Limiting Fishing Rights in Small Coastal Communities: the Alaska Halibut and Sablefish Longline Fisheries*

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prepared for presentation to the
Western Regional Science Association
annual meeting
Kamuela, Hawaii

February 1997

*This research was supported by NOAA grant NA26FD0184.

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Parzival Copes (1986) noted that awarding limited access rights to common property fisheries often fails to raise incomes in fishing communities in the long run. That is because awarding transferable property rights to a group of resource users creates a transitional gains trap (Tullock, 1975), in which the original beneficiaries can extract the capitalized value of these rights from the next generation.

Despite his word of caution about the transitional gains trap, Copes and other economists still justify limiting access as of *universal* merit because of the gains it can produce in economic efficiency. Efficiency gains generally come in three forms: (1) conservation of fish stocks, (2) freeing excess labor for other uses, and (3) freeing redundant capital for other uses. Economists typically assume that the right to participate in the common-property fishery -- the right taken away when access is limited -- is a right with no net value to society. Copes (1987) has gone so far as to declare the right to pursue the common property fishery as a social liability.[1]

The picture of the common property fishery as a destructive enterprise where redundant labor and capital pursue an overexploited stock to collapse may accurately characterize some fisheries around the world. In others, however, effective conservation strategies and limited alternative economic opportunities for labor and capital may leave a substantial residual economic value in the common property fishery that must be subtracted from the value of the fishery under limited access to obtain the net benefits from rationalization. For example, if neither fishers nor their boats can be gainfully employed in any alternative employment and fish stocks are adequately protected, then one may be justified in counting the total income earned in the common property fishery as social benefits that could be lost in a new management regime.

Can what is lost be worth as much as what is gained? I have argued elsewhere (Berman, 1990) that there are no theoretical assurances that the open access rights taken away from individuals in remote rural communities are larger than the limited access rights given to the recipient group. Even if the rights created may be worth more, the redistribution of rights may favor non-local residents in the long run, making it important to know what these communities may potentially be giving up.

The first step in this critical appraisal of limited fishing rights for remote fishing

[1] Analyzing the persistent depressed state of the Newfoundland economy, Copes wrote:

> Until quite recently, anyone could join the fishery without let or hindrance and take a share from the common pool of fish without charge. . . . When a farmer decides to move to another industry and sells off his farm, he has burnt his bridges--he has lost the right to return to his farm. But if a fisherman decides to try his luck in the city and finds he doesn't like it, there is (or was) nothing to stop him from re-entering the fishery--he doesn't have to buy his way back. He needs very little capital to obtain a small inshore boat and he needs none at all if he joins an existing crew as a shareman. (Copes, 1987, p. 9)

communities is to develop a mechanism to place a value on what is lost. This paper develops such a mechanism, using a model that treats common property fishing rights as a portfolio of real options. The model is then estimated empirically for the halibut and sablefish longline fisheries of Alaska, coastal fisheries which combine effective conservation and limited alternative opportunities for labor and capital.

In the next section of the paper I discuss the right to fish as an option available to participants in an uncertain fishery. Then, I briefly summarize the Alaska halibut and sablefish longline fisheries and outline a method to measure the value of the option to participate in the fishery. Next, I estimate the model and discuss values the model imputes to captains in these fisheries in coastal communities in Alaska and Pacific Northwest. Finally, I discuss the implications of the results for fisheries policy affecting small remote communities.

The Option to Participate in the Common Property Fishery

As anyone involved in the commercial fishing business can attest, fishing is an exercise in decision making under uncertainty. In spite of the obvious, the classic textbook on the economics of fisheries management (Anderson, 1986) barely mentions uncertainty.[2] Wilson (1990) provides a more realistic picture of the commercial fishery as a "large, complex, and rapidly changing environment" (p. 12), and analyzes how uncertainty influences the organization of fisheries.

Berman (1990) developed a model of the right to enter the uncertain common property fishery, and analyzed conditions that would add value to that right. Karpoff (1989) modeled imposing license limitation in a fishery as the creation an asset whose value depended on the value of the option to keep out new entrants. Taken together, these papers describe limiting access to fisheries as taking a potentially valuable right to fish away from some while making that right more valuable for others. Neither these studies, nor any others I am aware of, has attempted an empirical estimate of either of these two values. I now describe a simple model of the option to participate in the common property fishery that motivates the empirical work that follows.

Modeling the option to participate in the common property fishery

Commercial fishing is a business characterized by pervasive uncertainty. Unpredictable variations in stock abundance, fluctuating markets, managers' conservation strategies, and the weather lead to wide variations in subjective valuation of any given fishery, not only from season to season, but even from week to week. The most lucrative alternative earning opportunities for commercial fishers exploiting in a particular fishery are often other uncertain fisheries.

Most of these uncertain factors are revealed, however, when the fisher actually chooses whether or not to participate in a particular commercial opening. I begin by hypothesizing that the individual fisher faces a discrete choice of whether or not to par-

[2]Anderson (1986) discusses uncertainty only briefly, on page 45, as a rationale for fishery managers to use expected values in making decisions about policy. He does not discuss how commercial fishers might make decisions under uncertainty.

ticipate in a fishery of uncertain subjective value, or utility, y. Uncertainty appears in the form of states of nature i. The choice problem is repeated at least as often as the state of nature changes. The decision period could be as short as the duration of a weather forecast, or as long as a fishing season. If individual j chooses to participate in fishery k, he or she receives a utility y_{ijk} that depends on harvest quantity q_{ij}, technology τ, regulatory regime ρ_i, stock abundance s_i, product price, p_i, and factor price vector r_i, according to an indirect utility function:

$$y_{ijk} = y(p_{ik}, q_j(\tau, \rho_{ik}, s_{ik}), \tau, \rho_{ik}, s_{ik}, r_i).$$

The utility y_{ijk} represents the maximum (indirect) utility available to individual j from choosing fishery k when state i occurs. I refer to y as *utility* instead of *profit* to emphasize that income and costs -- including the cost of time and payments to crew members (who may be family and friends) -- are subjectively evaluated.

Viewed from the long run perspective of a potential entrant into the fishery, ρ, s, p, q, and r are all random variables. Additional entry may occur in fishery k if the present value of y exceeds fixed capital costs, K_{jk}. Once entry occurs, however, capital costs -- largely boats and gear -- are fixed for all who have already made these investments. In the short run -- when the fisher considers participating in a fishery in a particular time period -- uncertainty, while still present, is much reduced. The model assumes that the state of nature i is revealed to the fisher before he or she makes the participation choice.

The individual may choose a non-fishing activity as well, and receive a utility, y_{ij0}. The common property nature of the fishery broadly implies that the marginal entrant in the fishery reduces profits for others. In a fishery managed to protect stocks while allowing unlimited participation, the effect of regulation would be to raise fishing costs for the marginal entrant in the nth fishery until

$$y_{ijn} - K_{jn} = \max_{k/=n}(y_{ijk} - K_{jk}).$$

In the short run, those who have already incurred fixed costs will participate if

$$y_{ijn} > \max_{k/=n}(y_{ijk}).$$

The value of the option to choose the nth fishery if state i occurs is:

$$(1) \quad \psi_{ijn} = \max_k(y_{ijk}) - \max_{k/=n}(y_{ijk}).$$

I assume the addition of a choice -- even one that is never selected -- does not reduce utility, so that v_{ijk} is nonnegative for all i, j, and k. If π_i represents the probability of state i, the expected value of the option to participate in fishery k for a given time period EV_{jk}, is therefore:

$$(2) \quad EV_{jk} = \Sigma_i \, \pi_i \psi_{ijk}.$$

The net benefits of the fishery over a time period to is simply the (discounted) sum over time and j of option values EV_{jk}.[3]

It is worth emphasizing that equations (1) and (2) only count the incremental value

[3]Equation (2) defines an *option value* for the fishery. An option value is the value of an option in excess of its market price. Since access is free in the common property fishery, the price of the option is zero.

the option brings to the portfolio of opportunities available to the individual. For many residents of remote coastal communities, however, employment options are few; resident's options are basically limited to other uncertain fishing jobs, welfare, or out-migration. When access to the main private sector economic activity in much of coastal Alaska -- salmon fishing -- is already restricted because of the state's limited entry program, the value of the options to the remaining high-value near-shore fisheries such as halibut and sablefish increases still more. The next section discusses measurement of the option value in equation (2) for the case of these Alaska longline fisheries.

Measuring the Option Value of the Common Property Halibut and Sablefish Fisheries

In this section I first summarize the Alaska halibut and sablefish longline fisheries. Then I outline an empirical model that I use to estimate the value of the option to pursue these fisheries.

The Alaska Halibut and Sablefish Fisheries

The halibut and sablefish longline fisheries of Alaska present an ideal case for estimating the value of the option to participate in the common property fishery. Pacific halibut stocks in Alaska have been protected since 1923 under a treaty between the U.S. and Canada. The treaty organization -- the International Pacific Halibut Commission (IPHC) -- annually sets harvest targets by area and determines legal gear (hook and line gear only). In 1993, the longline fleet harvested 48 million pounds of halibut in Alaska offshore waters (IPHC, 1993). The Alaska halibut fishery benefited at Canada's expense with the passage of the federal Fishery Conservation and Management Act of 1976 (Magnuson Act), which asserted U.S. jurisdiction over the offshore fisheries.

Sablefish (black cod) can be caught with the same boats and gear as halibut. However, they inhabit deeper waters than halibut, so the fishery is generally prosecuted farther from shore. The Magnuson Act essentially created the Alaska longline sablefish fishery, and strengthening markets in Japan during the 1980s brought many new entrants into the fishery. The North Pacific Fishery Management Council (NPFMC) uses its authority under the Magnuson Act to set annual harvest quotas by gear for sablefish. Although sablefish may be legally caught with a variety of gear, the longline fishery predominates, and is the only gear type included in the present analysis.

Shortly after passage of the Magnuson Act, the Canadian halibut fleet was excluded from Alaska waters, and the U.S. harvest doubled However, the U.S. fleet climbed from about 1,000 vessels in 1975 to over 3,000 vessels by the early 1980s, where it remained for over a decade. The IPHC continued to cap harvest levels by steadily reducing season lengths from several months to just one or two days annually in the most productive areas (Berman and Leask, 1994). Increasing entry into the sablefish fishery at the same time likewise caused the NPFMC to reduce the season length for the main Gulf of Alaska longline fishery to just ten days in 1993 (National Marine Fisheries Service, unpublished data). Market, regulatory, and safety problems associated with these short derby-style fisheries motivated the NPFMC to recommend an individual transferable quota (ITQ) program for both longline fisheries. The ITQ program was implemented in 1995.

The rise in participation in Alaska's open access halibut and sablefish fisheries accompanied the introduction of state limited entry programs for salmon and other small boat fisheries such as herring. Closing access to these important coastal fisheries undoubtedly caused a "domino" effect on the halibut and sablefish fisheries. As a result, the longline fisheries took an important position in the economies to Alaska's small coastal communities. In 1993, 38 percent of the halibut catch and 41 percent of the sablefish catch was off-loaded and processed in Alaska communities with less than 1,000 inhabitants. About one-fourth of estimated 13,450 crew members working in the halibut fishery that year lived in small Alaska communities, while another 52 percent lived in larger Alaska communities. Of the estimated 3,000 sablefish crew, about one-sixth lived in small Alaska communities, and another 47% in larger Alaska communities (Berman and Leask, 1994). Many of these crew members have little alternative income earning opportunities besides commercial fishing.

A Random Utility Model of the Option to Fish

The Random Utility Model (RUM) (Domencich and McFadden, 1975; McFadden, 1981) was initially developed to estimate travel demand, and has been widely used to measure the value of the option to pursue discrete recreation opportunities. It may easily be extended to any instances where the analyst observes individuals making discrete choices which involve trading a good or service with a market value for an amenity that does not have a market value. In the case of the common property commercial fishery, commercial fishers are observed to trade a market value in the form of revenue from landings for the non-market value or opportunity cost of their time in alternative pursuits, whether fishing, household production, an unobserved paying job, or leisure. RUM makes use of revealed preference theory to deduce individual demand and value for specific options from the likelihood that they are selected.

RUM makes a number of restrictive assumptions about the form of the utility function in order to facilitate identification and estimation of welfare effects of changes in quality or availability of non-market goods. In particular, RUM assumes the utility function is separable into three terms: (1) a term for income and market goods assuming a constant marginal utility of income, a term for the non-market good, and a random term that is revealed to the individual before the decision but is not observed by the analyst. That is, utility in state of nature *i* may be written:

$$y_{ijk} = v_{ijk} + \varepsilon_{ijk},$$

where v_{ijk} is the fixed component, and ε_{ijk} is the random component of utility.

If the ε_{ijk} are independently and identically distributed with a type I extreme value (Gumbell) distribution, the probability of observing choice *k* is:

$$(3) \quad \pi^k = \exp(v_k)/S_k$$

where

$$S_k = \Sigma_k(\exp(v_k).$$

Expected maximum utility is then (subscripts *i* and *j* are implied)

$$(4) \quad \max_k(y_k) = \ln(S_k).$$

Equation (1) for the RUM model may be derived as follows:

$$\text{(5)} \quad \psi_{ijn} = \max_k(y_{ijk}) - \max_{k/=n}(y_{ijk})$$
$$= \ln(S_k) - \ln(S_{k/=n})$$
$$= \ln\Sigma_k(\exp(v_k) - \ln\Sigma_{k/=n}(\exp(v_k).$$

In order to estimate equation (5), one needs, of course to estimate v_k for each choice k, using an equation that retains the assumptions of separability and constant marginal utility of income. I model the Alaska longline fisheries using the three-tier choice structure depicted in Figure 1. Fishers choose in which fishery to participate based on the values of lower-tier (contingent) choices. The fisher choosing halibut and sablefish -- modeled in more detail -- then chooses an area in which to fish based on the historical catch rates. Given the choice to fish in an area and obtain a given expected harvest, the fisher chooses which processor port to which deliver the catch, based on prevailing ex-vessel prices. Fisheries other than halibut and sablefish are modeled with a single-tier structure in which the choice of fishery depends on average catch rates and prices.

The equation for v_{ijk} implied by the choice structure summarized in Figure 1 may best be elaborated from the lowest level upward. Again assuming subscripts for i and j are implied, the probability of selecting processor n, π_{ank}, given choice of area a for fishery k, is

$$\text{(6)} \quad \pi_{ank} = \exp(w_{ank})/S_n,$$

where

$$S_n = \Sigma_n(\exp(w_{ank}).$$

The value of choosing processor n, w_{ank}, is given by the following equation:

$$\text{(7)} \quad w_{ank} = \alpha[p_{nk}q_{ak} - C^n(z_{an}, \tau)],$$

where C^n, the cost of delivering catch, depends on distance, z_{an}.

The probability of choosing area a, π_{ak}, is:

$$\text{(8)} \quad \pi_{ak} = \exp(u_{ak})/S_a,$$

where

$$S_a = \Sigma_a(\exp(u_{ak}).$$

The value of choosing area a, u_{ak}, is given by:

$$\text{(9)} \quad u_{ank} = \beta[\ln S^n - C^a(q_{ak}(\rho^a, \tau, t), z_{ha}, \rho^a, \tau, t)],$$

where C^a, the cost of harvesting quantity q_{ak}, depends on distance from home port h to area a, z_{ha}, as well as on harvest regulations, ρ, technology, ρ, and time, t. Finally, the probability of selecting fishery k is given by equation (3), where v_k is given by

$$\text{(10)} \quad v_k = \gamma_1[\ln S^a - C^k(\tau)], \quad k = \text{halibut, sablefish;}$$

$$v_k = \gamma_2[p_k q_k - C^k(\tau)], \quad k = \text{herring, salmon, crab, groundfish, other shellfish.}$$

Empirical Findings

I estimated the discrete choice model represented by Figure 1 and equations (6) through (10) assuming a weekly choice horizon for all fishing boats that participated in either the halibut or the sablefish longline fisheries in 1993. The principal data source for catch rates and participation is the Alaska Department of Fish and Game (ADF&G) individual landings records. The Alaska Commercial Fisheries Entry Commission provided ex-vessel price data by region, and ADF&G vessel license files provide characteristics of fishing vessels such size and engine horsepower. Halibut fishing regulations, including opening and closing times and catch restrictions are described in IPHC (1993). Regulations for sablefish were obtained from the Alaska regional office of the National Marine Fisheries Service .

As mentioned above, 1993 was the next to last year that the halibut and sablefish fisheries were prosecuted in a derby-style open access fishery. The qualifying period for ITQs ended before 1993, and it had already been announced before the 1993 season began. This makes it unlikely that individuals were participating in these fisheries strategically to obtain a quota allocation. A number of alternative fisheries, notably salmon and herring, were limited entry fisheries. I included a fishery as a choice in 1993 for an individual vessel owner only if that vessel and owner made at least one landing in that fishery during the period 1989-1993. After removing about ten percent of the landings records that could not be matched to vessels or had missing data, the final data set had weekly observations on catch and landings for just under 3,000 boats.

Estimation of the choice structure begins with the lowest level of the decision tree. Table 1 shows the results of the processor choice equations (6) and (7). The fishery choice equations shown in Table 1 assume that harvest in a particular area is given. They measure the net revenue anticipated from landing the catch at different processing ports. One can obtain the estimated equation for net revenue from landing fish caught in a given fishing area for halibut and sablefish, by dividing all coefficient in Table 1 by the coefficient on revenue (α). The implied equation is:

Halibut: Net revenue = Gross revenue - [29.7 - 0.12*(vessel length) + 0.00010*pounds harvested)]*(miles to processor) - 8.8*(miles from processor to home port) + 1349*(if processor port = home port).

Sablefish: Net revenue = Gross revenue - [18.2 - 0.15*(vessel length) + 0.00023*pounds harvested)]*(miles to processor) - 1.7*(miles from processor to home port) - 1456*(if processor port = home port)

In order to estimate the area choice equations, one needs to predict weekly catch rates for halibut and sablefish in different fishing areas. Table 2 shows estimates of catch rates, as a function of characteristics of vessels such as length and engine horsepower, fishing regulations, and seasonal factors. They show as expected that larger boats and longer, less restricted fisheries openings produce higher catches. However, the catch rates vary strongly by area -- as shown by the area dummy variables, suggesting that a tradeoff indeed exists between the distance from home port to the fishing area and catch per unit effort.

Table 3 shows the results of the area choice equations (8) and (9). Data for the inclusive value and harvest quantity were derived using catch rates in each area predicted by the coefficients shown in Table 2. The coefficients in Table 3 imply, after dividing all coefficients by the coefficient on inclusive value (β),the following equation for operating profits from a fishing area, given the decision to fish for halibut or sablefish:

Halibut: Operating profit = Net revenue - 4280*(open fishing days) - [51.8 - 0.51*(vessel length)]*(miles from home port to fishing area) - [12067 - 0.21*(trip limit pounds)]*(trip limit dummy)

Sablefish: Operating profit = Net revenue - 1.95*(total pounds landed) - [12.2 - 0.14*(vessel length)]*(miles from home port to fishing area)

Vessel lengths are measured in feet.

Table 4 shows the results of the fishery choice equations (3) and (10). Dividing all coefficients in the table by the coefficient on halibut-sablefish inclusive value (γ_1), one obtains the following implied function for (subjective) net profits from fishing for halibut or sablefish:

Halibut: Net profit = Operating profit + 18016 - 716*(vessel length)

Sablefish: Net profit = Operating profit - 821 - 29*(vessel length)

Estimates of Net Benefits of the Option to Fish

Small and Rosen (1981) discuss estimates of welfare effects from changes in quality of a non-market good in a discrete-choice framework. For the RUM model, the compensating variation for eliminating the opportunity to choose alternative n is simply

(11) $CV_n = \psi_{ijn}/\eta = [\ln(S_k) - \ln(S_{k/=n})]/\eta = [\ln\Sigma_k(\exp(v_k) - \ln\Sigma_{k/=n}(\exp(v_k)]/\eta$,

where η represents the marginal utility of income. An estimate of the marginal utility of income -- constant by assumption -- may be obtained by differentiating equation (4) with respect to income. In the choice model estimated here, revenue in the landings equation is in money units. Therefore, an estimate of η is:

(12) $d(\ln S_k)/d(pq) = \alpha\beta\gamma_1$.

Under the distribution of states of nature that occurred in 1993, an estimate of net benefits for the option to fish for halibut and sablefish may easily be derived from equation (11). Table 5 shows the resulting estimates of compensating variation for the fishery as a whole in 1993, by size of boat. These estimates only value the options to fish for those that actually did participate in one or the other fishery in 1993, so it is likely to be a lower bound to the value. In addition, it is based on choices of fishing captains. Therefore, it does not count net value of crew jobs beyond the extent that captains consider crew incomes as a benefit when they make their participation decisions.

Table 5 shows estimated net benefits of $38 million for the halibut fishery in 1993, and an additional $4 million for sablefish. The value of the option to fish for halibut is nearly ten times as large as the value for sablefish, although the fisheries contributed roughly the same gross revenue in 1993. Net benefits estimated for halibut were over 60 percent of gross revenue, suggesting a high preference for this fishery. Table 5 shows that the small boat fleet -- boats up to 35 feet in length -- contributed about $13 million, or over one-third of the halibut total.

Table 6 sums the same estimates of net benefits by home port community. The ports are ordered in the table according to their share of landings in 1993. Vessels home ported in Kodiak have the highest halibut net value ($7.2 million), followed by Juneau, Homer, Sitka, and Petersburg. Many small communities, however, show estimates in the hundreds of thousands of dollars, however. Boats home ported in the Pacific Northwest accounted for only about $500,000, just 1.3 percent of the total. Juneau, followed by Homer, are the home port communities with the highest sablefish net benefits.

Conclusion

How significant are these numbers for Alaska coastal communities? The values in Table 6 represent net benefits, so it is inappropriate to compare them to gross measures of economic activity such as employment and income. However, such a comparison does provide some information about the scale of the figures for residents of the communities involved. Figure 2 shows a simple ratio of the 1993 net benefits of halibut and sablefish, from Table 6, divided by personal income from the 1990 U.S. Census. The communities are ranked in the figure according to the size of this ratio.

Two small fishing communities -- Pelican and Chignik -- record net benefits of around ten percent of personal income. This astonishing result suggests that in these communities, residents would be willing to pay as much as ten percent of their income, on the average, to have the option to continue prosecuting these fisheries. Net benefits exceed four percent of income for six additional communities, including the small communities of King Cove, Sand Point, and Yakutat.

While Figure 2 suggests fishers in these communities would benefit most from continuing to fish for halibut and sablefish -- particularly halibut -- in the ITQ fishery, there is no guarantee that they will be able to do so. That is because the net benefit estimate -- compensating variation -- does not measure ability to pay, especially when financing opportunities may be limited, as they often are in small communities. The introduction of ITQs into the Alaska halibut and sablefish longline fisheries in 1995 may hasten the decline of these communities. From Parzival Copes (1987) point of view, this is good public policy. Young people in these communities, however, are more likely to notice the large uncompensated "taking" of a valued opportunity to earn cash income near their home.

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Table 1. Choice of Landing Port, 1993

	Halibut		Sablefish	
Location	**Count**	**Percent**	**Count**	**Percent**
Southcentral AK	1200	19.63	801	37.39
Southeast AK	1575	25.76	494	23.06
Pacific NW	80	1.31	15	0.7
Western AK	363	5.94	179	8.36
Bering Sea	35	0.57	0	
Yakutat	41	0.67	68	3.17
Other SW AK	63	1.03	34	1.59
Home port	2757	45.09	551	25.72

Independent Variable	Estimated Coefficient	t-Statistic	Estimated Coefficient	t-Statistic
Gross revenue	2.724e-04	14.14	8.605e-04	17.68
Miles to processor	-8.082e-03	-29.02	-1.568e-02	-16.82
Miles times length	3.320e-05	6.04	1.253e-04	8.34
Miles times lbs	-2.792e-08	-5.06	-1.984e-07	-11.82
Miles back to port	-2.402e-03	-22.81	-1.466e-03	-7.19
Homeport constant	0.3674	9.87	-1.253	-14.40

auxiliary statistics				
log likelihood	at convergence	-6121		-1396
log likelihood	initial	-12714		-4168
number of observations		6114		2142
percent correctly predicted		57.9		82.5

Table 2. Fishery Catch Rates, 1993

	Halibut		Sablefish	
Dependent Variable: log(lbs)				
Independent Variable	**Estimated Coefficient**	**t-Statistic**	**Estimated Coefficient**	**t-Statistic**
Log of vessel length	0.6325	4.44	0.4251	2.08
Log of horsepower	0.0258	0.72	0.1761	2.62
Log of gross tons	0.3695	4.65	0.4343	3.17
Log of net tons	0.2179	3.21	0.1179	0.94
Fall dummy	--		0.9540	4.39
Bering Sea week	--		-0.0345	-2.58
Log of fishing days	0.1954	2.12	--	
Trip limit dummy	-0.0661	-1.42	--	
Area1	3.650	8.31	5.145	7.38
Area2	2.327	5.27	4.954	7.36
Area3	3.654	8.41	4.793	6.75
Area4	4.166	9.62	4.825	7.25
Area5	4.040	9.29	4.725	6.82
Area6	3.759	8.23	4.559	6.52
Area7	4.203	9.36	5.211	7.65
Area8	3.780	8.45	4.520	6.58
Area9	4.047	9.23	4.165	6.17
Area10	1.771	3.41	--	
Area11	4.555	10.37	3.836	4.71
Area12	3.912	8.94	4.510	6.62
Area13	4.320	9.50	4.452	6.30
Area14	4.525	10.29	3.440	4.64
Area15	4.543	9.58	4.021	5.28
Area16	4.112	5.76	--	
Area17	4.368	9.30	5.117	6.41
Area18	4.665	10.04	4.530	4.59
Area19	5.456	10.19	3.620	3.90
Area20	2.777	4.94	5.205	3.88
Area22	4.526	9.83	4.440	5.81
Area23	2.112	4.39	--	

	Halibut	Sablefish
Number of Observations	4866	1989
R-squared	0.388	0.303
Corrected R-squared	0.384	0.294
Sum of Squared Residuals	6922	2470
Standard Error of the Regression	1.196	1.121
Durbin-Watson Statistic	1.760	1.514
Mean of Dependent Variable	8.304	9.161

Table 3. Choice of Fishing Area, 1993

Fishing area	Halibut Count	Percent	Sablefish Count	Percent
1	214	3.51	37	1.82
2	197	3.24	100	4.92
3	680	11.17	122	6
4	1115	18.31	397	19.52
5	553	9.08	56	2.75
6	85	1.4	40	1.97
7	130	2.13	117	5.75
8	214	3.51	123	6.05
9	423	6.95	347	17.06
10	22	0.36	0	
11	668	10.97	6	0.29
12	722	11.86	494	24.29
13	196	3.22	110	5.41
14	332	5.45	23	1.13
15	57	0.94	11	0.54
16	5	0.08	0	
17	118	1.94	42	2.06
18	121	1.99	3	0.15
19	19	0.31	5	0.25
20	16	0.26	1	0.05
22	122	2	0	
23	80	1.31	0	

Independent Variable	Estimated Coefficient	t-Statistic	Estimated Coefficient	t-Statistic
Open fishing days	-0.68618	-14.86	--	
Catch quantity (lbs)	--		-1.215e-03	-11.94
Miles to fishing area	-8.310e-03	-40.39	-7.589e-03	-22.33
Length times miles	8.128e-05	19.77	8.792e-05	14.43
Trip limit dummy	1.935	11.31	--	
Trip limit lbs (000s)	-0.03323	-4.68	--	
Inclusive value ($\ln S_n$)	0.5885	24.48	0.7249	11.84

auxiliary statistics				
log likelihood	at convergence	-13261		-5119.8
log likelihood	initial	-17897		-6027.3
number of observations		6089		2047
percent correctly predicted		32.5		13.

Table 4. Choice of Fishery, 1993

Fishery	Count	Percent
Not fish	28090	58.96
Halibut	3583	7.52
Sablefish	1445	3.03
Herring	70	0.15
Salmon	13305	27.93
Crab	646	1.36
Other finfish	321	0.67
Other shellfish	183	0.38

Independent Variable	Estimated Coefficient	t-Statistic
Halibut-sablefish inclusive value ($\ln S_a$)	0.5822	66.01
Sablefish constant	-1.980	-17.30
Length times sablefish	5.623e-02	20.85
Other constant	-0.3659	-4.17
Length times other	1.679e-02	7.16
Other revenue	2.336e-04	30.78
Other lbs	-4.469e-06	-2.14
Fish constant	1.682	21.77
Length times fish	-6.687e-02	-35.75

auxiliary statistics		
log likelihood	at convergence	-31971
log likelihood	initial	-91784
number of observations		41807
percent correctly predicted		62.8

Table 5. Estimated Net Value of Option to Fish for Halibut and Sablefish By Size of Vessel, 1993

(Millions of Dollars)

Fishery	Value
Large boats (over 60 feet)	
halibut	2.8
sablefish	0.3
Medium boats (35 to 60 feet)	
halibut	22.3
sablefish	2.4
Small boats (under 35 feet)	
halibut	13.2
sablefish	1.2
All boats	
halibut	38.3
sablefish	3.9
Total	42.3

Table 6. Estimated Net Value of Option to Fish for Halibut and Sablefish By Home Port Community, 1993

(Thousands of dollars)

Home Port	Halibut	Sablefish	Total
Kodiak	7,238	273	7,511
Homer	3,652	419	4,071
Seward	580	153	732
Sitka	3,316	362	3,679
Petersburg	3,088	234	3,322
Dutch Harbor	80	0	80
King Cove	465	127	592
Cordova	892	93	985
Ketchikan	1,314	144	1,458
Pelican	304	30	334
Kenai	524	43	567
Sand Point	736	55	791
Excursion Inlet	29	13	43
Yakutat	345	18	363
Akutan	220	16	236
Chignik	361	52	414
Hoonah	267	62	330
Craig	662	61	724
Juneau	6,461	770	7,231
Wrangell	1,166	95	1,261
Anchorage	586	82	669
Pribilof Islands	146	3	148
Northern Puget Sd.	87	36	123
Southern Puget Sd.	291	75	366
Wash./Ore./Cal. Coast	128	30	158
Other Southern SE Alaska	1,306	127	1,434
Other Northern SE Alaska	1,543	183	1,726
Other Southcentral roaded	1,545	188	1,733
Other Southcentral no road	496	37	533
Other Southwest Alaska	384	125	509
Other Bering Sea	131	8	139
Total	38,345	3,916	42,260

Figure 1. Choice Structure for Longline Fisheries Model

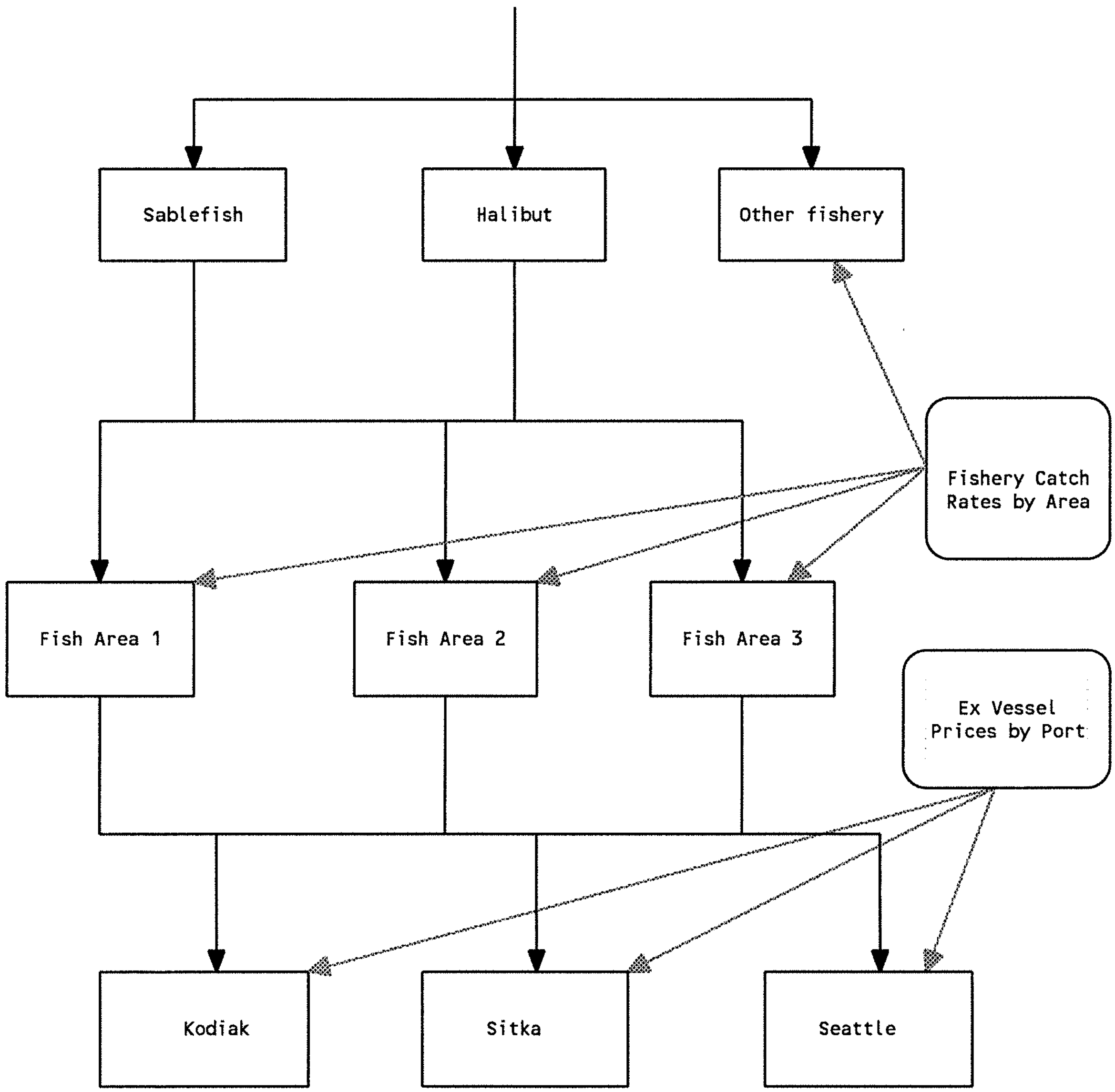

Figure 2. Net Benefits of Open Access Halibut and Sablefish Fisheries, 1993, as Percent of 1990 Personal Income