2.0 Amendment Proposal 6: Minimum size limit for sablefish (GOA and BS/AI).

2.1 Description of the Problem (and Need for the Action).

The sablefish resource has several characteristics that suggest that it may be possible to increase its yield by imposing a minimum retention size for sablefish taken in commercial fisheries off Alaska. These characteristics include the following: 1) sablefish are first available to the fishery at age 1 with an average length and weight of 30 cm and 0.25 kg when they are sexually immature equal to zero; 2) 50% of female sablefish are sexually mature at 65 cm, the corresponding age and weight are 5.7 years and 3.16 kg, males at this age are 57 cm and weigh 2.10 kg; 3) the exvessel price of sablefish is size dependent with the price per pound of the largest size category equal to almost three times that of the smallest size category (see Table 2.1). These characteristics have led to the imposition of minimum size limits for sablefish off California, Oregon, Washington, and the west coast of Canada. They have also led to a request by some fishermen for a similar size limit for sablefish taken in the EEZ off Alaska.

The Pacific Fishery Management Council (PFMC) size limit is 22 inches total length. However, trawlers and fixed gear vessels, respectively, are allowed to land up to 5,000 pounds and 100 pounds of fish less than 22 inches per trip. Retention of small amounts of fish under the 22 inch limit caught incidentally while targeting on larger sablefish or other groundfish species is permitted because the Pacific Council wanted to avoid the waste of a valuable catch that would suffer high discard mortality if it were not retained. The rationale for the PFMC size limit focused on the notion that continued catches of immature sablefish could limit the reproductive potential of the stock.

The Canadian size limit is 55 cm fork length and there is no provision for the retention of smaller fish. This limit resulted from three areas of concern: 1) to protect juvenile sablefish from harvest, 2) to maximize yield per recruit, and 3) to prevent recruitment overfishing.

The effects of a minimum size limit on potential long-term yield depend on the interactions of growth, natural mortality, rates of exploitation, availability of fish to specific gear, discard mortality, exvessel prices by size category, recruitment, and fishing costs. The discussion of the effects of minimum size regulations presented in this report are based on a yield per recruit model that accounts for these interactions.

A yield per recruit model can provide insights concerning the effects of a minimum size limit on average or over a long period of time. However, it is not well suited to evaluate the shortterm effects of a size limit for a species such as sablefish that is subject to large fluctuations in recruitment. Therefore, it must be emphasized that the results of the model are useful in determining the effects of minimum size regulations that would be in effect for a number of years and not subject to frequent revisions.

2.2 Alternatives (Including the Action)

Three general types of alternative are considered. They are as follows:

2.2.1 Alternative 1 Do nothing - Status quo (i.e., no minimum size regulations)

2.2.2 Alternative 2 Establish a single minimum size limit for all gear (including a limit of 22 inches)

2.2.3 Alternative 3 Establish a minimum size limit for fixed gear only (i.e., longline and pots) (including a limit of 22 inches).

2.3 Description of the Sablefish Fishery

Because sablefish is a fully utilized species off Alaska, only DAP (i.e., fully domestic) fisheries can target on sablefish. Sablefish are taken as both target catch and bycatch by trawlers and as target catch by longline and pot vessels. In 1986 sablefish accounted for 89%, 93%, and 4% of the total DAP groundfish catch (excluding halibut) of longline, pot, and trawl vessels, respectively off Alaska. For only those groundfish landings (i.e., trips) that included sablefish, sablefish accounted for 98%, 98%, and 36% of the catch for longline, pot, and trawl vessels, respectively, in the Gulf of Alaska. The corresponding values for the Bering Sea are 93%, 99%, and 13%. For individual trawl vessels, the percentage ranged from less than 1% to over 90%.

In the Gulf of Alaska the allocation of the sablefish quota for each regulatory area was established by Amendment 14. There are no gear allocations in the Bering Sea Aleutian Islands FMP.

In 1986, 444 longline vessels, 15 pot vessels, and 30 trawl vessels participated in the DAP sablefish fishery in the EEZ off Alaska. The corresponding numbers for the Gulf of Alaska are 440, 14, and 21, respectively. For the Bering Sea and Aleutians, the numbers of vessels were 49, 6, and 13. From this it is clear that most of the longline and pot vessels that fished in the Bering Sea also fished in the Gulf. This is not true for trawl vessels.

Despite the large fleet sizes, catches were heavily concentrated among relatively small numbers of vessels. The high level of concentration of catch is demonstrated by the percentage of each fleet's total sablefish catch that was taken by the top 10% of the vessels in terms of catch per vessel. The percentages were 45% and 34% for the Gulf and Bering Sea longline fisheries. The percentages tended to be higher for the other fleets. However, due to the smaller number of vessels in these fleets and State of Alaska confidentiality restrictions, the percentages cannot be reported for the other fleets.

The physical and operational characteristics of these vessels are summarized in Table 2.2. Catch data by region, month, and gear are provided in an appendix.

2.4 Impacts of the Alternatives on the Sablefish Fishery

A sablefish bioeconomic model (Fujioka, McDevitt, and Terry, 1987) was developed at the Northwest and Alaska Fisheries Center as a tool to assist the Council focus the debate concerning the effects of a minimum size limit. The results of the model are presented below. The results are preliminary for two reasons. First, there has not been sufficient time to include complete economic data for all the fleets. Second, the parameters and functions used in the model are thought to provide a reasonable representation of the sablefish fishery, but more complex assumptions could be incorporated into the analysis.

The model was used to estimate the effects of seven minimum sizes ranging from 37 cm to 61 cm fork length in increments of 4 cm. The lowest minimum size considered provides a good approximation of the results of the status quo, that is, no minimum size limit because relatively few fish are taken at or below 37 cm. The second to the largest size considered, 57 cm fork length, is approximately the length of a sablefish that weigh 3 pounds dressed, assuming a round weight to dressed weight recovery rate of 67%. The Council was asked to consider a size limit that would prohibit retention of fish below this weight. The evaluation of the alternatives will be in terms of comparisons between the status quo and each of the other alternatives.

The model estimates equilibrium yield as a function of the instantaneous rate of fishing mortality in the fixed gear fishery (F) for each of seven size limits. Yield is defined in terms of weight, exvessel revenue, and exvessel profit. Exvessel revenue equals the quantity of fish landed (in pounds) times the average exvessel price per pound. Exvessel profit equals exvessel revenue minus harvesting costs. Hereafter, when the terms revenue, profit, or price is used, it is implicitly modified by the term exvessel.

The model also estimates the reproductive potential of the stock in terms of the egg production potential as a function of F for each size limit.

The F for the trawl fishery was set such that the ratio of fixed gear catch to trawl catch was approximately 6.2 for each fixed gear F and for each size limit. This is the ratio of fixed gear to trawl gear quotas for the Gulf of Alaska in 1987. Therefore throughout the discussion of the model, F refers to the fixed gear instantaneous rate of fishing mortality for the part of the biomass that is available to the fishery; and there is an associated fishing mortality rate for trawl gear that maintains a constant ratio between fixed and trawl gear catches. The trawl Fs for each fixed gear F and for each size limit are presented in Tables 2.3 and 2.4, respectively, for the alternatives in which a size limit applies to all gear or to only fixed gear. Although the results of the model are specifically for the Gulf of Alaska, the implications of the model are assumed valid for the Bering Sea and Aleutian Islands Area.

2.4.1 Comparison of Alternative 1 (No Minimum Size) and Alternative 2 (Establishing a Minimum Size for All Gear)

Biological Yield

When the same size limit was applied to all gear, equilibrium yield as a function of F was higher with no size limit (i.e., for the smallest size

limit modeled which was 37 cm) than for any size limit considered for all Fs below 0.40 (see Table 2.5). This result indicates that, for Fs between 0.01 and 0.40, the potential increase in equilibrium yield that could be obtained with a size limit is more than offset by discard and natural mortalities.

Exvessel Revenue

The exvessel prices used in the model are based on fish ticket data for 1986. For the longline iceboat fishery, a large percentage of the sablefish fish tickets include both catch and revenue (i.e., exvessel value) by size. Therefore, the longline exvessel prices obtained from fish tickets are thought to provide good estimates of the average 1986 prices for longline iceboats. The percentages of sablefish that are both sized and priced on fish tickets for the other types of vessels are quite low and may not be representative of 1986 prices. This problem is most acute for the catcher/processors of all three gear types, since they usually do not report catch and value by size. Therefore, the prices used in the model tend to reflect those of shore based vessels and not catcher/processors.

The maximum equilibrium revenue occurs with a size limit of 53 cm (see Table 2.6). The maximum revenue with a size limit of 53 cm occurs with a fixed gear F of 0.150 and is less than 0.2% greater than the maximum revenue that occurs with no size limit at an F of 0.125. This suggests that increased revenue per fish is not quite offset by the increased discard and natural mortalities associated with a size limit of 53 cm. However, the small increase in maximum revenue is attained with a 20% increase in the fixed gear F and a corresponding increase in fishing effort and cost. For Fs below 0.3, equilibrium revenue was greater with no size limit than with the 57 cm limit the Council was asked to consider.

Exvessel Profit

The next evaluation of size limits is in terms of equilibrium profit. The following comments on the concept of equilibrium profit and the limits of the cost information currently included in the model are a necessary introduction to that evaluation.

As noted above, the associated concepts of yield per recruit and equilibrium yield are long term concepts. Therefore, when equilibrium profits are discussed, we are assuming that the period in question is long enough to permit vessels to either enter or exit the fishery. This means that the assumption concerning any restrictions on entry should be explicit. If it is assumed that there are no restrictions on entry, entry or exit will occur until economic profit is zero, that is until just the normal rate of return is being earned in the fishery. Therefore, in the absence of restrictions on entry, the equilibrium profit will be zero for each size limit and for any F. With the qualification that for some Fs, a commercial fishery would not be economically viable and would not occur.

The equilibrium profits provide little useful information with such an assumption. The alternative is to consider the equilibrium profit that would be attainable if there were adequate restrictions on entry. The estimates of equilibrium profit used in the evaluation of size limits in this report are of this latter type. That is, they describe the potential long-term profit

associated with different size limits and Fs. This assumption is incorporated into the model by holding the number of trips per vessel constant at six per year. If this restriction was not made, an excessive number of vessels would enter the fishery and the number of trips per vessel per year would be reduced until economic profit is forced to zero.

In estimating harvesting cost and profit, crew costs per trip were held constant at the estimated 1986 level. This was done so that changes in payments to crews per trip that result from changes in size limits and Fs are included as changes in the profit of the vessel owner and crew. Otherwise these benefits or costs to crew members would not be accounted for.

At this time the model utilizes very limited harvesting cost information. Harvesting cost for the fixed gear fleet is estimated based on detailed 1986 cost and operating characteristics data for one longline iceboat and partial information for a similar vessel. Information for other types of fixed gear vessels and trawl vessels will be used as it becomes available. Because, the model does not include trawl cost information, the estimates of equilibrium profit are for the fixed gear fishery only. The probable effects of both of these limitations are discussed in a later section that qualifies the model's results. The lack of more complete cost and price data is a function of the time that has been available to collect them, it is not due to any reluctance on the part of the industry to provide them.

The maximum potential profit occurs with a size limit of 45 cm and an F of 0.015 to 0.020 (see Table 2.7. The difference between maximum profit with a 45 cm limit and no limit was $500,000 for the entire fixed gear fleet. Most other size limits, including one of 57 cm, resulted in lower profits than no limit for Fs between 0.01 and 0.15. However, the maximum profits for different size limits from none to one of 57 cm did not differ by more than $1.2 million.

An important implication of these results is that due to the apparent cost per unit of effort, the economically relevant portion of all of the equilibrium curves is probably bounded on the upper end by Fs that do not greatly exceed the estimated 1986 Gulf of Alaska fixed gear F of 0.023. Therefore, the Fs of approximately 0.125 to 0.175 at which the equilibrium yield and revenue curves peak are beyond the relevant range. If this is correct the evaluation of size limits in terms of yield or revenue should be at relatively low Fs, not at the Fs that maximize yield and revenue. Tables 2.8 and 2.9 present estimates of how rapidly the profitability of the fishery decreases in terms of total profits for the fixed gear fleet and in terms of both catch and revenue per trip. The latter two estimates of the decline in profitability as F increases are not dependent on the cost assumption used in the model.

To test both the sensitivity of the ranking of the size limits in terms of maximum potential profit for the fixed gear fleet and the sensitivity of the economically relevant range of Fs to the estimate of cost per unit of effort used in the model, equilibrium profit was estimated for cost per unit of effort ranging from 25% to 150% of the initial estimate. The resulting estimates are presented in Table 2.10.

A change in the cost estimate used can affect the ranking of size limits in terms of maximum potential profit by changing the F(s) at which the equilibrium

profit curves peak. As the cost estimate increases, the F that maximize profit for each size limit decrease. The result that a limit of 45 cm maximizes profit was not affected by increasing cost per unit of effort by as much as 50% or by decreasing it by 25%. However, when cost per unit of effort was decreased by 50% or 75%, maximum potential profit for the fixed gear fleet was highest with no size limit.

With respect to the sensitivity of the relevant range of Fs, it was found that even with a 75% reduction in cost per unit of effort, the F that maximizes potential economic profit in the fixed gear fishery was 0.075. However, with costs reduced by that amount, potential profit was greater than zero for Fs as high as 0.2. The Fs at which potential profit equals zero for other cost estimates were as follows: 50% cost decrease F of 0.1, 25% decrease F of 0.05, no change in cost F of 0.025, 25% increase F of 0.015, and 50% increase F of less than 0.01.

Reproductive Potential and Biomass

The model indicates that the reproductive potential of a sablefish resource declines rapidly as F increases, but that it is relatively insensitive to the minimum size for a given F between 0.01 and 0.15. As F increases, the relative differences in reproductive potential for the different size limits increases. At an F of 0.15, the reproductive potential is 8% higher with a minimum size of 61 cm than with a limit of 37 cm. At an F of 0.025, which is about equal to the 1986 F, the corresponding difference is 0.5% (see Table 2.11). Therefore, it appears that the size limit has a sufficiently small effect on the reproductive potential of sablefish ,at the Fs for which the fixed gear fishery appears to be economically viable, that it is appropriate to base the evaluation of the alternatives on the results of the yield per recruit model without adjustments for differences in reproductive potential.

The level of biomass is another measure of the effect of a size limit. Estimates of biomass in terms of an index are presented in Table 2.12 for the various Fs and size limits considered. Equilibrium biomass was found to be similar to the reproductive potential in that it was much more sensitive to F than to the size limit and that the relative sensitivity to a size limit increased with an increase in F. With Fs of 0.025 or 0.150, the biomass was increased by a maximum of 1.7% or 13.1%, respectively, by going from no size limit to that which maximized biomass. For both Fs that limit was 57 cm.

Summary

To summarize, these results suggest that when a size limit is applied to all gear types: 1) maximum equilibrium yield would be decreased; 2) maximum equilibrium revenue would be increased with a 53 cm limit by less than 0.2% but require a 20% increase in F, and would be decreased by any other size limit in comparison to no limit; 3) maximum potential equilibrium profit for the fixed gear fleet would be increased with a 45 cm size limit by $500,000; and 4) neither reproductive potential nor biomass would be reduced by more than 10% by the absence of a size limit with an F of 0.1 and the effect would be less than 2% for an F of 0.025 which exceeds the estimated 1986 F of 0.023.

Comparison with Earlier Results

These results differ greatly with those of Francis (1985) that were prepared for the PFMC after the size limit had been established. The differences are explained by three factors. The current NWAFC model accounts for discard mortality of fish below the size limit. Specifically, the model assumes that discard mortality is 35% in the fixed gear fishery and 100% in the trawl fishery. Francis assumed 0 discard mortality. The second factor is the gear selectivity function used in each model. The models are naturally quite sensitive to what is assumed about the proportion of each size group that is available to a specific type of gear. Although it is difficult to estimate gear selectivity coefficients, it is believed that those used in the NWAFC model represent the best available information. The third factor is the large difference in the gear allocation assumed. The NWAFC model assumes a 6.2 ratio of fixed gear to trawl catch, this reflects the gear allocation implemented under Amendment 14 to the GOA groundfish FMP. The analysis done for the PFMC assumes a ratio of 1 and estimates the effect of going from no size limit and a ratio of 1 to a limit of 22 inches and a fixed gear only fishery.

The difference in assumptions concerning discard mortality are based on different assumptions concerning how each fleet will react to a specific size limit. In the research for the PMFC, it was assumed that if fishermen cannot retain fish of a given size, they will change their fishing strategies in such a way that such fish will no longer be caught. With the NWAFC model, the assumption is that fishing strategies will not change and the fish below the size limit will continue to be caught and discarded. Although neither assumption is expected to be strictly met, there are reasons to believe that the latter assumption is more appropriate at least for the sablefish fishery off Alaska.

A large part of the sablefish landings caught by trawl vessels in the future will be taken as bycatch as the trawl fleet continues to increase its catch of other species. The fishing strategies associated with this trawl effort would probably not be significantly affected by sablefish size limits. The vessels that target on sablefish already have a strong price incentive to target on larger sablefish, and as noted above much of the sablefish catch is taken by a group of very productive vessels that are quite likely to respond to such an incentive. Therefore, fishing strategies and the resulting catch of small fish may not be significantly altered by a size limit. Note that at Fs close to the current level, the effect of this assumption is small.

To the extent that fishing strategies would change and reduce the catch of small fish, the results of the NWAFC model tend to understate the benefits of a size limit. If for example, fishermen are currently targeting on small fish, a size limit would necessarily alter their fishing strategy and the benefits of a size limit would be greater than estimated above. Certainly if it is determined during the Council's discussion of size limits that such targeting does occur and takes significant amounts of sablefish, the model could be modified to account for such fishing strategies.

Estimates of the 1986 size composition by gear are presented in Table 2.13. These estimates are based on fish ticket data. As noted above, the percentage

of sablefish that are sized on fish tickets varies greatly by gear and type of operation. The percentages sized were as follows: longline 68%, pot 13%, and trawl 12%. Although these limited data indicate that sablefish less than 57 cm accounted for 62% of the trawl catch by weight, these data do not indicate the proportion of fish under 57 cm that were taken as target catch as opposed to bycatch. Because a low percentage of sablefish are sized for the trawl fleet and because much of the sized sablefish are probably for shore based trawlers and not from catcher/processors, the size composition estimates for the trawl fleet may not reflect the actual size composition.

Qualifications Concerning the Estimated Effects of Size Limits

It is necessary to qualify the results discussed above by indicating that they are preliminary. As the model is reviewed by the industry and others, it will be improved.

The economic sections of the model will be improved as more complete cost, price, and operating characteristic information are obtained. The current model only contains cost information for one type of longline iceboat. Therefore, the fishing cost for the fixed gear fishery does not account for the differences in fishing cost of the many different type of vessels in the fixed gear fleet. The model does not include fishing cost for the trawl fleet. Model deficiencies due to limited cost information do not bias the inferences with respect to size limits applied to all gear, because the relative positions of the equilibrium profit curves for the different sizes considered are not affected by even very large changes in the cost of a unit of effort. That is, cost per unit of effort was varied from 75% to 150% of the initial estimate without affecting the relative position (i.e., the ranking) of the equilibrium profit yield curves. Only when cost per unit of effort was reduced by 50% or 75% did the ranking change in favor of no size limit.

A potentially more critical deficiency is the lack of trawl fleet harvesting costs in the model. By excluding both trawl revenue and cost in estimating profit, the model tends to overstate the benefits of a size limit. This is true whether the trawl fleet takes sablefish as target catch or bycatch. If it is taken as bycatch, a size limit will tend to reduce trawl revenue but not affect costs. Therefore, the probable decrease in trawl profits associated with a size limit is not currently accounted for by the model. If the trawl fleet targets on sablefish, a size limit would tend to result in a larger increase in cost than revenue because the trawl Fs associated with a given fixed gear F increases significantly when a size limit is imposed. It is possible that this bias led to the result that a 45 cm limit would increase potential profits . However, it appears that the lack of complete information concerning the fleets does not limit the usefulness of the model in determining that there would probably not be a significant increase in potential profits with a size limit applied to all gear. Even with the trawl related bias in favor of a limit, the estimated increase in potential profits was small.

The model will tend to understate the benefits of a size limit, if a size limit results in a decrease in the proportion of catch taken by trawlers. However, as noted above, the potential expansion of trawl effort targeted on other groundfish species may assure that the trawlers' share of the quotas will be taken.

The model does not allow prices to respond to changes in sablefish catch. That is, prices by size category were assumed constant. Based on the lack of success of prior attempts to estimate price response relationship, it was decide that such an exercise was beyond the scope of the current modeling project. By not including such a relationship, the difference in the heights of the equilibrium revenue and profit curves for different size limits is overstated. However, their ranking should not be affected if the prices for all size categories change proportionally. Note that although the end of season Seattle prices submitted by the Fishing Vessel Owners' Association with their request that a size limit be considered were not used in the model, the relative differences in prices among size categories for the prices that were used were similar. It is be possible to estimate the effects of a size limit for any given set of prices or other parameters that with the industry's cooperation are determined to be appropriate.

2.4.2 Comparison of Alternative 1 (No Minimum Size) and Alternative 3 (Establishing a Minimum Size for Fixed Gear Only)

Biological Yield

Equilibrium yield would not be increased by a size limit that applied to fixed gear only (see Table 2.14). This result indicates that, for Fs between 0.01 and 0.40, the potential increase in equilibrium yield that could be obtained with a size limit is offset by discard and natural mortalities.

Exvessel Revenue

The maximum equilibrium revenue occurs with a size limit of 53 cm and an F of 0.150 to 0.175 (see Table 2.15). The equilibrium revenue with a size limit of 53 cm and a fixed gear F of 0.150 is 8.8% greater than the maximum revenue that occurs with no size limit at an F of 0.125. This suggests that increased revenue per fish is not offset by the increased discard and natural mortalities associated with a size limit of 53 cm. However, the 8.8% increase in maximum revenue is attained with a 20% increase in the fixed gear F and a corresponding increase in fishing effort and cost. For Fs at or above 0.05, equilibrium revenue was greater with the 57 cm limit the Council was asked to consider than with no limit. The percentage increase in maximum revenue was smaller and the result with respect to a 57 cm limit was different when the limit applied to all gear.

Exvessel Profit

The maximum potential profit occurs with a size limit of 45 cm and an F of 0.015 (see Table 2.16. The difference between maximum profit with a 45 cm limit and no limit was $1 million for the entire fixed gear fleet. Most other size limits, including one of 57 cm, resulted in lower profits than no limit for Fs between 0.01 and 0.025. For Fs above 0.025, profit was less than zero, (i.e., there were losses) but the losses were smaller with a 57 cm limit than with no limit. Each of these results is more supportive of a size limit than the corresponding results when the limit applied to all gear.

As noted earlier, an important implication of these results is that due to the apparent cost per unit of effort, the economically relevant portion of all of the equilibrium curves is probably bounded on the upper end by Fs that do not greatly exceed the estimated 1986 Gulf of Alaska fixed gear F of 0.023. Therefore, the Fs of approximately 0.15 to 0.20 at which the equilibrium yield and revenue curves peak are beyond the relevant range. If this is correct the evaluation of size limits in terms of yield or revenue should be at relatively low Fs, not at the Fs that maximize yield and revenue. Tables 2.17 and 2.18 present estimates of how rapidly the profitability of the fishery decreases in terms of total profits for the fixed gear fleet and in terms of both catch and revenue per trip. The latter two estimates of the decline in profitability as F increases are not dependent on the cost assumption used in the model.

The test of the sensitivity of the ranking of the size limits in terms of maximum potential profit for the fixed gear fleet to changes in the cost

per unit of effort showed that the profit maximizing limit of 45 cm was not affected by increasing cost per unit of effort by as much as 50% or by decreasing it by 25% (see Table 2.19). However, when cost per unit of effort was decreased by 50% or 75%, maximum potential profit for the fixed gear fleet was highest with a 53 cm size limit. This did not occur when the limit applied to all gear.

With respect to the sensitivity of the relevant range of Fs, it was found that even with a 75% reduction in cost per unit of effort, the F that maximizes potential economic profit in the fixed gear fishery was 0.075. However, with costs reduced by that amount, potential profit was greater than zero for Fs as high as 0.2. The Fs at which potential profit equals zero for other cost estimates were as follows: 50% cost decrease F of 0.1, 25% decrease F of 0.05, no change in cost F of 0.025, 25% increase F of 0.015, and 50% increase F of less than 0.01. These results are identical to those when the limit applied to all gear.

Reproductive Potential and Biomass

The model indicates that the reproductive potential of a sablefish resource declines rapidly as F increases, but that it is less sensitive to the size limit for a given F. As F increases, the relative differences in reproductive potential for the different size limits increases. At an F of 0.15, the reproductive potential is 37% higher with a minimum size of 61 cm than with a limit of 37 cm. At an F of 0.025, which is about equal to the 1986 F, the corresponding difference is 5.7% (see Table 2.20). Note that the reproductive potential was less sensitive to a size limit when the limit applied to all gear. This may change the previous conclusion that it is appropriate to base the evaluation of the alternatives on the results of the yield per recruit model without adjustments for differences in reproductive potential. But at Fs below 0.15, the conclusion does not change.

The level of biomass is another measure of the effect of a size limit. Estimates of biomass in terms of an index are presented in Table 2.21 for the various Fs and size limits considered. Equilibrium biomass was found to be similar to the reproductive potential in that it was much more sensitive to F than to the size limit and that the relative sensitivity to a size limit increased with an increase in F. With Fs of 0.025 or 0.150, the biomass was increased by a maximum of 6% or 39%, respectively, by going from no size limit to that which maximized biomass. For both Fs that limit was 61 cm. As with reproductive potential, biomass is considerably more responsive to a change in the size limit when the limit applies to fixed gear only.

Summary

To summarize, these results suggest that when a size limit is applied to fixed gear only: 1) maximum equilibrium yield would not benefit from a size limit; 2) maximum equilibrium revenue would increase with a 53 cm limit by 8.8% but require a 20% increase in F, but would not decrease with any other size limit in comparison to no limit; 3) maximum potential equilibrium profit for the fixed gear fleet would be increased with a 45 cm size limit by $1 million; and 4) both reproductive potential and biomass are more

responsive to a change in the size limit when the limit applies only to fixed gear, but at Fs near the current level it is not necessary to consider the effect of a size limit on both variables.

The differences in the estimated effects of a size limit depending on whether the limit applies to all gear or just fixed gear can be explained by the differences in the trawl Fs with the two alternatives. Remember that in both cases the trawl F is adjusted so that, for a given fixed gear F and size limit, the fixed gear catch to trawl gear catch ratio is maintained at 6.2. This requires an increase in the trawl F as the size limit is increased if the limit also applies to trawlers. But since the trawl discard mortality rate is assumed to be 100%, the increase in trawl F tended to result in a disproportionately large increase in mortality. Conversely, when the size limit applied only to fixed gear, an increase in the size limit resulted in a decrease in the trawl F. The corresponding fixed and trawl gear Fs for each size limit are given in the previously mentioned Tables 2.3 and 2.4 for the cases in which the size limit applies to all gear or only to fixed gear, respectively.

Qualifications Concerning the Estimated Effects of Size Limits

When a size limit applies only to fixed gear, the qualifications concerning the model's implications for size limits change. The lack of trawl costs in the model now results in a bias in favor of no size limit. The reason for this is that when the limit applies only to fixed gear, trawl revenue for a given fixed gear F is relatively constant but the trawl F and cost decrease as the size limit increases. Therefore, for a given fixed gear F, the potential profit for the trawl fleet increases as the size limit increases. This increase in profits is not accounted for by the model.

When the size limit applies to fixed gear only, the bias associated with not including the trawl fleet in the estimates of potential profit and the bias of assuming that fishermen will not change their fishing strategies if a limit is implemented both tend to have the model understate the net benefits of a size limit. Therefore, the model's conclusion that a size limit would be beneficial to the fisheries, is not the result of these biases.

2.5 Environmental Assessment

Alternative 2: Establish a single minimum size limit for all gears.

Possible environmental impacts which could result from the imposition of minimum size limits on all gear types which harvest sablefish are expected to be minimal. These impacts may fall into several categories:

i. Physical damage to the ocean floor from increased fishing effort is not expected to be measurable. If most sablefish harvested by the trawl fleet would be taken as bycatch while the trawlers are targeting on other species, there would be little increase in trawl effort above current levels. If sablefish are caught in directed trawl fisheries and a minimum size limit is imposed on them, they would likely change their operations to target as much as possible on the legal sized fish. This could result in some increase in effort. In the worst case, if trawlers do target on sablefish and do not change their fishing patterns with imposition of a minimum size limit, a relatively large increase in effort is possible. There is little reason to believe, however, that trawls do any significant damage to the benthic communities (see Natural Resource Consultants 1984, for a summary of ecological impacts of trawling). There is no evidence of physical damage from longline fishing effort.

ii. Change in sablefish biomass due to size limits imposed on the fisheries is not expected to be significant. Results from the model are summarized in section 2.4.1 above. The model indicates that biomass decreases rapidly with increasing F, but that for values of F less than .15 biomass was relatively insensitive to size limits (see Table 2.12).

iii. Relative reproductive potential of the sablefish stock as measured by total fecundity is not expected to change significantly with the imposition of size limits. Results from the model are summarized in section 2.4.1 above. The model indicates that egg production decreases rapidly with increasing F, but that for values of F less than .15 egg production was relatively insensitive to size limits (see Table 2.11).

iv. The imposition of minimum size limits on the fishing fleets will change the size structure of the sablefish population, but the change is expected to be minimal. As fishing mortality is increased on larger sizes and decreased on smaller sizes, the population size structure will shift slightly towards smaller fish. The effect on predator-prey relations precipitated by the minor changes in size distribution which could result from this alternative are expected to be undetectable.

Alternative 3: Establish a minimum size limit for fixed gear only.

Possible environmental impacts which could result from imposing a minimum size limit on fixed gear only are expected to be minimal. Impacts of alternative 3 relative to the status quo (alternative 1) are likely to be less than the impacts of alternative 2 relative to the status quo for all categories outlined above.

Natural Resource Consultants. 1984. Development of large-scale trawling in the Gulf Of Alaska and Bering Sea and its economic and ecological impacts. Processed Report. NRC, 4055 21st Ave. W., Seattle, WA 98199. 195p.

2.6 Regulatory Impact Review

The discussion of the effects of size limits in sections 2.4.1 and 2.4.2 of this report is the basis for many of the following statements concerning impacts.

2.6.1 Reporting Costs

Reporting costs do not differ among the three alternatives.

2.6.2 Administrative and Enforcement Costs

There will be additional administrative costs associated with establishing and implementing a size limit. These costs will be comparable to most any other change in the FMP. That is, a change requires that the Council and NMFS spend time and other resources approving and implementing a change. Other than these setup costs, the additional administrative costs should be minimal.

Both alternatives 2 and 3 would result in increased enforcement responsibilities but probably not increased expenditures on enforcement. This means that enforcement resources would have to be reallocated to some extent. A size limit would no doubt be enforced by the same method and at the same time other regulations are enforced.

Enforcement of a size limit is probably simplest if it can be in terms of a processor being in possesion of fish below the limit. For this type of enforcement to be possible, there cannot be any exceptions to the size limit or any size limit differentials by gear or area. The Pacific Council did make an exception for relatively small amounts of incidentally caught sablefish below the size limit. This suggests that the problem of not being able to enforce the limit in terms of possesion by processors was not considered to be a major problem. Therefore, enforcement is at the vessel level or at the point of sale. With this type of enforcement, exceptions and size differential by gear do not present a major problem. Size differentials by area do present a problem.

With a size differential by area, enforcement at sea may be necessary. Therefore, enforcement difficulty and perhaps cost would by higher if the same size limit did not apply to both the Gulf of Alaska and the Bering Sea.

The experience of the Pacific Council limit has demonstrated that there will be additional enforcement resources used in terms of setup costs. For example, it took some time and effort to determine the appropriate conversions to use in going from a limit stated in total length to a limit by length or weight for dressed or more fully processed fish. Their experience suggests two things: 1) enforcement meeds to be lenient while the conversions are being sorted out, and 2) reasonable conversion factors can be agreed upon.

A size limit would by more difficult to enforce for catcher/processors as are other regulations. But the enforcement of a size limit could occur as other regulations are enforced. That is, it is unlikely that the enforcement efforts targeting on catcher/processors would be increased.

Table 2.1 -- Sablefish lengths, weights, and price by age and sex.

Females

					Longline fishery		Trawl fishery	
Age	cm	inches	kg	pounds	$/lb.	$/fish	$/lb.	$/fish
0.5	22.1	9.3	0.1	0.1	0.00	0.00	0.00	0.00
1.0	29.0	12.1	0.2	0.3	0.00	0.00	0.00	0.00
1.5	35.1	14.5	0.4	0.6	0.00	0.00	0.00	0.00
2.0	40.6	16.7	0.7	1.0	0.45	0.45	0.12	0.12
2.5	45.3	18.6	1.0	1.5	0.45	0.65	0.12	0.17
3.0	49.6	20.3	1.3	1.9	0.45	0.87	0.12	0.23
3.5	53.3	21.7	1.7	2.4	0.64	1.57	0.49	1.20
4.0	56.6	23.0	2.0	3.0	0.64	1.90	0.49	1.46
4.5	59.5	24.2	2.4	3.5	0.76	2.65	0.67	2.34
5.0	62.1	25.2	2.7	4.0	1.03	4.11	0.88	3.52
5.5	64.3	26.1	3.0	4.5	1.03	4.62	0.88	3.95
6.0	66.3	26.9	3.4	4.9	1.03	5.10	0.88	4.36
6.5	68.1	27.6	3.6	5.4	1.27	6.83	0.94	5.06
7.0	69.6	28.2	3.9	5.8	1.27	7.35	0.94	5.45
8.0	72.2	29.3	4.4	6.5	1.27	8.27	0.94	6.13
9.0	74.3	30.1	4.8	7.1	1.28	9.15	0.99	7.02
10.0	75.8	30.7	5.2	7.6	1.28	9.79	0.99	7.51
11.0	77.1	31.2	5.4	8.0	1.28	10.31	0.99	7.91
12.0	78.0	31.6	5.7	8.4	1.28	10.73	0.99	8.23
13.0	78.8	31.9	5.8	8.6	1.28	11.06	0.99	8.49
14.0	79.3	32.1	6.0	8.8	1.28	11.33	0.99	8.69
15.0	79.8	32.3	6.1	9.0	1.28	11.54	0.99	8.85
16.0	80.1	32.4	6.2	9.1	1.28	11.70	0.99	8.98
17.0	80.4	32.5	6.2	9.2	1.28	11.83	0.99	9.08
18.0	80.6	32.6	6.3	9.3	1.28	11.93	0.99	9.16
19.0	80.8	32.7	6.3	9.4	1.28	12.01	0.99	9.22
20.0	80.9	32.7	6.4	9.4	1.28	12.08	0.99	9.27

Table 2.1 -- Continued.

Males

Age	cm	inches	kg	pounds	Longline fishery $/lb.	Longline fishery $/fish	Trawl fishery $/lb.	Trawl fishery $/fish
0.5	24.4	10.3	0.1	0.2	0.00	0.00	0.00	0.00
1.0	30.1	12.5	0.3	0.4	0.00	0.00	0.00	0.00
1.5	35.0	14.5	0.4	0.6	0.00	0.00	0.00	0.00
2.0	39.3	16.2	0.6	0.9	0.00	0.00	0.00	0.00
2.5	43.0	17.7	0.8	1.2	0.45	0.55	0.12	0.15
3.0	46.2	18.9	1.0	1.5	0.45	0.69	0.12	0.18
3.5	49.0	20.0	1.3	1.9	0.45	0.84	0.12	0.22
4.0	51.4	21.0	1.5	2.2	0.64	1.40	0.49	1.07
4.5	53.4	21.8	1.7	2.5	0.64	1.59	0.49	1.22
5.0	55.2	22.5	1.9	2.8	0.64	1.77	0.49	1.36
5.5	56.8	23.1	2.0	3.0	0.76	2.29	0.67	2.02
6.0	58.1	23.7	2.2	3.2	0.76	2.47	0.67	2.18
6.5	59.3	24.1	2.3	3.5	0.76	2.63	0.67	2.32
7.0	60.3	24.5	2.5	3.6	0.76	2.78	0.67	2.45
8.0	61.9	25.2	2.7	4.0	0.76	3.03	0.67	2.67
9.0	63.1	25.6	2.9	4.2	1.03	4.36	0.88	3.73
10.0	64.0	26.0	3.0	4.4	1.03	4.56	0.88	3.90
11.0	64.7	26.3	3.1	4.6	1.03	4.72	0.88	4.04
12.0	65.2	26.5	3.2	4.7	1.03	4.84	0.88	4.14
13.0	65.6	26.6	3.2	4.8	1.03	4.93	0.88	4.22
14.0	65.9	26.7	3.3	4.9	1.03	5.00	0.88	4.28
15.0	66.1	26.8	3.3	4.9	1.03	5.05	0.88	4.32
16.0	66.2	26.9	3.3	4.9	1.03	5.09	0.88	4.36
17.0	66.3	26.9	3.4	5.0	1.27	6.31	0.94	4.68
18.0	66.4	27.0	3.4	5.0	1.27	6.34	0.94	4.70
19.0	66.5	27.0	3.4	5.0	1.27	6.36	0.94	4.71
20.0	66.6	27.0	3.4	5.0	1.27	6.37	0.94	4.72

Fork length in cm
Total length in inches
Round weight in kg
Dressed weight in pounds (67% recovery rate)
Exvessel prices per pound dressed and per fish

Table 2.2 -- Summary statistics for different sectors of the sablefish fleets, EEZ of Alaska, 1986

All longline iceboats

NUMBER OF OBSERVATIONS : 424

	MEAN	STANDARD DEVIATION
SABLBS	74075.7	109710.
ALLGFLBS	76031.8	112313.
TRIPS	2.93396	2.04798
SABLBST	19439.2	19424.8
SABGF	96.4656	11.1123
LENGTH	50.1604	14.8548
NETTONS	32.3868	27.5706
HP	278.101	457.414

Top 50% of longline iceboats

NUMBER OF OBSERVATIONS : 212

	MEAN	STANDARD DEVIATION
SABLBS	137064.	126825.
ALLGFLBS	140161.	130102.
TRIPS	4.17453	2.15132
SABLBST	32253.8	19963.3
SABGF	98.0625	4.95009
LENGTH	56.2406	13.8548
NETTONS	42.6368	29.0800
HP	304.679	181.916

Top 20% of longline iceboats

NUMBER OF OBSERVATIONS : 86

	MEAN	STANDARD DEVIATION
SABLBS	244685.	139100.
ALLGFLBS	250405.	142884.
TRIPS	5.61628	2.19716
SABLBST	46232.1	21772.3
SABGF	97.7616	4.54626
LENGTH	58.7209	11.4303
NETTONS	42.2093	24.4267
HP	293.686	164.548

Table 2.2 -- Continued.

All longine freezer boats

NUMBER OF OBSERVATIONS : 12

		MEAN	STANDARD DEVIATION
SABLBS	.	186032.	310822.
ALLGFLBS	.	189254.	317359.
TRIPS	.	3.41667	2.60971
SABLBST	.	40817.6	60293.8
SABGF	.	98.3771	1.97291
LENGTH	.	71.8333	26.7916
NETTONS	.	94.4167	78.2031
HP	.	457.500	321.704

Top 50% of longline freezer boats

NUMBER OF OBSERVATIONS : 6

		MEAN	STANDARD DEVIATION
SABLBS	.	353169.	381369.
ALLGFLBS	.	359306.	390018.
TRIPS	.	4.66667	3.20416
SABLBST	.	71224.7	75665.1
SABGF	.	98.2687	2.37062
LENGTH	.	83.5000	29.0775
NETTONS	.	135.333	85.5796
HP	.	619.167	349.334

All pot iceboats

NUMBER OF OBSERVATIONS : 10

		MEAN	STANDARD DEVIATION
SABLBS	.	140640.	224687.
ALLGFLBS	.	142509.	230136.
TRIPS	.	5.50000	5.44161
SABLBST	.	47928.2	114074.
SABGF	.	99.7271	0.749816
LENGTH	.	79.0000	15.8325
NETTONS	.	101.500	40.6373
HP	.	596.500	277.279

Table 2.2. -- Continued.

Top 50% of pot iceboats

NUMBER OF OBSERVATIONS : 5

		MEAN	STANDARD DEVIATION
SABLBS	.	259420.	279470.
ALLGFLBS	.	263157.	287334.
TRIPS	.	8.00000	7.10634
SABLBST	.	88429.0	158603.
SABGF	.	99.4632	1.04426
LENGTH	.	89.2000	10.3779
NETTONS	.	123.800	37.2250
HP	.	781.000	283.293

All pot freezer boats

NUMBER OF OBSERVATIONS : 5

		MEAN	STANDARD DEVIATION
SABLBS	.	810645.	780157.
ALLGFLBS	.	824535.	768558.
TRIPS	.	3.80000	3.27109
SABLBST	.	183023.	192731.
SABGF	.	87.1783	27.5268
LENGTH	.	131.200	47.8195
NETTONS	.	253.600	312.828
HP	.	976.000	330.726

All trawler catcher boats

NUMBER OF OBSERVATIONS : 11

		MEAN	STANDARD DEVIATION
SABLBS	.	5739.91	5052.35
ALLGFLBS	.	145999.	232467.
TRIPS	.	1.63636	0.809040
SABLBST	.	3773.30	3924.01
SABGF	.	40.7946	43.4339
LENGTH	.	81.1818	19.2500
NETTONS	.	96.4545	44.3291
HP	.	619.545	275.331

Table 2.2 -- Continued.

Top 45% of trawler catcher boats

NUMBER OF OBSERVATIONS : 5

		MEAN	STANDARD DEVIATION
SABLBS	.	10287.4	3565.53
ALLGFLBS	.	169598.	240528.
TRIPS	.	2.00000	0.707107
SABLBST	.	6294.33	4483.06
SABGF	.	32.0375	39.4028
LENGTH	.	73.8000	15.4499
NETTONS	.	95.2000	42.3757
HP	.	554.000	284.306

All factory trawlers

NUMBER OF OBSERVATIONS : 19

		MEAN	STANDARD DEVIATION
SABLBS	.	377251.	530657.
ALLGFLBS	.	.162445E+07	.248886E+07
TRIPS	.	3.31579	1.94515
SABLBST	.	105262.	158651.
SABGF	.	44.6726	33.3117
LENGTH	.	133.000	58.0900
NETTONS	.	184.263	185.804
HP	.	1438.16	953.186

Top 47% of factory trawlers

NUMBER OF OBSERVATIONS : 9

		MEAN	STANDARD DEVIATION
SABLBS	.	467519.	564015.
ALLGFLBS	.	.272460E+07	.317941E+07
TRIPS	.	3.44444	2.06828
SABLBST	.	106567.	78679.0
SABGF	.	23.1575	16.9505
LENGTH	.	166.778	53.3263
NETTONS	.	228.889	239.879
HP	.	1973.33	603.656

SABLBS	Pounds of sablefish, round weight
ALLGFLBS	Pounds of all groundfish, round weight
TRIPS	Number of trips in which sablefish was reported
SABGF	100 * SABLBS/GFLBS
LENGTH	Vessel length
NETTONS	Vessel net tons
HP	Vessel horsepower

Table 2.3 -- Trawl Fs that maintain the fixed gear to trawl gear catch ratio at 6.2 for various fixed gear Fs and size limits that apply to all gear.

Fixed gear F	Size limits in centimeters 37	41	45	49	53	57	61
0.020	0.0087	0.0097	0.0103	0.0110	0.0120	0.0122	0.0159
0.021	0.0089	0.0104	0.0109	0.0115	0.0123	0.0125	0.0167
0.022	0.0092	0.0106	0.0113	0.0124	0.0126	0.0132	0.0174
0.023	0.0097	0.0109	0.0118	0.0127	0.0133	0.0157	0.0182
0.024	0.0101	0.0115	0.0123	0.0130	0.0139	0.0143	0.0189
0.025	0.0105	0.0119	0.0127	0.0134	0.0144	0.0148	0.0200
0.050	0.0189	0.0219	0.0233	0.0248	0.0263	0.0264	0.0375
0.075	0.0257	0.0300	0.0317	0.0330	0.0367	0.0370	0.0510
0.100	0.0316	0.0376	0.0399	0.0424	0.0387	0.0457	0.0650
0.125	0.0370	0.0440	0.0470	0.0502	0.0450	0.0570	0.0770
0.150	0.0413	0.0500	0.0523	0.0564	0.0509	0.0640	0.0870
0.175	0.0533	0.0560	0.0594	0.0620	0.0559	0.0700	0.0980
0.200	0.0585	0.0633	0.0634	0.0682	0.0622	0.0770	0.1060
0.225	0.0627	0.0660	0.0690	0.0690	0.0660	0.0815	0.1160
0.250	0.0686	0.0706	0.0742	0.0774	0.0695	0.0879	0.1210
0.300	0.0783	0.0803	0.0852	0.0718	0.0780	0.1002	0.1380
0.350	0.0878	0.0950	0.0937	0.0751	0.0854	0.1109	0.1520
0.400	0.0968	0.0968	0.0930	0.0816	0.0989	0.1108	0.1640
0.450	0.1293	0.1040	0.0836	0.0940	0.1090	0.1169	0.1790

Table 2.4 -- Trawl Fs that maintain the fixed gear to trawl gear catch ratio of 6.2 for various fixed gear Fs and size limits that apply to fixed gear only.

Fixed gear F	Size limits in centimeters 37	41	45	49	53	57	61
0.010	0.0044563	0.0044294	0.0043782	0.0042861	0.0041431	0.0039354	0.0036132
0.015	0.0065167	0.0064764	0.0063951	0.0062539	0.0060360	0.0057236	0.0052372
0.020	0.0083906	0.0083403	0.0082291	0.0081144	0.0078200	0.0074030	0.0067515
0.025	0.0102385	0.0101765	0.0100310	0.0097849	0.0094199	0.0088926	0.0080782
0.050	0.0182924	0.0181729	0.0178222	0.0172762	0.0165214	0.0154629	0.0138228
0.075	0.0249082	0.0246758	0.0240357	0.0231381	0.0219856	0.0202732	0.0180209
0.100	0.0304976	0.0301029	0.0291418	0.0279043	0.0262133	0.0241134	0.0211278
0.125	0.0351727	0.0346142	0.0332846	0.0317974	0.0295791	0.0270903	0.0234451
0.150	0.0392769	0.0384458	0.0367223	0.0348368	0.0323250	0.0294645	0.0251412
0.175	0.0429909	0.0421114	0.0396378	0.0377996	0.0346637	0.0310047	0.0266137
0.200	0.0464233	0.0453506	0.0429381	0.0402475	0.0371686	0.0324989	0.0277864
0.300	0.0580100	0.0563531	0.0517151	0.0477540	0.0431173	0.0373137	0.0296727
0.400	0.0679558	0.0656892	0.0588902	0.0516882	0.0448991	0.0379058	0.0307772

Table 2.5 -- Estimated equilibrium yield as a function of fixed gear F and a size limit applied to all gear (1,000 metric tons).

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	9.3	9.3	9.1	9.0	8.7	8.3	7.5
0.015	13.1	13.1	12.9	12.5	12.2	11.6	10.5
0.020	16.6	16.3	16.1	15.8	15.3	14.5	13.1
0.025	19.5	19.2	19.0	18.6	18.0	17.1	15.3
0.050	30.0	29.5	29.0	28.4	27.3	25.9	22.4
0.075	35.9	35.1	34.5	33.6	32.2	30.6	25.8
0.100	39.3	38.1	37.4	36.4	36.0	33.0	27.0
0.125	41.1	39.7	38.9	38.0	37.4	33.5	27.2
0.150	42.1	40.3	39.5	38.5	38.1	33.8	26.8
0.175	41.1	40.3	39.4	38.6	38.2	33.2	25.9
0.200	41.0	40.1	39.4	38.4	37.9	32.8	25.1
0.300	38.7	38.2	36.1	37.8	35.5	29.1	21.4
0.400	36.1	32.9	34.5	34.1	32.0	27.8	17.8

Table 2.6 -- Estimated equilibrium revenue as a function of fixed gear F and a size limit applied to all gear ($ millions).

F		Size limits in centimeters 37	41	45	49	53	57	61
0.010	All gear	14.0	14.0	14.4	13.7	13.6	13.5	12.7
	Fixed gear	12.8	12.7	13.1	12.4	12.4	12.1	11.4
	Trawl gear	1.3	1.3	1.3	1.3	1.2	1.4	1.3
0.015	All gear	19.4	19.7	20.0	19.1	19.2	18.9	17.7
	Fixed gear	17.7	17.5	18.2	17.5	17.3	17.0	15.9
	Trawl gear	1.8	2.1	1.7	1.7	1.9	1.9	1.8
0.020	All gear	24.3	24.5	25.0	23.9	24.0	23.5	21.8
	Fixed gear	22.1	21.9	22.8	21.8	21.6	21.0	19.6
	Trawl gear	2.3	2.6	2.2	2.2	2.4	2.5	2.3
0.025	All gear	28.6	28.7	29.3	28.1	28.1	27.5	25.5
	Fixed gear	25.9	25.7	26.8	25.6	25.4	24.7	22.8
	Trawl gear	2.6	3.0	2.6	2.5	2.7	2.9	2.7
0.050	All gear	42.7	42.9	42.0	41.8	42.1	41.3	37.1
	Fixed gear	38.8	38.3	38.2	38.1	38.1	37.2	33.3
	Trawl gear	3.9	4.6	3.8	3.7	4.0	4.1	3.9
0.075	All gear	51.1	50.0	48.6	48.6	48.9	47.9	42.6
	Fixed gear	46.6	44.7	44.4	44.6	44.3	43.1	38.4
	Trawl gear	4.5	5.3	4.2	4.1	4.6	4.8	4.2
0.100	All gear	53.7	53.1	52.1	51.4	53.1	50.5	44.3
	Fixed gear	48.8	47.3	47.7	47.0	48.8	45.4	39.9
	Trawl gear	4.8	5.8	4.5	4.4	4.3	5.1	4.4
0.125	All gear	54.7	54.0	52.9	52.2	54.6	51.0	44.3
	Fixed gear	49.7	48.0	48.4	47.8	50.2	45.6	39.9
	Trawl gear	5.0	5.9	4.5	4.4	4.4	5.5	4.4
0.150	All gear	54.5	52.5	52.6	51.9	54.8	50.9	43.6
	Fixed gear	49.5	47.7	48.3	47.6	50.4	45.5	39.3
	Trawl gear	5.0	4.8	4.3	4.3	4.4	5.4	4.3
0.175	All gear	51.4	51.4	51.4	51.1	54.4	50.0	42.0
	Fixed gear	45.8	46.7	47.1	46.9	50.1	44.9	37.9
	Trawl gear	5.6	4.7	4.3	4.2	4.3	5.1	4.1
0.200	All gear	49.9	49.7	50.2	49.6	53.2	48.7	40.1
	Fixed gear	44.4	45.0	46.2	45.6	48.9	43.6	36.2
	Trawl gear	5.5	4.7	4.0	4.0	4.3	5.1	3.9
0.300	All gear	42.6	43.3	43.2	45.5	47.1	42.6	34.4
	Fixed gear	37.7	39.5	39.8	42.5	43.3	38.1	30.7
	Trawl gear	4.9	3.8	3.4	2.9	3.8	4.5	3.7
0.400	All gear	36.3	38.5	36.3	38.0	42.3	37.6	26.1
	Fixed gear	31.9	35.4	33.7	36.4	37.7	33.8	23.0
	Trawl gear	4.4	3.1	2.6	1.6	4.6	3.8	3.1

Table 2.7 -- Estimated potential equilibrium profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to all gear ($ million).

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	3.5	3.5	3.9	3.2	3.2	2.9	2.1
0.015	3.9	3.7	4.4	3.7	3.5	3.2	2.1
0.020	3.7	3.5	4.4	3.4	3.2	2.6	1.2
0.025	3.0	2.8	3.8	2.6	2.5	1.8	-0.1
0.050	-6.4	-6.9	-7.1	-7.1	-7.2	-8.1	-12.0
0.075	-20.5	-22.4	-22.7	-22.5	-22.8	-24.0	-28.7
0.100	-39.6	-41.1	-40.7	-41.4	-39.6	-43.0	-48.5
0.125	-59.5	-61.1	-60.8	-61.4	-59.0	-63.6	-69.2
0.150	-79.9	-81.8	-81.1	-81.8	-79.1	-84.0	-90.1
0.175	-103.4	-102.6	-102.1	-102.3	-99.1	-104.3	-111.3
0.200	-124.2	-123.5	-122.4	-122.9	-119.6	-124.9	-132.4
0.300	-203.5	-201.7	-201.4	-198.7	-197.9	-203.1	-210.5
0.400	-275.2	-271.7	-273.4	-270.7	-269.4	-273.3	-284.1

Table 2.8 -- Estimated equilibrium landings, revenue, cost, and profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to all gear (catch in 1,000 metric tons and $ in millions).

		Size limits in centimeters						
F		37	41	45	49	53	57	61
0.010	Catch	8.0	8.0	7.9	7.7	7.5	7.1	6.5
	Revenue	12.8	12.7	13.1	12.4	12.4	12.1	11.4
	Total cost	9.2	9.2	9.2	9.2	9.2	9.2	9.2
	Profit	3.5	3.5	3.9	3.2	3.2	2.9	2.1
0.015	Catch	11.3	11.2	11.1	10.9	10.5	10.0	9.1
	Revenue	17.7	17.5	18.2	17.5	17.3	17.0	15.9
	Total cost	13.8	13.8	13.8	13.8	13.8	13.8	13.8
	Profit	3.9	3.7	4.4	3.7	3.5	3.2	2.1
0.020	Catch	14.2	14.1	13.9	13.6	13.2	12.5	11.3
	Revenue	22.1	21.9	22.8	21.8	21.6	21.0	19.6
	Total cost	18.4	18.4	18.4	18.4	18.4	18.4	18.4
	Profit	3.7	3.5	4.4	3.4	3.2	2.6	1.2
0.025	Catch	16.8	16.6	16.4	16.1	15.5	14.7	13.2
	Revenue	25.9	25.7	26.8	25.6	25.4	24.7	22.8
	Total cost	22.9	22.9	22.9	22.9	22.9	22.9	22.9
	Profit	3.0	2.8	3.8	2.6	2.5	1.8	-0.1
0.050	Catch	25.8	25.4	25.0	24.4	23.5	22.4	19.3
	Revenue	38.8	38.3	38.2	38.1	38.1	37.2	33.3
	Total cost	45.3	45.3	45.3	45.3	45.3	45.3	45.3
	Profit	-6.4	-6.9	-7.1	-7.1	-7.2	-8.1	-12.0
0.075	Catch	31.0	30.2	29.8	29.1	27.8	26.3	22.2
	Revenue	46.6	44.7	44.4	44.6	44.3	43.1	38.4
	Total cost	67.1	67.1	67.1	67.1	67.1	67.1	67.1
	Profit	-20.5	-22.4	-22.7	-22.5	-22.8	-24.0	-28.7
0.100	Catch	33.8	32.8	32.3	31.4	31.0	28.4	23.3
	Revenue	48.8	47.3	47.7	47.0	48.8	45.4	39.9
	Total cost	88.4	88.4	88.4	88.4	88.4	88.4	88.4
	Profit	-39.6	-41.1	-40.7	-41.4	-39.6	-43.0	-48.5
0.125	Catch	35.4	34.2	33.5	32.7	32.3	28.8	23.4
	Revenue	49.7	48.0	48.4	47.8	50.2	45.6	39.9
	Total cost	109.2	109.2	109.2	109.2	109.2	109.2	109.2
	Profit	-59.5	-61.1	-60.8	-61.4	-59.0	-63.6	-69.2
0.150	Catch	36.3	34.8	34.1	33.2	32.8	29.1	23.1
	Revenue	49.5	47.7	48.3	47.6	50.4	45.5	39.3
	Total cost	129.4	129.4	129.4	129.4	129.4	129.4	129.4
	Profit	-79.9	-81.8	-81.1	-81.8	-79.1	-84.0	-90.1

Table 2.8 -- Continued.

0.175	Catch	35.4	34.7	33.9	33.4	32.9	28.6	22.3
	Revenue	45.8	46.7	47.1	46.9	50.1	44.9	37.9
	Total cost	149.2	149.2	149.2	149.2	149.2	149.2	149.2
	Profit	-103.4	-102.6	-102.1	-102.3	-99.1	-104.3	-111.3
0.200	Catch	35.3	34.4	34.0	33.1	32.5	28.3	21.7
	Revenue	44.4	45.0	46.2	45.6	48.9	43.6	36.2
	Total cost	168.5	168.5	168.5	168.5	168.5	168.5	168.5
	Profit	-124.2	-123.5	-122.4	-122.9	-119.6	-124.9	-132.4
0.300	Catch	33.3	32.9	31.1	32.5	30.6	25.0	18.5
	Revenue	37.7	39.5	39.8	42.5	43.3	38.1	30.7
	Total cost	241.2	241.2	241.2	241.2	241.2	241.2	241.2
	Profit	-203.5	-201.7	-201.4	-198.7	-197.9	-203.1	-210.5
0.400	Catch	31.1	28.3	29.7	29.4	27.4	24.0	15.4
	Revenue	31.9	35.4	33.7	36.4	37.7	33.8	23.0
	Total cost	307.1	307.1	307.1	307.1	307.1	307.1	307.1
	Profit	-275.2	-271.7	-273.4	-270.7	-269.4	-273.3	-284.1

Table 2.9 -- Estimated equilibrium number of vessels, catch per trip, and revenue per trip for the fixed gear fleet as a function of fixed gear F and a size limit applied to all gear (catch in 1,000 lbs. dressed and revenue in $1,000).

		Size limits in centimeters						
F		37	41	45	49	53	57	61
0.010	Vessels	30.9	30.9	30.9	30.9	30.9	30.9	30.9
	Pounds/trip	63.9	63.6	62.7	61.5	59.8	56.6	51.8
	Revenue/trip	68.7	68.5	70.7	67.0	66.8	65.3	61.3
0.015	Vessels	46.3	46.3	46.3	46.3	46.3	46.3	46.3
	Pounds/trip	60.2	59.6	59.0	58.0	55.9	53.2	48.3
	Revenue/trip	63.6	63.1	65.6	62.9	62.2	61.2	57.2
0.020	Vessels	61.6	61.6	61.6	61.6	61.6	61.6	61.6
	Pounds/trip	56.8	56.3	55.6	54.5	52.6	50.0	45.2
	Revenue/trip	59.7	59.3	61.7	58.9	58.5	56.9	53.0
0.025	Vessels	76.8	76.8	76.8	76.8	76.8	76.8	76.8
	Pounds/trip	53.8	53.2	52.6	51.5	49.7	47.2	42.2
	Revenue/trip	56.3	55.8	58.1	55.5	55.1	53.6	49.5
0.050	Vessels	151.7	151.7	151.7	151.7	151.7	151.7	151.7
	Pounds/trip	41.9	41.2	40.6	39.6	38.2	36.3	31.3
	Revenue/trip	42.7	42.1	42.0	41.9	41.8	40.9	36.6
0.075	Vessels	224.8	224.8	224.8	224.8	224.8	224.8	224.8
	Pounds/trip	33.9	33.1	32.6	31.9	30.4	28.8	24.4
	Revenue/trip	34.6	33.1	32.9	33.0	32.9	32.0	28.4
0.100	Vessels	296.1	296.1	296.1	296.1	296.1	296.1	296.1
	Pounds/trip	28.1	27.3	26.8	26.1	25.8	23.6	19.4
	Revenue/trip	27.5	26.6	26.8	26.5	27.5	25.6	22.4
0.125	Vessels	365.7	365.7	365.7	365.7	365.7	365.7	365.7
	Pounds/trip	23.8	23.0	22.5	22.0	21.7	19.4	15.7
	Revenue/trip	22.6	21.9	22.1	21.8	22.9	20.8	18.2
0.150	Vessels	433.7	433.7	433.7	433.7	433.7	433.7	433.7
	Pounds/trip	20.6	19.7	19.4	18.8	18.6	16.5	13.1
	Revenue/trip	19.0	18.3	18.6	18.3	19.4	17.5	15.1
0.175	Vessels	499.9	499.9	499.9	499.9	499.9	499.9	499.9
	Pounds/trip	17.4	17.1	16.7	16.4	16.2	14.1	11.0
	Revenue/trip	15.3	15.6	15.7	15.6	16.7	15.0	12.6

Table 2.9 -- Continued.

0.200	Vessels	564.6	564.6	564.6	564.6	564.6	564.6	564.6
	Pounds/trip	15.4	15.0	14.8	14.4	14.2	12.3	9.5
	Revenue/trip	13.1	13.3	13.6	13.5	14.4	12.9	10.7
0.300	Vessels	808.1	808.1	808.1	808.1	808.1	808.1	808.1
	Pounds/trip	10.1	10.0	9.5	9.9	9.3	7.6	5.6
	Revenue/trip	7.8	8.1	8.2	8.8	8.9	7.9	6.3
0.400	Vessels	1028.8	1028.8	1028.8	1028.8	1028.8	1028.8	1028.8
	Pounds/trip	7.4	6.8	7.1	7.0	6.6	5.7	3.7
	Revenue/trip	5.2	5.7	5.5	5.9	6.1	5.5	3.7

Table 2.10 -- Estimated potential equilibrium profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to all gear for different estimates of cost per unit of effort ($ millions).

Cost reduced by 75%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	10.4	10.4	10.8	10.1	10.1	9.8	9.1
0.015	14.2	14.1	14.8	14.0	13.8	13.5	12.4
0.020	17.5	17.3	18.2	17.2	17.0	16.4	15.0
0.025	20.2	20.0	21.0	19.8	19.7	18.9	17.1
0.050	27.5	27.0	26.9	26.8	26.8	25.9	22.0
0.075	29.8	27.9	27.6	27.8	27.5	26.4	21.6
0.100	26.7	25.2	25.6	24.9	26.7	23.3	17.8
0.125	22.4	20.7	21.1	20.5	22.9	18.3	12.6
0.150	17.1	15.3	16.0	15.3	18.0	13.1	7.0
0.175	8.5	9.3	9.8	9.6	12.8	7.6	0.6
0.200	2.2	2.9	4.0	3.5	6.8	1.5	-6.0
0.300	-22.6	-20.8	-20.5	-17.8	-17.0	-22.2	-29.6
0.400	-44.8	-41.4	-43.1	-40.4	-39.1	-43.0	-53.8

Cost reduced by 50%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	8.1	8.1	8.5	7.8	7.8	7.5	6.8
0.015	10.8	10.6	11.3	10.6	10.4	10.1	9.0
0.020	12.9	12.7	13.6	12.6	12.4	11.8	10.4
0.025	14.5	14.3	15.3	14.1	13.9	13.2	11.4
0.050	16.2	15.7	15.6	15.5	15.4	14.6	10.6
0.075	13.1	11.1	10.8	11.0	10.8	9.6	4.8
0.100	4.6	3.1	3.5	2.8	4.6	1.2	-4.3
0.125	-4.9	-6.5	-6.2	-6.8	-4.4	-9.0	-14.7
0.150	-15.2	-17.0	-16.4	-17.1	-14.4	-19.2	-25.4
0.175	-28.8	-28.0	-27.5	-27.7	-24.5	-29.7	-36.7
0.200	-39.9	-39.3	-38.1	-38.7	-35.3	-40.6	-48.1
0.300	-82.9	-81.1	-80.8	-78.1	-77.3	-82.5	-89.9
0.400	-121.6	-118.2	-119.9	-117.1	-115.9	-119.7	-130.5

Table 2.10 -- Continued.

Cost reduced by 25%

F	Size limits in centimeters 37	41	45	49	53	57	61
0.010	5.8	5.8	6.2	5.5	5.5	5.2	4.5
0.015	7.3	7.2	7.9	7.1	6.9	6.6	5.5
0.020	8.3	8.1	9.0	8.0	7.8	7.2	5.8
0.025	8.8	8.5	9.6	8.4	8.2	7.5	5.6
0.050	4.9	4.4	4.3	4.2	4.1	3.2	-0.7
0.075	-3.7	-5.6	-6.0	-5.8	-6.0	-7.2	-12.0
0.100	-17.5	-19.0	-18.6	-19.3	-17.5	-20.9	-26.4
0.125	-32.2	-33.8	-33.5	-34.1	-31.7	-36.3	-42.0
0.150	-47.6	-49.4	-48.8	-49.5	-46.7	-51.6	-57.8
0.175	-66.1	-65.3	-64.8	-65.0	-61.8	-67.0	-74.0
0.200	-82.1	-81.4	-80.2	-80.8	-77.5	-82.8	-90.2
0.300	-143.2	-141.4	-141.1	-138.4	-137.6	-142.8	-150.2
0.400	-198.4	-194.9	-196.6	-193.9	-192.6	-196.5	-207.3

Cost increased by 25%

F	Size limits in centimeters 37	41	45	49	53	57	61
0.010	1.2	1.2	1.6	0.9	0.9	0.6	-0.2
0.015	0.4	0.3	1.0	0.2	0.0	-0.3	-1.4
0.020	-0.9	-1.1	-0.2	-1.2	-1.4	-2.0	-3.4
0.025	-2.7	-2.9	-1.9	-3.1	-3.3	-4.0	-5.8
0.050	-17.8	-18.3	-18.4	-18.5	-18.5	-19.4	-23.3
0.075	-37.3	-39.2	-39.5	-39.3	-39.6	-40.7	-45.5
0.100	-61.7	-63.2	-62.8	-63.5	-61.7	-65.1	-70.6
0.125	-86.8	-88.4	-88.0	-88.7	-86.3	-90.9	-96.5
0.150	-112.3	-114.1	-113.5	-114.2	-111.4	-116.3	-122.5
0.175	-140.7	-139.9	-139.4	-139.6	-136.4	-141.6	-148.6
0.200	-166.3	-165.7	-164.5	-165.1	-161.7	-167.0	-174.5
0.300	-263.8	-262.0	-261.7	-259.0	-258.2	-263.4	-270.8
0.400	-351.9	-348.5	-350.2	-347.5	-346.2	-350.0	-360.9

Table 2.10 -- Continued.

Cost increased by 50%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	-1.1	-1.1	-0.7	-1.4	-1.5	-1.7	-2.5
0.015	-3.1	-3.2	-2.5	-3.3	-3.4	-3.7	-4.8
0.020	-5.5	-5.6	-4.8	-5.8	-6.0	-6.6	-8.0
0.025	-8.4	-8.7	-7.6	-8.8	-9.0	-9.7	-11.6
0.050	-29.1	-29.6	-29.7	-29.8	-29.8	-30.7	-34.6
0.075	-54.0	-56.0	-56.3	-56.1	-56.3	-57.5	-62.3
0.100	-83.8	-85.3	-84.9	-85.6	-83.8	-87.2	-92.7
0.125	-114.1	-115.7	-115.3	-116.0	-113.6	-118.2	-123.8
0.150	-144.7	-146.5	-145.8	-146.5	-143.8	-148.7	-154.9
0.175	-178.0	-177.2	-176.7	-177.0	-173.7	-179.0	-186.0
0.200	-208.5	-207.8	-206.6	-207.2	-203.9	-209.2	-216.6
0.300	-324.1	-322.3	-322.0	-319.3	-318.5	-323.7	-331.1
0.400	-428.7	-425.3	-427.0	-424.2	-422.9	-426.8	-437.6

Table 2.11 -- Estimated equilibrium reproductive potential index as a function of fixed gear F and a size limit applied to all gear.

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	100.0	100.1	100.0	100.1	100.7	100.6	100.3
0.015	93.2	92.8	93.1	93.5	93.5	93.9	93.5
0.020	86.8	86.6	86.8	87.1	87.3	87.9	87.3
0.025	81.1	80.9	81.1	81.4	81.7	82.4	81.5
0.050	58.9	58.5	58.8	59.3	59.9	61.0	59.6
0.075	44.1	43.7	44.1	44.8	45.1	46.5	45.4
0.100	33.8	33.3	33.7	34.3	36.0	36.6	35.1
0.125	26.3	26.0	26.2	26.8	28.7	28.9	27.8
0.150	20.9	20.4	20.9	21.2	22.9	23.5	22.5
0.175	16.3	16.2	16.7	17.3	19.0	19.6	18.4
0.200	13.2	12.9	13.4	14.2	15.4	16.1	15.4
0.300	7.0	7.1	7.6	8.5	9.3	9.5	10.0
0.400	3.0	3.1	3.5	5.3	4.6	5.1	6.9

Index is 100 for F of 0.01 and 37 cm.

Table 2.12 -- Estimated equilibrium biomass index as a function of fixed gear F and a size limit applied to all gear.

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	100.0	100.1	99.9	100.1	100.6	100.6	100.3
0.015	94.2	93.8	94.2	94.5	94.4	95.0	94.5
0.020	88.8	88.6	88.8	89.0	89.1	90.0	89.3
0.025	84.0	83.0	83.2	84.2	84.5	85.4	84.4
0.050	64.6	64.0	64.4	65.0	65.7	67.1	65.3
0.075	51.9	51.4	51.9	52.8	53.5	55.0	53.6
0.100	42.9	42.3	42.8	43.7	46.2	46.7	45.0
0.125	36.3	35.7	36.5	37.2	39.9	40.0	38.9
0.150	31.2	30.7	31.6	32.3	35.0	35.3	34.3
0.175	26.6	26.7	27.5	28.6	31.3	31.6	30.3
0.200	23.3	23.3	24.6	25.5	28.1	28.5	27.6
0.300	15.4	15.8	16.6	18.8	20.3	20.7	20.1
0.400	11.5	11.8	12.9	14.8	15.8	16.9	16.2

Index is 100 for F of 0.01 and 37 cm.

Table 2.13.--1986 Gulf of Alaska catch composition by market size categories and year.

Size (lbs,dressed)	Size (kg,round)	Length (cm)	Longline landings (cummulative percent)	Pot landings (cummulative percent)	Trawl landings (cummulative percent)
1	0.677	40.4	1.2	3.4	45.8
2	1.354	50.1	10.7	25.2	62.1
3	2.031	56.8	37.2	57.9	85.9
4	2.708	62.1	63.5	80.9	96.1
5	3.385	66.5	92.2	95.3	99.5
7	4.739	73.8	99.6	100.0	100.0
8	5.416	86.9	100.0		

Table 2.14 -- Estimated equilibrium yield as a function of fixed gear F and a size limit applied to fixed gear only (1,000 metric tons).

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	9.3	9.3	9.2	9.0	8.8	8.4	7.8
0.015	13.1	13.1	13.0	12.8	12.4	11.8	11.0
0.020	16.5	16.5	16.3	16.1	15.6	14.9	13.8
0.025	19.5	19.4	19.3	19.0	18.5	17.7	16.4
0.050	30.0	30.0	29.8	29.5	28.8	27.6	25.6
0.075	36.1	36.0	35.8	35.5	34.7	33.3	31.0
0.100	39.5	39.4	39.3	39.0	38.3	36.9	34.1
0.125	41.4	41.3	41.3	41.2	40.3	38.8	35.9
0.150	42.4	42.2	42.2	42.3	41.6	40.0	36.8
0.175	42.8	42.6	42.6	42.7	42.1	40.2	37.3
0.200	42.9	42.6	42.7	43.0	42.2	40.4	37.3
0.300	41.2	41.3	40.7	41.4	41.1	39.7	35.4
0.400	39.2	39.5	38.5	37.8	37.7	37.8	33.4

Table 2.15 -- Estimated equilibrium revenue as a function of fixed gear F and a size limit applied to fixed gear only ($ millions).

F		Size limits in centimeters 37	41	45	49	53	57	61
0.010	All gear	14.1	14.1	14.6	13.9	13.8	13.5	12.8
	Fixed gear	12.8	12.7	13.2	12.5	12.5	12.3	11.7
	Trawl gear	1.4	1.4	1.4	1.3	1.3	1.2	1.2
0.015	All gear	19.6	19.6	20.6	19.5	19.4	19.1	18.1
	Fixed gear	17.7	17.6	18.7	17.6	17.6	17.3	16.5
	Trawl gear	1.9	1.9	1.9	1.9	1.8	1.8	1.6
0.020	All gear	24.5	24.5	25.4	24.5	24.4	23.8	22.6
	Fixed gear	22.1	22.1	23.0	22.1	22.1	21.6	20.6
	Trawl gear	2.4	2.4	2.4	2.4	2.3	2.2	2.0
0.025	All gear	28.8	28.8	29.9	28.8	28.8	28.1	26.8
	Fixed gear	26.0	25.9	27.1	26.0	26.1	25.5	24.4
	Trawl gear	2.8	2.8	2.8	2.7	2.7	2.6	2.4
0.050	All gear	43.2	43.3	43.5	43.8	44.2	43.4	41.7
	Fixed gear	39.0	39.1	39.3	39.6	40.1	39.4	38.0
	Trawl gear	4.2	4.2	4.2	4.2	4.1	4.0	3.7
0.075	All gear	51.8	50.6	51.0	51.7	52.6	51.8	50.1
	Fixed gear	46.8	45.6	46.1	46.8	47.7	47.0	45.7
	Trawl gear	5.0	5.0	4.9	4.9	4.9	4.7	4.4
0.100	All gear	54.4	54.3	54.6	55.7	57.2	56.5	54.9
	Fixed gear	49.1	49.0	49.3	50.4	51.9	51.3	50.1
	Trawl gear	5.3	5.3	5.3	5.3	5.3	5.2	4.8
0.125	All gear	54.7	54.7	56.1	56.7	58.6	58.4	57.5
	Fixed gear	50.1	50.1	51.6	52.0	54.1	52.9	52.6
	Trawl gear	4.6	4.6	4.6	4.6	4.6	5.4	5.0
0.150	All gear	54.5	54.7	56.3	57.1	59.5	58.5	58.9
	Fixed gear	49.9	50.1	51.8	52.5	55.0	53.9	53.8
	Trawl gear	4.6	4.5	4.5	4.6	4.6	4.5	5.0
0.175	All gear	52.3	53.9	55.8	56.8	59.6	58.7	58.5
	Fixed gear	47.9	49.5	51.3	52.2	55.1	54.2	54.2
	Trawl gear	4.5	4.4	4.4	4.5	4.5	4.5	4.3
0.200	All gear	50.9	52.7	54.7	55.9	59.3	58.4	58.5
	Fixed gear	46.6	48.4	50.3	51.5	54.8	54.0	54.2
	Trawl gear	4.3	4.3	4.4	4.5	4.5	4.4	4.2
0.300	All gear	44.1	47.2	49.0	51.1	54.1	54.8	54.7
	Fixed gear	40.6	43.1	45.4	46.9	50.2	50.7	50.9
	Trawl gear	3.5	4.1	3.6	4.3	3.9	4.1	3.8
0.400	All gear	38.7	42.8	41.7	44.5	49.8	50.0	46.0
	Fixed gear	35.1	39.2	38.0	40.7	46.0	46.5	42.6
	Trawl gear	3.6	3.7	3.7	3.8	3.9	3.5	3.4

Table 2.16 -- Estimated potential equilibrium profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to fixed gear only ($ million).

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	3.5	3.5	4.0	3.3	3.2	3.0	2.4
0.015	3.9	3.8	4.9	3.8	3.8	3.5	2.7
0.020	3.7	3.7	4.7	3.7	3.7	3.2	2.2
0.025	3.1	3.0	4.2	3.1	3.2	2.6	1.5
0.050	-6.3	-6.2	-6.0	-5.7	-5.2	-5.9	-7.3
0.075	-20.3	-21.5	-21.0	-20.3	-19.4	-20.1	-21.4
0.100	-39.3	-39.4	-39.1	-38.0	-36.5	-37.1	-38.2
0.125	-59.1	-59.1	-57.6	-57.1	-55.1	-56.2	-56.6
0.150	-79.5	-79.3	-77.7	-76.9	-74.5	-75.5	-75.6
0.175	-101.4	-99.8	-97.9	-97.0	-94.1	-95.0	-95.0
0.200	-121.9	-120.1	-118.2	-117.0	-113.8	-114.6	-114.3
0.300	-200.6	-198.1	-195.8	-194.3	-191.0	-190.5	-190.3
0.400	-272.0	-267.9	-269.1	-266.4	-261.1	-260.6	-264.5

Table 2.17 -- Estimated equilibrium landings, revenue, cost, and profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to fixed gear only (catch in 1,000 metric tons and $ in millions).

		Size limits in centimeters						
F		37	41	45	49	53	57	61
0.010	Catch	8.0	8.0	7.9	7.8	7.6	7.2	6.7
	Revenue	12.8	12.7	13.2	12.5	12.5	12.3	11.7
	Total cost	9.2	9.2	9.2	9.2	9.2	9.2	9.2
	Profit	3.5	3.5	4.0	3.3	3.2	3.0	2.4
0.015	Catch	11.3	11.3	11.2	11.0	10.7	10.2	9.5
	Revenue	17.7	17.6	18.7	17.6	17.6	17.3	16.5
	Total cost	13.8	13.8	13.8	13.8	13.8	13.8	13.8
	Profit	3.9	3.8	4.9	3.8	3.8	3.5	2.7
0.020	Catch	14.2	14.2	14.1	13.8	13.5	12.9	11.9
	Revenue	22.1	22.1	23.0	22.1	22.1	21.6	20.6
	Total cost	18.4	18.4	18.4	18.4	18.4	18.4	18.4
	Profit	3.7	3.7	4.7	3.7	3.7	3.2	2.2
0.025	Catch	16.8	16.7	16.6	16.4	15.9	15.2	14.1
	Revenue	26.0	25.9	27.1	26.0	26.1	25.5	24.4
	Total cost	22.9	22.9	22.9	22.9	22.9	22.9	22.9
	Profit	3.1	3.0	4.2	3.1	3.2	2.6	1.5
0.050	Catch	25.9	25.8	25.7	25.4	24.8	23.7	22.0
	Revenue	39.0	39.1	39.3	39.6	40.1	39.4	38.0
	Total cost	45.3	45.3	45.3	45.3	45.3	45.3	45.3
	Profit	-6.3	-6.2	-6.0	-5.7	-5.2	-5.9	-7.3
0.075	Catch	31.1	31.0	30.9	30.5	29.9	28.7	26.7
	Revenue	46.8	45.6	46.1	46.8	47.7	47.0	45.7
	Total cost	67.1	67.1	67.1	67.1	67.1	67.1	67.1
	Profit	-20.3	-21.5	-21.0	-20.3	-19.4	-20.1	-21.4
0.100	Catch	34.0	33.9	33.9	33.6	33.0	31.8	29.4
	Revenue	49.1	49.0	49.3	50.4	51.9	51.3	50.1
	Total cost	88.4	88.4	88.4	88.4	88.4	88.4	88.4
	Profit	-39.3	-39.4	-39.1	-38.0	-36.5	-37.1	-38.2
0.125	Catch	35.7	35.6	35.5	35.5	34.8	33.4	30.9
	Revenue	50.1	50.1	51.6	52.0	54.1	52.9	52.6
	Total cost	109.2	109.2	109.2	109.2	109.2	109.2	109.2
	Profit	-59.1	-59.1	-57.6	-57.1	-55.1	-56.2	-56.6
0.150	Catch	36.5	36.4	36.4	36.4	35.8	34.5	31.7
	Revenue	49.9	50.1	51.8	52.5	55.0	53.9	53.8
	Total cost	129.4	129.4	129.4	129.4	129.4	129.4	129.4
	Profit	-79.5	-79.3	-77.7	-76.9	-74.5	-75.5	-75.6

Table 2.17 -- Continued.

0.175	Catch	36.8	36.7	36.7	36.8	36.3	34.6	32.1
	Revenue	47.9	49.5	51.3	52.2	55.1	54.2	54.2
	Total cost	149.2	149.2	149.2	149.2	149.2	149.2	149.2
	Profit	-101.4	-99.8	-97.9	-97.0	-94.1	-95.0	-95.0
0.200	Catch	36.9	36.7	36.8	37.0	36.4	34.8	32.1
	Revenue	46.6	48.4	50.3	51.5	54.8	54.0	54.2
	Total cost	168.5	168.5	168.5	168.5	168.5	168.5	168.5
	Profit	-121.9	-120.1	-118.2	-117.0	-113.8	-114.6	-114.3
0.300	Catch	35.5	35.6	35.1	35.7	35.4	34.2	30.5
	Revenue	40.6	43.1	45.4	46.9	50.2	50.7	50.9
	Total cost	241.2	241.2	241.2	241.2	241.2	241.2	241.2
	Profit	-200.6	-198.1	-195.8	-194.3	-191.0	-190.5	-190.3
0.400	Catch	33.7	34.0	33.1	32.6	32.4	32.8	28.8
	Revenue	35.1	39.2	38.0	40.7	46.0	46.5	42.6
	Total cost	307.1	307.1	307.1	307.1	307.1	307.1	307.1
	Profit	-272.0	-267.9	-269.1	-266.4	-261.1	-260.6	-264.5

Table 2.18 -- Estimated equilibrium number of vessels, catch per trip, and revenue per trip for the fixed gear fleet as a function of fixed gear F and a size limit applied to fixed gear only (catch in 1,000 lbs. dressed and revenue in $1,000).

		Size limits in centimeters						
F		37	41	45	49	53	57	61
0.010	Vessels	30.9	30.9	30.9	30.9	30.9	30.9	30.9
	Pounds/trip	63.9	63.6	63.0	61.9	60.2	57.4	53.1
	Revenue/trip	68.7	68.5	71.1	67.5	67.2	66.2	62.9
0.015	Vessels	46.3	46.3	46.3	46.3	46.3	46.3	46.3
	Pounds/trip	60.2	60.0	59.5	58.5	56.8	54.3	50.3
	Revenue/trip	63.6	63.5	67.3	63.5	63.3	62.4	59.5
0.020	Vessels	61.6	61.6	61.6	61.6	61.6	61.6	61.6
	Pounds/trip	56.9	56.7	56.3	55.3	53.8	51.4	47.6
	Revenue/trip	59.8	59.8	62.4	59.8	59.8	58.4	55.8
0.025	Vessels	76.8	76.8	76.8	76.8	76.8	76.8	76.8
	Pounds/trip	53.9	53.7	53.3	52.5	51.1	48.8	45.3
	Revenue/trip	56.4	56.3	58.9	56.5	56.6	55.3	52.9
0.050	Vessels	151.7	151.7	151.7	151.7	151.7	151.7	151.7
	Pounds/trip	42.0	41.9	41.7	41.2	40.2	38.5	35.7
	Revenue/trip	42.8	42.9	43.2	43.5	44.0	43.3	41.7
0.075	Vessels	224.8	224.8	224.8	224.8	224.8	224.8	224.8
	Pounds/trip	34.0	33.9	33.8	33.4	32.7	31.5	29.2
	Revenue/trip	34.7	33.8	34.2	34.7	35.4	34.9	33.9
0.100	Vessels	296.1	296.1	296.1	296.1	296.1	296.1	296.1
	Pounds/trip	28.3	28.2	28.2	27.9	27.4	26.4	24.4
	Revenue/trip	27.6	27.6	27.7	28.4	29.2	28.9	28.2
0.125	Vessels	365.7	365.7	365.7	365.7	365.7	365.7	365.7
	Pounds/trip	24.0	24.0	23.9	23.9	23.4	22.5	20.8
	Revenue/trip	22.8	22.8	23.5	23.7	24.6	24.1	24.0
0.150	Vessels	433.7	433.7	433.7	433.7	433.7	433.7	433.7
	Pounds/trip	20.7	20.7	20.6	20.7	20.3	19.6	18.0
	Revenue/trip	19.2	19.3	19.9	20.2	21.1	20.7	20.7
0.175	Vessels	499.9	499.9	499.9	499.9	499.9	499.9	499.9
	Pounds/trip	18.1	18.1	18.1	18.1	17.9	17.1	15.8
	Revenue/trip	16.0	16.5	17.1	17.4	18.4	18.1	18.1
0.200	Vessels	564.6	564.6	564.6	564.6	564.6	564.6	564.6
	Pounds/trip	16.1	16.0	16.0	16.1	15.9	15.2	14.0
	Revenue/trip	13.8	14.3	14.9	15.2	16.2	15.9	16.0

Table 2.18 -- Continued.

0.300	Vessels	808.1	808.1	808.1	808.1	808.1	808.1	808.1
	Pounds/trip	10.8	10.8	10.7	10.9	10.8	10.4	9.3
	Revenue/trip	8.4	8.9	9.4	9.7	10.4	10.5	10.5
0.400	Vessels	1028.8	1028.8	1028.8	1028.8	1028.8	1028.8	1028.8
	Pounds/trip	8.1	8.1	7.9	7.8	7.8	7.8	6.9
	Revenue/trip	5.7	6.3	6.2	6.6	7.4	7.5	6.9

Table 2.19 -- Estimated potential equilibrium profit for the fixed gear fleet as a function of fixed gear F and a size limit applied to fixed year only for different estimates of cost per unit of effort ($ millions).

Cost reduced by 75%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	10.5	10.4	10.9	10.2	10.2	10.0	9.4
0.015	14.2	14.2	15.2	14.2	14.1	13.9	13.1
0.020	17.5	17.5	18.5	17.5	17.5	17.0	16.0
0.025	20.3	20.2	21.4	20.3	20.3	19.8	18.7
0.050	27.6	27.7	28.0	28.3	28.8	28.1	26.7
0.075	30.0	28.9	29.3	30.0	31.0	30.3	28.9
0.100	27.0	26.9	27.2	28.3	29.8	29.2	28.0
0.125	22.8	22.8	24.3	24.7	26.8	25.6	25.3
0.150	17.6	17.8	19.4	20.2	22.6	21.6	21.5
0.175	10.6	12.2	14.0	14.9	17.8	16.9	16.9
0.200	4.5	6.3	8.2	9.4	12.7	11.8	12.1
0.300	-19.7	-17.2	-14.9	-13.4	-10.1	-9.6	-9.4
0.400	-41.7	-37.6	-38.8	-36.1	-30.8	-30.3	-34.2

Cost reduced by 50%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	8.1	8.1	8.6	7.9	7.9	7.7	7.1
0.015	10.8	10.7	11.8	10.7	10.7	10.4	9.6
0.020	12.9	12.9	13.9	12.9	12.9	12.4	11.4
0.025	14.5	14.5	15.7	14.6	14.6	14.0	12.9
0.050	16.3	16.4	16.7	17.0	17.4	16.8	15.4
0.075	13.2	12.1	12.5	13.2	14.2	13.5	12.2
0.100	4.9	4.8	5.1	6.2	7.7	7.1	5.9
0.125	-4.5	-4.5	-3.0	-2.5	-0.5	-1.7	-2.0
0.150	-14.8	-14.6	-12.9	-12.2	-9.8	-10.8	-10.9
0.175	-26.7	-25.2	-23.3	-22.4	-19.5	-20.4	-20.4
0.200	-37.6	-35.8	-33.9	-32.8	-29.5	-30.3	-30.1
0.300	-80.0	-77.5	-75.2	-73.7	-70.4	-69.9	-69.7
0.400	-118.4	-114.4	-115.5	-112.8	-107.6	-107.1	-110.9

Table 2.19 -- Continued.

Cost reduced by 25%

F	Size limits in centimeters 37	41	45	49	53	57	61
0.010	5.8	5.8	6.3	5.6	5.5	5.4	4.7
0.015	7.3	7.3	8.3	7.3	7.2	7.0	6.1
0.020	8.3	8.3	9.3	8.3	8.3	7.8	6.8
0.025	8.8	8.8	10.0	8.9	8.9	8.3	7.2
0.050	5.0	5.1	5.3	5.7	6.1	5.5	4.0
0.075	-3.5	-4.7	-4.3	-3.5	-2.6	-3.3	-4.6
0.100	-17.2	-17.3	-17.0	-15.9	-14.4	-15.0	-16.2
0.125	-31.8	-31.8	-30.3	-29.8	-27.8	-29.0	-29.3
0.150	-47.1	-46.9	-45.3	-44.6	-42.1	-43.2	-43.3
0.175	-64.1	-62.5	-60.6	-59.7	-56.8	-57.7	-57.7
0.200	-79.8	-78.0	-76.1	-74.9	-71.6	-72.4	-72.2
0.300	-140.3	-137.8	-135.5	-134.0	-130.7	-130.2	-130.0
0.400	-195.2	-191.2	-192.3	-189.6	-184.3	-183.9	-187.7

Cost increased by 25%

F	Size limits in centimeters 37	41	45	49	53	57	61
0.010	1.2	1.2	1.6	1.0	0.9	0.7	0.1
0.015	0.4	0.4	1.4	0.4	0.3	0.1	-0.8
0.020	-0.9	-0.9	0.1	-0.9	-0.9	-1.4	-2.4
0.025	-2.7	-2.7	-1.5	-2.6	-2.6	-3.2	-4.3
0.050	-17.6	-17.5	-17.3	-17.0	-16.5	-17.2	-18.6
0.075	-37.1	-38.2	-37.8	-37.1	-36.1	-36.8	-38.2
0.100	-61.4	-61.5	-61.2	-60.1	-58.6	-59.2	-60.3
0.125	-86.4	-86.4	-84.9	-84.4	-82.4	-83.5	-83.9
0.150	-111.9	-111.7	-110.0	-109.3	-106.8	-107.9	-108.0
0.175	-138.7	-137.1	-135.2	-134.3	-131.4	-132.3	-132.3
0.200	-164.1	-162.2	-160.3	-159.2	-155.9	-156.7	-156.5
0.300	-260.9	-258.4	-256.1	-254.6	-251.3	-250.8	-250.6
0.400	-348.7	-344.7	-345.9	-343.2	-337.9	-337.4	-341.3

Table 2.19 -- Continued.

Cost increased by 50%

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	-1.1	-1.1	-0.7	-1.3	-1.4	-1.6	-2.2
0.015	-3.1	-3.1	-2.0	-3.1	-3.1	-3.4	-4.2
0.020	-5.5	-5.5	-4.5	-5.5	-5.5	-6.0	-7.0
0.025	-8.4	-8.4	-7.2	-8.3	-8.3	-8.9	-10.0
0.050	-29.0	-28.9	-28.6	-28.3	-27.8	-28.5	-29.9
0.075	-53.9	-55.0	-54.6	-53.9	-52.9	-53.6	-54.9
0.100	-83.5	-83.6	-83.3	-82.2	-80.7	-81.3	-82.4
0.125	-113.7	-113.7	-112.2	-111.7	-109.7	-110.8	-111.2
0.150	-144.2	-144.0	-142.4	-141.6	-139.2	-140.3	-140.3
0.175	-176.0	-174.4	-172.5	-171.6	-168.7	-169.6	-169.6
0.200	-206.2	-204.4	-202.5	-201.3	-198.0	-198.8	-198.6
0.300	-321.2	-318.7	-316.4	-314.9	-311.6	-311.1	-310.9
0.400	-425.5	-421.5	-422.6	-419.9	-414.7	-414.2	-418.0

Table 2.20 -- Estimated equilibrium reproductive potential index as a function of fixed gear F and a size limit applied to fixed gear only.

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	100.0	100.1	100.4	100.7	101.1	101.6	102.2
0.015	93.1	93.3	93.7	94.2	94.7	95.4	96.2
0.020	86.9	87.1	87.6	88.1	88.8	89.7	90.8
0.025	81.2	81.5	82.0	82.7	83.5	84.5	85.8
0.050	59.1	59.4	60.2	61.2	62.4	63.9	65.9
0.075	44.2	44.7	45.5	46.7	48.0	49.9	52.3
0.100	33.9	34.4	35.3	36.5	37.9	40.0	42.3
0.125	26.5	27.0	27.8	29.0	30.6	32.7	34.8
0.150	21.1	21.4	22.3	23.1	24.8	27.0	29.0
0.175	17.0	17.2	18.1	18.9	20.8	23.0	24.7
0.200	13.8	13.9	14.8	15.9	17.1	19.4	21.2
0.300	7.5	7.8	8.7	9.3	10.6	12.1	15.2
0.400	3.4	3.5	4.0	6.0	5.7	6.9	11.5

The index is 100 for F of 0.01 and 37 cm.

Table 2.21 -- Estimated equilibrium biomass index as a function of fixed gear F and a size limit applied to fixed gear only.

	Size limits in centimeters						
F	37	41	45	49	53	57	61
0.010	100.0	100.1	100.5	100.8	101.2	101.9	102.6
0.015	94.2	94.4	94.8	95.3	95.9	96.8	97.9
0.020	88.9	89.2	89.8	90.3	91.1	92.2	93.6
0.025	84.1	83.7	84.3	85.8	86.7	88.0	89.7
0.050	64.7	65.2	66.1	67.3	68.8	70.7	73.1
0.075	52.1	52.6	53.7	55.2	57.0	59.3	62.2
0.100	43.1	43.6	44.8	46.5	48.6	51.1	54.3
0.125	36.5	37.0	38.3	40.1	42.4	44.9	48.3
0.150	31.4	31.9	33.5	35.1	37.6	40.1	43.7
0.175	27.6	28.0	29.6	31.2	33.8	36.3	40.0
0.200	24.3	24.8	26.4	28.1	30.7	33.4	37.0
0.300	16.4	16.9	18.3	20.1	22.6	25.3	29.0
0.400	12.2	12.8	14.1	16.0	18.4	21.1	24.4

The index is 100 for F of 0.01 and 37 cm,