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A Method for Analyzing Trip Limits in Northeast Fisheries: A Case Study of the Spiny Dogfish Fishery

by

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Abstract

The usual approach to projecting the effectiveness of trip limits as a conservation tool is limited to consideration of observed landings of the particular species of interest. This report describes an alternative approach in which we develop a simple economic model to predict how trip limits affect fishing behavior. The principal point of departure for this model is that trip decisions are not based upon catch of the regulated species alone. Specifically, if a vessel owner can expect to earn enough revenue from the combination of the regulated species (up to the trip limit) and the component catch to cover its operating costs then the trip may be expected to occur. Conversely, if projected operating costs exceed potential revenues, the trip may no longer be profitable and would not take place. As a case study, the model was applied to trip limits proposed for the Spiny Dogfish Fishery Management Plan in 2000. Model results indicate that expected changes in the conservation benefits differ substantially when trip economics are explicitly considered.

Introduction

Trip limits have become a common tool in marine fisheries management. Many federal Fishery Management Plans (FMPs) in the United States feature trip limits to address short and long run conservation objectives. In New England and in the Mid-Atlantic, trip limits have been used to reduce catches of groundfish (particularly Atlantic cod and haddock), summer flounder, and monkfish. Recently, trip limits have also been implemented for spiny dogfish.

Typically, the projected efficacy of proposed trip limits is evaluated retrospectively using historical landings data. Data on pounds per trip on fishing trips where the species of interest was landed are retrieved and sorted in ascending order. All trips where actual landings were less than the proposed trip limit are assumed to be unaffected. Trips where landings exceed the proposed trip limit are generally treated in one of two ways. The most common approach is to simply truncate the landings distribution and assume that all trips above the trip limit will not occur. This approach generally overstates the conservation benefit of a trip limit. At the other extreme, an assumption could be made that the trip limit would have no effect on expected fishing patterns and fishermen will simply discard any catch in excess of the trip limit. The conservation benefit would then be related to the survival of discards. An alternative approach, developed in this paper, is to make some assumptions about how a trip limit affects fishing choices (i.e., fishing behavior).

Whether a trip limit will affect fishing patterns depends upon the interaction of several variables including the trip limit itself, revenues earned from bycatch or component catches, and fishing costs. This report describes a trip limit model that incorporates these considerations, and in which it is assumed that vessel owners seek to maximize net revenues on each trip. On trips where landings are expected to exceed the trip limit, vessel owners are assumed to choose between continuing to fish and discarding any fish in excess of the trip limit, or simply not fishing at all. If a vessel owner can expect to earn enough revenue to cover operating costs from the species regulated by the trip limit and the component catch then the trip will take place. If projected operating costs exceed potential revenues, it is assumed that the trip will not occur. The following describes the mathematical specification of the trip limit model for spiny dogfish.

Trip Limit Model

In the absence of a trip limit, net revenues (NR) may be calculated as:

$$NR = p_i q_i + \sum_{j}^{J} p_j q_j - VC \tag{1}$$

where: p is price, q is quantity, VC represents variable costs, i denotes the species, that may be subject to a trip limit, and j denotes component species. Equation 1 is unchanged when q_i is less than the trip limit. For trips where q_i exceeds the trip limit, q_i is replaced by the trip limit (TL_i) and net returns are calculated as:

$$NR = p_i(TL_i) + \sum_{j}^{J} p_j q_j - VC \tag{2}$$

When q_i exceeds the trip limit, the vessel owner may: (1) continue to fish while discarding any fish in excess of the trip limit; (2) switch to another fishery or area where discard rates may possibly be lower; or (3) simply not fish at all. Since the trip limit analysis relies upon historical trip reports, the option of switching to another fishery or area was not incorporated in the model. Hence, if landings of a species are expected to exceed the trip limit, a vessel owner is assumed to choose one of the following two strategies that yields the highest net return: (1) continue to fish and discard all fish above the trip limit, or (2) stay tied-up at the dock and not go fishing.

Methods

As a case study, the model was applied to trip limits proposed in the Spiny Dogfish Fishery Management Plan for the year 2000[1]. Landings and background discard data collected through the Northeast Vessel Trip Report program during 1994, 1995, 1996, 1997, and 1998 were used to evaluate how the proposed trip limits would have affected landings and discards during these unregulated years. The management measures initially proposed for 2000 in the Spiny Dogfish Fishery Management Plan included an annual quota of 2.9 million pounds, subdivided into semiannual commercial quotas of 1.68 million pounds in quota period 1 (May 1 - Oct 31) and 1.22 million pounds in quota period 2 (Nov 1 - April 30). The quota was projected to rise slightly thereafter, but remain at about 3 million pounds for the next 10 years. Therefore, we decided to model the effects of varying trip limits in combination with the two proposed semiannual quotas.

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[1] A similar model was developed to assess the effects of trip limits proposed to manage silver hake and other small mesh species in the development of Amendment #12 to the Multispecies FMP(NEFMC 1999).

The data analyzed included any trip in which one or more pounds of spiny dogfish were landed and recorded in individual vessel trip reports. For simplicity, spiny dogfish discard estimates provided in these reports were not considered in this study. Reported discards represent nonmarketable spiny dogfish; dogfish culled at sea due to size, quality, etc. Although these discards result in additional spiny dogfish mortality, the primary purpose of the trip limit model is to estimate the discard mortality that will occur as a direct result of the trip limit (i.e., regulatory discards).

Average prices were obtained from Northeast dealer reports (sales receipts). Average fishing costs (adjusted for inflation) were calculated by vessel tonnage class using data obtained through the Northeast Fisheries Science Center's sea sampling program and the NMFS Capital Construction Fund (CCF) program. Sea sampling data was used to estimate daily operating costs for gillnet vessels and the CCF data used to estimate daily operating costs for otter trawl vessels. Together, gillnetters and otter trawlers accounted for greater then 90% of the spiny dogfish landings during 1994-1998. The model includes only daily operating costs (ice, water, food, fuel, oil, gear, supplies, lumping, auction, and packing fees) as these are the costs vessel owners generally consider when deciding whether or not to make a fishing trip. Because many vessels that landed spiny dogfish during 1994-1998 were not required to complete a vessel trip report, all landings data were expanded up to the level in the dealer records. It was assumed that all landings of spiny dogfish were reported in the Northeast dealer data base.

Results

Table 1 shows projected landings, regulatory discards, and the likely closure date associated with various trip limits during the two quota periods. The top set of projections refer to quota period 1 and the estimates at the bottom of the Table refer to quota period 2. Projections are shown for a complete closure and trip limits of 300, 500, 1000, 2000, 3000, 4000, 5000, 6000, and 7000 pounds during both quota periods. A 75% discard mortality rate was assumed in all projections.

Model results are presented for each trip limit and represent average values over the five-year period 1994-1998 (Column 1). Column 2 (Estimated Percent Reduction in Effort During Quota Period 1 and 2) shows the estimated percent reduction in trips that would likely have occurred under the indicated trip limit and assumed quota. The model projected about 36% of the trips, on average, would not have been able to earn enough revenue to offset their operating costs given a 300 pound trip limit during quota period 1. In quota period 2, approximately 30% of the trips, on average, would not have earned enough revenue to cover their operating costs under a 300 lb trip limit. In the model presented here, it is assumed that this effort will no longer take place. Although it is possible that this effort could be transferred into other fisheries that contains spiny dogfish bycatch, no attempt was made to project the implications of switching behavior. In contrast, the model predicted approximately 64% of the trips, on average, would have earned enough revenue from the combination of regulated spiny dogfish (up to the trip limit) and the component catch to offset earnings lost through the implementation of a 300 pound trip limit during quota period 1. The 64% figure also includes trips taken where net revenues were estimated to be positive after the projected closure date but prior to the start of quota period 2 (i.e., a zero trip limit).

Column 3 (Projected Quota Period 1 and 2 Closure Date) shows the date on which the sum of spiny dogfish landings and regulatory discard mortality would have exceeded the quota during periods 1 and 2. For example, on average, given a 300 pound trip limit, the period 1 quota would have been exceeded after approximately 44 fishing days and the period 2 quota after 41 days.

Column 4 (Projected Landings at Period 1 and 2 Closure Date) reports the total estimated landings (million lbs) that would have been reported under the indicated trip limit at the closure date if regulatory discard mortality also counted against the quota. The model assumes the quota will take into account landings and regulatory discard mortality.

Column 5 (Projected Mortality of Regulatory Discards at Period 1 and 2 Closure Date) shows the estimated regulatory discard mortality (million lbs) of spiny dogfish prior to the closure date given the indicated trip limit. Regulatory discards would have occurred because a large number of trips that exceeded the indicated trip limit of spiny dogfish during the open season earned enough gross revenue from the combination of allowable spiny dogfish landings (up to the trip limit) and other species to cover operating costs. Thus, vessels on those trips would have simply discarded the excess spiny dogfish. The sum of Column's 4 and 5 triggers the closure of a quota period.

Column 6 (Projected Mortality of Regulatory Discards After Closure Up to the Start of the Next Quota Period) shows the likely regulatory discard mortality that would have occurred on trips estimated to be profitable after the fishery is closed up to the start of the next quota period.

For example, given a 300 pound trip limit, the model estimated that the regulatory discards between the period 1 closure date and the start of quota period 2 would have resulted in approximately 7.8 million pounds of spiny dogfish mortality, on average, during 1994 through 1998.

Column 7 (Projected Total Mortality During the Indicated Quota Period) shows the total projected mortality of spiny dogfish during the indicated quota period. Total mortality is equal to the sum of Column's 4, 5, and 6 in each quota period.

Column 8 (Projected Total Mortality During Quota Period 1 & 2) shows the total projected mortality summed over both quota periods.

Conclusions

To be an effective management tool implementation of trip limits as a conservation management tool must induce some change in fishing patterns. The level of change depends upon the interaction of several variables including the trip limit itself, revenues earned from bycatch or component catch, and fishing costs. Failure to account for behavioral change will likely bias the perceived effectiveness of a proposed trip limit. In this paper, we developed an approach to predict how trip limits may change fishing behavior by comparing projected trip revenues and costs.

For low-valued species caught in mixed fisheries, such as spiny dogfish, the model shows that trip limits may not be an effective tool for reducing fishing mortality rates. Given a 7,000 pound trip limit from 1994 through 1998, total projected mortality would have been only about

1.05 million pounds (7%) higher, on average, than the 300 pound trip limit scenario (Table 1). While the directed fishery is projected to be phased out, the supplemental revenue obtained from vessels landing spiny dogfish as bycatch is generally not sufficient to cause trip earnings to fall below break-even. Thus, as trip limits are lowered marginally profitable trips will drop out, but in a relatively large number of instances spiny dogfish landings simply get converted into regulatory discards.

In contrast, trip limits may induce the desired change in fishing behavior necessary to reduce fishing mortality rates without significantly increasing discards if earnings from the regulated species comprise the majority of trip revenues. In the development of the silver hake fishery management plan, a similar model was used to estimate changes in landings and discards resulting from implementation of proposed trip limits. Model results indicated that trip limits may provide the reduction in mortality necessary to meet the conservation objectives of the plan without significantly increasing discards.

Although the model was designed to predict how trip limits will change fishing patterns, the current version does not capture the effects of switching behavior. On trips where net revenues were estimated to be negative, the model assumes that no trip will take place. In most instances, these vessels will likely switch to other fisheries using the same gear, resulting in some level of unmeasurable bycatch.

Additionally, since the model relies upon observed trips, the option of moving to another area where discard rates might possibly be lower was not incorporated in the model. The model assumes that if a vessel owner can expect to earn enough revenue from the combination of the regulated species and the component catch to cover operating costs then that particular trip would take place. Switching behavior may take place if vessels are able to at least maintain current profit levels by moving to another area. However, in multi-species fisheries such as spiny dogfish, beyond altruistic reasons for switching to another area to minimize discards there appears to be very little economic incentive for vessel owners that could continue to earn a profit to alter their behavior. Implementation of any of the proposed trip limits would essentially eliminate directed spiny dogfish trips. Therefore, the remaining profitable trips would generally be landing spiny dogfish as bycatch. Trips that are actively seeking high concentrations of other more valuable species have no profit incentive to switch areas to reduce incidental catches of spiny dogfish other than to lower marginal handling costs. Vessels seeking more valuable species are fishing in areas known to contain the target fishery. If catches of spiny dogfish occur, the majority of the vessels would likely land what they're allowed and discard any excess.

There is a need to develop procedures for evaluating alternative opportunities and the mortality impacts that result from this switching behavior. Multinomial logit and random utility models have the capability of providing information of this kind and could be used to improve the model presented here. We hope to explore the feasability of incorporating these procedures in future trip limit analyses. Furthermore, since fishing costs play such an important role in the model's decision rules cost estimates should be corroborated through industry advisor input or through other sources of data. At a minimum, sensitivity analyses should be conducted in the future to determine the range of possible outcomes.

Table 1 - Average Projected Landings (million lbs), Discards (million lbs), and Closure Dates Associated with Various Trip Limits for Spiny Dogfish (1994-1998)

Quota Period 1

Trip Limit	Estimated Percent Reduction in Effort During Quota Period 1	Projected Quota Period 1 Closure Date	Projected Landings at Period 1 Closure Date (million lbs)	Projected Mortality of Regulatory Discards at Period 1 Closure Date (million lbs)	Projected Mortality of Regulatory Discards After Closure Up to Quota Period 2 (million lbs)	Projected Total Mortality During Quota Period 1 (million lbs)
0	38.56	16-Jun	0.00	1.70	7.56	9.26
300	37.03	13-Jun	0.26	1.43	7.83	9.52
500	36.71	11-Jun	0.40	1.30	7.93	9.63
1000	36.61	7-Jun	0.62	1.07	8.25	9.94
2000	36.29	7-Jun	0.94	0.74	8.27	9.95
3000	36.34	5-Jun	1.13	0.55	8.36	10.04
4000	36.51	4-Jun	1.27	0.41	8.38	10.06
5000	36.37	4-Jun	1.37	0.31	8.40	10.08
6000	36.57	4-Jun	1.44	0.24	8.40	10.08
7000	36.44	4-Jun	1.50	0.18	8.42	10.10

Quota Period 2

Trip Limit	Estimated Percent Reduction in Effort During Quota Period 2	Projected Quota Period 2 Closure Date	Projected Landings at Period 2 Closure Date (million lbs)	Projected Mortality of Regulatory Discards at Period 2 Closure Date (million lbs)	Projected Mortality of Regulatory Discards After Closure Up to Quota Period 1 (million lbs)	Projected Total Mortality During Quota Period 2 (million lbs)	Projected Total Mortality During Quota Period 1 & 2 (million lbs)
0	34.82	15-Dec	0.00	1.23	2.76	3.99	13.25
300	32.52	11-Dec	0.19	1.03	2.91	4.13	13.65
500	29.72	5-Dec	0.27	0.99	3.02	4.28	13.91
1000	30.55	28-Nov	0.40	0.82	3.25	4.47	14.41
2000	30.44	26-Nov	0.61	0.61	3.31	4.53	14.48
3000	30.94	25-Nov	0.75	0.47	3.32	4.54	14.58
4000	30.89	23-Nov	0.86	0.37	3.35	4.58	14.64
5000	30.03	23-Nov	0.93	0.29	3.35	4.57	14.65
6000	30.94	23-Nov	0.99	0.23	3.35	4.57	14.65
7000	30.92	22-Nov	1.03	0.19	3.38	4.60	14.70