PRELIMINARY SCHEME OF LARGE SCALE SWORDFISH *(XIPHIAS GLADIUS)* IN THE INDIAN OCEAN.

By

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1 CONTEXT

The Reunion longline fishery emerged progressively from the beginning of 1990s. This emergence is linked to several factors among which one could be noted: the landing at Reunion harbor of big tuna by the Taiwanese longline fishery, the catch of large pelagics around local anchored FADs, the good results of the technical test achieved by a local fisherman, a special tax regulation system for fishing investment in the French overseas areas. At first, the fleet targeted albacore *(Thunnus alalunga)* but rapidly targeted swordfish as the results obtained from this species was satisfactory. The longline domestic fleet progressively evolved during the ten last years and is composed currently of 31 vessels measuring between 10 and *25* m (Poisson and Taquet, billfish session). The annual swordfish catch evolved from few tons in 1991 to 2000 tons in 1999. The CPUE decreased sharply from 16 to 9 fishes for 1000 hooks between 1994 and 1996, before leveling of around 8 fish/l000 hooks in the last three years.

As early as the beginning of the fleet activity, the Ifremer laboratory has monitoring this fishery in the framework of different regional programs: le Programme Thonier Regional (PTR - phase II), then the on-going Reunion Longline Program (PPR) which will be achieved in December 2001. The 6 different tasks aimed to collect data in order to monitor and to help the sustainable management of this fishery. The fundamental question asked by the stakeholders (fishermen, managers and scientists) is to know the maximum sustainable yield of the stock. The short term development of the reunion fishing companies depends on the sustainable management of this stock because of the limited availability of other exploitable species.

The priority for stakeholders is to have a regional management (IOTC) of the swordfish stock. The set up of a voluntary logbook system and other scientific works, like determination of growth rate, sex-ratio and maturity stages, have the objective to provide the required parameters for evaluation.

2 WHY TAG SWORDFISH?

Besides the difficulties in gathering sufficiently reliable fisheries data for stock assessment, the problems of determining stock structure, the spatial distribution, the mixing zones remains the important factors to realize a stock assessment project. In parallel with other techniques like biological, chemical, parasitical tags (otolith, DNA and parasite), the tag could contribute towards providing a better knowledge on the migration pattern of swordfish betwe en the Indian Ocean towards the Atlantic (South Africa) or the Pacific (Australia).

Within a particular stock, the knowledge of the individual behavior in a smaller area could help to model the spatial distribution following the size and/or the sex that can be indispensable for VPA Analysis.

A better knowledge of the individual behavior is necessary for reproduction purposes. Differences observed in the sex-ratio from different areas could be related to the behavior of each sex to environmental conditions (accessibility) or different behavior to the gear (vulnerability). Noting that vulnerability could be strongly age dependent, the size of the fish must be taken into account.

The knowledge of the behavior of pelagic species like swordfish influence reliability of stock assessment, it is equally indispensable for the implementation of management measures. In fact, helping the fleet to target favorable fishing zones where they can catch bigger fish is in itself more efficient than preventing the landing of sma ll fish which is more difficult to enforce.

3 WHAT TYPE OF TAG?

3.1 Spaghetti tags

These are widely used to assess migration and growth rates of various species including pelagics. For the

latter tagging operations uses the free swimming or the schooling behaviors of the species in question. Swordfish are generally solitary, in pairs or rarely in small groups of a few individuals. This behavior exclude all possibilities of an intensive tagging operations based on the hiring of a research vessels. The number of recaptures for this species observed in the Atlantic is very low. This form of tagging from commercial fishing operation poses several problems. The first being financial consideration, each fish to be tag as to be purchased from the skipper. Secondly, low survival rate of the fish that is to be released. Due to the length of commercial longline and the time taken to haul the gear means that the fish are often dead or not in a condition to be tagged. Results of this type of tagging essentially considers the growth rate of only a few fish. The point of release and recapture should provide information on the route of migration which is still unknown.

For the above reasons the spaghetti tags will not be considered for this project.

3.2 The archival tags

These are used in big tagging operations on different pelagic species, notably southern bluefin tuna, where theyprovide a range of information on the tagged fish such as:

- Regular geographic location
- Swimming depths
- Ambient water temperature
- Internal temperature of the fish (trophic indexes)

They have provide a better knowledge on the behaviors and migration patterns of various species.

Regarding swordfish, the geographical position could be difficult to analyse. In fact the calculation of geographical positions used the concept of luminosity (day length, sunrise and sunset), but it is well known that swordfish have a diurnal migration pattern related to vertical movement of trophic layer. Some authors have proposed that they always maintain certain preference to light intensity. This behavior can be easily verified by the used of the tag luminosity sensor. If we can test this hypothesis, the luminosity factor will provided valuable position and distribution indexes for swordfish in the ocean.

The difficulties encountered from tagging of fish should also be analyzed. In fact the tag should be placed in the interior of the fish (with the light sensor extruding). It is therefore required that each fish is operated on : slit, insert the tag, stitch and disinfect. This procedure is particularly difficult to realize on an already stressed fish caught on a longline (high mortality risk following the operation) or otherwise on a robust fish but difficult to manipulate.

The low probability of recapture and the high cost of each tag should be taken into account (several thousand francs)

3.3 Acoustic tag

Short term, as it requires tracking the fish at sea, this type of tagging provides unique data : the spatial movement of the fish during the operation (from a few hours to 2 or 3 days maximum). Placing at the same time temperature salinity and dissolved oxygen gauges in situ should provide us with profiles of these parameters. It should be interesting to complement the above parameters with light readings to test the hypothesis of “isolume” behavior.

It is possible to connect the acoustic prospection so as to follow the movement of trophic layers with the taggered fish. It should be interesting to complement the variables of the medium with a topographic reading of the sea bed.

This type of tagging should help to analyze the behavior of swordfish as a function of different parameters of the medium. These observations may result in behavioral models such as IBM and help to evaluate migration problems on a larger scale.

On the operational side, acoustic tagging requires the use of a fast vessel dedicated to the operation. The number of trackings should be sufficient in order to result in reliable hypothesis regarding behavior. However, it is required that work be carried out on species of different sizes and sex which require boat time as well as scientists in order to obtain significant results.

3.4 Archival pop-up tag

In spite of an heavy cost (30000 French francs), this tag is very interesting because it is equipped with the same sensors (except internal temperature) than archival tag and allowed a great recapture rate *(95 %)*. In fact, this type of tag is able to pop up at surface at a programmed date and it transmits data by the way of the Argos system. It is an external tag easier to attach to the fish.

4 PRELIMINARY CHARACTERISTICS OF A REGIONAL TAGGING PROJECT

At the preliminary steep, we just summarize the

fundamental questions necessary to elaborate such a program.

4.1 Where?

Problems of stock structure are fundamental and must to be studied on the basis of the first hypothesis formulated from genetic results. The first results obtained in this field show an unidirectional migration flux from Indian Ocean towards Atlantic Ocean. South Africa seems to be a priority zone of tagging for the above reason and furthermore because a new swordfish fishery began in 1997. The catch of this fishery rise 468 mt in 1998 and is essentially composed of large individuals.

The Reunion longline fishery works in a large area of the south west Indian Ocean (between *15°* and *25°* S). It offer a good possibility of collaboration with fishermen in a zone with reproductive activity (Poisson and Taquet, *billfish session)*

Northwards, Seychelles archipelago represent an interesting tagging area. Swordfish is fished in this zone since 1994 and this fishery is being monitored by SFA scientists.

Eastwards, the Australian fishery develops his activity at the oriental boundary of the Indian Ocean. It seems very important to include this zone in the program. From a geographical point of view, extension of tagging zone on others regions is desirable furthermore in countries where a swordfish fishery exist.

4.2 How many fish?

First of all it is essential to identify the different sub-population (in a statistical sense) that will be tagged. An initial separation in term of sex should be carried out. Then, for each sex, distinguish the different class size. As a prerequisite, the matures and juveniles fish of the two sexes should occupy different strata. All that remain is to define the number of individuals in each stratum bearing in mind the high recapture rate ***(95%)***of this tag.

Without secondary sexual characteristics, it will be impossible to identify the sex without taking a sample of the flesh during the tagging process, without the possibility of obtaining a result before the release of the fish. We should then take into account this actual limitation, when choosing the fish for tagging with respect to the sex. On this point, an identification kit based on the in situ analysis of the flesh samples is currently being developped in Germany (Dusseldorf University).

A minimum 80 tags seem to be sufficient for a serious swordfish tagging project.

4.3 When?

The pop-up archival tag available at present time, provides the possibility to record data on an hourly basis up to a maximum period of one year. In the initial phase the procedure that will provide the best results in term of cost/knowledge of behavior consistency to tag simultaneously in four geographical areas.

4.4 How?

To realize this tagging project we need to schedule specific campaigns on commercial or research boats. In fact, the length of the gear used during commercial trip are to long to obtain a good percentage of live fish. Therefore the project's budget should take into account hiring of vessels.

The characteristics of the fishing operation could be define according to experiment results gathered in Reunion. The results show that for 1000 hooks we get an average of 2 live fish. By the reducing the length of the fishing operation, meaning the number of hooks per set, we will increase the possibility to obtain fish in better condition for tagging. Moreover, according to Ifremer preliminary results with "hook timers", 44 % of swordfish are caught during the 3 hours following the deployment. We estimate that to tag 80 fish we have to deploy 40000 hooks per set of 500, so a total of 80 sets.

4.5 Cost estimation

An initial estimation of the budget that will be required to implement this project can be done:

		Unitary Cost (FF)	Total (FF)
Purchasing tags	80 units	31500	2520000
Hiring of vessels	80 days	10000	800000
Access to the Argos system	80 units	300	24000
Sensibilisation compaign and rewards		30000	120000
		Total	3464000

5 CONCLUSION

The tagging operation realize in the frame of the present program (PPR) can provide validation to the tagging procedures. It is for this reason that we are proposing that we wait for the results of the pilot study before starting a regional program. The tagging techniques used in Reunion will be applied during a common campaign SFA/Ifremer, on the research vessel "L'amitié", that will be realized in October. The efficiency of short longlines (400 hooks) will be tested on this occasion. In parallel, electronic tagging of swordfish will take place in reunion during the coming months.