BIOLOGICAL AND ECONOMIC ANALYSIS OF LOBSTER FISHERY POLICY IN MAINE

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by

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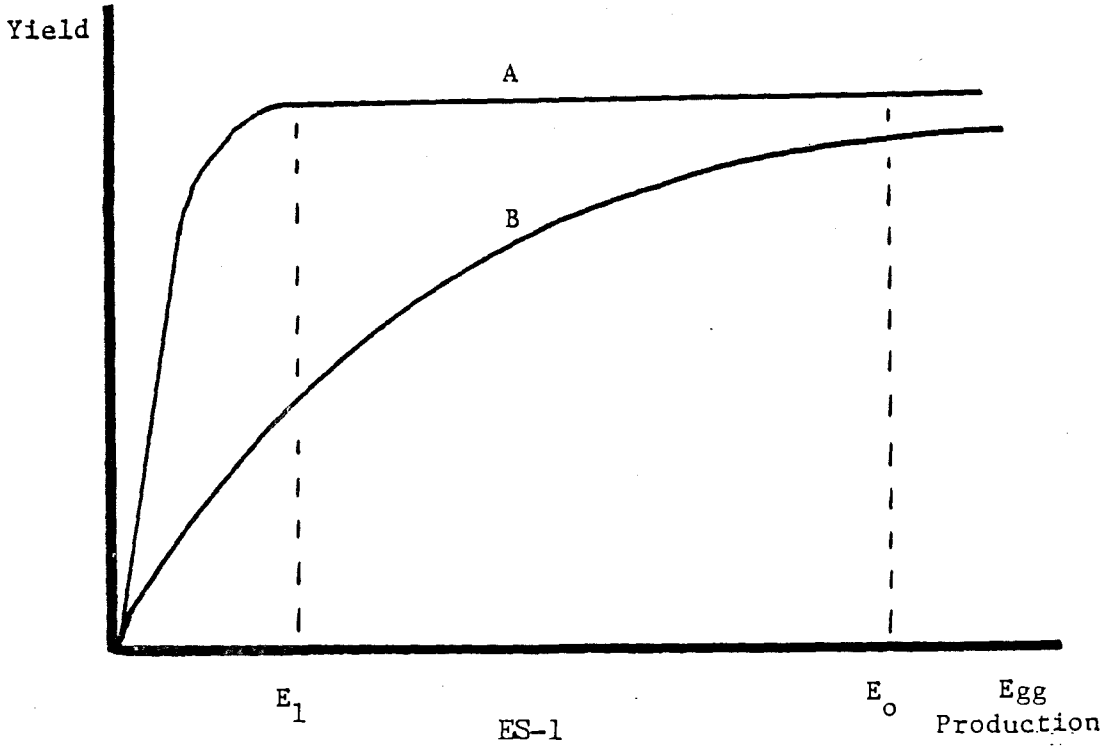
EXECUTIVE SUMMARY

Although there is widespread agreement with the goal of maintaining a high level of productivity in the Maine lobster fishery, there is less agreement between managers, lobstermen, dealers, and researchers as to how to ensure it. Controversies over the status of the stocks and what (if anything) needs to be done about it have persisted for the nearly ninety years that lobster fishing has been managed in Maine. Such conflict is not unusual, however, and appears in most open access fisheries where managers (who are charged with stewardship of the resource) must constrain the activities of increasing numbers of fishermen who are competing for a fixed common property resource. Unfortunately, it is also apparent that the conflicts that now characterize the Maine lobster fishery are inevitably bound to escalate in the future as more effort is drawn into the fishery. The purpose of this report is to assess the validity of various issues raised in these policy debates and to provide some steps toward resolution of existing conflict.

Of the many potential impacts of management actions, two stand out as most important to both managers and lobstermen; total catch (or value of catch) and stock safety. Whereas total catch is readily observable and measurable, stock safety is particularly difficult to assess or even define in practical terms. We do know that as fishing effort increases, fewer eggs will be produced by the population unless other measures are taken simultaneously. The effect of reduced egg production on subsequent recruitment (number of young entering the fishery) is not well understood, however. Two possibilities present themselves as shown in Figure ES-1 below.

Figure ES-1: Hypothetical Egg Production/Recruitment Relationships.



One possibility (labelled Curve B) is that there is warning when egg production begins to fall below viable levels because recruitment and hence yield begins to fall. It is important to note, however, that even in this case, the response to reduced egg production will not be felt in the fishery for the 5-7 years that it takes recruits to mature from eggs. The other possibility (and the one most fisheries biologists believe) is that the relationship is more like curve A. If this is the case, the fishery can reduce egg production substantially without any measureable effects on yield over a large range. At some point, however (labelled E_1), further decreases in egg production will cause a sudden and drastic fishery collapse.

Unfortunately, it is not known which of these relationships applies to the Maine lobster fishery, nor do we know whether egg production currently is relatively "safe" (E_0) or close to a threshold (E_1). We do know that fishing effort has increased substantially over the past two decades and that inshore egg production must have been reduced, other things equal. Recruitment to the inshore stocks may be coming from offshore stocks and there may be some recruitment provided by programs such as the V-notching program. Whether either of these is true, however, is unknown at present. What is clear is that if measures are undertaken to increase egg production, the stock will be more "safe" than at present. In the analysis that follows, therefore, we present projections of management policies both in terms of yield and total system egg production.

The ultimate confidence that we can place in our projected results of various management options depends on the knowledge used to make the projections. Population dynamics of the Maine lobster stocks are not completely understood, but we know more about some aspects than others. With regard to individual lobsters, we know that when they enter the fishery they are molting once a year and the increase in carapace length is approximately 14 percent. Molting frequency declines with age, and mature females generally molt every other year. We also know quite a bit about reproduction. We know the size at which lobsters mature (50 percent are mature at 4 inches), how many eggs they produce at each size (this increases as they grow larger), and how often they bear eggs (generally every other year). We know that the mortality rate due to fishing is quite high (about 90 percent is removed each year), but we have a very poor idea of the natural mortality rate of those that survive the fishery (we think it is between 5 percent and 25 percent per year). Another facet of behavior about which we know little is offshore migration. Most mature lobsters appear to undergo a seasonal offshore migration of 20 or so miles, but some mature lobsters migrate a longer distance on a more permanent basis. The fraction of large lobster moving permanently has been measured to be 10 to 15 percent.

Overall, even though some of the parameters are not known exactly, we have a good idea of how the fishery functions. Because of a sampling program instituted by the Maine Department of Marine Resources (DMR), we have a good record of catch and the distribution of lobster sizes in the fishery. Most of the catch each year are lobsters that have just molted into the fishable size range (i.e. they are between 3 and 3/16 inches and 3 and 9/16 inches). More than 90 percent of these are removed by fishing or

natural causes in the first year in the fishery and each year thereafter, except when they are either berried or V-notched. This results in a "stair step" pattern of abundance by size class. Due to the high combined mortality rates, only a small fraction survives to become sexually mature, and even fewer reach the upper limit of 5 inches.

An important aspect of the fishery that is not well understood is the impact of the V-notching program. DMR V-notches about 10,000 lobsters each year and the fishermen V-notch an unknown number of lobsters each year. The total number of V-notched lobsters in the population and the effects of the process of V-notching on reproduction and mortality are unknown, however. (There has been one attempt to measure the number of V-notched lobsters in the population, but more effort in this area is needed).

Economic aspects of the lobster fishery and markets are reasonably well understood. The market is supply driven, and total supply varies unpredictably from year to year by about plus or minus 10 to 20 percent. There is also a seasonal variation in supply which is partially smoothed by Canadian imports and pound supplies. Price is relatively unresponsive over the ranges for which we have data. Thus, we can be reasonably sure that an increase in catch will lead to an increase in revenues and a decrease will lead to a fall in revenues.

Based on all of the above outlined knowledge of lobster biology and markets, we have constructed a computer model of the fishery, and used it along with other information, to evaluate various policy options. In addition to projecting the impacts on future catch and egg production, we have also evaluated the effects of our less certain knowledge of various aspects of the population and fishery dynamics. Thus, we not only project the results of the options, but also suggest the confidence that can be placed in our projections.

The first option available is to do nothing and continue with the status quo. It is fairly certain that as real prices rise (due to population and income growth) more effort will be attracted into the fishery, hence egg production will decline. What is not known is whether the egg production/recruitment relationship is a "threshold" type and, if so, how close we are now to the threshold. If no counteracting measures are taken and the exploitation rate continues to increase, the fishery will decline at some point, however.

The first "active" option is to increase the lower gauge. This would lead to an initial short term decline in catch followed by a gradual increase to a higher long-term average catch after about 4 or 5 years. The initial decline varies with the amount by which the gauge is increased, roughly 8 percent for each 1/16 of an inch. Gradual changes in smaller increments would diminish the first year impacts proportionately but increase the time to reach the long term yield. The final long-term yield also varies with the size of the change; each 1/16 inch gauge increase will lead to approximately a 2.6 percent increase in yield. (See Table ES-1) An increase in the lower gauge also increase egg production. For example, an increase of 1/16 inch will increase egg production by about 30% over the baseline case.

Table E1: Summary of the Impact of Management Options.

	Catch (millions of pounds)	Egg Production (billions)
Baseline		
l.g. = 3 3/16" u.g. = 5" berried protection no V-notching	22.46	5.5
Gauge Increase		
l.g. = 3 1/4"	23.04 (+2.6%)	7.0 (+27%)
l.g. = 3 5/16"	23.68 (+5.4%)	9.3 (+69%)
No Upper Gauge	22.51 (+0.2%)	3.8 (-31%)
V-Notching (percent of trapped berried females notched)		
10 percent	22.44 (-0.1%)	9.0 (+64%)
25 percent	22.39 (-0.3%)	13.4 (+144%)
50 percent	22.33 (-0.6%)	18.8 (+242%)
100 percent	22.26 (-0.9%)	25.2 (+358%)

These projections are sensitive to our estimates of mortality and growth rates. If natural mortality rate is as high as 30 percent per year, there would be no long term gain from a gauge increase. The initial decline following a gauge increase is sensitive to our measurements but we can be reasonably sure that it will be about 8 percent for a 1/16 inch increase made all at once (rather than incrementally). The gauge increase results do not appear to be sensitive to measured levels of offshore migration.

Another option is removal of the upper gauge measure of 5 inches. We found that in spite of the fact that very few individuals reach that size, it does provide some potential protection of broodstock. Our model projects that removal of the upper gauge would decrease egg production to about 70 percent of its former value with a very small effect on long term yield. These projections assume that the prohibitions on landing lobsters over 5"

are actually effective in keeping fishermen from retaining trapped oversize lobsters. Most anecdotal evidence suggests, however, that the prohibition on landing lobsters over 5" simply imposes an extra cost on lobstermen and that these lobsters are sold outside of Maine or unrecorded. If this is the case, then our projected benefits of leaving the maximum gauge in force are overstated and may even be overshadowed by the extra costs imposed and by the loss of valuable data.

Another important option is to depend on the V-notching program for stock safety through egg production by V-notched lobsters. Our model results show that V-notching has the potential to contribute substantially to egg production. (See Table ES-1). For example, if 10 percent of all trapped females that were bearing eggs were V-notched, egg production would be equivalent to egg production with a lower gauge increase of 1/8 inches. This result assumes that V-notching has no adverse effect on reproduction, growth, and survival and that V-notches are maintained until death. No one has examined whether V-notching itself delays molts, changes extrusion rates or increases mortality. If any of these prove significant (and if V-notched lobsters are not re-notched after a few molts), the benefits from this program could be overstated.

An important issue associated with a complete dependence by the state of Maine on V-notching is that the current number of V-notched lobsters in the population is not known. Adoption of a policy of complete dependence on V-notching for stock safety would require a monitoring program to ensure sufficient levels of reproductive V-notched lobsters are being maintained in the population.

These results point to several areas of lobster biology critical to effective management, but which are still poorly understood. Some of the outstanding uncertainties are amenable to further research. An important area that could benefit from further research is the effect of V-notching on lobster growth, reproduction and mortality. Another area in which research should continue is the issue of offshore migration. Further information on growth, mortality and migration could be obtained by additional analysis of DMR size distributions.

Some of the areas in which research by the state of Maine is unlikely to bring short-term (less than 5 years), inexpensive rewards would be natural mortality rate and the source of Maine's recruitment. The former is probably impossible to determine because of difficulties in measuring natural mortality in fished populations. The latter is an important problem and should be pursued, but it will be long-term and expensive. The issue could possibly be approached in cooperation with other states and Canada.

In attempting to weigh each of these options aginst the other, we have come to the conclusion that no one policy stands out as a clear "best" alternative. Both V-notching and gauge increases add to egg production and thus increase stock safety. Gauge increases have the added advantage of increasing total yield and altering catch composition towards larger, higher valued lobsters. These benefits do not come without sacrifice however, since some short term yield decreases must be absorbed before the gains are

earned. It is possible to tailor the approach to a gauge increase in many ways, however, including a very gradual increase whose first year costs would be less than the normal year-to-year variation in a catch. As an "investment," a gauge increase is probably worthwhile by any reasonable standards.

There is considerable support among fishermen for the V-notching program as a means of maintaining egg production. As we have found, their support is well-grounded since V-notching could potentially add to egg production. There are some important unknowns involved yet which ought to be investigated in parallel with any program relying solely on existing practices or on stepped-up programs. Chief among these are the impacts of V-notching on lobster reproduction, growth and mortality, and studies of the overall abundance of V-notched lobsters in the population.

A final observation is that there is a considerable amount of antagonism and dissension among major participants which is as much an impediment to effective management as is the lack of scientific understanding of some processes. There are inherent reasons for some of this conflict, and much of it is associated with a structure which has evolved that is basically adversarial as opposed to cooperative. In addition, because this system is complicated and often counter-intuitive, there are misconceptions and misinterpretations of observations that need to be resolved to the satisfaction of all participants. We have identified some important widely held and controversial beliefs that are particular sources of disagreement. Probably the most significant controversy is over the number of V-notched lobsters in the Maine population. A second question is whether lobsters leave the Maine fishery when they become sexually mature. The only evidence for permanent migration is from a tagging study in which 10 to 15 percent appear to have migrated permanently. A third is that since the size of maturation is so far above the lower gauge, moving it up will have an insignificant effect on egg production. This is only "half true." While the actual numbers by which egg production is increased are small compared to possible egg production with no fishery, the model results show that gauge increases contribute the same order of magnitude increases to egg production as any of the possible management options. A fourth significant belief is that stable catches or the slight recent increase in catch is evidence that the stock is safe. Absolute safety is as impossible to determine as a collapse is to predict. The fact that something has not yet happened is not good evidence that it will not.

While we have addressed most of these issues in this report in more detail, we suspect that debate over them will continue. These are only examples of the kinds of issues that need to be resolved in order to forge consensus in the Maine lobster fishery.