Alaska Spotlight Article

The Economics of Bycatch and Bycatch Management in the U.S. EEZ Groundfish Fisheries off Alaska

Introduction

In response to concerns about the levels of bycatch in the Bering Sea/Aleutian Islands (BSAI) area and Gulf of Alaska (GOA) groundfish fisheries, the North Pacific Fishery Management Council (NPFMC) has recommended and the Secretary of Commerce has approved and implemented a variety of management actions that are intended to help control the bycatch of Pacific halibut, crab, herring, and salmon in the groundfish fisheries. Recently, the bycatch of groundfish in the groundfish fisheries and the bycatch of crab in the BSAI area crab fisheries have also received increased attention. Of the 34 amendments to the BSAI groundfish fishery management plan (FMP) that have been considered by the NPFMC since 1982, 13 addressed primarily bycatch issues and 9 additional amendments addressed some aspect of bycatch management.

This spotlight article presents a conceptual framework that can be used to understand the nature and source of the bycatch problem and to evaluate alternative management measures to control bycatch. It also identifies bycatch management measures that have been used to control bycatch in groundfish fisheries within the U.S. Exclusive Economic Zone (EEZ) off Alaska, with an emphasis on the BSAI area fisheries. These are open-access fisheries in which quotas are used to control total catch (i.e., retained and discarded catch) by groundfish species or species group.

The Nature and Sources of the Bycatch Problem

The nature and sources of the bycatch problem are explained by the answers to the following five questions: 1) What is bycatch? 2) Why does bycatch occur? 3) When is bycatch a problem? 4) What is the appropriate level of bycatch? (5) Why are there currently excessive levels of bycatch? Each question is answered in detail below.

What is Bycatch?

Bycatch, or more specifically bycatch mortality, is a consumptive use of living marine resources (LMR's) which includes most of the components of total fishing mortality. The components of total fishing mortality include: 1) the retained catch of the targeted species, 2) the retained catch of nontargeted species, 3) the discarded catch that does not survive, 4) mortality resulting from lost fishing gear (i.e., ghost fishing), and 5) mortality resulting from other direct interactions between fish and fishermen, fishing vessels, or fishing gear. Often, it is difficult to obtain good estimates for the amount of retained catch, and it is even more difficult to generate good estimates for the other components of fishing mortality. In addition, it is often difficult to differentiate between targeted and nontargeted species.

Bycatch mortality clearly includes the discarded catch that does not survive and excludes the retained catch of the targeted species. Although there is no general agreement concerning whether bycatch mortality should include the other three components of fishing mortality listed above, they are included as bycatch in this report. Therefore, bycatch mortality is defined as the total fishing mortality excluding that accounted for directly by the retained catch of the targeted species. The components of fishing mortality included in this definition of bycatch are by-products of efforts to catch specific fish that will be retained. That is, the objective of fishermen is

to catch and retain specific groups of fish defined by species, size, quality, sex, or usability, but in doing so they also inflict fishing mortality on other groups of fish.

With a narrower definition of bycatch, bycatch could be reduced without decreasing the fishing mortality not accounted for by the retained catch of the targeted species. That is, one of the by-product components of fishing mortality might simply be replaced by another. The distinction is made between bycatch and bycatch mortality because not all of the former results in fishing mortality. This distinction is important in that it identifies reductions in the handling or discard mortality rates as a potential method of reducing discards as a source of fishing mortality. This distinction is made for the halibut bycatch limits that are used in the BSAI area and GOA groundfish fisheries. The limits, which are in terms of estimated bycatch mortality, have resulted in effective efforts to decrease both incidental catch rates and discard mortality rates. For purposes of this discussion, bycatch mortality will be referred to simply as bycatch.

Why Does Bycatch Occur?

Bycatch occurs because fishing methods are not perfectly selective and because fishermen often have a sufficient incentive to catch more fish than will be retained. Although some methods of fishing are more selective than others, there are few examples of methods that are perfectly selective for species, size, quality, or sex. An incentive exists to catch more fish than will be retained if the fisherman's cost of the additional catch is less than the expected benefit; the latter depends on the probability that the catch will be retained.

When is Bycatch a Problem?

When fish are taken as bycatch in a specific fishing operation and fishery, other uses of those fish are precluded. The alternative uses of fish include: 1) retained target catch by that fishing operation, 2) catch and bycatch in the same commercial fishery but by another fishing operation, 3) catch and bycatch in another commercial fishery, 4) catch and bycatch in subsistence and recreational fisheries, and 5) contributions to the stock and other components of the ecosystem.

The value to the Nation of a specific use of fish is determined by the net benefit of that use and by the distribution of the net benefit. The net benefit of a use is the difference between the value of the outputs from that use and the value of all the inputs associated with that use. The inputs used in a commercial fishery include fish taken as target catch and bycatch; other LMR's; the fishing vessels, gear, and bait used in harvesting; the plants or vessels, equipment, and materials used for processing; the fuel and labor used throughout the production process, and all the inputs used to manage the commercial fishery. The cost of each input should be measured in terms of its opportunity cost, which is its value in its highest valued alternative use.

Bycatch is a problem if it precludes higher-valued uses of fish and if the cost of reducing bycatch is significant. If the former condition is not met, there is not a better use of the fish taken as bycatch. If the latter condition is not met and if higher-valued uses exist, the solution to the problem is trivial: all bycatch would be eliminated at an insignificant cost. Bycatch can also be a problem if it significantly increases the difficulty of monitoring and controlling total fishing mortality.

What is the Appropriate Level of Bycatch?

Basically, it makes sense to reduce bycatch in a cost-effective manner to the level at which further reductions would increase costs more than benefits. Both costs and benefits should be defined broadly from the Nation's perspective to include those that accrue to direct and indirect participants in the fishery as well as to other members of society. Those who harvest or process fish, those who provide support services to the harvesting and processing sectors of the fishing industry, and consumers of the fishery products are examples of direct and indirect participants in the fishery and of other members of society, respectively. "Cost-effective" refers to the lowest cost method of achieving a given reduction in the level of bycatch.

The hypothetical marginal benefit and marginal cost curves in Figure 1 present graphically the concept of the optimum level of bycatch. The marginal benefit and cost curves, respectively, depict the benefit and cost of reducing bycatch by

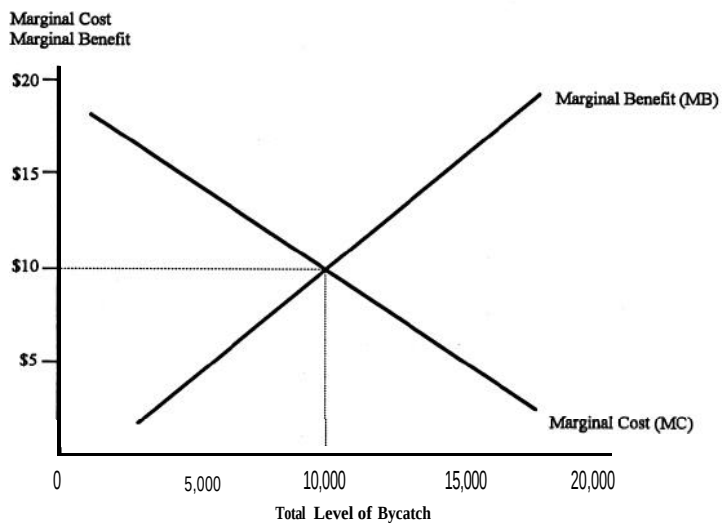

Figure 1
The marginal benefit and marginal cost of reducing bycatch and the optimum level of bycatch.

one unit for a given level of bycatch. For example, when the level of bycatch is 5,000 units, the marginal cost is about $15 and the marginal benetit is about $4. One unit would be one fish if bycatch is measured in the number of fish taken as bycatch, or one unit would be 1 metric ton if bycatch is measured in metric tons. For the groundfish fisheries, the salmon and crab bycatch is measured in numbers of salmon and crab, respectively, but halibut, herring, and groundfish bycatch is measured by weight, usually in metric tons or kilograms.

The following two definitions can be used to ensure that each change in benefits and costs is accounted for in either the marginal benefit or marginal cost curve but not in both. First, marginal benefit equals the sum of the increases in benefits and the decreases in costs of a reduction in bycatch. Second, marginal cost equals the sum of the increases in costs and decreases in benefits of a reduction in bycatch. Other definitions can be used to assure that all benefits and costs are accounted for once, but only once, without changing the conclusions presented below.

Given these two definitions, marginal benefit includes the decrease in the total opportunity cost of using fish as bycatch, the decrease in the cost of sorting the catch, and any other decrease in fishing costs. Marginal cost includes the increase in fishing costs and the decrease in benefits from any reduction in retained catch.

The marginal benefit is expected to increase, but not necessarily steadily, as bycatch increases. At very low levels of bycatch, most of the fishing mortality of the species taken as bycatch is accounted for by other uses and the value of some of the other uses probably are quite low; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are low. However, at very high levels of bycatch, much of the fishing mortality is accounted for by bycatch and the lower valued uses would have been eliminated; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are high.

The opposite trend is expected for marginal cost; that is, marginal cost is expected to decrease, but again not necessarily steadily, as bycatch increases. When there are high levels of bycatch and little has been done to control bycatch, there are probably some simple and low-cost actions that can be taken to reduce bycatch. Eventually however, increasingly difficult and often very costly methods would be necessary to eliminate the last few units of bycatch.

If the marginal benefit and cost curves include all the benefits and costs to the Nation, the optimum level of bycatch, in terms of total net economic benefits, is the level at which marginal cost and marginal benefit are equal. In the hypothetical example depicted in Figure 1, marginal cost and marginal benefit both equal $10 when bycatch equals 10,000 units. At lower levels of bycatch, the marginal cost of reducing bycatch is greater than $10 and the marginal benefit is less than $10; therefore, reducing bycatch below 10,000 units would decrease net benefit. However, at higher levels of bycatch, the marginal cost is less than $10 and the marginal benefit is greater than $10; therefore, net benefit would be increased by decreasing bycatch.

The implications of not using cost-effective methods of controlling bycatch are depicted in Figure 2. Curves MC1 and MC2 in Figure 2, respectively, are the marginal cost curves when cost-effective methods are and are not used. In this example, the optimum level of bycatch is 10,000 units when the cost-effective methods are used, but it is 15,000 units when they are not used. This discussion illustrates the critical role of technology in determining the optimal levels of bycatch reduction.

Why are There Currently Excessive Levels of Bycatch?

A common response to this question is that greed or lack of concern by the fishermen results in excessive bycatch. Perhaps a more productive response is that excessive bycatch is but one symptom of flawed fisheries management which substantially reduces the net economic benefits generated by the commercial fisheries.

More specifically, excessive bycatch is the result of the following set of circumstances: 1) the level of bycatch and the methods used to reduce bycatch are determined by individual fishermen in response to a variety of incentives and constraints that reflect the economic, social, regulatory, biological, and physical environments in which they operate, 2) an individual fisherman will tend to control bycatch up to the point where further changes would increase his cost more than his benefit, 3) a fisherman will define cost-effective methods of reducing bycatch in terms of the costs he pays, 4) the fisherman's benefit from reducing his bycatch is less than society's; and 5) in an open-access fishery for which there is a quota, the fisherman's cost of reducing his bycatch is greater than society's. These circumstances result in an individual fisherman making inadequate and noncost-effective efforts to control bycatch. Basically, due to the existence of external benefits and costs, individual fishermen receive the wrong signals or incentives and make the wrong decisions from society's perspective, as well as from the perspective of the fishermen as a group. There are external benefits (costs) when there are differences between the benefits (costs) to the fisherman and to society as a whole associated with an action taken by a fisherman.

This set of circumstances and the results are depicted by curves MBF, MBS, MCF, and MCS in Figure 3, which are, respectively, the marginal benefit curves for a fisherman and for society at large including the fisherman, and the corresponding marginal cost curves. In this case, the marginal cost and benefit are for a one-unit reduction in bycatch by a specific fisherman or fishing operation.

The MBS curve includes the reduction in the opportunity cost of using fish as bycatch and the decrease in sorting cost for the fisherman. However, because the fisherman does not pay the opportunity cost of the bycatch, the MBF curve includes principally the reduction in sorting cost.

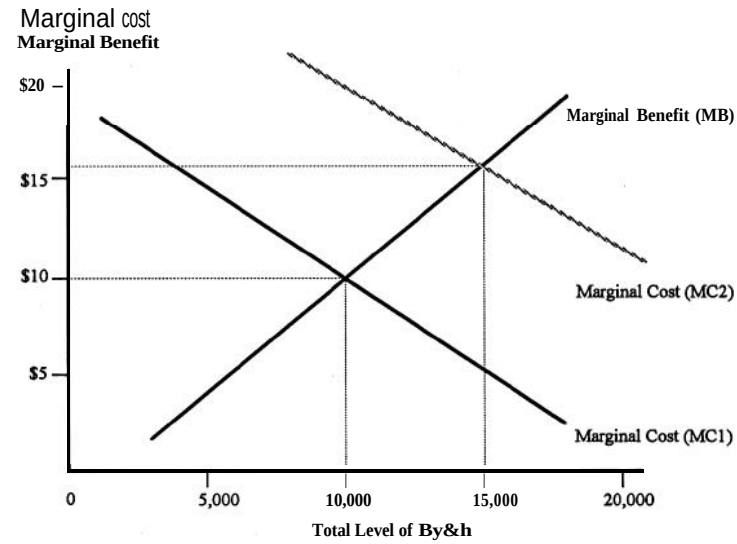

Figure 2
The marginal benefit (MB), marginal cost of reducing bycatch with cost-effective methods **(MCl),** marginal cost of reducing bycatch without cost-effective methods **(MC2),** and the optimum levels of bycatch with and without cost-effective methods of reducing bycatch.

That is, because the opportunity cost of bycatch is an external cost, the MBS curve is above the MBF curve.

In an open-access fishery with a catch quota, the MCF curve is above the MCS curve due to the external cost caused by the race for fish. This externality exists because, although the cost to the fisherman includes a reduction in his catch if his attempts to reduce bycatch decrease his rate of harvest relative to that of the rest of the fleet, the reduction in the fisherman's catch is not a cost to society. For the fleet as a whole, there is a redistribution of catch among fishermen, not a reduction in catch. This externality also results in a fisherman selecting methods to control bycatch that are not cost-effective from society's perspective. The externality does this by creating a bias in favor of methods that do not decrease a fisherman's catch. As a result of noncost-effective methods being used by fishermen to reduce bycatch, the MCS curve is higher than it would otherwise be.

From the fisherman's perspective, it makes sense to control bycatch to the point at which the MBF and MCF curves intersect. For the hypothetical example depicted in Figure 3, the MBF and MCF curves intersect when bycatch for this one fishing operation is about 285 units. However, the

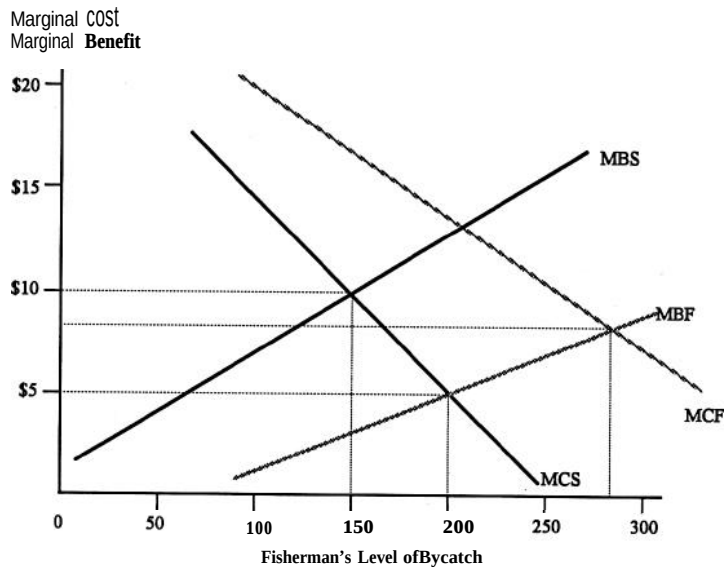

Figure 3
The marginal benefit to the fisherman (MBF), marginal benefit to society including the fisherman (MBS), marginal cost to the fisherman (MCF), marginal cost to society (MCS) of reducing bycatch, and the optimum levels of bycatch, respectively, for the fisherman and for society.

MBS and MCS curves intersect when bycatch is 150 units. Therefore, in this example, the optimum level to the fisherman exceeds the optimum level to society by 135 units and it is the optimum level to the fisherman that determines what bycatch will be. In addition, the fisherman's use of noncost-effective methods to decrease bycatch results in the MCS curve being unnecessarily high. Therefore, had cost-effective methods been used, the optimum level of bycatch for this fisherman from society's perspective would have been less than 150 units.

BYCATCH MANAGEMENT MEASURES USED OR BEING CONSIDERED FOR USE IN THE BSAI GROUNDFISH FISHERY

Many management measures have been used to control bycatch in the BSAI area groundfish fishery: 1) prohibitions on the retention of specific nongroundfish species which are referred to as prohibited species, 2) time and area closures and seasonal apportionments of groundfish quotas, 3) gear restrictions, 4) groundfish quota allocations by gear type, 5) reductions in groundfish quotas, 6) extensive at-sea and onshore observer programs to monitorbycatch, 7) extensive requirements for reporting catch and product utilization, 8) bycatch limits by fishery for some prohibited species, 9) a vessel incentive program (VIP) with civil penalties for fishing vessels that exceed established bycatch rates for Pacific halibut or red king crab, 10) a community development quota (CDQ) program for walleye pollock, 11) an industry-sponsored voluntary program to fund Pacific salmon bycatch research, 12) required retention of Pacific salmon bycatch until counted by an observer, 13) an industry-sponsored voluntary program that facilitates the retention of bycatch salmon for food banks, 14) individual transferable quota (ITQ management for the fixed-gear Pacific halibut and sablefish fisheries, 15) target fishery definitions, and 16) careful release regulations for longline fisheries.

The additional measures that are being considered include: a harvest priority program that would reserve part of the groundfish quotas or seasons for vessels that meet specific bycatch standards, regulations that would both prohibit at-sea discards of the major groundfish species and limit the percentage of the catch that is not used to produce products for human consumption, individual transferable bycatch quotas, multispecies ITQ management in which groundfish and nongroundfish quotas would be monitored in terms of total catch, not simply retained catch, and methods to decrease the time between capture and release of Pacific halibut in groundfish trawl fisheries.

CONCLUSIONS

The conceptual framework presented above addresses the source and nature of the bycatch problem. This framework can be used to evaluate alternative bycatch management measures even when accurate estimates and projections of all costs and benefits are not feasible. Such an evaluation considers the expected effects of a management measure on the external benefits and costs that result in fishermen making decisions concerning bycatch that do not reflect society's perspective.

Based on this conceptual framework, the following conclusions can be reached: 1) for society, the optimum level of bycatch is not zero unless the benefit of eliminating the last unit of bycatch equals or exceeds the cost, 2) individual fish-

ermen make inappropriate decisions concerning bycatch because they do not pay for the opportunity cost of using fish as bycatch and because the race for fish in an open access fishery distorts their choice of methods to reduce bycatch, 3) the contribution of commercial fisheries to the well-being of the Nation is decreased further by focusing on a narrow set of alternative uses and ignoring the importance of the distribution of fishing mortality among other uses, 4) physical measures of bycatch are of limited use in comparing the magnitude of the bycatch problem among fisheries because neither the benefit nor the cost of reducing bycatch is the same for all species or even for all fish of the same species, 5) bycatch is a multispecies problem because actions to decrease the bycatch of one species can increase or decrease the bycatch of other species and because the bycatch of one species can affect the status of other species through predator, prey, or other biological interactions, and 6) it is highly unlikely that the use of management measures that limit the choices of fishermen rather than eliminate the externalities will result in cost-effective reductions in bycatch to the optimum levels.

Management measures that eliminate or decrease the externalities that are the source of the bycatch problem have several potential advantages. Often these measures have lower information requirements for fishery management decisionmakers and, in fact, provide information that is required by fishery management decisionmakers. These measures also provide increased incentives for fishermen to use their knowledge and ingenuity to decrease bycatch effectively and efficiently. These measures tend to encourage technological improvements. Finally, these measures can decrease the need for ongoing regulatory changes when fishery conditions and optimum levels of bycatch change. Unfortunately, enforcement and transaction costs may be substantially greater for a management measure that effectively eliminates the external benefit of reducing bycatch than for a measure that limits the bycatch choices of fishermen.

A careful evaluation of the tradeoffs between these two types of measures is required to identify the appropriate mix of bycatch management measures. In making such an evaluation, it should be recognized that bycatch and many other management problems have a common source and therefore the benefit of reducing the bycatch problem could include the benefit of reducing several other management problems. The common source of these problems is that individual fishermen do not pay the opportunity cost of the fish and other LMR's they use. In evaluating alternative bycatch management measures, it is also important to recognize that, in the fishery management decision-making process, the effects on the distribution of net economic benefits can be at least as important as the effects on the magnitude of net economic benefits. However, failure to take advantage of the conclusions drawn from this conceptual model can result in unnecessarily high costs to some groups to provide a given increase in benefits to another group.