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POSSIBLE UTILITY OF CATCH LIMITS FOR INDIVIDUAL PURSE-SEINE VESSELS TO REDUCE FISHING MORTALITY ON BIGEYE TUNA IN THE EASTERN PACIFIC OCEAN

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ABSTRACT

To ensure the sustainability of the bigeye tuna (*Thunnus obesus*) in the eastern Pacific Ocean (EPO), the Inter-American Tropical Tuna Commission has imposed a range of restrictions. The current stock assessment indicates that large reductions in fishing mortality are necessary to allow the stock to rebuild toward a level that would support the average maximum sustainable yield (AMSY). We investigate the effect of catch limits for individual purse-seine vessels as a measure to reduce fishing mortality. Using historical catch and effort data, we investigate what catch levels would have been appropriate in previous years and how many vessels would have been affected by these limits.

We found that 50% of the bigeye catch came from a small number of vessels, and that these vessels fished almost exclusively on fish associated with floating objects. If sets on bigeye-dominated aggregations were restricted, or vessels were able to catch the skipjack in these aggregations while avoiding the bigeye, large reductions in bigeye catches could be achieved without large losses in skipjack catches.

If individual vessel catch limits were introduced to reduce bigeye catches, limits of about 350 metric tons (t) (based on unloading estimates) would be sufficient in most years, and would affect about 35 vessels (out of the 138 vessels that unloaded at least 50 t of bigeye over the 1998-2003 period). An important practical implication of catch limits is the choice of data with which to estimate bigeye catches. It may be necessary to make predictions from observer records to allow "real-time" monitoring.

INTRODUCTION

In order to ensure the sustainability of tuna resources in the eastern Pacific Ocean (EPO) the Inter-American Tropical Tuna Commission (IATTC) approves conservation measures to restrict fishing mortality. Generally, conservation measures are directed at two of the three main tuna species, yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) tuna. Recent assessments for skipjack tuna are extremely uncertain, but do not indicate any conservation concerns. Recent assessments for yellowfin and bigeye tuna, however, indicate that current fishing effort is above that necessary to allow for the maximum sustainable yield *if recruitment is strongly dependent on the amount of spawning*.

Various conservation measures have been adopted to restrict fishing mortality on bigeye tuna by the purse-seine fleet. These have included limits on total catch, limits on catches of small (less than 60 cm) bigeye, restriction on setting on fish associated with floating objects, and time/area closures. Measures directed at bigeye tuna often affect skipjack as well. For closed areas, losses of skipjack catch can be as large as the reductions in the catch of bigeye. Restrictions on floating-object sets could result in larger losses for skipjack.

In this paper we use historical catch and effort data to investigate how catch limits for purse-seine vessels could be used to reduce fishing mortality. We also analyze set-by-set data to better understand the characteristics of the fishery.

METHODS

Data sources

We focused on the recent history of the fishery, from 1998 to 2003. We used trip-level estimates of catches based on unloading data to determine the distribution of catches across vessels and for investigating catch limits. For the detailed analysis of the characteristics of the fishery, we used set-by-set data collected by observers or the logbooks of the fishing vessels.

RESULTS AND DISCUSSION

Distribution of catches among vessels.

To determine the distribution of bigeye catches across the fleet we ranked the vessels in ascending order in terms of their bigeye catches in each year of the 1998-2003 period, and plotted the cumulative sum of catch versus the number of vessels that caught it (Figure 1). We included only vessels which unloaded bigeye at least once during this period. We found that 11-15 vessels generally caught 50% of the bigeye unloaded in given year, and between 23 and 30 vessels landed 75% of the bigeye. This suggests that a small number of vessels is responsible for most of the bigeye catches. Overall, 138 vessels unloaded at least 50 metric tons (t) of bigeye tuna during the six years.

Analysis of top bigeye-catching vessels

To better understand how the fishery operates, we undertook a descriptive catch and effort analysis, using set-by-set data, for the vessels that were in the top five bigeye-catching vessels in each year (Table 1). As some vessels were in the top five in several years, only 19 vessels were included in the analysis.

For these vessels, the median annual bigeye unloading ranged from 344 to 1,771 t, with 12 vessels exceeding 1,000 t. For most of the vessels, bigeye comprised between 20 and 30% of their total tuna catches. For some of the vessels with lower catches the proportions were less than 20% and for one vessel (Vessel 13) bigeye comprised almost 40% of its total tuna catch.

The top vessels set almost exclusively on schools of fish that were associated with floating-objects. (We did not distinguish between sets on flotsam or fish aggregating devices.) Almost half of the vessels made 95% of their sets around floating objects. This rate was generally higher for vessels with higher median annual unloadings.

The proportion of floating-object sets that caught bigeye tuna ranged from 0.6 to 0.8 for most of the vessels. Vessel 13 had a much greater proportion of floating-object sets to catch bigeye (0.89) than other vessels.

To make sensible management recommendations it is important to determine the distribution of bigeye catches among sets, *i.e.* are small amounts of bigeye tuna caught in high proportion of sets or are the catches made up of a small number of sets with high bigeye catches. We examined this for the top vessels by calculating the proportion of each vessel's total bigeye catches that were taken in sets in which bigeye comprised more than 50% of the total tuna catch. We found that for most vessels 50-70% of bigeye tuna are caught in bigeye-dominated sets, while for one vessel (Vessel 18) 83% of its bigeye catches came from the bigeye-dominated sets.

These statistics suggest that if vessels were to avoid setting on aggregations that were dominated by bigeye, bigeye catches could be reduced by over 50%. An important consideration is how much skipjack might be foregone by not setting on these aggregations. Generally 10% of the total skipjack catch of the top vessels comes from sets that caught predominantly bigeye tuna. This suggests that the losses in skipjack catches may not be excessive, especially when compared to the potential losses if all purse-seine fishing were restricted (*e.g.* large time/area closures) to achieve the necessary reductions in fishing mortality on bigeye tuna. Losses could be even less if vessels are able to develop fishing techniques that allow them to catch the skipjack tuna without the bigeye tuna.

For Vessel 13, 24% of its skipjack catch came from bigeye-dominated sets. This statistic and the others described above, suggest that this vessel may be more "efficient" at catching bigeye tuna than other vessels.

Comparison between the top vessels and the rest of the fleet

We were interested in whether any of these statistics differed between the top 19 vessels and other vessels that catch bigeye tuna (Table 2). In this analysis we restricted our attention to vessels that unloaded at least 50 t of bigeye tuna over the six-year period.

There were 119 vessels that we included in the "other" category, compared with 19 in the top vessels. The median annual bigeye catch of these 118 vessels was only slightly greater than the catches for the top vessels. Several of the top vessels have only recently entered the fishery and have contributed to the "top" catches for only 1-2 years. This suggests that targeted reductions directed at a small part of the fleet could yield substantial benefits.

Bigeye make up only a small part of the overall catch of the other 118 vessels (8% versus 22% for the 19 top vessels). The other vessels also make far fewer floating-object sets (52% versus 93%), and the sets that they make are less likely to contain bigeye (41% versus 68%). Interestingly the proportion of their bigeye catch that comes from bigeye-dominated sets is similar, but the proportion of their skipjack catch that comes from these sets is much lower (4% versus 10%).

Vessel limits to restrict bigeye catches

One possible measure to reduce bigeye catches is to put restrictions on the annual catch that a vessel can take. This should encourage vessels to avoid bigeye. We used historical unloadings data to estimate what catch limits would have been necessary to reduce bigeye catches by 50% (Table 3).

In most years individual vessel limits of about 350 t would be sufficient to reduce bigeye catches by 50%. The exception was 2000 where bigeye catches were very high and a limit of over 800 t would have been sufficient. We estimated that, in each year, 31 to 38 vessels would have their bigeye catches restricted by these limits.

A practical question for the implementation of vessel limits is which estimates of bigeye landings to use. Our analysis was based on estimates from unloading data. Presently the bigeye assessment uses landings estimated from species composition sampling, as these are thought to be more reliable. However, these estimates are not available in “real time.” Also, unloading estimates can take several months to be reported to the IATTC. For size class six vessels, observer estimates are available in real time, but comparative analyses have shown that estimates differ among the three methods. If catch limits are to be based on unloadings or species composition sampling, it may be necessary to use estimates from other sources, calibrated, to allow real-time monitoring.

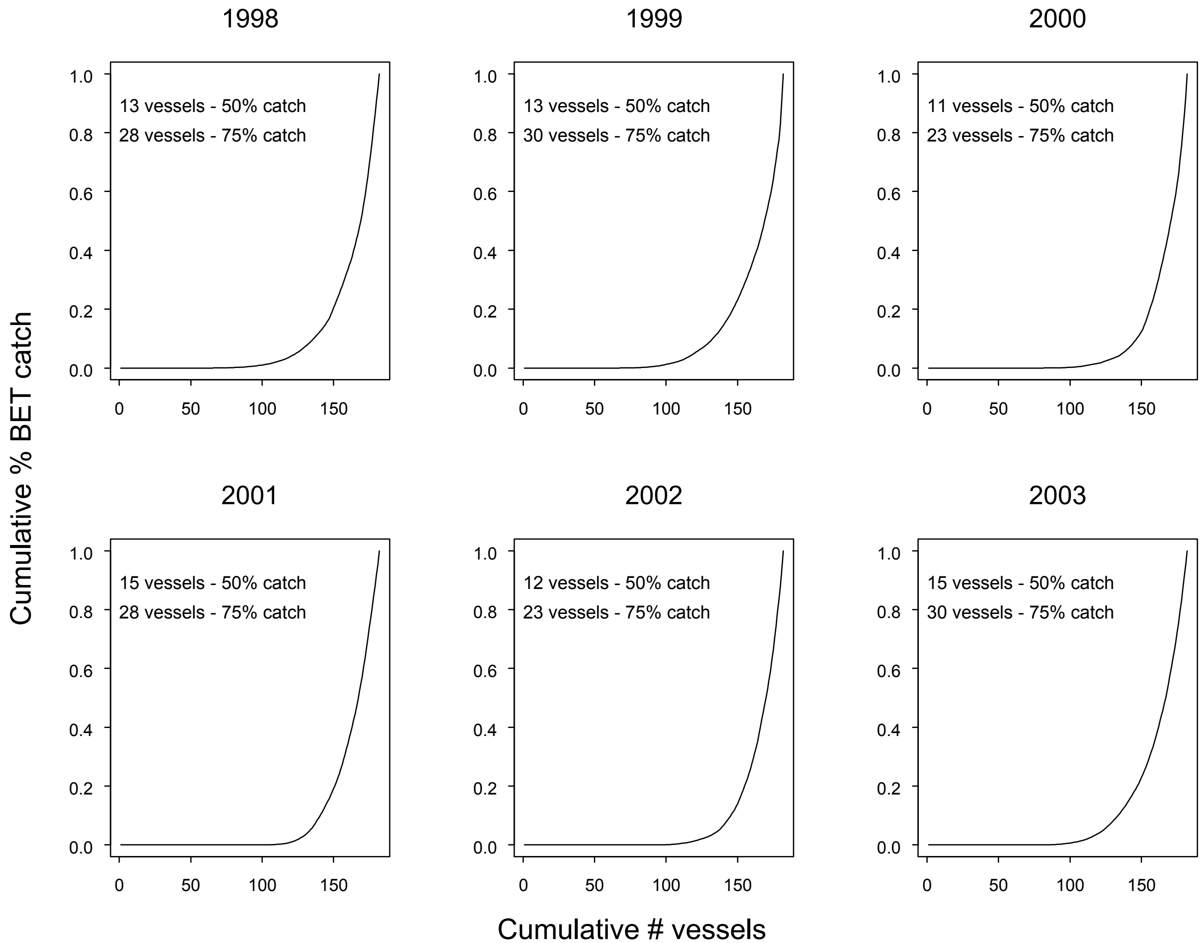

Figure 1. Cumulative proportion of bigeye (BET) landings and number of vessels that landed for 1998-2003.

Table 1. Descriptive catch and effort analysis for top bigeye-catching vessels for the years 1998-2003. The first two columns are based on the analysis of landings estimated from unloading data and the others are based on set-by-set data from scientific observers.

Vessel	Median annual bigeye landings (t) estimated from unloading data	Proportion of bigeye in total landings from unloading data	Proportion of sets of floating objects	Proportion of floating-object sets to catch bigeye	Proportion of total bigeye catch from bigeye-dominated sets	Proportion of total skipjack catch from bigeye-dominated sets
1	1,771	0.24	0.94	0.64	0.57	0.07
2	1,623	0.20	0.95	0.69	0.61	0.08
3	1,601	0.29	0.89	0.76	0.57	0.13
4	1,513	0.27	0.96	0.74	0.57	0.10
5	1,489	0.32	0.94	0.78	0.71	0.14
6	1,481	0.18	0.97	0.74	0.65	0.12
7	1,374	0.23	0.88	0.69	0.65	0.09
8	1,328	0.17	0.97	0.60	0.58	0.08
9	1,260	0.24	0.94	0.61	0.70	0.11
10	1,232	0.22	0.97	0.62	0.58	0.08
11	1,216	0.23	0.97	0.70	0.56	0.09
12	1,172	0.31	0.94	0.76	0.65	0.10
13	943	0.39	0.97	0.89	0.69	0.24
14	908	0.24	0.97	0.66	0.72	0.12
15	796	0.20	0.88	0.66	0.61	0.07
16	489	0.16	0.81	0.67	0.72	0.10
17	445	0.17	0.88	0.68	0.58	0.10
18	422	0.11	0.96	0.47	0.83	0.09
19	344	0.09	0.81	0.52	0.66	0.09

Table 2. Comparison of top vessels with other vessels that unloaded at least 50 t during 1998-2003. The first two columns are based on the analysis of landings estimated from unloading data and the others are based on set-by-set data collected by observers.

	Median annual bigeye landings (t) estimated from unloading data	Proportion of bigeye in total landings from unloading data	Proportion of sets of floating objects	Proportion of floating-object sets to catch bigeye	Proportion of total bigeye catch from bigeye-dominated sets	Proportion of total skipjack catch from bigeye-dominated sets
Top vessels (19)	18,450	0.22	0.93	0.68	0.64	0.10
Other vessels (118)	21,990	0.08	0.52	0.41	0.65	0.04

Table 3. Analysis of annual vessel limits for bigeye tuna based on landings estimated from unloading data.

Year	Total bigeye landings from unloading data (t)	Estimated catch limit (t)	Number of vessels affected by limit
1998	35,154	353	35
1999	40,674	348	38
2000	70,287	833	31
2001	42,961	414	36
2002	35,677	397	32
2003	40,810	352	35