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FAD-RELATED RESEARCH

1. INTRODUCTION

Given the current condition of the stocks of bigeye and yellowfin tuna in the eastern Pacific Ocean (EPO), and the fact that the fishery on fish-aggregating devices (FADs) results in the capture of juveniles of both species, it has become of critical importance to explore ways to (a) better understand the way this fishery operates; (b) improve the quality of the data collected for the assessments of those and other stocks; and (c) reduce the fishing mortality of yellowfin and bigeye by improving the species selectivity of those sets. As skipjack tuna is the main target of the FAD fishery, it is desirable to uncouple the catches of the target species from other, less desirable impacts.

Besides these effects on the target stocks, the Commission is working on a program to mitigate the bycatches of all species caught in these sets, which include sharks, billfishes, sea turtles, and large pelagic fish species (dorado, wahoo, *etc*.).

Another approach to reducing the fishing mortality of bigeye tuna in the purse-seine fishery, which could be extended to other species of conservation concern, is to avoid their capture when they are present in mixed-species aggregations associated with floating objects. A proposed research program, consisting of the two complementary studies, would evaluate the feasibility of this approach.

2. RESEARCH PROPOSALS

2.1. Identification of individual FADs

In order to understand the drift patterns of FADs, estimate their abundance, and improve the stock assessments of the different species that associate with them, it is important for the observers aboard tuna purse-seiners to be able to identify individual FADs.

The information required includes not only catches and bycatches of all species associated with the FADs, but also visits by vessels to FADs without any catch. For this purpose, a system will be required by which individual FADs can be identified, using tags with markings that can be read by the observer from a reasonable distance. This latter requirement complicates the design and construction of the tags.

In 1989, the IATTC conducted an experiment in which 10 labels, made out of 60 x 60 cm color-coded white PVC plates, with an alphanumeric code painted on each plate with paint resistant to sunlight, temperature changes, and exposure to seawater, were tethered to floating objects. Some of these tags were found in the Philippines many years after deployment. For the FAD-marking program currently proposed, hundreds of such tags would be needed, to be given to observers on every vessel fishing with FADs. One of the requirements is that the tag must be legible from some distance, in case the boat approaches a FAD but does not set on it. As a first test, 500 tags would be deployed as soon as possible to explore the performance and durability of the tags and tethers. Observers would attach a tethered tag to any FAD deployed and record the position at deployment, and attach a tag to any untagged FAD picked up and redeployed by the vessel . A simple identification system will be a colored strip and a letter followed by five numbers, providing a unique code. The colored strip could indicate the year of deployment. There will be no identification of the vessels that deployed or redeployed the FAD.

The observers will record information on all catches and bycatches on individual FADs on standard IATTC data forms, but with special care not to violate the confidentiality rules that the IATTC follows. The positions at deployment will not be communicated to anyone. The results will be used for the stock assessments, but will not be portrayed by vessel or in any way that allows the identification of the vessel deploying or removing the FAD.

2.2. Experiments with different depths of webbing hanging under the FAD

A statistical analysis has shown possible effects of two factors on the presence of bigeye bycatch: 1) the depth of the purse seine, and 2) the depth of the webbing hanging below the FAD. In order to explore whether these results could be turned into helpful management recommendations, it is suggested that an experiment be carried out to test the second factor, because it would be a simple and cheap change that might perhaps contribute to the solution of the problem of bycatches of small bigeye. The expectation is that if more bigeye is caught in sets when the webbing under a FAD is longer (*e.g.* because it reaches deeper waters), then shortening these pieces of webbing could lower the bigeye catch. This concept has not been proven, but the statistical results show some potential, and the experiment should be quite simple to perform.

For this experiment, a number of vessels would be "recruited" to participate; the higher the number, the quicker an answer will be arrived at. All participating vessels will deploy FADs with webbing hanging at three depths (10 m, 20 m, or 30 m), in a systematic sequence with a random start (*e.g.* Vessel 1: 20-30-10, 20-30-10, *etc*., Vessel 2: 30-20-10, 30-20-10, *etc*., Vessel 3: 10-30-20, 10-30-20, *etc*.). Sixty FADs, 20 of each depth, will be deployed by each vessel. The FAD types will be clearly identifiable to the observer. The timing and location of the FAD deployment should be selected by targeting areas with high bigeye catches. It is recommended that this experiment be carried out in the region between latitudes 2ºN and 7ºN, and longitudes 95ºW and 110ºW during September-November. The timing of deployment should take into account the time lag normally allowed for FADs to aggregate fish. One option would be to allow the participating vessels to fish on other FADs for two weeks, and then concentrate on those deployed as part of the experiment. After the two-week grace period, each vessel would start visiting the FADs in a sequence that balances the probability of visiting FADs of the three types, and the observers will start reporting when sets were made and whether there were tuna aggregated or not, and their species composition and sizes. The observers involved in these duties should receive extra training in the identification of tuna species of all sizes.

2.3. Experiments with sorting grids

Feasibility experiments performed to test the use of sorting grids in purse seines have included:

a. Field test of a single rigid grid, a design used in Norwegian purse-seine fisheries.

   Outcome: too cumbersome to use.

b. Laboratory experiments of tuna escape at the IATTC's Achotines Laboratory.

   Outcome: tunas will go through a grid, and survival was quite high.

c. Field tests of flexible grids, a modification of a rigid design by Mr. Aurelio Arrue (NIRSA, Ecuador). Several tests were performed.

   Outcome: The initial grid included some very wide openings that allowed the escape of large tunas. Subsequent designs experimented with reductions of the size of the openings, using openings of two sizes, and the addition of weights to the lower part of the grid. The optimum width of the opening was determined based on the data available on morphometric relationships between the width of the tuna itself, and its length (R. Olson, pers. com.). Tunas, mahi-mahi and other species were seen escaping the net, but there is not much information to judge whether (i) there were substantial escapes, and (ii) there was size or species selectivity involved in the process (*e.g.* does the grid function differently than a hole in the net?)

Even though it is not quite clear which are the exact dimensions to use in the design, we would like to start testing only one design at a time, and avoid introducing changes in the gear in the middle of the experiment. The captains and crews should be told that the design should not be changed until the experiment is concluded. We propose an initial height of 25 cm, and a width of 9 cm for the openings. The overall dimensions of the grid and its location in the net will be initially the same as those with which the last test was started (3.3 m x 3.4 m), although both of those characteristics were established arbitrarily and should be the subject of experimentation at some stage. The construction will be the current one, with as much weight as possible added in the lower part of the grid, to keep the shape of the openings and the grid lines taut.

Several participating vessels will be outfitted with the grids. All vessels should put netting outside the grid to retain all the escaping fish. These fish will be identified, measured, and examined for external marks or injuries. A sample of fish from inside the net will also be examined for injuries and marks. All possible retained fish should be identified and measured either at sea or in port.

One vessel will be designated to carry out a survival experiment. Fish escaping through the grid will be retained in netting outside the seine, and transferred to a floating pen. The vessel will carry a dismantled pen, and will set it up prior to setting on a FAD. A small longliner will be chartered to remain tied to the pen, and, if possible, it will deploy an auxiliary boat to catch fish for feeding the captured fish. Fish will be kept in the pen for 2 weeks. Divers will recover dead fish and remove them for identification and measurement. The experiment will be replicated 3 times, from capture to the end.

2.3.1. Grid construction materials

The rigid grid used initially was too cumbersome, in the opinion of the crew. However, given the current conditions of the fishery, and the stringent management measures being considered, what was cumbersome before might become acceptable in view of the other alternatives. A modified rigid grid should be an alternative to consider, based on the fact that it would retain its shape better than any alternative. No design will be proposed until we have discussed the concept with the fishers, net makers, *etc*.

Additionally, other ways of deploying the rigid grid should be considered.

a. Flexible plastic plate with cut openings. Peter Nelson, a researcher working on a project for the IATTC, proposed using a thick plastic sheet with oval openings cut in it. Two prototypes were built, and are available in Manta, Ecuador, for testing. This design should be given a field test, since it appears it will meet the requirements of keeping its shape, and going through the power block. The two prototypes would be installed in the nets of two cooperating vessels, and observers would make underwater observations with a camcorder and record the responses of tunas and other species. If escapes are observed, then we should proceed along the same track as for Arrue's grid.

b. Other alternative materials: Materials that could keep a reasonably fixed shape, but allow the grid to go through the power block, should be explored. New technology has been developed for different marine applications (aquaculture facilities, grids for trawls, *etc*.), and it is quite likely that alternative materials with the desired properties exist.

2.3.2. Alternative grid designs

Some researchers have suggested the use of a number of rigid shapes (circles, ovals, hexagons, or whatever shape is selected) made out of very strong plastic or even metal, and fitted permanently in the purse seine. The shapes will have the dimensions of the openings in the sorting grid, but will be rigid openings included in the mesh, and therefore should be able to go through the power block.

2.3.3. Self–destruct FADs

A series of vessels will be selected to test FADs with the ability to self-destruct after some time. Two mechanisms will be tested: (a) buoy/transmitter connected to the FAD with a tether that contains a corrodible link; (b) FADs tied up with wire with an expected life of 2-3 months.

Experimental prototypes (10 of each) will be built and kept under observation in some coastal location, where they could be visited periodically to assess their condition.

2.4. Characterization of mixed aggregations associated with floating objects

Another approach to reducing the fishing mortality of bigeye tuna in the purse-seine fishery of the EPO is to avoid their capture, using advanced detection technology and modifications to fishing methods when bigeye are present in large quantities in mixed-species aggregations associated with floating objects. This approach could also be extended to other species of conservation concern.

The proposed field research designed to evaluate the feasibility of this approach consists of two complementary studies, to determine: 1) the fine-scale spatial and temporal dynamics of mixed-species aggregations associated with floating objects by means of ultrasonic telemetry, and 2) the species and size composition of these aggregations before a set, using acoustic imaging and complementary techniques, coupled with validation after the set.

2.4.1. Spatial and temporal dynamics of tunas

The objectives of this study are to elucidate fine-scale spatial and temporal behavioral differences between skipjack and bigeye tunas and other species within the aggregations, in order to define opportunities for capturing skipjack without capturing bigeye or other species in purse-seine sets. We propose conducting observations and collecting time-series behavioral data, using several proven methodologies. The experimental design would consist of collecting several sets of observations on different aggregations and floating objects.

The methodology involves monitoring and quantifying the simultaneous fine-scale spatial and temporal dynamics of skipjack and bigeye schools associated with floating objects, using a suite of complementary tools. This would require a chartered vessel, and would include the use of both active and passive three-dimensional ultrasonic telemetry of tunas tagged with acoustic tags, echosounder imaging and scanning sonar, and underwater video recordings.

Some preliminary observations and research on this topic revealed that skipjack commonly move significant distances away from floating objects, typically just after dawn, in single-species schools. Further investigation and validation of the frequency of this behavior through this first study, and evaluations of the feasibility, in the second study, of catching those schools with purse-seine vessels when they are separated from the bigeye schools, could provide an option for reducing the fishing mortality of bigeye and other species.

2.4.2. Characterization of tuna schools

The objectives of the second study are to evaluate, using acoustic imaging and other complementary techniques, the accuracy in pre-set identification, abundance estimation, and size frequencies of the various species in these aggregations. This research would be conducted using a chartered purse-seine vessel with the acoustic equipment necessary for the post-set validation of the pre-set estimates.

The methodology to be employed in this second study would involve the use of echosounders and sonars on the bridge of the vessel, coupled with the *a priori* knowledge of the acoustic signatures, depth distributions, and behavior of the various species, along with visual observations of the aggregations. Several different aggregations associated with floating objects would be evaluated, and estimates recorded of the species composition, abundance, and sizes of the fish before and after the set. In addition, estimates of the catches in these sets would be obtained when the vessel unloaded in port. During the charter period the vessel would also be used for evaluating the feasibility of catching skipjack associated with floating objects during the periods when single-species skipjack schools separate from the other species in the aggregation.

Some preliminary research on this topic indicates that the application of tuna species identification and estimation of quantities and sizes, using acoustic imaging, provides some potential for avoiding sets on floating objects when large quantities of bigeye tuna are present.