economic returns to the groundfish processing/marketing sector. In 1986, the PFMC imposed trip limits for widow rockfish, other rockfish (the Sebastes complex), and for sablefish. The Sebastes complex trip limit in August of 1986 permitted vessels north of Coos Bay, Oregon to land weekly 30,000 pound of Sebastes of which no more than 12,500 pounds could be yellowtail rockfish. Sablefish trip limits for trawl gear was set at 8,000 pounds (no limit for longline and pot gear), and a maximum of 5,000 pound per trip are allowed to be smaller than 22 inches in length. Some trawl captains delivering loads of mixed species while subject to all of these numerical limits found that they often had to discard an excessive amount of fish or risk running afoul of one of the limits.

Thus, when applied to several species in a mixed species fishery, a significant weakness is exposed—that trip limits assume fishermen have precise control over the mix of species caught. High discards of desirable species do not promote economic efficiency, stock conservation, or flexibility. Rigid numerical quotas for specific trips or short time periods do not recommend themselves for trawl fisheries. Still, trip limits may be useful in lengthening the season openings and in improving the product quality in extremely crowded, single-species fisheries like that for the Pacific halibut.

Conclusions

Conventional approaches to fishery regulation have an important role to play in the achievement of management objectives. They can assure that fish stocks are not overfished; that fishing is tailored to regions and substocks; that patterns of fishing mortality conform to age-class, size, and species compositions maximizing physical yield; and that fish catches are allocated to groups of fishermen with historical or other claims on the fishery.

Conventional regulations also cause unintended, and often undesired, reallocations of harvest shares among segments of the fishing fleet. They do not maximize overall economic benefits of commercial fishing, because they encourage excess fishing capacity, overcapitalization, and short fishing seasons. The prevalence of short, congested fishing seasons in high-valued fisheries under quota regulation (e.g., Pacific halibut, sablefish, west coast salmon), may cause unbalanced fishing on various sub-stocks, resulting in sub-optimal biological yields. Modifying prohibited species regulations to permit some legal harvest of by-catches, and setting trip limits to slow down the rate of landings, however, could improve the utilization of high-valued species, like halibut, that are subject to excessive fishing pressure.

V. Limited Access—Options and Program Elements

Limited access systems vary widely in detail, but they share a common trait. They deal directly with the underlying cause of excess fishing capacity in open access fisheries, by replacing open access to fish stocks with clearly allocated fishing rights. Under favorable circumstances, any of the common variants—license limitation, allocation of individual fishing quotas, or assignment of full property rights—can significantly improve the management of fisheries. Whether a particular implementation secures significant economic benefits, satisfies objectives of equity, and promotes fish stock conservation will depend upon the specific program design and the particular implementation. Extensive experience in Alaska, Canada, Australia, New Zealand, and elsewhere clearly demonstrates that management objectives can be addressed by limiting access, and that there are predictable pitfalls.[1] The following discussion describes and evaluates various options that might be considered in Alaska groundfish.

The Range of Options

There are basically four options for limited access: license limitation, individual quotas, full private property rights, and full public enterprise operation of the fishery.[2] The first two of these are given most serious attention, while discussion of the latter two serves to place the other two in perspective.

License limitation, the most widely used limited access method, restricts fishing rights to a group of identified license holders. Most licensing systems give licensees co-equal rights to harvest. Some licensing program deviate from co-equal rights by creating special classes of license holders.[3] No specific quantity of fish is assigned to licenses, but a wide variety of ancillary restrictions on gear, area, timing, and species may be attached to licenses.

Individual quotas assign specific quantities of annual harvest rights to each harvester. The total allowable catch for a given stock or for several inter-related stocks, may be divided up among individual quotas. Two principal alternatives for individual quotas are fixed quantitative rights (e.g., a right to harvest 10 tons of sablefish) and annually variable share quotas (e.g., a right to harvest 1 percent of the total allowable catch). Several different versions of individual quotas go by the names "individual fisherman quota" (IFQ), "individual tradeable quota" (ITQ), "enterprise allocation," and "share quota."

Full private property rights would mean ownership of fish stocks by individuals, corporations, or other entities. The resource owners would have the full range of rights and responsibilities accorded owners of land-based resources, and they would harvest from the stocks in accordance with their own objectives and capabilities. Fish stock owners would be responsible for stock assessment, harvesting, and sale of fish. They would have access to the judicial system for redress of damages to their property (e.g., to seek compensation for unauthorized harvesting), and they could petition for public policing to prevent trespass and injury to their stocks. This option is not given much attention for two principal reasons: (1) it is difficult to establish and enforce ownership to fugitive fish in the ocean, and (2) long tradition and existing laws would have to be drastically revised to permit private ownership of marine fish.[4]

A public enterprise in a marine fishery would operate like a private resource owner. The public enterprise would eliminate open access competition for fish by hiring its own fishing vessels or by contracting with private harvesters to catch annual quotas. Fishing contracts, like contracts to build roads or to dredge harbors, could be issued on a competitive basis. Each fishing contract would stipulate a quantity, species or mix of species, fish condition, fishing time, and landing location. The public enterprise would supply fish to the market at a fair price. Like irrigation water or electric power provided by public enterprise agencies (e.g., Bureau or Reclamation or Bonneville Power Authority) the fish could be delivered to private processors on schedules and at prices agreed to in written contracts. This option is not under current discussion, because, like the full private property option, it would entail massive alterations of existing legal and institutional arrangements for fishing.[5]

In comparison to full public or private ownership of fish stocks, the two common limited access options represent moderate alterations in the current system of open access.

Elements Of A Limited Access System

It is useful to organize a discussion of license limitation and individual quotas around a list of essential program elements. The following list was recently developed for a discussion of limited access to Pacific coast groundfish.[6]

1. Scope of fishing activities covered,
2. Means of limiting access,
3. Basis for initial allocation of harvest rights,
4. Transferability of harvest rights,
5. Duration of harvest right,
6. Means of altering number of licenses or quotas,
7. Means of settling disputes regarding issuance and transfer of rights.

Options available for each of these are described below.

1. Scope of Fishing Activities—Gear, Species, Areas

Fishing rights under limited access could be very broad (e.g., any groundfish in the Gulf of Alaska using any gear during any season), or they could be restricted to specific species and gears (e.g., halibut and sablefish caught by longline in the Kodiak area). Licenses or individual fishing quotas can be subject to limitations on quantity of gear, timing, fish size, and/or incidental catches.

These additional restrictions may incorporate many of the conventional fishing regulations already adopted in the fishery management plans.

Fishing Gear—Gear types currently used to harvest groundfish are fish pots, bottom and midwater trawls, longlines, and other hook and lines. A license system could include all gear types under a single license, or there could be separate and specific licenses for different gears. An individual fisherman quota system may also designate specific authorized gear types. But it is not necessary for individual quotas to be limited in this way. New Zealand's ITQ system, for example, permits the quota owners to choose among gear types.

Existing regulations prohibit the use of drift or set gill nets, beach seines, or other gear for groundfish. Continuation of this gear limitation would prevent the addition of gears that are not now important. Current Gulf of Alaska regulations preclude the use of pot gear to catch sablefish in the Eastern Area, and they will expand this prohibition to the entire Gulf in 1989. It is simple to incorporate this planned phase-out of pot gear in either license limitation or individual quota systems. Licenses specifying pot gear would specifically denote the prohibition of pots after 1989 in the Gulf of Alaska; and individual quotas for sablefish would stipulate that fish pots were unacceptable after the same date.

Species—Alternatives include at least the following three: (1) All groundfish species included under a single limitation system; (2) Separate licenses for various species or groups of species; (3) Some species included while others remain open access. For example, licenses for fixed gear only (longline and fish traps) could be established for harvest of halibut, sablefish, rockfish, and Pacific cod. Licenses for trawl gear would be intended for harvest of various flatfishes (excluding Pacific halibut), pollock, sablefish, Pacific ocean perch, other rockfish, thornyheads, Atka mackerel, squid, and Pacific cod.

Geographical Area—Licenses and individual quotas may pertain to the entire EEZ, or to more limited fishing areas. Allocation of quotas to specific areas and gear types assures some geographic spreading of fishing mortality that may be necessary for stock conservation when substantial excess fishing capacity threatens to overfish sub-stocks. A drawback to extensive geographic subdivision, is that it may cause inefficiently small scale fishing operations, and, by reducing the fisherman's flexibility, subject fishermen to more income uncertainty than under existing regulations. Thus a trade-off between precision in control of area specific harvests and flexibility of fishing operation must be evaluated.

An alternative approach is the staggered openings and closings as used in the halibut fishery. Since most groundfish species have not yet attracted a vast excess of fishing capacity, it should be unnecessary to attempt a fine geographic distribution of effort through restrictions on licenses. Only divisions based upon established scientific assessments of species and sub-stock populations structure would be necessary.

Jurisdictional scope must be considered. Federal authority could limit licenses for fishing in EEZ areas, leaving state waters open. A combination State and Federal license, or at least a coordinated overall effort, could be helpful in preventing the territorial sea fishery from eventually becoming a troublesome unlimited sector.

2. Means of Limiting Access

Whether the license limitation or individual quota option is selected, there are still a number of choices regarding how the fishing rights should be assigned to entities. A license or individual quota can be attached to the vessel (as in the California salmon license program), or it can be assigned to an individual (as in the Alaska salmon limited entry system), or it can be held independently of vessel ownership or personal fishing activity (as in the New Zealand ITQ system). Yet another option would be to assign quantitative rights to large, integrated firms involved in processing and fishing vessel operation (as in the enterprise quotas of Atlantic Canada).

Additional limitations are often placed upon who or what is licensed. For example, corporations are not permitted to own Alaska salmon licenses. Conditions for leasing fishing rights, or required presence of rights holders aboard fishing vessels can be controlled through ancillary restrictions. A prohibition on corporate ownership would be troublesome in groundfish, since the large capital investments involved can rarely be mounted by individual persons, and the limited liability of a corporate entity is a major factor in attracting investment through capital markets. Other restrictions on ownership may, however, accommodate national policy objectives associated with Americanization of the fishery. Examples include: (1) stipulation that only U.S. citizens own harvest rights, (2) limitation to citizens or corporations whose owners are U.S. citizens, and (3) requirement that licensed fish be harvested by vessels constructed or re-fitted in U.S. shipyards.

3. Basis for Initial Allocation

An equitable basis for starting a limited access program is perhaps the most critical requirement. Once the system is well established, the initial allocation will be of diminishing importance. But, a license system begun badly, through a highly contentious allocation phase, is likely to develop political opposition which can lead to repeated re-opening and judicial review of the allocation decisions. Such reviewing constitutes a threat to existing license or quota holders, and it can undermine confidence in the system. Long term planning and rational investment decisions depend upon the establishment of secure and stable access rights. Such stability depends upon broad public acceptance of the system. Hence, a decisive, legally defensible, and equitable initial allocation is critically important.

As noted in Section III above, several different concepts of equity are in common use. If equity is taken to mean equality of fishing rights (as with inalienable rights like free speech, voting rights, etc), then every citizen should have the same right to fish. This concept of equity is consistent only with the open access system. Limiting access clearly implies the rejection of equality as a basis for equity. A variant on equality of fishing rights is equality of opportunity to obtain fishing rights. A practical approach to achieving equality of opportunity, without allowing everyone to fish, would be to issue fishing licenses by lottery. A lottery would be equitable in providing everyone an equal chance to fish, even though only a limited number of winners would obtain the fishing rights and associated benefits. Neither equal rights nor equal opportunity to obtain rights are commonly adopted as criteria for initial allocations in limited access systems.

In previous resource allocation systems past sacrifice and established use are common criteria for allocation. Elizabeth Rolph (1983) reports that governments allocating property rights to resources previously used communally nearly always use past use as a criterion. Agency decision-makers apparently seek to avoid a direct redistribution of economic wealth. While any modification of resource use rights will inevitably cause some alteration in distribution of economic benefits among users and ancillary industries, accommodation of historic use in allocations of rights will tend to avoid abrupt redistribution of wealth. Allocation of resource use rights based upon past use and financial commitment is a specific case of the "no losers" approach. Thus common administrative practice and economic theory support historic use as an important criterion for assuring equity in allocating fishing rights.

Application of the "no losers" criterion to groundfish limited access would be feasible, at least as applied to identifiable groups of fishermen. All existing gear types, regional groupings, and individuals with documented fish landings could be protected from "losing" in the initial allocation of fishing rights by assigning to them a right to harvest at least as much fish as they had been harvesting in the past.

Past participation in the groundfish fishery as a basis for initial allocation would qualify thousands of longliners, pot fishermen, coastal trawlers, joint venture trawlers, and factory trawlers. Also, extension of the criterion to include those with recent substantial investment in construction or conversion of a vessel for entry into the groundfish fishery before a cut-off date would add a number of additional qualifiers. Another consideration for qualification could be participation in related fisheries such as the Washington-Oregon-California groundfish fishery, the king or tanner crab fisheries, the Gulf of Alaska or west coast pink shrimp trawl fisheries. Inclusion of these could add at least another five hundred fishing vessels or two thousand fishermen.

In sum, a license limitation system allocating fishing privileges to everyone with a history of participation in groundfish or related fisheries, would begin with excessive fleet capacity. To effectively limit fishing capacity, the entry criteria must be tightened up; or the fleet could be reduced later (e.g., through a license buy-back program), or the licenses must be encumbered by significant ancillary restrictions (such as on vessel size, gear, or area fished). Clearly, the initial allocation scheme determines the necessity for other program elements such as fleet reduction and restrictions on licensed fishing rights.

The Alaska salmon license program reduced the number of initial permits issued by establishing eligibility rules based upon past participation and economic dependency. A point system was developed to rank applicants, giving most points to those who would experience the greatest hardship if excluded from fishing. A fixed number of permits were issued to applicants in order of points. The assignment of points had to be based upon specific facts that were not always clearly documented. Consequently, various disputes and legal challenges to permit application decisions became a significant source of controversy and expense for the Alaska Commercial Fisheries Entry Commission. In comparison to wholesale inclusion of all past participants, the Alaska salmon permit allocation process was complex and expensive (Schelle and Muse, 1986).

Initial allocations of individual quotas or shares would also need to meet equity standards. The initial shares could be based upon past harvests, future planned harvest, or some explicit formula including past harvests and quantitative measures of investment or vessel capacity. Total allocations of quotas to domestic fishermen could be kept to not more than the total allowable catches. Where the fishery has not yet utilized the full potential annual yield, additional individual quotas could be distributed after the initial allocation through direct sales, auctions, lotteries, first come-first served, or other methods not based upon historic use.

4. Transferability

Whether licenses should be transferable by sale, gift, and bequest used to fuel a lively debate. The issue now seems to be decisively settled in favor of transferability. To be able to sell a fishing license or quota share provides a means to convert value of prospective future earnings into cash. The prospect of a potential future sale makes license holder more attentive to resource conservation needs, and transferable fishing rights provide valuable business collateral and become a source of income in retirement. Owning a license in a limited fishery is a bit like owning a share of the fish stock, although it may be worthless if fishing capacity is not effectively controlled.

Arguments against transferability include the notion that fishing rights should not have monetary values placed on them, that the market value placed on freely distributed fishing rights represents an unfair windfall gain to the original recipients, and that market prices for licenses represent a significant barrier to new entrants. The first argument stems from an ethical judgement that is irreconcilable with private markets in property rights (i.e., in opposition to capitalist economic conventions). If such ethical standards were widespread, it would indeed be futile to discuss marketable fishing rights.

The second argument holds that it is unfair to distribute economic wealth based upon criteria used to allocate fishing rights. It is true that license ownership patterns influence the distribution of wealth derived from fishing. If licenses are awarded free of charge, the initial license holders are given a potentially valuable capital asset. The value of this capital asset (based upon profitability of fishing) will be reflected in a market price. While it would be difficult to claim that any awarding of capital assets is unfair, the particular pattern of capital assets associated a limited access system could be unfair. If the initial allocation is done fairly, then indeed the asset values will have been fairly distributed.

The third argument against market transfer involves some confusion regarding the role of capital asset values in the economy. A successful license or individual quota program that stabilizes fishing profits at a higher level, should foster rising license or quota prices. Sellers may make significant capital gains, and new entrants to the industry will face larger start-up capital costs than those faced by the original group of licensees. The additional cost of entry will not be a barrier to entry, however, since the value of the license reflects the greater earnings potential, and financial institutions are more likely to lend the necessary start-up capital to a new business that has an established share in a more stable industry.

5. Duration of Fishing Rights

Like transferability, the question of duration is generally settled, with permanent rights being the preferred option. Annually renewable licenses are still used in some fisheries (California having most of the existing license systems of this sort), and limited duration, 10-year, licenses were recommended by the Pearse Commission (Pearse, 1982). Limited duration, however, has two distinct disadvantages. As the license nears its termination date the permit owner will suffer all the disadvantages of a non-transferable permit, and the short-timer will have reduced incentive to conserve fish stocks. It is recommended that harvest rights, whether licenses to fish or individual quotas, be perpetual.

6. Means of Adjusting Number of Licenses or Quotas

Since the initial number of licenses or initial allocation of individual quotas may not be the optimal number, managers will need a mechanism for adjustment. Both the economic efficiency and management flexibility objectives require this. With license limitation, if the initial number is too large, reductions in numbers of outstanding licenses through "buy-back" or attrition will be desirable. A buy-back fund may be created from royalties on fish landings, or it may be taken from general tax revenues. In the first case, both the remaining fishermen and those selling licenses to the buy-back authority will benefit; and it will not impose any additional cost on taxpayers. In the second case, all fishermen potentially benefit, but the taxpayers may not. Without a buy-back program, and assuming licenses are non-transferable, the fleet could be reduced through attrition of bankrupt, injured, or retired fishermen. This approach may ultimately decrease excess capacity, increasing average profits for remaining fishermen, but it imposes a hardship on those leaving the fishery.

If an increase in numbers is warranted, new licenses may be issued by auction, lottery, or selection from a list of qualified applicants. The latter selection can be based upon first-come, first-served, or applicants can be selected by a complicated point system. These same mechanisms can be used in any subsequent allocation of additional licenses.

With individual quotas the initial allocations will probably not exceed total allowable catches. Adjustments to outstanding quotas will be necessary, nevertheless, in order to tailor annual catches to fluctuating fish stocks. The available procedures will depend upon whether the individual quotas are absolute quantities or shares. Since quota shares are percentages of total allowable catch, adjustment of annual total outstanding quota rights requires only that advance notice be given to quota holders. With fixed quantity individual quotas, the management agency will need a procedure to issue additional quotas for fish species that are in high abundance and to reduce outstanding quotas for fish species that are in reduced abundance. This procedure can include purchase and sale of quotas by the management agency. The New Zealand groundfish system seems to be the only case of market operations to adjust quotas.

7. Means of Settling Disputes

Under any system of private fishing rights, disputes will arise regarding initial qualifications of individuals to participate in the fishery, and concerning subsequent transfers and usage of permits or quotas. During the initial allocation of licenses or individual quotas, documentation of facts will be an important element of the process, especially facts concerning past groundfish harvests, commitments to invest, and any other elements adopted as allocation criteria. There are several possible approaches to handling these. Any of several different authorities could settle disputes: (1) a special review board appointed by the NPFMC or NMFS; (2) a Federal official like the NMFS Regional Director or NOAA Administrator; or (3) an Administrative Law Judge could be given jurisdiction. It is important to establish the procedures well before any complaints are lodged against the system.

During the subsequent operation of a limited access system additional disputes are bound to involve questions of ownership and delegated authority. With transferable licenses and quotas, it will be necessary to establish exactly when ownership changes hands. However, since transactions in fishing rights will differ little from other commercial transactions, existing judicial procedures should be capable of handling associated disputes. A specific statement in the limited access program documentation should clarify the intended role of civil courts and note any special procedures, such as registration of licenses and individual quotas, needed to clarify ownership of fishing rights.

Relationship to Conventional Regulations

Recent studies have uniformly concluded that license limitation does not obviate the need for conventional regulations limiting fishing mortality rates on a stock by stock basis.[7] Because groundfish fishing operations often range over several species and areas, limiting the total number of vessels will not restrict fishing effort for species needing stronger protection due to diminished abundance or for high-priced species that are more avidly pursued. Hence, annual harvest quotas, closed seasons, area closures, and other direct regulations will be needed despite license limitation.

Individual quotas more directly limit fishing mortality rates for individual species, but there will remain a need to control the pattern of fishing to obtain optimal results. Allocations among gear types, size limits, prohibited species quotas, and closures of some areas to trawl gear could be retained even under a individual transferable quota system. It is unrealistic to assume that conventional regulations will be entirely, or even substantially, dismantled, but it is reasonable to suppose that limited access, especially the individual quota option, will permit significant simplification and reduction in the number of these regulations.

Making Limited Access Consistent with National Fishery Policy

Creation of marketable fishing rights creates a new instrument for ownership and control of fish production. Free trade in these rights will clearly open the door to foreign ownership of fishing rights, just as it is now open to foreign investors in other assets. Substantial foreign participation is already a fact of life in the U.S. groundfish fishery, with foreign companies having direct and equity investments and as well as other financial ties to many of U.S. fishing companies. Some industry spokesmen note that the groundfish fishery is being internationalized, not Americanized.

Clear standards for foreign ownership of fishing rights can reconcile limited access with the national fishery policy. Two distinct options are apparent: (1) We could permit fishing rights to be traded without regard to nationality, or (2) we could establish requirements for American ownership. The first option is equivalent to the policy established for almost all U.S. assets, such as real estate and farm land. Fishing licenses and individual quotas, represented by official certificates and records, would be purchased and sold by foreign and domestic individuals and business firms with no unusual restrictions. The second option would require careful development of specific ownership requirements that limit foreign participation in fishing rights.

Free trade in fishing rights would permit foreign fishing companies to control the U.S. catch in few ways that are not now possible. Assuming that the MFCMA is not amended, and that preference to domestic fishing and processing firms in quota allocations is retained, allocations would continue to be made first to U.S. processors, then to joint venture companies, and then to direct foreign fishing. Foreign participation in ownership of U.S. fishing companies does not make the company a foreigner for allocation purposes now, and this would presumably not change under limited access. It is unclear, therefore, that foreign ownership of individual fishing quotas or licenses would permit foreign firms to gain greater influence over the allocation process, with negative consequences for American participants.

However, if it is decided that foreign ownership should be limited, we need to develop detailed criteria on levels of permissible foreign participation, taking full recognition of the complexity of ownership arrangements. For example, New Zealand prohibits direct foreign purchase of quotas, and imposes a limit of 25 percent foreign ownership in companies that own quotas. In the U.S. a ban on foreign ownership of quotas could be implemented by allowing only U.S. registered vessels to catch fish using licenses or quotas. This would relegate the problem of defining U.S. ownership to the maritime registration procedures.

An effective restriction on foreign ownership of companies owning quotas must be much more complicated than this, of course, since "foreign ownership" needs to be defined very clearly. Most large fishing companies are corporations. Some of these are publicly held, in which case ownership is a matter of record, and some are privately held. It is not unusual for a fishing corporation to be wholly owned by another corporation, nor for one corporation to own shares in another corporation. To trace the lines of ownership for marketable fishing licenses and transferable quotas would require the employment of corporate legal specialists, unless, of course, some strong restrictions on forms of fishing business organization are implemented. It is beyond the scope of this study to develop the necessary rules and standards for limited foreign ownership.

Conclusions

This review of limited access options supports a variety of conclusions that do not differ greatly from those reached in previous studies. Under ideal circumstances, limiting access directly addresses the objective of improving economic benefits by bringing fishing capacity in line with total allowable catches. Limited access also may enhance fish stock conservation by helping to spread fishing effort over seasons and substocks, and by decreasing the prevalence of discards during short fishing seasons. Because replacement of open access with limited access changes the structure of the commercial fishing business, equity in the distribution harvest rights is the paramount concern in the initial allocation of limited licenses or quotas. Enunciating explicit standards of equity is a most difficult task for management agencies and represents a potential roadblock to establishment of limited access.

The objective of maintaining flexibility in management calls for procedures to vary total allowable catches and continued use of ancillary regulations such as area closures, gear restrictions, fish size limits, and some prohibited species designations. Flexibility in commercial fishing can be dealt with by providing transferability of licenses or quotas, by creating relatively wide geographic scope for harvest rights, and by minimizing gear restrictions. Recognition of national interests in continued Americanization of the groundfish fishery may require specific restrictions on foreign ownership of licenses, on registration of vessels harvesting individual quotas, and on foreign participation in companies owning fishing licenses or quotas.

Of the two versions of limited access considered, individual quotas most clearly facilitates achievement of economic objectives. Assuming that the initial allocation of individual quotas is consistent with the total allowable catches, managers need not close fishing seasons to conserve stocks, and fishing companies can maximize their profits from harvest by choosing appropriate timing, and location of fishing. License limitation cannot effectively limit fishing capacity unless either (1) the number of licenses initially issued is severely limited, or (2) a license buy-back program is funded and successfully carried out, or (3) significant additional gear or vessel restrictions are attached to the licenses. Even with these measures, license limitation is a second best form of harvest capacity control simply because fishing capacity of a given fishing vessel can be expanded through investment in technical improvements.

With either license limitation or individual quotas, the most critical management decisions are choice of initial allocations and choice of restrictions on ownership of harvest rights. Because initial allocations strongly influence the ultimate distribution of costs and benefits from the fishery, the equity issue is the paramount concern in initial allocation. Rights based on historic use and/or current commitment to the fishery could meet a standard of equity based upon of creating "no losers" of harvest rights. Second, the assignment of fishing rights to individual fishermen, to vessel owners, to vessel operators, or to persons regardless of ownership or participation in the fishery, will determine initial bargaining strengths of competing commercial interests. Most existing license and quota systems assign the rights initially to owners of fishing vessels.

Further development of limited access in Alaska groundfish will have to address a series of specific issues including: whether to license fishing or processing; whether to explicitly allocate among joint venture, factory trawler, and coastal trawler fleet; whether to include longline and trawl fleets in a single system; and whether to preserve an open access portion of the fishery to preserve intangible benefits associated with a "way of life" rather than conventional economic returns.

The deepest and most contentious issues are likely to represent the most difficult hurdles to establishing a limited access system. Because transferable quotas and licenses permit exchange among people of different regions, a transferable fishing rights program implies acceptance of market competition as a regulator of the location and structure of the fishing industry. Whether specific coastal communities or high seas fishing fleets eventually predominate in the fishery will not be under the control of fishery managers once the market system is established. Political favors for special interests will be difficult to deliver, diminishing the power and influence of management agencies. Thus, limited access, especially the individual tradeable quota system, can overturn long-standing relationships among government agencies, political actors, and industry participants. This fact, and the uncertainties regarding distribution of initial shares, probably accounts for the current high degree of suspicion and opposition to limited access.

Endnotes to Section V

1. License limitation has been extensively reviewed and analyzed in Rettig and Ginter (1978), Sturgess and Meany (1979), Pierce (1982), Rettig (1984), Anderson (1985), Mollett, ed. (1986), and Huppert, ed. (1987).
2. Landings taxes, fees, and royalties are sometimes included in the list of access limitation methods. While taxes and fees can create proper economic disincentives to overfishing, I do not include them, because they do not involve an act of limiting access to the fish stock to any particular group of people. With the kinds of limited access considered in this paper, a landings royalty or tax could be used to redistribute the economic returns from fishing, but would not be an instrument of limitation.
3. The original British Columbia salmon license program, for example, created permanent "A" licenses that permit replacement of vessels, and limited term "B" licenses which were to phase out in 10 years and remained attached to the original vessel. See A. Fraser (1978).
4. Japanese Fisheries Cooperative Associations exercise sea-tenure rights that are equivalent in many ways to land tenure rights. It is clear from the study of the Japanese system of coastal fishing rights, that their establishment stemmed from a long tradition extending back to the feudal period. See K. Ruddle (1987).
5. Dr. E.A. Keen, San Diego State University, is one proponent of this public enterprise approach. Detractors of the approach would point out that public enterprises tend to be inefficient and unresponsive to diverse public interests. It is unclear from general principals whether these sources of inefficiency would be greater or smaller than those inherent in private use of common property marine fisheries.
6. See Huppert, 1987; p. 13-17.
7. See in particular R. L. Stokes (1983), and S. Hanna and W. Silverthorne (1987).

VI. Implementing Improved Groundfish Management

The rapid expansion in domestic groundfish harvesting and processing alters the economic and political circumstances confronting the management system. Americanization of the fishery (1) shifts the focus of conservation measures from foreign to domestic fishing, (2) creates an opportunity for gaining greater economic returns from the fishery resources, (3) increases the need for meticulous information collection from the domestic fishery, and (4) initiates extensive shifts in patterns of economic activity. Besides changing the task of fishery managers, new rivalries are kindled, and existing conflicts among competing segments of the industry are renewed. The ongoing economic transformation of the fishery will undoubtedly materialize in additional, yet unanticipated, ways. Devising an equitable treatment of competing user groups will be a critical task for improving fishery management.

This report has explored several aspects to improved groundfish management, covering both modified conventional regulations and various forms of limited access. Sections II through V have delineated management objectives, summarized emerging problems, characterized new options, and highlighted controversial issues. This concluding section draws together the various logical threads of the foregoing discussion, reviewing earlier observations and conclusions, and suggesting specific management approaches to achieve the major objectives. The presentation is focussed on a two illustrative proposals to meet the various management needs and objectives.

The review of conventional regulations in Section IV revealed no new and startling opportunities, but it did confirm the importance of imposing total allowable catches, sub-dividing quotas to geographic areas based upon population structure, and applying fish size and gear regulations to increase yield and harvest values. Some modifications, such as allocation of incidental catch of prohibited species among target and non-target fisheries, can increase the landings and economic value of halibut, for example. Just as importantly, reallocating halibut as incidental catch in non-halibut longlining will help facilitate the economic harvest of alternative target species such as Pacific cod. Beyond these specific suggestions, no substantial improvements in the basic set of conventional regulations have been identified.

While this report was being written, the North Pacific Fishery Management Council voted to develop a limited entry system for the longline sablefish fishery, and it adopted provisional cut-off dates for determining qualification for entry into the groundfish fishery. The Council appointed a Future of Groundfish Management Committee to consider and recommend directions for improving management of the fishery. It is not yet clear whether the Council will decide to limit access to Alaska groundfish, and, if so, what specific objectives will be embraced. Whatever course is taken by the Council, however, successful implementation depends upon a clear, logical plan linking policy objectives, choice of alternatives, and program elements. The Council's thwarted attempt at license limitation in the Pacific halibut fishery demonstrated the vulnerability of an incomplete limited access plan.[1] An initial moratorium or license limitation for groundfish, for example, is unlikely to be easily sold as a useful step toward economic rationalization unless it is teamed with a more comprehensive, long run approach to management.

A comprehensive plan will need to promise real economic gains through effective control of fishing effort. It will need to meet standards of fairness and equity in the allocation of harvest rights and in the resulting distribution of economic rewards; including measures to avoid undue concentration of harvest rights, and provisions for sharing resource rents with the public "owners" of the fish stocks. It will need to allow flexibility in providing for both fish stock conservation and normal commercial business planning. Finally, a comprehensive limited access plan will need an enforcement, monitoring, and fishery data collection plan meeting the minimal requirements of scientists and enforcement agents.

Meeting all these criteria will require careful planning, review, and technical scrutiny. To assist in that task, this concluding section organizes the ideas expressed earlier by developing strategies for limiting access. These strategies are not formal proposals and they do not seek to preempt other proposed groundfish management systems. Rather, they illustrate promising strategies for change. These illustrative proposals are intended to draw criticism and to foster additional discussion of management alternatives.

Strategies for Future Management of the Groundfish Fishery

Each of the two alternative strategies developed below includes a limited access management system. The first alternative proposes an initial license limitation system, followed by individual transferable quotas. The second strategy starts directly with individual quotas and follows more closely the intent of the Americanization policy. The two approaches are designed to appeal to different interest groups.

STRATEGY 1

The strategy is developed in four steps: (1) A groundfish license limitation program establishes the numbers of harvesters and specific conditions on transfer among license owners; (2) an expanded enforcement and monitoring program including at-sea observers, audits of landings receipts, Coast Guard sea and air operations, and scientific sampling of catches; (3) allocation of transferrable share quotas to groundfish license holders; and (4) a funding mechanism for management functions that could involve various alternatives to Federal general funds, including annual license fees, royalties on quota shares, and charges for at-sea observers.

The strategy could be implemented in the sequence presented, or some steps could be combined and implemented simultaneously. Truly comprehensive and rational planning might call for the whole strategy to be refined and implemented at once. Experience indicates, however, that key participants in the process will not be ready to deal with the later steps, such as new funding methods, until the benefits of earlier steps are realized.

STEP 1: LICENSE LIMITATION. A groundfish license would be issued to owners of all U.S. registered vessels harvesting groundfish in the EEZ in the Gulf of Alaska, Bering Sea, or off the Aleutian Islands during a base period, possibly 1985 through 1987. Each license would name one vessel authorized to fish groundfish. Licensees would include factory trawlers, coastal trawlers, joint venture trawlers, longliners, and other vessels using legal gear to land pollock, cod, sablefish, soles, flounders, Atka mackerel, rockfish, or other groundfish. Floating processors, motherships (of U.S. or foreign flag), tenders, and cargo vessels would not receive licenses, although they would continue to obtain the permits required under the existing groundfish regulations.

Operational rules required to monitor and enforce the license limitation program include the usual possession and display requirements. Any vessel owner intending to harvest groundfish, or to deploy any gear normally targeting on groundfish species must possess a groundfish license. Penalties and fines for fishing without a license would have to be established at a level sufficient to deter cheating.

Each vessel licensed would be assigned to one of the following classes: hook and line or pot fishing vessel, trawl vessel delivering to shoreside or at-sea processor, factory trawler of less than 200 feet in length, factory trawler of 200 to 300 feet in length, and factory trawler of greater than 300 feet in length. Designation of class of vessel would be based upon registration records and legal documentation of fish landings during the base period. Vessels with records showing more than one class (e.g., a vessel using both longline and trawl) would have a special license naming both gear types.

Owners of vessels not fishing during the base period for one of the following reasons would have a right to apply for a new license within twelve months: (1) vessel was fishing in a different fishery (e.g., tanner crab) or elsewhere (e.g., Pacific coast) but had a history of fishing groundfish off Alaska, (2) vessel was laid up for repairs, or conversion during the entire base period, (3) vessel was not yet operational during the base period but was in construction for entry to Alaska groundfish fishery. The standards for issuing licenses to vessel owners not qualifying on the basis of landings would be formulated by the NPFMC, and would include a definition of what constitutes adequate evidence.

The groundfish licenses would be transferable by private transaction among vessels within classes, allowing new vessels to enter the fishery as another vessel exits. License transfers would be registered with the NMFS Regional Offices within one week.

In addition to registering vessels, buyers of groundfish would need to be licensed so that records can be kept of all sales and purchases. Foreign and domestic buyers would be required to maintain and periodically submit records of quantity, condition, and species of fish bought. This information would be equivalent to existing State requirements for "fish tickets."

DISCUSSION OF STEP 1. Because it allows license transfers within vessel classes, this first step is not a simple moratorium. It limits the size of the domestic fleet but permits some substitution of vessels. Because vessels could be upgraded within class, total fishing capacity would not be effectively limited by this license limitation program. It is intended to be a temporary and transitional step to an individual quota system. It would be inappropriate as a permanent system, because the flexibility among vessel classes and growth in the factory trawler fleet is not sufficiently accommodated.

STEP 2: UPGRADED MONITORING AND ENFORCEMENT. After the licenses are established, the system for monitoring and enforcement of groundfish catch quotas, prohibited species regulations, and other conventional regulations would be reviewed and upgraded as necessary. Scientific sampling requirements and on board observer coverage necessary for monitoring total catch, landings, and usage in at-sea processing plants would be established by joint committees of industry, NPFMC, and management agencies. A full plan for Coast Guard surveillance of foreign and domestic vessels at sea, state/Federal agency audits of catch records, radio and logbook reporting requirements, and on board observer protocols would be designed with the objective of providing accurate and complete information regarding withdrawals of groundfish by U.S. vessels in the EEZ. NMFS and/or the NPFMC would publish a complete and detailed document for review and adoption.

DISCUSSION OF STEP 2. The intention here is clearly to provide adequate data for enforcement, monitoring, and scientific assessment of groundfish catches. Under this strategy, the data system would be developed before the at-sea processing fleet grows substantially beyond its current size. This is, and will continue to be, a significant source of controversy. Shoreside processing companies and many management agency biologists may contend that observer coverage of domestic trawlers should be the same as coverage of foreign vessels. Some operators of domestic factory trawlers will oppose mandatory observers as an unreasonable and costly intrusion. Because there are such strong economic incentives to under-report fish caught and processed at sea, however, unmonitored operations could destroy the credibility of a conservation regime. An individual quota system that does not impose some mandatory coverage of at-sea operations would be particularly vulnerable. Thorough coverage of on-shore landings may require observers in shoreside processing plants to a similar degree. While it is not the purpose here to provide a detailed design for the data system, I emphasize the importance of rigorous data collection process to any management system that relies on either aggregate or individual quotas.

STEP 3: ISSUE SHARE QUOTAS TO LICENSED OPERATORS. Once the catch monitoring system is sufficiently upgraded to assure completeness and accuracy of species catch reports, the licensees would be issued shares of the total allowable catches. Documentation would be assembled regarding each vessel's catch of groundfish during the previous five years. A formula for determining shares would be developed for making an initial allocation. This formula could have some of the following features:

1. Each licensee could choose the year of record for use in establishing his or her share;
2. Licensees not having an adequate catch record could choose to take a share equal to the class median. For example, a longliner having fished only a partial season due to mechanical breakdowns could opt for a share equal to the median catch by longliners of similar length.
3. Allocations of shares would be expressed as a percent of the current year's total allowable catch. The percent allocated to a licensee would be computed by dividing that licensee's catch of record by the Allowable Biological Catch in the year of record. If the sum of the shares calculated by this procedure exceeds 100 percent, then each share will be reduced proportionately until total of the shares issued equals 100 percent.
4. For some species the shares allocated will total less than 100 percent of the TAC (e.g., for species like Pacific cod that are not fully utilized). Additional shares for the under-utilized species would be issued on a first-come, first-served basis to original licensees or to any new owners of groundfish vessels. The size of these new shares would be based upon the typical share already allocated to license holders. To avoid non-productive speculative activity, new shares would be non-transferable for one year, and would be cancelled if the owner does not harvest a substantial portion of the share allocated within a year.

Allowable catch for any foreign fishing still occurring, would be limited to the Total Allowable Catch minus the sum of joint venture and fully domestic quotas. No shares would be issued for foreign fishing.

Individual quotas would be transferable among groundfish license holders and to new vessel owners who have appropriately registered with the NMFS Regional Office. A computer-linked trading system would be established in all major fishing ports, having a continuously updated list of quota share holders and their share holdings. Actual catch data would not be publicly available during the fishing year in accordance with data confidentiality requirements. All transactions among license holders are required to be recorded expeditiously to the NMFS Regional Office (e.g., within one week of sale).

Once the quota trading system is operational, the number of groundfish licenses would no longer be limited, but each participant would continue to be required to register with the NMFS Regional Office. This would permit screening of quota ownership for excessive accumulation of shares and for foreign participants. To prevent excessive control of shares in the groundfish fishery, no single entity would be permitted to own a preponderance of the total quotas in either the Bering Sea and Aleutian Islands area or in the Gulf of Alaska.

The Americanization policy could be preserved with a slight modification to this strategy. The species quotas would be sub-divided into fully domestic and joint venture, with the JV share equal to TAC minus domestic. To encourage the phase-out of joint venture fishing, the joint venture vessel's initial quota shares would be calculated as a percentage of the overall joint venture allocation rather than of the TAC. Thus, as the domestic fishery expands and takes larger shares of TAC, the joint venture shares become smaller and smaller as the pool of JV allocation diminishes. To obtain domestic shares, vessels active in the JV fishery would apply for shares of species that are not already completely claimed for DAP fishing. Once obtained they would deliver these harvest shares to U.S. processing plants or to U.S. registered at-sea processors.

DISCUSSION OF STEP 3. These quotas would be percentage shares of the annual TAC, so that actual quantities for a given share will fluctuate with the annual TACs. This is somewhat less convenient than ITQ quantity shares for the vessel owner, but it is vastly simpler for the management agencies to alter TACs if they do not have to buy and sell quotas in the open market.

Another important feature of this individual quota plan is the free distribution of initial shares based upon historic use, combined with distribution of additional share quotas for under-utilized species. To retain their shares, share owners would have to remain active in the fishery. This would prohibit the stockpiling of unused quota shares.

An important issue not explicitly dealt with in the individual quota description was the method to determine whether a fishing vessel is a U.S. operation. Current Americanization policy gives higher priority to fully domestic fishing than to joint venture fishing in the allocation of TACs. With tradeable quotas, the ownership of shares will change frequently, and the nationality of the ultimate owners will not be immediately apparent. The requirement that each quota owner maintain registration with the NMFS Regional Office provides a possible mechanism for reviewing ownership, but developing specific procedures for determining nationality of owners may require substantial legal expertise.

STEP 4: ESTABLISH A SYSTEM OF SHARED FUNDING. The costs of collecting and analyzing information for stock assessments and annual TAC determinations, as well as costs of routine monitoring and enforcement of quotas, should be shared equitably between the general taxpayer and private businesses operating in the groundfish industry.[2] Two key issues will need to be resolved in establishing a shared funding system. First, appropriate principles for dividing costs between taxpayers and commercial firms needs to be established; and, second, a mechanism needs to be designed for collecting funds and appropriating them to research, monitoring, and enforcement tasks.

The first issue could be dealt with pragmatically by establishing agreement on one of the following principles:

1. As the groundfish processing fleet becomes fully domestic, the share of management costs paid directly by the U.S. taxpayers should not increase. Because the foreign processing fleet paid for the costs of running the foreign observer program, the expansion of the domestic processing fleet with similar observer coverage would, without a mechanism for industry contributions, require increasing support from public funds. One approach to fairly distributing the burden of cost would be to create a funding mechanism relying on contributions from the industry.
2. Extensive resource surveys, stock assessments, and management institutions (NPFMC) involve large fixed costs that accompany resource management responsibility, whereas the additional cost of monitoring and enforcing regulations on an additional vessel as it enters the fishery is directly attributable to the investment or operating decision of a commercial firm. The former expense is logically a public responsibility, while the latter cost should be levied on the commercial firm. This logic is consistent with an incremental, "user pays" approach to resource management.

Acceptance of either of these lines of reasoning would support the collection of an amount of money directly linked to the costs of monitoring and enforcing management rules on groundfish vessels. Several sorts of fees could be considered: a lump-sum license fee, an *ad valorem* quota share royalty, or a landings tax. The license fee is easiest to administer, as it involves simply collecting an annual amount from each licensed groundfish vessel owner. The *ad valorem* royalty would be calculated, like a property tax, as a percent of the value of groundfish shares held. The value of the fish could be based upon recorded quota share sales. Because the shares change hands regularly, the tax would be based upon registered shares held as of some particular date, possibly January 1.

The third option, a landings tax, is the most complicated to administer because it requires either (1) the tax be collected after each and every transaction (many of which may occur at sea), or (2) that a cumulative tax payment be collected periodically based upon cumulative groundfish landings values. The annual royalty on shares held is preferable to the tax on catch, because it is administratively simpler and because it creates far less incentive to distort catch records and sales receipts.

Whatever basis for calculating specific charges for fishing vessels is accepted, the funds collected would be placed in an ear-marked fund for sole use of the groundfish monitoring and enforcement program. If implemented by the Federal government, tying the collection of funds to a specific use would require special authorization of the Office of management and Budget, and possibly legislative action. As noted earlier, the MFCMA does not now provide a mechanism for collecting substantial fees for fishing to cover management costs. Consequently, further exploration of industry funding of research and management activities will have to proceed through voluntary organizations or through legislative action.

DISCUSSION OF STEP 4. This step is likely to provoke substantial opposition from those paying the fees and lukewarm support from those not paying the fees. Consequently, this is a politically difficult step to take. It is justified on equity grounds, however, as a reasonable contribution by those standing to gain the substantial economic benefits that the individual quota system can provide. Whether funding from the commercial industry should cover just the costs of catch monitoring, or whether it should shoulder a greater share of the stock assessment and management costs is a contentious issue. The proposed solution to this follows the spirit of the "no losers" standard; neither the taxpaying public nor the commercial fishing interests obtaining share quotas will lose.

Specific proposals for fees should be designed to meet specific management costs. Since this study did not investigate the level of management costs, specific fees are not being proposed. For illustration, however, the total funds needed to cover major costs can be judged from the fee schedules established to cover costs associated with foreign fishing. A 1980 amendment to the MFCMA established the requirement that MFCMA-related costs be imposed on foreign fishing companies in proportion to foreign catch as a fraction of total catch in U.S. waters (P.L. 94-265, Sec. 204b(10)). This policy was implemented by establishing permit and poundage fees using a standard formula (including research, management, surveillance, and data collection costs, but not at-sea observer program costs).

During 1982 through 1986 the foreign fee computation procedure remained essentially unchanged, with most of the revenue collected from poundage fees. For example, poundage fees for foreign fishing in the EEZ off Alaska in 1984 came to a total of around $46 million, or about $35.3 per metric ton averaged over 1.3 million metric tons of pollock, Pacific cod, flounders, and other groundfish. Assuming that the management and enforcement costs were reasonably computed, a domestic royalty on groundfish quota shares could be based upon some reasonable proportion of this total tonnage cost. A fifty percent share of costs would lead to a $17.6 royalty per ton. The royalty rate could vary among species to reflect exvessel values of different species, as was the practice in setting foreign fees. More detailed examination of the cost components is needed in order to determine what proportion of total management costs would be reasonable to derive from user fees or quota royalties.

STRATEGY 2

The second strategy differs from the first strategy mostly in steps 1 and 3. The initial allocation of licenses and quota shares in Strategy 1 relied upon past participation and harvest records over the previous several years. In this second strategy there would be no initial license limitation, and the rights to harvest shares would be accumulated through documented harvests over a number of years. Because the upgraded monitoring and enforcement system (Step 2) and the management cost sharing system (Step 4) are equally important to the two strategies, the extensive discussion need not be repeated here. The presentation of Strategy 2 follows the four-step format followed for Strategy 1.

STEP 1: REGISTER AND DOCUMENT VESSELS AND FISH BUYERS. The first step is simply to establish a complete and consistent system of registration for owners or prospective owners of groundfish fishing vessels. The registration of vessels would involve little more than a continuation of the existing system operated by the NMFS Alaska Regional Office. The vessel owners would submit necessary information on vessel characteristics (including Coast Guard registration numbers, and radio call letters) and information regarding how management personnel may contact them. Unlike the Strategy 1, this would not constitute a limit to entry of new vessels. Since the licenses would have no market values and would not be limited in number, no transfers of licenses would be anticipated.

Buyers of groundfish would need to be licensed so that records can be kept of all sales and purchases. Foreign and domestic buyers would be required to maintain and periodically submit records of quantity, condition, and species of fish bought. This information would be equivalent to existing State requirements for "fish tickets."

STEP 2: UPGRADED MONITORING AND ENFORCEMENT. This step would be essentially identical to Step Two of Strategy 1, except that the enhanced monitoring functions associated with enforcement of ITQs would be phased in over a number of years as the ITQs are issued.

STEP 3: ALLOCATION OF INDIVIDUAL TRADEABLE QUOTAS. Individual rights to harvest fish would be established over a period of years, based upon documented performance in the fishery. This would be a variant on the "homestead" concept in which resource ownership rights are given to those demonstrating a commitment to using the resource. The owner of any U.S. registered vessel landing groundfish in the U.S. or catching and processing groundfish in the EEZ would be issued certificates giving perpetual rights to harvest groundfish. These certificates would be individual transferable quota shares designating species, quantity, areas and any other stipulations consistent with fishery management regulations. The harvest rights would be accumulated in the following fashion:

1. During year 1 (for example, assume this is 1989) the fishery proceeds as usual under conventional fishery regulations. Each vessel's harvest would account for a documented portion of the TACs for the year. At the end of the year, each vessel owner would be issued ITQ certificates equal to 20 percent of actual documented TAC shares landed on shore or processed at-sea on U.S. registered vessels. Vessel owners would also be issued ITQ certificates equal to 10 percent of joint venture harvests. Thus a shoreside trawler or a factory trawler would get twice the credit for each ton landed as a joint venture trawler. (This proportion could be negotiated among NPFMC and industry advisors; a two-to-one ratio is used here for illustration.)
2. In year 2, open access fisheries are held for each species, with each species quota equal to the TAC established by NPFMC/NMFS minus the quantity allocated to individuals through ITQs. Holders of ITQs can harvest in accordance with all other pertinent regulations during the open access season and/or during periods of the year when the open access fishery has taken its quota and is closed. The ITQs are transferable via private transaction; transfers must be recorded at the NMFS Regional Office weekly. ITQs are to be used for landing fish at shoreside locations and for processing at sea aboard factory trawlers, U.S. registered motherships, or floating processors. At the end of the year, each vessel owner would be issued additional ITQ certificates equal to 20 percent of actual documented DAP harvest (including both open access and ITQ harvest) and 10 percent of documented JV harvest.
3. In succeeding years, open access fisheries would be held for each species, with quotas equal to the share of TAC not yet allocated in ITQs through the prior year. Holders of ITQs can, as in year 2, harvest during the open access season or during the remainder of the year in accordance with all other fishery regulations. Unless the total allocation would exceed 100 percent of the TAC, vessel owners would continue to receive additional ITQ certificates at the end of each year at the rate of 20 percent for DAP and 10 percent for JV fishing. At the end of any year in which the normal allocation of new ITQs would cause total outstanding shares to exceed 100 percent, the year-end ITQ allocations will be adjusted downward until the total ITQ shares issued just equals 100 percent.

This strategy would eventually allocate out all TACs for groundfish to privately held ITQ certificate holders. If the domestic fishery continues to grow during the five-year allocation period, the JV fishery will decline, and most of the ITQs will be issued to DAP fishermen. To illustrate how this might work, a numerical example has been worked out (Tables 3 and 4). This is not a serious attempt to predict the future course of the fishery. In this example, we assume a constant total TAC of 2.1 million metric tons. We also assume that there is no foreign fishery, that the DAP fishery grows to absorb the entire TAC between 1989 and 1994, and that the JV fishery shrinks to accommodate the DAP fishery. This future course for the groundfish fishery is displayed in Table 3.

Table 3. Hypothetical future groundfish harvests.

Year	Harvest by Sector		
	JV	DAP	Total
	——thousands of metric tons——		
1989	1200	500	1700
1990	1000	800	1800
1991	700	1200	1900
1992	400	1600	2000
1993	100	2000	2100
1994	0	2100	2100
1995	0	2100	2100

Table 4. Hypothetical ITQs issued during seven-year period.

Year	New ITQs issued to JVs	Cummulative ITQs to JVs	New ITQs issued to DAP	Cummulative ITQs to DAP	Total ITQs issued
	——thousands of metric tons——				
1989	120	120	100	100	220
1990	100	220	160	260	480
1991	70	290	240	500	790
1992	40	330	320	820	1150
1993	10	340	400	1220	1560
1994	0	340	420	1640	1980
1995	0	340	120	1760	2100

This scenario assumes ITQs issued to JV vessels equal to 10% of harvest and to DAP vessels equal to 20% of harvest, and that DAP sector expands as indicated in Table 3a.

Given these assumptions, the allocation rules suggested above would lead to the division of quota shares between JV vessel owners and DAP vessel owners displayed in Table 4. By the end of 1993 the JV vessel owners would have accumulated 340 thousands tons of ITQs, while the DAP vessels owners would have 1,220 thousand metric tons of ITQs. After 1993, the domestic sector would take the entire TAC, but the 20% entitlement rule would continue phasing in the ITQ allocations until the end of 1995. In 1995, the last year in which an open access fishery would occur, year-end allocation would constitute only a portion of the earlier 20% of harvest rule.

DISCUSSION OF STEP 3. This step addresses the criteria of fairness in allocation of harvest rights, while adhering to the spirit of the Americanization process, by allowing the competition for fish to determine the ultimate distribution of fishing rights. Several aspects of this approach warrant emphasis:

1. Documented harvests before 1989 would not enter into the allocation of ITQ shares. Using actual harvests during the phase-in allocation period to determine shares, however, would seem to meet the MFCMA requirement that limited access systems take into account the present participation, historical fishing practices in, and dependence on the fishery.
2. This ITQ allocation system gives each groundfish vessel owner a fair chance to accumulate harvest rights, because it opens opportunities to claim quota shares over an extended period of time. Operational or market problems encountered in any given year will not have undue influence on the eventual ITQs accumulated by vessel owners. No vessel active during the period will fail to acquire some harvest rights, although vessels in joint ventures will acquire rights at a reduced rate. Also, additional shares will be available through private transactions; permitting more efficient or profitable firms to expand, and permitting all vessel owners the opportunity to tailor species quota shares to meet their production plans or fishing luck.
3. The rate of growth in the domestic processing industry will determine how quickly the JV fishery shrinks (just as under the current management system), and it will also determine what fraction of the ITQs are eventually issued to JV vessel owners. If many years go by without significant growth in the DAP fishery, the ITQs accumulated through JV fishing may become a large portion of the total TAC. Since these ITQs are supposed to be used for DAP harvests, and are not required for JV fishing, lack of a domestic market could cause these ITQs to remain unutilized. However, so long as the DAP fishery is expected to harvest less than the TAC, a JV allocation would continue to be established each year (just as under the existing groundfish management regime).

STEP 4: ESTABLISH A SYSTEM OF SHARED FUNDING. As in Strategy 1, some management costs would be shifted to the private industry through fees and royalties. Because the individual quota shares would be allocated over a number of years under Strategy 2, it would seem reasonable to phase in the user fees in a similar fashion. This could be done by linking the fees to ITQs owned. A fee per ton of ITQ issued, or an ad valorem tax on ITQs owned would accomplish this. An initial issuance fee (e.g., 1 dollar per ton of ITQ) could be combined with an annual fee to assure sufficient funding for management operations before ITQs are actually being used in the fishery.

Conclusions

Improving the management of groundfish off Alaska can result in increased net economic returns from the commercial fishery, and it can distribute those returns equitably among fishermen and taxpayers, while assuring fish stock conservation and maintaining management and private business flexibility. Conventional regulations can assure conservation of fish stocks, and they can preserve past harvest shares among user groups. To generate the estimated $120 million to $200 million in net economic values, however, requires substantial reform of the harvest rights system. Limiting fishery access through individual quotas shares seems to be the most feasible approach. The paramount concern in establishing a limited access system is equity in the distribution of fishing rights and economic wealth. Additional concerns are (1) accuracy and completeness of scientific and compliance monitoring data, and (2) enforcement of catch and by-catch quotas.

The two illustrative programs of management improvement described above seek to address all of these concerns in a logical sequence. The first strategy starts with a license limitation system for the groundfish fleet, temporarily slowing expansion of the groundfish fleet to provide time for development and implementation of a comprehensive enforcement and data collection system. The second strategy skips the license limitation step. Both strategies require a significant early effort to expand and solidify the management information data base. Without the data provided such a system, neither an individual quota nor the traditional aggregate, open access quota approach can successfully conserve fish stocks.

In both strategies the third step involves the allocation of individual share quotas to licensed fishing vessel owners. The first strategy allocates based upon past harvest shares, and it provides additional shares of under-utilized species to U.S. fishing companies on a first-come, first-served basis. The second strategy sets up a several year phase in period, during which vessel owners gain rights to quota shares by harvesting fish. Both strategies can be structured so that the existing preference for domestic fish processing over joint venture processing is retained. If desired, Americanization of the groundfish industry can be built into a share quota system.

The fourth step of each strategy institutes a user fee system to cover at least that portion of the management costs associated with monitoring and enforcing catch quotas on each vessel. A minimum version of this funding system would be similar to the observer fees system used for the foreign observer program. Profits from fishing operations under an individual share quota system would be more than adequate to pay these fees. The sharing of management costs between taxpayers and commercial fishing companies is consistent with common notions of equity.

The foregoing programs for groundfish management are offered as models for consideration by the North Pacific Fishery Management Council, the Council's advisory committees, and others interested in conservation of groundfish resources. While they clearly require further development in detail, the proposed strategies demonstrate possible ways of achieving the variety of objectives associated with public management and use of the vast groundfish resources in the EEZ off Alaska. Development of more comprehensive and politically feasible management strategies will require intensive efforts involving participation by government officials, management experts, and industry representatives.

The current rate of development in the U.S. fishery offers a relatively small window of opportunity (two years or so, in this authors estimation) for implementing the management institutions needed to assure substantial achievement of the objectives. Conventional management measures are clearly not up to the task. A frequent impediment to adopting limited access, especially individual quota shares, is the fear of uncertain consequences. However, change is inherent in the process of fishery development. The illustrative strategies developed above are a positive attempt to devise an efficient and equitable style of groundfish management.

Endnotes to Section VI

1. After lengthy discussion and development of an individual quota system for Pacific halibut, the NPFMC proposed a simple moratorium to take effect in June 1983. The moratorium was rejected by NOAA on recommendation of the Director of the Office of Management and Budget who claimed, in part, that it "would not . . . resolve the excess investment problem without creating additional economic problems . . ." and "that an adequate showing has not been made of the need for the lengthy moratorium proposed, and that the moratorium would be likely to delay consideration of alternative measures to resolve the halibut management problem in a fair, lasting, and economically efficient manner." (All quotes taken from Richards and Gorham, 1986; pp 44-48) Different interpretations of this rejection place varying degrees of confidence on the technical versus political underpinnings. Most would agree that the plan was deficient in some respects.

2. The concept of extracting substantial economic rent from the fishery is not pursued further here due to the poor prospects for political support. Rent extraction as such would involve setting fees or sales prices for quota shares at levels high enough to capture most of the potential net economic value of the fishery. Populists and single taxers may applaud the taxation of rents because they fall "upon those who receive from society a peculiar and valuable benefit..." (Henry George, 1953; p. 139) My deletion of the common exhortation to capture rents from a public resource, more or less follows the logic explored by R. Stokes (1986).

   Stokes draws upon the theory of interest group/government interaction devised by Mancur Olsen (1971), to conclude that among efficient public policies the more feasible ones are those that support concentrated as opposed to diffuse interests. In the typical commercial fishery, economic efficiency consequences are essentially the same whether potential profits accrue to owners of quota shares or to the public treasury. Since quota share holders will represent a concentrated interest group whose economic welfare depends upon retaining private title to resource rents, they will strongly oppose a public policy that extracts rent. The beneficiaries of rent taxation, the public at large, is too diffused an interest group to promote its interests effectively against those of the commercial industry. Hence, political feasibility militates against the full taxation proposal. Nevertheless, minimal standards of equity seem to call for collection of fees to allay public fishery management costs.

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APPENDIX

Computation of Optimum Factory Trawl/Mothership Fleet and Potential Economic Return from Bering Sea/Aleutian Islands Fishery

The objective of this computation is to determine number and type of fishing vessels needed in a factory trawler/mothership fleet to harvest the total allowable catches of BSAI groundfish. As noted in the text of Section II, and further explained in Huppert and Squires (1987), any such calculation is contingent on the data and assumptions used. Because broad assumptions and preliminary estimates are incorporated along with more precise information, the results are considered suggestive rather than conclusive. This Appendix lays out all the assumptions, so that those willing to dig into the details may develop interpretations of the model and results that are consistent with the data and assumptions.

Linear programming (LP) is a standard operations research technique that maximizes a linear objective function subject to a set of linear inequality constraints. A solution to an LP consists of the calculated optimum level of all variables affecting the objective function. In this application, net economic return (i.e. total groundfish product value minus fishing and processing cost) is the objective. Requiring that the sum of the catch across vessel classes for each species is no greater than the total allowable catch represents a set of linear inequality constraints. Each solution to the trawl fleet model involves determining the number of vessels in each of five classes of trawlers and motherships, and determining how to deploy the potential fishing days of this fleet across various species targeting modes and areas in the BSAI. Each possible fleet size and deployment pattern generates a set of catches, which result in a set of fish product quantities, product values, fishing and processing costs, and fixed costs. The linear programming method finds the single combination of vessel numbers and fishing day allocations that achieves the highest possible net economic value. Each part of the computation involves the data summarized in the Tables below. In order to assure than the number of vessels in the solution is an integer, we use a special version of the linear programming algorithm, called mixed integer programming. These computations were performed on a microcomputer using the LP/MIP83©, Version 5.00 program (copyrighted by Sunset Software, San Marino, California).

Net economic return for each vessel class (described in Table 1), fishing mode, and area is computed in several stages. First, the quantities caught by a vessel of any given class are computed by multiplying days of operation times the species-specific rates of catch or processing. Second, catch quantities are allocated to fish product classes (Table 2). Third, quantities of fish products are calculated by multiplying catch quantities by product yield rates (product weight divided by raw fish weight, Table 3). Fourth, revenues are equal to product quantities multiplied by product prices (Table 4). Fifth, these dollar values are summed over all species caught by all vessels, in all areas, and all modes of operation, creating a gross product value per day of operation. Sixth, the variable costs per day of operation (Table 1) are subtracted from each gross product value per day to form a variable net return per day.

For any given fleet size and fishing effort deployment, the net returns are summed across all days fished, and the annual fixed costs per vessel are subtracted, yielding a net economic value for the year in each vessel class. Annual fleet-wide net economic return (equivalent to profit) is the sum of the returns from all vessel classes.

The primary data requirements are (1) catch rates by vessel class, area, and target fishery; (2) vessel operating and fixed costs; (3) allocations of raw fish to product categories; (4) product yields; (5) product prices; (6) constraints on total catches by species and area; and (7) limits on number of operating days per year for vessels in each class.

For simplicity, the term "catch rate" is used for both trawlers and motherships, recognizing that mothership "catch" rates actually represent processing plant use and catcher vessel delivery rates. Catch rates for small and medium factory trawlers were computed using weekly reports compiled by the NMFS Alaska Regional Office during 1986 and 1987 (through mid-August). Catch rates have been calculated from foreign vessel observer data from 1986 and 1987 (through mid-August), using data files made available to us by R. Nelson of NMFS' Northwest and Alaska Fisheries Center. The catch rates are computed for each species target mode by assigning fishing days to target categories based upon predominance of species reported (highest percent in catch).

Additional modifications to the computed average catch rates and fishing seasons were incorporated based upon the author's subjective judgements. The two main adjustments were to walleye pollock catch by large motherships and Pacific cod catch rates by medium factory trawlers. In each case, the adjustment to computed data was deemed necessary to obtain reasonable results from the model. First, pollock catch rates for Class 5 motherships were reduced from 620-670 metric tons per day to 500 tons per day in the main fishing zones (Areas I and II in the Bering Sea). This adjusted catch rate is more in line with capacity limits for 460-foot mothership operations as projected by Natural Resources Consultants (1984b). Second, in preliminary runs of the LP model, the high computed Pacific cod catch rate for medium factory trawlers (about 42 mt/day in area I) led to a solution in which 22 medium trawlers were assigned to Pacific cod fishing, resulting in huge and probably unrealistic profits. This result was considered unrealistic because it ignores the marked seasonality in Pacific cod availability to trawl gear. Based upon monthly Pacific cod trawl catch information (Bakkala and Balsiger, eds.; p. 41), it was determined that the really high catch rates can be reliably obtained for only about four months per year. To incorporate this seasonal factor, an additional constraint was added that permits the high-yield Pacific cod fishery to occur for only four months per year. Pacific cod catch rates for other vessel classes and in non-Pacific cod targetting modes were not adjusted. These were the only two departures from the straightforward use of computed average catch rates in the linear programming model.

Costs of operating the fleet are divided into variable and fixed. Variable costs are further sub-divided into those cost elements that accrue during vessel operations independently of actual catch processed and those that increase with quantity or type of fish processed. The "catch independent" variable costs include fuel, groceries, supplies, repair and maintenance, crew payments, and crew transportation. Catch dependent variable costs include packaging, freight and distribution costs, storage, additives to surimi, duties for fish exported, and, most importantly, payments by motherships to catcher vessels. Fixed costs include interest costs (based upon vessel value), hull insurance, overhead, and P & I insurance. The data used in this model are derived from diverse sources; including Natural Resources Consultants, 1984 (July), various cost data sheets available from the Northwest and Alaska Fisheries Center, and direct interviews with industry members. Several cost elements (fuel price, insurance rates, interest rates) were updated to values appropriate to 1987. All of the underlying information, in the format of cost summaries, are listed at the end of the Appendix. Use of subjective judgements in establishing these cost elements is unavoidable, and the reader should be aware that the results of the computations are sensitive to the assumed costs, prices, and other parameters.

Product prices (Table 4) and product yields (Table 3) are derived from several sources; including NMFS' Market News, reports of joint venture companies summarized by NMFS' Alaska Regional Office, and various personal contacts. Allocations of fish across product categories (Table 2) are based upon the same sources as cost information, with the addition of various judgements based upon discussions of fishing strategy with fishing industry members.

The total catch constraints used in the linear program represent recent estimates of Acceptable Biological Catches (ABCs) for 1988, and percentage distributions of catch across regulatory areas are based upon actual distributions from 1986 through mid-August, 1987 (Table 5). Maximum assumed days fishing per year for each vessel class (Table 1) are derived from NRC (1984), confidential information supplied by the Northwest and Alaska Fisheries Center, and personal communications.

The basic solution to the linear programming model is displayed in Table 6. In this solution, the program is forced to include at least one vessel in each class. This solution delineates the following optimal factory trawler and mothership groundfish fleet in the Bering sea: (1) a total of 34 processing vessels are needed -- 1 small factory trawler, 3 medium factory trawlers, 21 large factory trawlers, 6 fillet motherships, and 3 large surimi motherships (2) a total of 1,741,812 metric tons of groundfish would be harvested, (3) the processed products would be worth roughly $884 million, (4) the net profit from this operation would be $124 million, and (5) 1,195,792 metric tons of the total ABCs would not be harvested. Given that catcher vessels supplying the motherships can harvest 16,000 to 18,000 metric tons per year (NRC, 1984b; p. 9), the associated catcher fleet will need to contain 44 to 49 vessels.

The second run of the linear program (Table 7) was intended to reveal whether the economic and catch data entered was consistent with each vessel class being a potentially profitable operation. In this run all data and constraints remain as before except that the fleet is limited to one vessel of each type. The solution to this LP, while not representing an answer to how large the fleet should be, shows that each vessel class is potentially profitable. The reason that the optimal solution to fleet size (Table 6) includes only one Class 1 vessel is not that such vessels cannot be profitable, but the fish can be caught more profitably by the other types of vessels. This conclusion is dependent upon the species mixes and catch rates assigned to each vessel class. Because the catch rates by species for each class of vessel are important variables, additional work may be warranted to assure that the assumed catches are consistent with the increasing experience with U.S. factory trawlers.

The results depicted in Table 8 represent the base economic assumptions and catch constraints, but with the deletion of class 5 motherships from the model. With this additional constraint, the optimum fleet would include just a few more large factory trawlers and small fillet mothership operations, but would be smaller overall. The total catch drops to 1.48 million metric tons, gross value of product drops to $747 million, and the aggregate economic fleet profit decreases to $98 million.

The next two Tables reflect the basic model assumptions again (i.e. no special constraints on number of vessels) but with all fish product prices alternately increased and decreased by 20 percent. The hypothetical increase in prices results in only 1 additional large factory trawler in the optimum fleet, while the net profit from the groundfish fleet operation would increase to $281 million per year. As shown in Table 10, a decrease of 20 percent in all prices would cause a radical decline in the optimum fleet to only 13 vessels with an annual profit of $3.3 million. Clearly, the extreme sensitivity of optimum fleet size to a twenty percent price reduction is a result of model assumptions, particularly the fixed cost levels.

The results of this linear programming model cannot be taken as definitive proof that any particular processor fleet configuration is best. It is also wrong to take the profits for a given class of vessel shown in the LP solution as estimates of profits actually being earned by U.S. groundfish vessels. Each vessel in operation has unique characteristics and fishing patterns that deviate somewhat from any of the vessel classes characterized in this analysis. And, more importantly, the profits computed here are consistent with efficient fleet investment and deployment, something that has never been tried in a U.S. groundfish fishery. The underlying assumption is that no excess fishing capacity will be built. Under existing fishery institutions, a much larger fleet will be built, with each additional vessel providing a return on investment to its owners. This is simply a restatement of the usual conclusion that open access to fishing draws excessive fishing capacity causing a reduction in overall profit (resource rents). While a rational central planner, or a competitive fishery having quantitative harvest rights, might develop an optimum fleet, a competitive fishery with open access to the fish stock would not.

This is a provisional model. Various cost and price assumptions need to be checked further, and the catch rates and product allocations may require verification. The parameter values used in the model are accurate enough, however, to support general conclusions. First, mothership operations appear to be profitable, but large factory trawlers also have an important place in harvesting and processing pollock. Also, the fleet needed to exploit the Bering sea groundfish efficiently, is much smaller in number than the fleet that has been operating there in foreign and joint venture fisheries. Finally, total potential profits from the fishery are large enough to warrant extensive public interest and participation in the development of efficient fishery management programs.

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Appendix Table 1. Descriptions and assumed operating and fixed costs per vessel in each class.

	Class 1	Class 2	Class 3	Class 4	Class 5
Description	Factory Trawler	Factory Trawler	Factory Trawler	Mother-ship	Mother-ship
Length (feet)	162	200	300	300	460
Crew Size	25	38	85	85	300
Max. operating days: At-sea	220	260	300	300	320
Processing or fishing	220	260	265	265	265
Fixed costs per year[1] ($1,000s)	$1,736	$3,376	$6,784	$8,032	$11,556
Variable cost[2]					
1. Daily - catch indep.	$11,550	$27,077	$32,323	$24,906	$59,683
2. Cost per MT caught	$47.3	55.6	68.10	221.89	203.89

[1]The major items of fixed cost are cost of capital investment, hull insurance, and P & I insurance. Rather than estimate loan costs, opportunity cost of owner's equity, and depreciation; we have included a single cost of capital investment equal to the annual payment on a 10%, 15-year loan for the original vessel price.

[2]Variable costs are divided into (1) those that accrue daily as the vessel operates at sea, and (2) those that are incurred only as fish are processed. The first group includes fuel, groceries, fishing gear, repair and maintenance, and crew payments. Crew payments are treated like wages and salaries rather than as shares in these computations. The second set of variable costs includes packaging, freight & distribution, storage, and fish purchases on motherships. At-sea fish purchase prices are assumed to be $132/mt for pollock and $236/mt for Pacific cod. While the catch-related variable cost depends upon the actual catch per day the costs reported above are averages based upon the calculated average cost per mt ton from the linear programming solution listed in Table 8 below.

Appendix Table 2. Allocation of catch to various product categories.

	Roe	Surimi	Fillet	Block	H & G
1. Small Trawlers					
Pollock	0	0	100	0	0
Cod	0	0	100	0	0
Yellowfin Sole	0	0	0	0	100
Other Flatfish	0	0	0	0	100
Sablefish	0	0	0	0	100
Rockfish (including POP)	0	0	0	0	100
Atka Mackerel	0	0	0	0	100
Other groundfish	0	0	0	0	100
2. Medium Trawlers:					
Pollock	0	0	100	0	0
Cod	0	0	100	0	0
Yellowfin Sole	0	0	0	0	100
Other Flatfish	0	0	0	0	100
Sablefish	0	0	0	0	100
Rockfish (including POP)	0	0	0	0	100
Atka Mackerel	0	0	0	0	100
Other groundfish	0	0	0	0	100
3. Large Trawlers					
Pollock	30	60	20	12	0
Cod	0	0	35	35	30
Yellowfin Sole	0	0	0	0	100
Other Flatfish	0	0	0	0	100
Sablefish	0	0	0	0	100
Rockfish (including POP)	0	0	0	0	100
Atka Mackerel	0	0	0	0	100
Other groundfish	0	0	0	0	100
Small (Fillet) Mothership					
Pollock	30	0	78	12	0
Cod	0	0	35	35	30
Yellowfin Sole	0	0	0	0	100
Other Flatfish	0	0	0	0	100
Sablefish	0	0	0	0	100
Rockfish (including POP)	0	0	0	0	100
Atka Mackerel	0	0	0	0	100
Other groundfish	0	0	0	0	100

Appendix Table 2. Allocation of catch to various product categories - cont'd.

	Roe	Surimi	Fillet	Block	H & G
Large (Surimi) Mothership					
Pollock	30	80	0	12	0
Cod	0	0	35	35	30
Yellowfin Sole	0	0	0	0	100
Other Flatfish	0	0	0	0	100
Sablefish	0	0	0	0	100
Rockfish (including POP)	0	0	0	0	100
Atka Mackerel	0	0	0	0	100
Other groundfish	0	0	0	0	100

Appendix Table 3. Product yields.

Product	Percent
Pollock Surimi	23.00%
Pollock Roe	3.00%*
Pollock Fillets	20.00%
Pollock Blocks	20.00%
Cod Fillets	20.00%
Headed & Gutted Cod	50.00%
Headed & Gutted YFsole	80.00%
Headed & Gutted Flatfish	75.00%
Headed & Gutted Sablefish	65.00%
Headed & Gutted Rockfish	50.00%
Headed & Gutted Other SP.	75.00%

*Roe yield applied to all pollock caught in roe fishery, i.e. about 30% of pollock catch.

Appendix Table 4. Assumed prices for groundfish products.

Fish Product	$/lb	$/metric ton
Surimi	1.00	2206
Pollock Roe	2.40	5291
Pollock Fillets	1.00	2204
Pollock Blocks	1.00	2204
Cod Fillets	1.90	4189
Headed & Gutted Cod	0.72	1786
Headed & Gutted Flatfish	0.47	1036
Headed & Gutted Sablefish	1.35	2976
Headed & Gutted Rockfish	1.14	2513
Headed & Gutted Other	0.40	882

Appendix Table 5. Catch limits based upon 1988 ABC and allocation of ABCs across regulatory areas in the Bering Sea.

Species and Area	MSY Total	Percent
* Pollock	1,660,000	100.00%
Area 1	1,119,026	67.41%
Area 2	504,819	30.41%
Area 4	36,155	2.18%
* Pacific cod	385,300	100.00%
Area 1	288,097	74.77%
Area 2	37,274	9.67%
Area 4	59,935	15.56%
* Yellowfin sole	254,000	100.00%
Area 1	253,478	99.79%
Area 2	488	0.19%
Area 4	33	0.01%
* Sablefish	12,200	100.00%
Area 1	351	2.87%
Area 2	0	0.00%
Area 4	11,850	97.13%
* Atka Mackerel	21,000	100.00%
Area 1	158	0.75%
Area 2	2	0.01%
Area 4	20,839	99.24%
* Other Flatfish	455,500	100.00%
Area 1	377,334	82.84%
Area 2	73,137	16.06%
Area 4	5,029	1.10%
* Rockfish	24,100	100.00%
Area 1	618	2.57%
Area 2	1,930	8.01%
Area 4	21,552	89.43%
* Other Groundfish	64,000	100.00%
Area 1	43,720	68.31%
Area 2	8,818	13.78%
Area 4	11,462	17.91%

Appendix Table 6. Linear program solution for base assumptions.

	Class 1	Class 2	Class 3	Class 4	Class 5	Totals
	Metric tons					
Pollock	0	3715	834750	381695	397500	1617661
Pacific cod	491	35645	44520	4420	2255	87332
Yellowfin sole	0	4	8081	48	6	8138
Sablefish	461	334	323	0	0	1119
Atka mackerel	0	0	0	0	2	2
Other flatfish	120	4476	14583	1988	129	21295
Rockfish	1536	5	172	64	5	1781
Other	0	10	3663	684	127	4484
Total catch	2610	44189	906092	388898	400024	1741812
No. of vessels	1	3	21	6	3	34
	$1,000s					
Gross revenue	3537	37408	462246	185900	194836	883929
Variable costs	2648	23577	241581	125892	128967	522665
Fixed costs	1736	10128	142468	48193	34669	237195
Total costs	4384	33705	384050	174086	163636	759860
Net revenue	-846	3703	78197	11815	31200	124068
Revenue per vessel	$3,537	$12,469	$22,012	$30,983	$64,945	$25,998
Profit per vessel	($846)	$1,234	$3,724	$1,969	$10,400	$ 3,649

Appendix Table 7. Linear program solution with one vessel in each class.

	Class 1	Class 2	Class 3	Class 4	Class 5	Totals
	Metric tons					
Pollock	54	1238	39750	63616	132500	237158
Pacific Cod	584	11882	2120	737	904	16226
Yellowfin Sole	0	1	385	8	0	394
Sablefish	390	111	15	0	0	517
Atka Mackerel	0	0	0	0	2	2
Other Flatfish	2452	1492	694	331	60	5030
Rockfish	269	2	8	11	5	294
Other	14	3	174	114	58	364
Total catch	3764	14730	43147	64816	133529	259986
No. of Vessels	1	1	1	1	1	5
	$1,000s					
Gross revenue	4820	12469	22012	30983	65096	135381
Variable costs	2719	7859	11504	20982	43041	86105
Fixed costs	1736	3376	6784	8032	11556	31485
Total Costs	4455	11235	18288	29014	54597	117590
Net revenue	365	1234	3724	1969	10499	17791
Revenue per vessel	$4,820	$12,469	$22,012	$30,983	$65,096	$27,076
Profit per vessel	$365	$1,234	$3,724	$1,969	$10,499	$3,558

Appendix Table 8. Linear program solution with no Class 5 vessels.

	Class 1	Class 2	Class 3	Class 4	Class 5	Totals
	Metric tons					
Pollock	1	1238	874500	507752	0	1383490
Pacific Cod	491	11882	46640	5909	0	64922
Yellowfin sole	0	1	8466	86	0	8553
Sablefish	461	111	339	0	0	911
Atka mackerel	0	0	0	0	0	0
Other flatfish	123	1492	15277	2659	0	19551
Rockfish	1535	2	180	84	0	1800
Other	0	3	3838	911	0	4752
Total catch	2611	14730	949239	517400	0	1483980
No. of vessels	1	1	22	8	0	32
	$1,000s					
Gross revenue	3539	12469	484258	247347	0	747614
Variable costs	2648	7859	253085	167615	0	431206
Fixed costs	1736	3376	149253	64258	0	218623
Total costs	4384	11235	402338	231872	0	649829
Net revenue	-845	1234	81920	15475	0	97785
Revenue per vessel	$3,539	$12,469	$22,012	$30,918		$23,363
Profit per vessel	($845)	$1,234	$3,724	$1,934		$ 3,056

Appendix Table 9. Linear program solution with all fish prices increased by 20%.

	Class 1	Class 2	Class 3	Class 4	Class 5	Totals
	Metric tons					
Pollock	0	3715	847817	381695	394863	1628091
Pacific cod	490	35645	47669	4420	2267	90492
Yellowfin sole	0	4	9876	48	5	9933
Sablefish	462	334	326	0	0	1122
Atka mackerel	0	0	0	0	3	3
Other flatfish	100	4476	20406	1988	129	27099
Rockfish	1548	5	175	64	5	1795
Other	0	10	4176	684	133	5003
Total catch	2599	44189	930445	388898	397407	1763538
No. of vessels	1	3	22	6	3	35
	$1,000s					
Gross revenue	4231	44890	573341	223080	232285	1077828
Variable costs	2647	23577	251410	136340	139003	552977
Fixed costs	1736	10128	149253	48193	34669	243979
Total costs	4383	33705	400663	184533	173672	796956
Net revenue	-152	11185	172679	38547	58614	280872
Revenue per vessel	$4,231	$14,963	$26,061	$37,180	$77,428	$30,795
Profit per vessel	($152)	$3,728	$7,849	$6,424	$19,538	$8,025

Appendix Table 10. Linear program solution with all fish prices decreased by 20%.

	Class 1	Class 2	Class 3	Class 4	Class 5	Totals
	Metric tons					
Pollock	54	1238	39750	63616	1192500	1297158
Pacific cod	584	11882	2120	737	6310	21632
Yellowfin sole	0	1	385	8	21	415
Sablefish	390	111	15	0	0	517
Atka mackerel	0	0	0	0	2	2
Other flatfish	2452	1492	694	331	336	5306
Rockfish	269	2	8	11	5	294
Other	14	3	174	114	334	639
Total catch	3764	14730	43147	64816	1199508	1325965
No. of vessels	1	1	1	1	9	13
	$1,000s					
Gross revenue	3856	9976	17609	24787	467246	523474
Variable costs	2719	7859	11504	19241	354867	396190
Fixed costs	1736	3376	6784	8032	104007	123935
Total costs	4455	11235	18288	27273	458874	520125
Net revenue	-599	-1260	-679	-2486	8372	3348
Revenue per vessel	$3,856	$9,976	$17,609	$24,787	$51,916	$40,267
Profit per vessel	($599)	($1,260)	($679)	($2,486)	$930	$ 258

Appendix Table 11. General cost assumptions

Price of Fuel per Gallon	0.80
Groceries per crewman/day	15.00
Packaging:	
Surimi / lb	0.01
Fillet & Roe / lb	0.03
Freight & Distribution:	
Surimi & Roe / lb	0.07
Fillets / lb	0.11
Storage	0.02
Crew Transportation:	
Trip/Crewman/Year	1.50
Average Trip Cost	1,200.00
Surimi Additives/mt	75.00
Duty /lb	0.05

Appendix Table 12. Small Factory Trawlers.

Length	162 feet
Crew size	25
Fixed Costs	
Vessel value	$7,500,000
Interest rate	10.00%
Length of loan (years)	15
Capital costs	$ 986,053
Hull insurance rate	6.00%
Hull insurance cost	$ 450,000
P & I rate/crew man	$ 8,000
P & I cost	$ 200,000
Overhead	$ 100,000
Total annual fixed cost	$1,736,053
Variable Costs (Catch independent)	
Fuel	$ 600,000
Repair & maintenance	350,000
Crew transportation	36,000
Fishing gear	115,000
Crew salaries	$1,440,000
Total variable costs	$2,541,000
Variable cost per day	$ 11,550

Appendix Table 13. Medium factory trawlers.

Length	200 feet
Crew size	38
Fixed Costs	
Vessel value	$15,000,000
Interest rate	10.00%
Length of loan (years)	15
Capital costs	$1,972,107
Hull insurance rate	6.00%
Hull insurance cost	$ 900,000
P & I rate/ crewman	8,000
P & I cost	$ 304,000
Overhead	$ 200,000
Total annual fixed cost	$3,376,107
Variable Costs (Catch independent)	
Fuel	$ 900,000
Groceries	100,000
Repair & maintenance	350,000
Crew transportation	70,000
Fishing gear	120,000
Crew salaries	$5,500,000
Total variable costs	$7,040,000
Variable cost per day	$ 27,077

Appendix Table 14. Large factory trawlers.

Length	300 feet
Crew size	85
Fixed Costs	
Vessel value	$30,000,000
Interest rate	10.00%
Length of loan (years)	15
Capital cost	$3,944,213
Hull insurance rate	6.00%
Hull insurance cost	$1,800,000
P & I rate/crewman	8,000
P & I cost	$ 680,000
Overhead	360,000
Total annual fixed cost	$6,784,213
Variable Costs (Catch independent)	
Fuel rate/Oper. day (gl)	4,650
Fuel costs	1,395,000
Groceries	382,500
Production supplies	35,000
Repair & maintenance	400,000
Crew transportation	153,000
Fishing gear	200,000
Crew salaries	$6,000,000
Total Variable Costs	$8,565,500
Variable Costs Per Day	$ 32,323

Appendix Table 15. Fillet (small) mothership.

Length	300 feet
Crew size	100

Fixed Costs

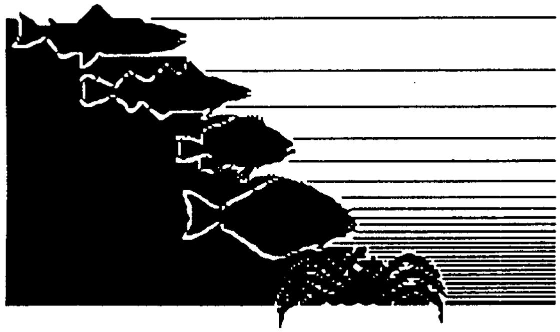
Vessel value	$ 30,000,000
Interest rate	10.00%
Length of loan (years)	15
Capital cost	$3,944,213
Hull insurance rate	6.00%
Hull insurance cost	$1,800,000
P & I rate/crewman	8,000
P & I cost	$ 800,000
Overhead	$1,488,000
Total annual fixed cost	$8,032,213

Variable Costs (Catch independent)

Fuel rate/Oper. day (gl)	3,000
Fuel	$ 900,000
Groceries	450,000
Production supplies	35,000
Repair & maintenance	635,000
Crew transportation	180,000
Crew salaries	$4,400,000
Total variable costs	$6,600,000
Variable costs per day	$ 24,906

Appendix Table 16. Surimi (large) mothership.

Length	460 feet
Crew size	300
Fixed Costs	
Vessel value	$45,000,000
Interest rate	10.00%
Length of loan (years)	15
Capital costs	$5,916,320
Hull insurance rate	6.00%
Hull insurance cost	$2,700,000
P & I rate/crewman	8,000
P & I cost	$2,400,000
Overhead	540,000
Total annual fixed cost	$11,556,320
Variable Costs (Catch independent)	
Fuel rate/Oper. day (gl)	4,400
Fuel	$ 1,056,000
Groceries	1,350,000
Production supplies	70,000
Repair & maintenance	800,000
Crew transportation	540,000
Crew salaries	$12,000,000
Total variable costs	$15,816,000
Variable costs per day	$ 59,693



THE FOUNDATION

The Fisheries Management Foundation was formed in 1985 to support fisheries scientists and managers working to develop innovative solutions to the problems of fisheries management. The Foundation's Board of Managers is composed of recognized experts in fisheries management: Dr. D.L. ("Lee") Alverson, former Director of Northwest and Alaska Fisheries Center, National Marine Fisheries Service, Professor Don E. Bevan, Professor Emeritus and former Dean of Fisheries of the University of Washington, and Professor James A. Crutchfield, Professor Emeritus, Department of Economics of the University of Washington. The initial funding for the Foundation was provided in 1985 by Dr. Keith B. Jefferts and Dr. Lynn B. Squires. The Board will review proposals of fisheries scientists, researchers, and managers in light of the Foundation's broad goals.

THE CHALLENGE

The Foundation's goals are:

- Harvest levels consistent with long-term economic biological productivity of marine and aquatic resources.
- Optimum economic return from the nation's publicly-owned marine and aquatic resources.
- Production of top quality seafood and aquatic products.
- Education of the general public regarding fisheries issues.

THE SEARCH

To promote the gathering and dissemination of reliable, timely information, the Foundation provides grants for a wide range of projects. These grants are designed to allow scientists, researchers, and managers to work and teach unburdened by other commitments in an environment free from the influence of institutional policies or political pressures. The Foundation considers proposals involving all aspects of fisheries management: biological, sociological, economic, educational, political, technological, and environmental projects to improve the accuracy, availability, and timeliness of fishery data are particularly solicited.

Grant selections are made by the Board of Managers. Proposals are evaluated in terms of conceptual soundness, contribution to improved fishery management, experience and training of the applicant, and adequacy of the proposed budget. The Board may from time to time request outside review of the proposals by qualified experts. The National Science Foundation format for research proposals should be followed.

Inquiries concerning the Foundation and its program should be directed to Fisheries Management Foundation, 2445 Perkins Lane West, Seattle, Washington 98199.

FISHERIES RESEARCH INSTITUTE

Founded in 1947, the Fisheries Research Institute (FRI) joined with the School of Fisheries in 1958 to become its primary research unit. Research staff and activities steadily enlarged over the years, and the diversity of sponsored research projects has greatly increased since the initial years of exclusive emphasis on salmon problems in Alaska.

FRI has evolved into an institute dedicated to developing, administering, and conducting the School of Fisheries research program in the area of Fisheries Science and Management. The objectives of this program are threefold. First, the program provides relevant research and training opportunities for graduate students. Since fisheries science is a rapidly developing science, it is impossible for faculty to teach and train effectively unless they are deeply involved in that development. Second, the research program exists to advance the state of knowledge, the fundamental understanding, in the field of fisheries science and management. Third, since fisheries is an applied science, the research program must explore methods of applying our understanding to public needs. In this context, FRI, and the University, play a unique role as a link between basic fisheries science, management, and resource user groups. This third role is carried out through contract and grant research, direct participation of FRI faculty, staff, and students in the management process, and the use of FRI as a forum for the development of public fisheries science and management policy.

Fisheries is a broad science, drawing on a large variety of disciplines. Its roots are in the basic biological sciences (icthyology, physiology, behavior, ecology, genetics), and encompasses the physical sciences (limnology and oceanography), mathematics (population dynamics and statistics), social sciences (economics, sociology, public policy), and engineering (hydroacoustics, fishing gear technology).

Fisheries science is also oriented toward solving problems. The FRI program attempts to address these problems in a comprehensive way by conducting individual research efforts in the basic areas and, in addition, developing large multidisciplinary research programs around specific themes or problem areas such as the Alaska salmon fishery. These programs are team efforts that require the active participation of more scientists than can be justified by an academic program alone. These programatic research efforts must have longevity to be of real use to the advancement of fisheries science and the link to managers and users; FRI provides this continuity by employing research faculty and staff and housing postdoctoral fellows and visiting scientists drawn from around the world.