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POSSIBLE INTERACTIONS BETWEEN THE PURSE SEINE AND BAIT BOAT SKIPJACK FISHERIES IN THE INDIAN OCEAN

Fonteneau Alain and Hallier Jean Pierre

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POSSIBLE INTERACTIONS BETWEEN THE PURSE SEINE AND BAIT BOAT SKIPJACK FISHERIES IN THE INDIAN OCEAN

By

Alain FONTENEAU (1) and J.P. HALLIER (2)

ORSTOM scientists
(1)CRODT, BP2241, DAKAR SENEGAL
(2)SFA,antenne ORSTOM, Seychelles

SUMMARY

This paper analyses the potential interactions between the skipjack purse seine fisheries and the maldivian artisanal skipjack fishery. This analysis is based on the trends of skipjack catches by sizes in the two fisheries. A simulation model is utilized to test the interaction effects between fisheries operating on mixing fraction of stocks, exerting each one a given local fishing mortality. The preliminary conclusions from this analysis is that there is presently little or no negative action from the purse seine increased catches on the maldivian fishery. This situation can be explained by a low mixing rate between the two areas, a low exploitation rate, or a combination of those two factors. This situation may be related to the relatively short exploited life of skipjack and to the moderate distance covered by this species in its migrations, as suggested by tagging and recovery results in other oceans. Those conclusions are very preliminiry and cannot be extrapolated to different fishing conditions (total catches or sizes taken, fishing areas for instance). Only an intensive tagging program conducted in both the purse seine and the bait boat area can improve the knowledge on exploitation rates and on mixing rates, which are the major cause of potential interactions.

1. INTRODUCTION

One of the major characteristics of the Indian Ocean tuna fisheries is the existence of important and old traditional fisheries using pole and line and bait boat fishing. The major fishery in this category is the maldivian fishery, which has probably been active for centuries (Stequert and Marsac 1986), catching tunas, predominantly skipjack tuna, in the Exclusive Economical Zone of the Maldives. The Sri Lanka artisanal fishery catch a smaller proportion of skipjack, but its catch is also significant.

Since the early eighties, an important purse seine fishery has been developed very quickly and at a wide scale in the western Indian Ocean, primarily by France and Spain. Skipjack tuna is not the major target species of this purse seine fleet, but this species is seasonally heavily fished by this fleet: the recent skipjack catches by purse seiners is now much more important in weight that the maldivian catches (table 1).

As the skipjack resources are supposed to belong to the same Indian Ocean skipjack stock, the question of a possible negative impact of increased catches by purse seiners upon the maldivian baitboats catch rates and catches, has been raised.

The goal of this paper is to review the nature of this problem, based on the most recent statistical data upon the two fisheries, and using a migratory simulation model in order to provide a better understanding of the possible interactions between the two fisheries. This analysis will be conducted in comparison of other skipjack fisheries active in other oceans, especially on stocks where intensive tagging has been done.

2 . SKIPJACK FISHERIES IN THE INDIAN OCEAN BY MALDIVIAN AND PURSE SEINE FISHERIES :

2.1. FISHING ZONES :

The major fishing zones of skipjack tunas by the purse seine fishery during the period 1985-1987 are shown in figure 1, and compared to the maldivian fishing area. The purse seine fleets predominantly catch skipjack in three major fishing areas :

(a)the area between Seychelles islands and changes
(b)the area off-shore Somalia
(c)the area north west of Madagascar, in the north of the Mozambique canal.

The distances between each of those 3 areas and the Maldives area is an important factor to consider :

Distance from the (a)fishery to Maldives : 700 milles.
Distance from the (b)fishery to Maldives : 1000 milles.
Distance from the (c)fishery to Maldives : 1900 milles.

The maldivian baitboat fishery operates only in the Exclusive Economical Zone of this country.

2.2. CATCH TRENDS OF THE 2 FISHERIES:

The catches by the baitboat and international purse seine fleets during recent years are given in table 1.

This table clearly shows a dramatic increase in the catches by both fisheries. The increase of catches by the maldivian fishery may be related to the development of inboard engines in the local "doni" fleet.

The increased catches by purse seine fleet may be related to two factors:

+ first the increase of fishing effort of this fleet,
+ second its increased fishing efficiency, especially upon tunas taken under floating logs (where skipjack is more often taken HALLIER 1990). This increase of catches is noticed, even taking into account the fact that skipjack tuna is not an economically interesting species, because of its low market value (about half of the yellowfin price per ton during recent years). However, this low price of skipjack can be partially offset by very high potential catch rates in some time and area strata.

2.3. SIZES TAKEN BY EACH FISHERY :

An important factor to consider in all interaction study is the size composition of the catches taken by each fleet.

Using the average profile of the skipjack sizes taken by each fleet, an average histogram of catches by sizes has been established and is shown in figure 2. This figure gives the profile of sizes taken by each fishery extrapolated to its average level of catches during recent years (period 1984 to 1987).

This figure based on sizes taken during recent years (1985 to 1987 for the purse seine fleet, 1985 and 1986 for the baitboat fleet) indicates that the sizes of skipjack taken by the maldivian fishery cover a wider range than the purse seine catches. From this sampling, this fleet takes smaller skipjack (in the range 20 to 35 cm) than the purse seine fleet, but also much more large and very large (and older) skipjack in the range 60 to 75 centimetres. The average weight in the maldivian fishery tends thus to be heavier (32 kg versus 42 kg).

The reality and the stability (between years) of those differences need to be checked and explained, but the present size profile of figure 2 has been accepted as a real typical difference between the two fisheries, as a working hypothesis.

3. SIMULATION OF INTERACTIONS BETWEEN FISHERIES OPERATING IN DIFFERENT AREAS: BIOLOGICAL DATA, HYPOTHESIS AND MODEL USED

3.1. INTRODUCTION TO SIMULATIONS OF GEOGRAPHICAL INTERACTIONS BETWEEN FISHERIES :

In the absence of scientific data and analysis, one easy (but dangerous..) solution to measure the interactions between fisheries, is to conduct some type of intensive fishing in one area, and to wait if some negative effects are appearing in the other fisheries. This scenario of testing at a real fishery scale has been to some extent experimented in the Indian Ocean during recent years because of the fast and important development of skipack catches by purse seiners in the western Indian Ocean. This real scale "experiment" can provide some interesting "a posteriori" informations......

An alternate and scientific solution is to run simulation models on the same problem, where tuna boats and tuna stocks are in a computer, so that the interactions can be predicted in advance, and management errors can be avoided.

The nature of those simulations would be quite easy in the ideal situation if all the parameters concerning the stock structure and the stock and fisheries parameters, are known.

In the ideal case :

- the growth of the tuna,
- its natural and fishing mortalities,
- its population size by time and area strata (so its migrations)

- the age specific catchability of the stock to each gear, are known precisely,

it would become fairly simple to simulate the potential interactions between fisheries operating in different areas.

Thus, an alternate solution to evaluate the possible interactions, is to run simulation models under a set of selected realistic hypothesis. Those hypothesis may be obtained from the fishery data and from the biological parameters ,known or obtained from other oceans. This type of world wide biological hypothesis may seems doubtful, but is interesting to consider for skipjack tuna: this species seems to have many similarities in every oceans, the inter-ocean biological differences being possibly more important than the intra ocean differences between time and area strata.

3.2. WORKING HYPOTHESIS IN THE SIMULATIONS AND MODEL USED :

- Natural mortality: equal to .8, value often used in other oceans (Cayre et al. 1988).

- Growth: in the absence of an accepted Indian Ocean growth curve for skipjack, the Atlantic growth given by BARD and ANTOINE 1986 is used. Based on tagging and recovery results, it follows a Von Bertallanfy growth curve, with k=.32 and L infinity equal to 80 cm.

- Fishing pattern of each fleet (purse seiners and bait boats) :

The average catch at size given in figure 2 has been converted in catchabilities at age (given in figure 3)using the Pope's cohort analysis, under the 2 previous hypothesis of growth and M. Several critical problems limit the absolute validity of this result; it may however be accepted, not as a result, but as a reasonable working hypothesis for further simulations.

- Simulation model used :

The model used has been described by Fonteneau 1981 and is very simple. The equations used in this simulation model are the catch equations described by Thomson and Bell 1934. Basically two fisheries exploit two fractions of a stock inhabiting adjacent areas with some mixing. There are known mixing rates between the 2 areas, which are applied at the end of each quarter (unit of time in the model). The population size at age in each area is known. Each gear in each area excerts an age specific fishing mortality, following a given fixed fishing pattern. Natural mortality and growth in weight by time units (quarter) are known. For any simulated fishing effort, the model calculates the quarterly yields of each fishery, in transition and in equilibrium. Thus, this model will rely, at least in this case, upon several critical hypothesis; however it may help to explore the mixing rates between areas and the local exploitation rates which are compatible with the recent observed Indian Ocean trends of fisheries.

- Several simulations have been conducted under different hypothesis concerning :

.the mixing rates between the two fractions of stocks.
.the population sizes in each of the two fisheries.
.the fishing efforts in each of the two fisheries.

3.3 RESULTS OF SIMULATIONS :

There are serious practical difficulties to show all those results in a short paper. Some typical results are given in table 2.

The major conclusions from those various simulations, even if they are very preliminary, can be summarized as follows :

1. When an interaction is observed, the negative effects on catches are observed quickly, within 2 to 4 years, because of the similar range of the skipjack sizes taken by the 2 fisheries.

2. The simulated negative effect of purse seine catches depends of 2 major factors :

(a) The exploitation rate of the stock.

(b) The nature and intensity of the age specific migration pattern between the two geographical areas.

- In the simulations where the stock is heavily exploited and with important mixing rates between areas, a significant interaction between purse seine and baitboat should be observed.

- In the simulations where the two fractions of stocks are underexploited and/or the mixing are low (for instance 10 % of the population migrating each quarter) between the two sub-stocks, then the interactions tend to be very small .

4 . DISCUSSION

The present analysis and simulation is a preliminary and crude one, based upon many critical hypothesis. However its conclusions may seem reasonable in term of stock assessment and in comparison of other skipjack fisheries, for instance in the eastern Atlantic or western Pacific. This type of conclusion is for instance well explained and documented for the western Pacific skipjack by Hilborn and Sibert 1988. The conclusion of those authors is that there may be various examples, for this species, at least for large EEZ, of very low or no interactions between fisheries. This situation is primarily explained by the short duration of the exploitation, the relatively small range of migrations, and the relatively low exploitation rate (in this area). The range of migrations is estimated to be small for skipjack because of the average small apparent distances between tagging and recovery positions. Those small distances, which are in fact observed for skipjack (statistically) in most tagging and recovery programs, indicate that the interactions between EEZ could be often limited (as in the simulations). In the Atlantic skipjack fisheries, similar conclusions are obtained (FONTENEAU 1990): the average apparent migratory distance for skipjack is less than 300 milles, and there is very little or no apparent interactions between the skipjack fisheries operating in the major coastal EEZ of west Africa where skipjack is fished: Senegal, Ghana and Gabon for instance, separated by distances of and milles..

Based on those observations, and on the stability (and even increasing trend) of catches in the baitboat maldivian fishery, one could probably conclude to the present absence of significant interaction between purse seine and baitboat fishery.

However this conclusion is only provisional for two reasons:
- first, it is based upon fragmentary informations, especially at the biological level.
- second and more critical, it is not yet known if this present lack of apparent interactions is due:
. to a still low exploitation rate of skipjack,
. to a low mixing rates between the two fractions of stock exploited by the two fisheries.

Both hypothesis may be reasonable :

Skipjack stocks are often very large, and there are very few or no examples of overfished skipjack stocks in the world. The recent increase of the maldivian catches, following the motorisation of the doni fleet, indicates also that at least the local fraction of the skipjack stock was not yet fully exploited in the early eighties. Otherwise, the increase of effective effort would have been unsuccessful in increasing significantly the catches.

The distance between the two fisheries, 700 milles, is much more greater than the average distance usually observed between tagging and recovery. However this distance is still moderate and can probably be biologically covered by any fish during its seasonal or life span migrations. This hypothesis can be accepted because many potential bias in the analysis of tagged tunas tend to underestimate the real biological potential of migrations. However, as the EEZ of the Maldives Islands is very large, and as the environment in the area is relatively stable (Stequert and Marsac 1987), the "island effect" may concentrate a large and stable biomass of skipjack in the EEZ during long periods of time. This isolated fraction of stock could then, in this hypothesis of a sedentary fraction of stock, be considered to some extent as a stock.

Those uncertainties could only be solved with an intensive tagging of the skipjack stock in the two areas. The most important tagging should be done in the purse seine fishing area: the more important mixing rate to estimate in this interaction study is probably the transfer rate of tunas between the purse seine area, towards the Maldives area. This rate can be estimated if tagging is conducted in the western side of the Indian Ocean. It is also obvious that this future tagging should be done at a large scale, for instance several 10000 of skipjack tagged, if statistically significant mixing rates are expected from the tagging program. The present maldivian tagging program is clearly a very interesting one, but will not be able to solve alone the interaction problem.

5. CONCLUSION

The present data on Indian Ocean skipjack fisheries indicate that there is presently very little or no apparent interactions between the purse seine and the baitboat maldivian fisheries. This lack of interactions can be easily explained by some common biological characteristics of this species.

However there are still serious uncertainties to explain in details in a comprehensive manner this lack of interactions, and to make previsions on the possible effects of possible increased catches, or of changes in purse seine fishing zones. It must be also kept in mind that the same catch of skipjack tuna taken by purse seiners, may have a different impact on other fisheries, depending of the size of tuna caught and of the area exploited.

An intensive tagging program, conducted at least in the two areas, is the only solution to understand the real causes of the present situation: low exploitation rates or/and low mixing rates. The results from such a program could allow a better future management of the skipjack resource, especially allowing a full exploitation of the skipjack stock, without jeopardizing the local resources exploited by the traditional baitboat fisheries, from the Maldives and from other island countries.

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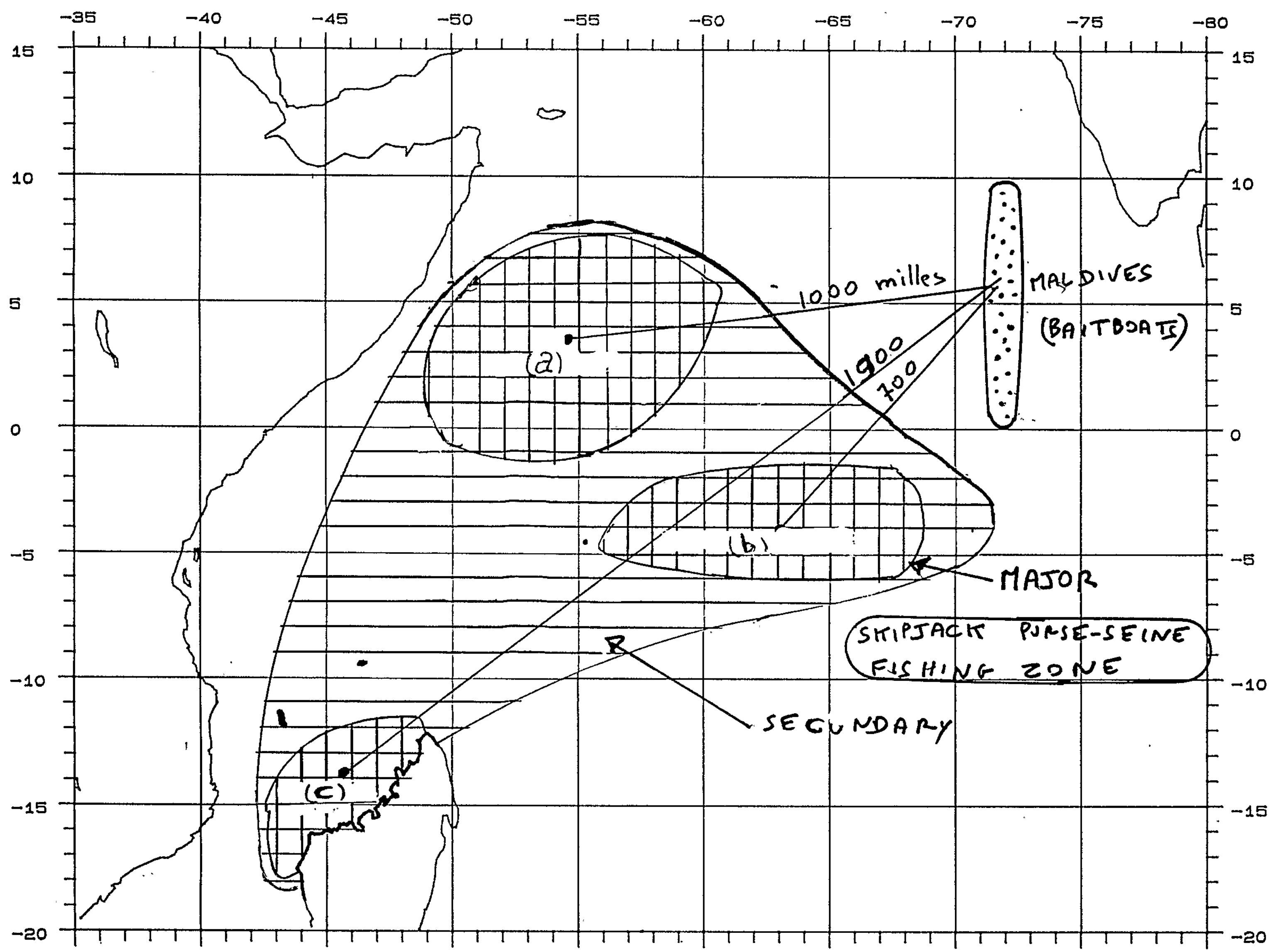

Figure 1.- : An Average skipjack fishing zones for of the purse seine fleet (1984-1986) and of the maldivian baitboats.

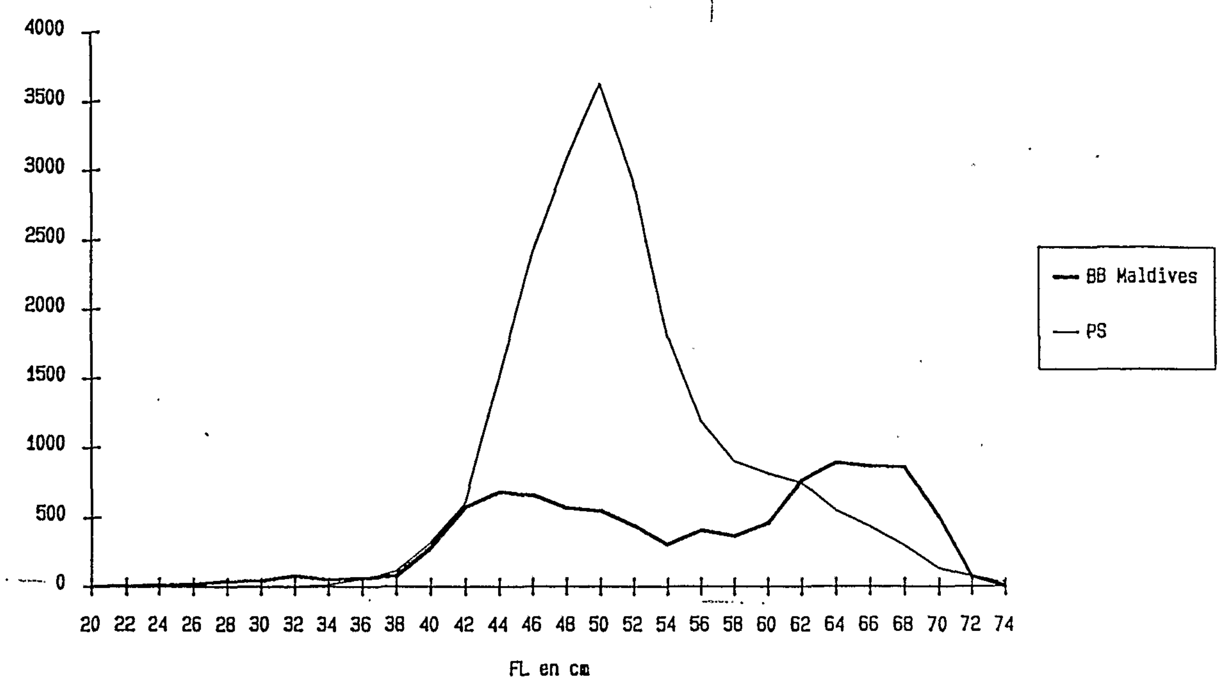

Figure 2.- : Catch by size of skipjack by the purse seine fishery (average 1985 to 1987) and by the maldivian baitboat fishery (1985-1986 sizes extrapolated to the 1984-1987 catches).

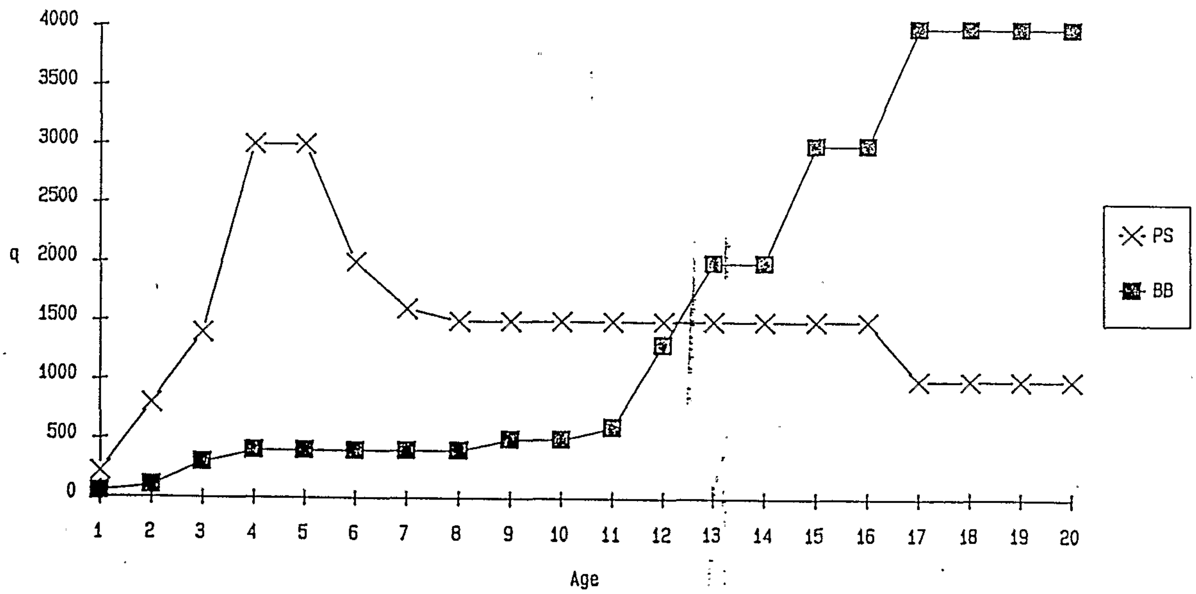

Figure 3.- : Estimated catchability coefficient by age of maldivian baitboats and of purse seiners (corresponding to the catch by size given in figure 2) (with an M =•8 and a growth curve L : 80 cm and k=0.32).

Table 1.- : Yearly catches of skipjack by maldivian and Sri Lanka baitboats and by Spanish, french, and Maurician purse seiners.

	MALDIVES BB	SRI LANKA GILLNET ~~BB~~	(SPAIN+FRANCE+MAURITIUS) PURSE SEINE
1978	13.4	10.9	0
1979	18.1	8.3	0
1980	23.6	12.7	1.0
1981	20.6	13.7	2.0
1982	15.9	13.2	3.2
1983	19.7	13.9	11.5
1984	32.0	11.6	36.4
1985	42.6	12.1	58.0
1986	45.4	13.7	67.1
1987	42.1	12.9	81.9
1988	58.5	13.4	95.1

Tableau 2.- : Simulated purse seine and baitboat skipjack catches under different hypothesis of mixing rates and fishing efforts.

EFFORT	EFFORT PS	MALDIVES CATCHES			PURSE SEINE CATCHES		
		MIGRATION RATE : 1	2	6	MIGRATION RATE : 1	2	6
PRESENT	0	40.8	41.2	41.7	0	0	0
PRESENT	HALF	39.4	39.7	39.9	39.6	39.5	39.6
PRESENT	PRESENT	38.4	38.2	39.8	75.9	76.4	76.9
PRESENT	DOUBLE	36.3	36.2	35.4	141.0	143.7	145.6
PRESENT	X5	31.0	30.7	27.1	28.7	300.7	11.6
DOUBLE	0	75.7	77.1	78.7	0	0	0
DOUBLE	DOUBLE	67.1	66.2	66.8	140.0	141.8	143.9

FORM A : SCHOOL SIGHTINGS

Observer :

Seiner:

Form number :

TRIP SPECIFICATION								ECHO SOUNDING					SEA SURFACE SIGHTINGS				ENVIRONMENTAL DATA							
								BAIT		TUNA														
Year	Month	Day	Hour	Sign Latitude	Longitude	Log	ACTIVITY	Mean depth of detection	Thickness	Species	Abundance	Mean depth of detection	Related sightings	Appearance of Indications	Species	School behaviour	Sea Temperature	Cloudiness	Sea condition	Wind direction	Wind speed	Current direction	Current speed	SET NUMBER
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	23	24	25	26

FORM B : DETAILS OF FISHING OPERATIONS

Observer: Seiner : Form number :

Year	Month	Day	Set Number	Sign Latitude	Longtitude	Time Skiff is launched	Time Net is closed	Time Scooping begins	Time Skiff is onboard	SET CATCH (mT)					By-Catch (x 100 kg)	Nil Set	Type of Set	Thermocline depth
										Yellowfin	Skipjack	Bigeye	Albacore	Others				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19