5

Potential Economic Benefits of Limited Entry

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In deciding whether to adopt a limited access system, one consideration would be the economic benefits and costs. To pass the benefit-cost test, the potential economic benefits must exceed the total public and private costs of public program implementation. This chapter summarizes the results of an effort to estimate potential economic returns from the groundfish trawl fishery. Chapter 6 presents available information on possible administrative costs.

The economic benefit calculation is abstracted from Huppert and Squires (1986). Benefits from limited access are presumed to occur through increased economic efficiency in fishing fleet construction and deployment. Thus the estimated benefits are derived from a model which calculates, under stated conditions and assumptions, the total fleet profit possible with an optimal fleet size and optimal deployment of fishing effort.

TRAWL FLEET PROFITS

The mathematical model used to calculate potential economic profits is not intended to describe an actual limited access program. Instead, it computes the optimal solution to the fishing fleet construction and deployment problem as though there is a profit-seeking centralized manager of the fishery. This hypothetical manager operates the fleet as if he is starting from scratch. That is, he does not take into consideration the investments sunk into the existing fishing fleet. Therefore, our estimate of maximum economic returns for the fleet is a hypothetical one, describing an ideal result that could be achieved only after a long period of adjustment. We cannot recommend that the trawl fleet be forced into conformance with our computed optimum fleet by a limited access program. This hypothetical model is useful, nevertheless, because it yields a reasonable estimate of what can be achieved in a commercial fishery when the trawl fleet is managed to maximize economic profit.

The Pacific trawl fishery's optimum economic return is computed by linear programming. This procedure calculates the maximum economic profit available to the entire fleet given that the fleet's total catch cannot exceed allowable catch levels. Vessels with non-trawl gear are assumed to continue catching a portion of the total harvest as observed during 1981-84. To implement the linear program, we have to establish catch rates, exvessel prices, and costs of fishing for trawl vessels. Amounts of fishing effort for vessels in each of five length classes are expressed in number of fishing weeks. Each vessel is assumed to be capable of fishing a certain number of weeks during each calendar quarter. Each element of the model has been derived from data collected during the last few years as summarized below.

Allowable catch levels for eight groundfish species and species groups were adopted from the Pacific Fishery Management Council's (1985) estimates for 1985. The proportion of the allowable catches to be taken by the trawl fleet is assumed to equal the average proportion observed during 1981-84. Pacific whiting presented a special problem because it is taken mainly in the joint venture fishery. We examined three different levels for the joint venture Pacific whiting catch centered on the 1984 harvest level. Maximum annual harvest of pink shrimp by trawlers was set at the average 1981-82 total catch (which is close to the recent 12-year average harvest). The average annual trawl fleet catch in 1981-82 was also used to determine the Dungeness crab allowable catch level. Finally, the linear programming model assumes that vessels do not fish more than the typical number of weeks fished by very active trawlers during 1981 and 1982.

The Pacific trawl fishery is considered to have six distinct production processes or fishing modes: (1) mixed-species groundfish trawling in the Vancouver-Columbia area, (2) mixed-species groundfish trawling in the Eureka area, (3) mixed-species groundfish trawling in the Monterey area, (4) single-species pink shrimp trawling, (5) single-species Dungeness crab pot harvesting, and (6) single-species joint venture fishing for Pacific whiting. Eight species categories are caught in the groundfish modes: Dover sole, other flatfish, cod and lingcod, widow rockfish, other rockfish, whiting, sablefish, and a miscellaneous category. The study considers the four calendar-year quarters and five vessel size classes: (1) 40-49 ft., (2) 50-59 ft., (3) 60-69 ft., (4) 70-79 ft., and (5) 80-95 ft. All lengths are Coast Guard registered lengths.

Multispecies groundfish, shrimp, and Dungeness crab catch rates were obtained from the PACFIN research data base (Huppert et al. 1984) maintained at the Southwest Fisheries Center in La Jolla. Average weekly catches for 1981-82 were computed for each fishing mode, area, size class, and season. Catch rates for Pacific whiting joint venture fishing were based upon information from private companies and financial reports. Cost data covering the years 1980-83 were used to estimate average weekly operating costs and annual fixed costs for each length class. Exvessel fish prices were taken from the PACFIN management data base at the Northwest and Alaska Fisheries Center in Seattle. All of these estimates were combined in the program to compute the fleet's profit (gross exvessel value of harvest minus fleetwide operating and fixed costs) for any combination of weeks fished and number of vessels. To provide a baseline for comparison, the prospective fleet profit was calculated for the 1984 trawl fleet while assuming the pattern of fishing weeks observed for the fleet in 1982. This baseline estimate does not correspond to the actual trawl fleet profit in 1984, but it does offer a representative benchmark reflecting the fleet's current economic status.

Table 1 displays a summary of the main results from the linear program. The first column of data in Table 1, representing the baseline 1984 fleet, shows a $10 million loss under the assumed conditions. Columns 2 through 4 report that the trawl fleet could achieve a total profit of between $7.6 and $17.7 million per year depending upon the size of the joint venture whiting fishery. Without a joint venture fishery, the optimum hypothetical fleet would have 238 vessels and would generate $7.6 million in profits annually. Adding a 1984-level joint venture fishery increases the optimum hypothetical fleet to 265 vessels and the annual profit to $11.96 million. Should the joint venture fishery expand to harvest the entire Pacific whiting maximum sustainable yield, the optimum fleet operated by the hypothetical manager would have 338 vessels earning $17.7 million in profits per year. This indicates that the estimated profit and fleet size are sensitive to the assumed level of joint venture activity, an unsurprising result. Because the joint venture fishery employs foreign processing vessels, however, the likely size of this fishery depends upon domestic politics and foreign economic policies as well as standard economic considerations such as the Pacific whiting price and operating costs.

The most reasonable assumption might be that the joint venture fishery remains at the 1984 size. In this case the optimum fleet would enjoy an increase of over $22 million per year from that of a baseline. Slightly more than one-third of the profit is due to multispecies groundfish trawling, about one-quarter comes from shrimp harvesting, about one-quarter is from joint venture fishing of Pacific whiting, and only one-tenth is from crab harvesting.

Table 1—Results of linear programming for the Pacific trawl fleet. JV = joint venture; MSY = max. sustainable yield.

		Optimum fishery[2]		
	Baseline fleet in 1984[1]	JV takes whiting MSY	1984 JV harvest	With no JV fishery
	Number of vessels			
Class 1	106	0	0	0
Class 2	118	245	180	180
Class 3	138	0	0	0
Class 4	55	93	85	58
Class 5	12	0	0	0
Total	429	338	265	238
	Profit ($million)			
	$ −10.25	$17.7	$11.96	$7.61
Proportion from[3]:				
Shrimp fishing	0.324	0.180	0.267	0.362
Crab fishing	0.038	0.081	0.109	0.143
Joint venture fishing	0.306	0.475	0.263	0.000
Groundfish	0.332	0.264	0.360	0.495
	Total weeks			
	11,763	11,034	9,041	8,054
Proportion in:				
Shrimp fishing	0.218	0.320	0.380	0.440
Crab fishing	0.044	0.042	0.050	0.060
Joint venture fishing	0.074	0.280	0.130	0.000
Groundfish	0.664	0.358	0.440	0.500

[1]The 1984 baseline fleet does not represent an optimum distribution of fishing weeks. The number and size distribution of vessels represents the 1984 fleet, while the distribution of weeks fished is taken from the 1982 PACFIN research data base (Huppert and Thomson 1985). All prices and costs used in calculating profits are in 1984 dollars.

[2]Various joint venture harvest constraints all assume pink shrimp harvest constraint equals average 1981-82 catch (17,218 short tons).

[3]This is the proportion of operating profit (or net revenue), not economic profit. Fixed costs of vessels are not allocated among fisheries in calculating this proportion.

The size distribution of vessels in the hypothetical fleet operated by a centralized manager differs markedly from the baseline fleet. The optimum hypothetical fleet is composed of 180 vessels in the 50-59 ft. size class and 85 vessels in the 70-79 ft. size class. Absence of the largest and smallest vessel size classes in the optimum fleet is perhaps not unexpected. The surprising absence of mid-sized trawlers in the 60-69 ft. size class in the optimum hypothetical fleet evidently occurs because the greater harvest rates achieved by these vessels, as compared with 50-59 ft. vessels, do not sufficiently counterbalance the proportionately greater increase in harvesting costs.

The analysis does not consider all important aspects of fishing vessel size, however, and these results should not be taken as definitive regarding optimum vessel size. The linear programming approach, for example, does not consider safety, crew comfort, or seaworthiness of the vessels. It also ignores the flexibility that a large vessel may have for cruising to Alaska and for remaining at sea during storms. Relatively small changes in vessel construction or operating cost may cause the linear program to designate that a given size vessel is more

Table 2—Optimum economic values as trawl fleet size is reduced sequentially while maintaining the 1984 size distribution of vessels. Assumes the 1984 level of joint venture whiting catch, and 1981-82 average pink shrimp catch.

	Trawl fleet size	Total fleet profit	Total revenue	Fixed cost	Variable cost	Total weeks fished
		($millions)				
1984 base*	429	3.6	73.7	27.5	42.6	10,006
−10%	385	5.5	72.4	24.8	42.1	9,883
−20%	343	6.5	70.4	22.0	41.9	9,885
−30%	301	7.1	66.0	19.3	39.6	9,178
−40%	258	7.3	58.3	16.5	34.5	7,970
−50%	215	7.2	49.8	13.8	28.8	6,641
−60%	171	6.9	40.7	11.0	22.8	5,273
−70%	129	6.5	32.4	8.3	17.6	4,049
−80%	86	5.8	24.3	5.5	13.0	2,291
−90%	44	3.0	12.4	2.8	6.6	1,496

*Baseline is 1984 trawl fleet with an optimal allocation of fishing weeks across seasons, areas, and fishing modes.

Table 3—Capacity utilization with 10 to 90% reductions in vessel numbers. Assuming 1984 size distribution of vessels, 1984 level of joint venture whiting catch, and 1981-82 average pink shrimp catch.

	Trawl fleet size	Percent utilization				
		Class 1	Class 2	Class 3	Class 4	Class 5
1984 base	429	79.5	81.5	48.3	69.1	0.0
−10%	385	79.5	98.9	53.1	82.4	0.0
−20%	343	100.0	100.0	65.3	100.0	0.0
−30%	301	100.0	100.0	92.2	100.0	0.0
−40%	258	100.0	100.0	75.8	100.0	0.0
−50%	215	100.0	100.0	75.8	100.0	0.0
−60%	171	100.0	100.0	75.8	100.0	0.0
−70%	129	100.0	100.0	80.6	100.0	0.0
−80%	86	100.0	100.0	100.0	100.0	0.0
−90%	44	100.0	100.0	100.0	100.0	0.0

advantageous than another, while in reality decisions on vessel size must recognize these unquantified factors as well as captain's or owner's preferences.

The level and distribution of weeks fished by fishing mode and vessel size class (aggregated over seasons) also differ between the baseline and optimum hypothetical fleets. The optimum fleet's total weeks fished is 9,041, a decline of about 31% from the baseline. All of the fishing time in the optimum hypothetical fleet is concentrated in the second and fourth vessel length classes: 63% in Class 2, and 37% in Class 4. Several other important changes in fishing patterns occur in the optimum hypothetical fleet: the proportion of weeks fished for pink shrimp trawling increases from 22% to 38% of the total; mixed-species groundfish trawling declines by almost one-third; and joint venture fishing for Pacific whiting almost doubles from 7% of the total to 13%.

Further characteristics of the optimum trawl fleet are examined in detail in Huppert and Squires (1986) referenced above. It is shown that the size of this hypothetical optimum fleet is strongly influenced by the size of the pink shrimp fishery. Also, the conclusions are relatively insensitive to variations in fixed costs, weeks available for fishing per year, and catch rates for Dungeness crab and rockfish. The optimum hypothetical fishery would not fully utilize the available sustainable yields of Dover sole, other flatfish, Pacific cod and lingcod, sablefish, or miscellaneous species. It would fully or nearly completely utilize the sustainable yields of widow rockfish, other rockfish, pink shrimp, and Pacific whiting to the extent permitted by the joint venture fishery.

As noted earlier, these results are pertinent to a hypothetical fleet manager who does not have to deal with the existing trawl fleet. Given the current number and size distribution of trawlers, a manager might suboptimize by deploying the existing fleet's fishing weeks across seasons, areas, and fishing modes. As depicted in the first row of Table 2, this restricted profit maximization generates an annual fleet profit of $3.60 million. The hypothetical central manager might try to expand annual profit by reducing the number of vessels through attrition. We assume that attrition reduces all size classes in proportion. As shown in Tables 2 and 3, the fixed and variable costs of fishing would fall faster than the total revenue earned as the fleet is reduced up to 40% from the base 1984 level. The maximum fleet profit through this attrition program is only $7.3 million.

In evaluating the attrition program, we require that the hypothetical manager pay the fixed costs of maintaining the prescribed fleet, but we do not require that all vessels actually be deployed in the fishery. Some vessels may well be treated as surplus capacity and tied up to the dock. Table 3 shows the percent utilization of the total fishing weeks available to the manager with each fleet size. In particular, this shows that the Class 5 vessels are so uneconomic that they would not be used even though the manager is charged the substantial fixed cost for interest and depreciation. If the Class 5 vessels were not in the fleet, revenue from harvests would be unaffected, but the cost would be reduced by $110,550 per vessel. Without Class 5 vessels, the annual fleet profit would rise to $4.9 million with the 1984 base fleet, and to $8.1 million with a fleet reduced by 40%.

The current fleet is a multipurpose fleet composed of trawlers which, depending upon conditions, might target mixed-species groundfish, pink shrimp, Dungeness crab, or Pacific whiting through joint venture operations. The set of results presented in Table 4 demonstrates the economic importance of maintaining a multipurpose fleet. Columns 1-3 show the optimum vessel numbers, total fleet profit, and weeks fished for three hypothetical specialized fleets harvesting (1) only multispecies groundfish and crab, (2) only pink shrimp, and (3) only joint venture Pacific whiting at the 1984 level. Each of these three separately operated fleets could be profitable. Yet, the sum of the three fleets would contain 149 more vessels, would yield $3.78 million less in annual profits, and would fish 1,061 weeks more than an optimal hypothetical multipurpose fleet. This result suggests that a limited access program seeking to improve fleet profits should not create divisions in the fleet based upon exclusive licensing for groundfish, pink shrimp, and joint venture Pacific whiting fishing.

In summary, the analysis of the Pacific coast trawl fishery suggests a maximum fleet annual economic profit of around $12 million. This represents the total profit that might be attained by a hypothetical central manager designing a new trawl fleet. The maximum economic surplus from this hypothetical fleet occurs with a trawl fleet about 38% smaller than the fleet existing in 1984, with a 23% reduction in weeks fished. Without altering the size distribution of vessels, a reduction of about 40% in the trawl fleet would yield a profit of around $7 million, again assuming the fishing weeks are optimally deployed among seasons, fishing areas, and fishing modes.

Table 4—Comparison of specialized and multipurpose optimum trawl fleets assuming 1984 joint venture (JV) harvest and 1981-82 average pink shrimp harvest.

	Specialized fleets				Change from multipurpose fleet
	Groundfish/ crab only	Shrimp only	JV whiting only	Total	
	Number of vessels				
Class 1	61	0	0	61	+61
Class 2	36	154	77	267	+87
Class 3	0	0	0	0	0
Class 4	42	0	0	42	−43
Class 5	0	0	0	0	0
Total	139	154	77	370	+105
	Profit ($million)				
	$4.12	$0.217	$3.85	$8.18	$−3.78
	Weeks fished				
	4,724	3,929	1,449	10,102	+1,061

NON-TRAWL FLEET

If the entire groundfish fishery is placed under a limited access system, the potential profits would be somewhat larger than that estimated for the trawl fleet alone. During the base period of 1981-84, the fixed gear fleet took the following portions of the total Pacific coast groundfish harvest: 12% of cod and lingcod, 6% of other rockfish, 42% of sablefish, and 7% of the miscellaneous fish. Assuming that the fixed gear fleet would continue to take these portions of the total allowable catches, and that it receives the same exvessel prices as trawlers, the non-trawl gross revenue would be about $3.5 million. Without incorporating non-trawl fishing cost information, we cannot accurately estimate the level of profits that this would generate.

As a first approximation, however, we could assume that profits would be the same percentage of gross revenue (i.e., total exvessel value of harvests) for fixed gear as for trawlers. For the trawl fleet as a whole, profits would be about 17.5% of gross revenue for the optimum fishery. Our corresponding educated guess of non-trawl groundfish profits would be about $605,000.

IMPLICATIONS FOR LIMITED ACCESS

The total potential economic profit of $12.6 million represents an annual commercial profit under very specialized conditions. This is a useful rough assessment of net economic benefit attributable to the harvesting of commercial groundfish. It is not clear, however, that this is a reasonable assessment of potential benefits from limiting access to the fishery. There are two main concerns. First, achievement of this total profit requires a trawl fleet that is substantially different from the fleet existing today. But any real limited access program must begin with today's fishing fleet. Also, without detailed consideration of several additional vessel design factors, one cannot be very confident that these particular changes in vessel size distribution will be as beneficial as the model predicts. Second, the practical means of limiting access cannot literally mimic the centralized decision-maker concept, and hence cannot necessarily result in the level of fleet profits calculated. License limitation, for example, would not result in the optimal deployment of fishing effort that the mathematical model recommends. To achieve the economically optimal deployment across species, areas, and seasons, either the manager must wield incredibly detailed direct control over the fleet or the independent vessel operators must have economic incentives that lead them to the optimal solution. Discussion of these two concerns should place this chapter in proper perspective.

Any limited access system likely to be adopted in a commercial fishery would undoubtedly begin by "grandfathering in" the existing fishing fleet. Thus the optimum vessel numbers and size configuration would not be adopted immediately. A more reasonable estimate of potential profit would be the $7.3 million shown in Table 3. Adding the non-trawl profit to this gives us an estimate of about $8 million per year. This is our current best estimate of the size of potential profits from the fishery under the conditions assumed by our mathematical model.

The second concern is that practical limited access systems may not be able to approximate the optimum fleet management assumed in the model. Experience with license limitation programs, for example, shows that limiting numbers of vessels or fishermen does not effectively limit the level of fishing effort, nor does it necessarily lead to an optimal redeployment of effort to maximize overall economic benefit. Increased investment in fishing capacity by licensed vessels can cancel out the capacity-reducing effects of limiting number of participants, and this will cut into the potential profit. Various restraints may be placed upon fishing capacity in order to prevent this from happening. Improvements in fishing technology, comfort, and safety aboard commercial vessels, however, will all involve capital investments. In the long run we cannot prevent these changes in order to preserve economic profits. Thus it is difficult to imagine a license limitation program that would preserve both economic profits and technological progressiveness.

Of equal concern is the conservation effect of excess fishing effort. Even though their numbers may be limited, the fishing fleets for salmon, halibut, and herring roe (to name just three examples) must be further restricted in order to conserve fish stocks. As explained in Chapters 1 and 4, the limit on licenses helps to create a group of common resource users who may coordinate their actions to optimize the resource harvest. But the act of limiting membership to the group of harvesters does not immediately assure the high degree of cooperative behavior needed to achieve optimum results. The kinds of restrictions placed upon fishing fleets to restrain fishing effort in these circumstances often cause increases in fishing costs. Again, this would prevent the fleet from achieving the potential economic profits. It seems more likely that quantitative harvest rights systems, such as New Zealand's Individual Transferable Quotas (ITQs), will succeed at meeting the multiple economic objectives of an efficient harvesting industry. But there are potential problems with the ITQ system as well, including enforcement and control of discards. Thus the economic benefit estimates developed in this chapter should be taken as a sort of target level which may or may not be achievable with a practical limited access program.