EVALUATION OF THE EFFECT ON THE BIGEYE STOCK OF DIFFERENT PURSE SEINE FISHING EFFORT REDUCTION SCENARIOS

by

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ABSTRACT

This document presents different management strategies, alternatives to the time-area closure, based on the reduction of purse seine fishing effort and its effects on the tropical species catches as well as in the Indian bigeye stock through YPR analyses. The resulting decrease in the bigeye catch goes from a 4% to a 20% with similar reduction in the total catch. The results show that any measure of control of effort applied during the last half of the year is more efficient to reduce the bigeye catch and the juvenile catches of yellowfin and bigeye due to the high seasonality of the fishing on floating objects. Reducing only the purse seine effort YPR analysis shows lightly increases in YPR (less than 2%) and more significant increases in SSBPR (between 4.5% and 9.5%). The inclusion of the LL in the analysis produce reductions in YPR less than 3.5% and increase in spawning biomass per recruit up to 10% if longline alone is reduced or to 20% if both purse seine and longline efforts are reduced.

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INTRODUCTION

During the IOTC 7th session meeting, the Commission expressed its concern about the increase in catches of yellowfin and bigeye, in general, and of juvenile yellowfin and bigeye associated with floating objects, in particular, and the need to seek management measures that lead to a reduction in the juvenile fishing mortality. Within these measures, the application of time-area closure of fishing on floating objects was considered, though bearing in mind that this might be an effective measure only if closure were based on a scientific recommendation and, furthermore, that the Commission were in a position to demand the fulfilment of the measure by all the purse seine fleets currently fishing in the Indian Ocean.

Regarding this possible measure, several questions must be considered:

- There is a recommendation of the Scientific Committee about applying a moratorium to floating objects, but this recommendation goes back to 2000, and subsequently has not taken into account the results of the more recent assessments, nor the changes that have occurred in the fishery since then.
- The experience of time-area closure that has been carried out in the Atlantic Ocean since 1997 shows that it is very difficult, at the present time to apply control measures to force all the fleets to comply with the moratorium.

As alternative to the time-area closure, this document presents different management strategies based on the reduction of purse seine fishing effort and its effects on the tropical species catches as well as in the Indian bigeye stock.

MATERIAL AND METHODS

Catch and effort data come from logbooks. The logbooks system provide detailed information at set level and was introduced in tropical purse seine fleets in the Atlantic at the beginning of the eighties. The system was transferred to the Indian Ocean, when the fleets moved there in the mid-eighties. At present, the logbooks have 100% cover in the Indian Ocean, including the fleet component with European Community interests that fishes under other flags.

Within the Scientific Committee of the Indian Ocean Tuna Commission (IOTC), information from the logbooks is considered as high quality.

The analysis was performed on Spanish, French, Seychelles and other purse seine fleets with European Community interests fishing under other flags. These are virtually all the purse seine fleets fishing in the western Indian Ocean.

The most recent period 1999-2001 has been taken as the reference period.

Analyses were conducted considering the vessel as reference unit. For each vessel, calculations were made at trip level obtaining different statistics as: trip duration, catches by species and commercial category and number of sets. This has allowed us to estimate the number of trips, trip duration, total effort in days at sea and total catches per species and category for yellowfin and bigeye (<10 Kg., 10-30 Kg. >30 Kg.) by vessel and year. A minimum threshold of 5 trips by vessel and year was established so that the results obtained should be representative of the normal activity of the fleet.

Keeping the vessel as unit, these data were used to calculate average values (1999-2001) for the following statistics: total catch rates (total catch/sea days), catch rates by species and catch rates of small (<10 Kg.) yellowfin and bigeye, trip duration, number of trips by year and average number of sets per day at sea.

The estimations of the current total effort and catch and the catch and effort resulting of the application of the different management strategies based on effort reduction were performed using these average values. The product of the average annual number of trips by the average duration of the trip was considered as an estimate of the annual average effort per vessel. Total catch, catch by species and total number of sets per vessel, were obtained by multiplying the average catch by day at sea and the average number of sets by day at sea by the estimated annual effort (days at sea). The total values were obtained by adding the total estimates by vessel.

6 different scenarios were established as management alternatives:

- Scenario 1: 10% effort reduction (days at sea)
- Scenario 2: 15% effort reduction (days at sea)
- Scenario 3: 20% effort reduction (days at sea)
- Scenario 4: increase in landing times by 1 day
- Scenario 5: increase in landing times by 2 days
- Scenario 6: increase in landing times by 3 days
- Scenario 7: increase in landing times by 4 days

Calculations were carried out on an annual basis, by considering that effort reduction is undertaken homogenously throughout the year, and on a six-monthly basis, considering that effort control is performed exclusively during the latter six months of the year, a period when the largest catches of fishing on floating objects are made. Effort reductions were applied to annual effort and to the effort corresponding to the second semester, respectively.

In order to assess the effect of the different effort reduction strategies on bigeye stock, multi-gear yield per recruit models were used. Current fishing mortality vectors for longline and purse seine were considered to be those used as inputs in the multi-gear yield per recruit analysis conducted during the last bigeye stock assessment (Table 1). From these values we have applied a reduction to the purse seine fishing mortality equal to the effort reduction resulting from the different strategies tested assuming equivalence between effort and fishing mortality. Also we have assumed that the reduction of effort is the same for all ages. The forward scenarios were broader than the assumptions of effort reduction contemplated in the analyses and were extended to other fleets, such as the longline.

From the estimates we have also conducted some comparative analyses of fleets. ANOVA was used considering year and fleet as explanatory variables and different estimators as response variable. Contrast treatment was applied with the purpose of having a direct interpretation of the coefficients.

Finally, and considering the daily vertical migrations of bigeye shown by archival tags [Schaefer, 2002 #834], the catch and its species composition by time interval was studied. The aim was to see the effectiveness of limiting the starting time of the fishing operations in a given day to avoid bigeye catches while not reducing significantly catches of other species.

For this purpose, observer data collected in the EU Project “Etude des causes de l’augmentation des prises de thon obese dans l’Atlantique par les senneurs communautaires” (EU 96/028) and during the FAD moratorium in the Atlantic (98-99 and 99-00) and Indian (98-99) oceans was used. Fishing operations on FADs which were sampled by observers were selected (475 sets in the Patudo Project, 928 sets in the Indian moratorium and 581 sets in the Atlantic moratorium).

The difference between the time of the fishing operation and the theoretical sunrise time in the same location and season was computed. This variable was grouped in 1 hour intervals. Interval 0 includes half an hour before and after sunrise.

RESULTS

Comparison between fleets

The results of the different ANOVA conducted using the overall catch rate and catch rates by species as explanatory variables show significant differences between fleets. Figure 1 shows the fleet’s coefficients estimated by the different ANOVAs. In all the cases the Spanish and NEI fleets seem to be more efficient than the other fleets. However, the results show some differences in the target species by fleet. French and NEI fleets seem to be targeted in YFT while the Seychellois fleet does not show any special targeted species.

Table 2 and figures 2-5 show the estimated statistics per vessel corresponding to the average 1999-2001. In terms of effort (number of trips, average trip duration, fishing days), the results seem to be very similar for all fleets, except for the Seychellois fleet where there was a lower trip duration than for the rest of the fleets. On the contrary, where fishing efficiency is concerned, the Spanish fleet and the NEI show significantly higher efficiency, as seen in the results from the different ANOVA.

Effort reduction strategies

Table 3 shows effort, total catch, catch by species, catches of yellowfin and bigeye under 10 kg and the number of current sets in addition to those resulting from the application of the different scenarios of effort reduction on an annual basis. The table also shows reduction (number and %) on current values, effort, catches and number of sets that would take place by applying the same scenarios. Table 4 shows the same information on a six-monthly basis.

Figures 6 and 7 give graphically the same information.

Considering the year as a whole and with the method used, catch reductions correspond to effort reductions in an equal percentage. However, the data shows the seasonality of the fishery with greater activity during the latter six months of the year. Comparing fishery activity during the second half of the year with the annual total (Table 5), we observe that the estimated total catch for the six-month period is almost 70% of the annual total catch and effort is close to 60% of the annual effort. However, seasonality is not the same for all species and sizes. While the average yellowfin catch per day at sea during the second semester is practically the same as the average annual value, the skipjack catch rate is 33% higher and the bigeye catch rate 23%. This is due to the increase in the fishing on floating objects during the second semester of the year. Considering the sizes, catches of small (< 10 kg) yellowfin and bigeye make up 66% and 72%, respectively, of the annual catches. Therefore, if management strategies aim to reduce bigeye catches, effort should be managed during the last half of the year. Regarding the juvenile bigeye, 15% effort reduction during the second half of the year is equivalent to 7.9% annual effort reduction and produces a decrease in catches similar to a 10% reduction of the total effort. In contrast, the decrease in skipjack catches, species not subjected to any management recommendation, would be greater if the regulation were exclusively applied during the second six-month period than throughout the entire year.

Effect of different strategies on stock

The different strategies tested are transformed into effort reductions that range from 5% to 20%. The figures 8 and 9 show yield per recruit and spawning biomass per recruit resulting from effort reductions in purse seine by 10%, 15% and 20%. In all the cases the increases in YPR are less than 2%. Increases in spawning biomass per recruit are more obvious, between 4.5% and 9.5%. The table 6 and figures 10 and 11 show the changes in YPR and SSBPR resulting from the different effort reduction strategies for both purse seine and longline. In all cases, yield per recruit is much less sensitive to effort changes than spawning biomass per recruit. Reductions in YPR when longline effort is reduced, either alone or accompanied by reductions in purse seine, do not exceed 3.5%, while the increase in spawning biomass per recruit may reach 11% if longline alone is reduced and 22% if both purse seine and longline reduce their effort by 20%.

Limiting the starting time of the FAD fishing operations

Catch by set, species composition and number of sets analysed by time interval among the Patudo Project is given in Table 7 and figure 12. Table 8 and figure 13 also show the percentage in which each species contributes to the total catch, by time interval.

The catch distribution by time interval and species according to observer data for the Indian and Atlantic oceans is given in figures 14 and 15.

These results show that highest catches in FAD associated sets occur when the fishing operation starts half an hour before or after sunrise, although highest catches per set are given in the previous time interval.

Bigeye percentage in the catch remains around 30% in all time intervals except near sunset where it increases (which could be due to the low number of observations in this time interval).

Eliminating the first set of the day (or starting fishing one hour after sunrise) would reduce a great part of the juvenile bigeye catch but also the rest of the species. The catch would not be more selective in terms of juvenile bigeye, but it would mean a general reduction of the catches of all species. So this measure is not considered to be effective due to its high cost to the fleet.

REFERENCES

SCHAEFER K.M. Y FULLER D.W. (2002): Movements, behavior, and habitat selection of bigeye tuna (*Thunnus obesus*) in the eastern equatorial Pacific, ascertained through archival tags. *Fish. Bull.* 100, 765-788.

Table 1. Fishing mortality vectors from last bigeye stock assessment used for yield per recruit analysis.

Age	F PS	F LL
0	0,0426	0,0000
1	0,2267	0,0006
2	0,0980	0,0388
3	0,0617	0,1598
4	0,0467	0,2976
5	0,0562	0,4724
6	0,0256	0,5616
7	0,0057	0,5790
8	0,0057	0,5790

Table 2. Average values (1999-2001) estimated by vessel and fleet considering a minimum of five trips per boat and year. Categories 1, 2 and 3 define fish less than 10 Kg., between 10 and 30 Kg. and over 30 Kg.

Average values (1999-2001) estimated considering vessels with 5 trips and more by year												
Fleet	n. of trips	catch/fd	set/fd	yft/fd	skj/fd	bet/fd	yft1/fd	yft23/fd	bet1/fd	bet23/fd	fd	days of trip
Spain	10.8	26.4	0.7	10.1	14.0	2.3	3.9	6.2	1.7	0.6	295.6	28.0
France	9.9	19.7	0.8	8.5	9.5	1.7	2.4	6.2	1.2	0.6	266.6	27.1
Seychelles	9.2	18.2	0.6	6.8	10.0	1.4	1.8	4.9	1.0	0.4	239.6	25.2
NEI	9.1	25.2	0.7	10.9	12.2	2.1	3.3	7.6	1.5	0.5	245.9	27.2

Table 3. Catches and effort estimated from the average values calculated per vessel and trip for the period 1999-2001 and catch and effort reduction (number and %) in relation to the current values as a result of different effort reduction applied throughout the year.

	Annual catch and effort estimated from the average values							
	Effort (f.d.)	**Total Catch**	**yft**	**skj**	**bet**	**yft1**	**bet1**	**# sets**
Current	15405.8	354486.8	143676.8	180807.2	30003.3	45945.8	21609.0	11150
10% effort reduction	13865.2	319038.1	129309.1	162726.5	27002.9	41351.2	19448.1	10035
20% effort reduction	12324.6	283589.4	114941.4	144645.8	24002.6	36756.6	17287.2	8920
1 day reduction of trip	14837.1	341409.7	138378.5	174139.2	28892.5	44243.8	20808.8	10741
2 day reduction of trip	14268.4	328332.7	133080.2	167471.1	27781.8	42541.8	20008.7	10332
3 day reduction of trip	13699.8	315255.7	127781.9	160803.1	26671.1	40839.8	19208.5	9923
4day reduction of trip	13131.1	302178.6	122483.6	154135.1	25560.3	39137.9	18408.3	9514
	Reduction in relation to current values							
10% effort reduction	1540.6	35448.7	14367.7	18080.7	3000.3	4594.6	2160.9	1115
20% effort reduction	3081.2	70897.4	28735.4	36161.4	6000.7	9189.2	4321.8	2230
1 day reduction of trip	568.7	13077.0	5298.3	6668.0	1110.7	1702.0	800.2	409
2 day reduction of trip	1137.3	26154.1	10596.6	13336.1	2221.5	3404.0	1600.3	818
3 day reduction of trip	1706.0	39231.1	15894.9	20004.1	3332.2	5105.9	2400.5	1227
4day reduction of trip	2274.7	52308.2	21193.2	26672.1	4442.9	6807.9	3200.7	1636
	Reduction in % in relation to current values							
10% effort reduction	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
20% effort reduction	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
1 day reduction of trip	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%	3.7%
2 day reduction of trip	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.4%	7.3%
3 day reduction of trip	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.1%	11.0%
4day reduction of trip	14.8%	14.8%	14.8%	14.8%	14.8%	14.8%	14.8%	14.7%

Table 4. Catches and effort estimated from the average values calculated per vessel and trip for the period 1999-2001 and catch and effort reduction (number and %) related to the current values as a result of different effort reduction measures applied in the last six months of the year.

	July-December catch and effort estimation from the average values							
	Effort (f.d.)	**Total Catch**	**yft**	**skj**	**bet**	**yft1**	**bet1**	**# sets**
Current	8417.7	219262.0	75993.7	123925.8	19342.7	28786.0	14444.3	5686
10% July-Dec. effort reduction	7576.0	197335.8	68394.4	111533.2	17408.4	25907.4	12999.8	5117
15% July-Dec. effort reduction	7155.1	186372.7	64594.7	105336.9	16441.3	24468.1	12277.6	4833
20% July-Dec. effort reduction	6734.2	175409.6	60795.0	99140.6	15474.1	23028.8	11555.4	4549
2 day reduction of trips (July-Dec.)	7726.4	201218.9	69681.7	113797.4	17740.0	26402.1	13247.2	5219
3 day reduction of trips (July-Dec.)	7380.7	192197.4	66525.7	108733.1	16938.7	25210.1	12648.6	4986
4day reduction of trips (July-Dec.)	7035.1	183175.8	63369.7	103668.9	16137.4	24018.2	12050.1	4752
	Total reduction of annual current values							
10% July-Dec. effort reduction	841.8	21926.2	7599.4	12392.6	1934.3	2878.6	1444.4	568.6
15% July-Dec. effort reduction	1262.7	32889.3	11399.1	18588.9	2901.4	4317.9	2166.6	852.9
20% July-Dec. effort reduction	1683.5	43852.4	15198.7	24785.2	3868.5	5757.2	2888.9	1137.2
2 day reduction of trips (July-Dec.)	691.3	18043.1	6312.0	10128.4	1602.7	2383.9	1197.1	466.9
3 day reduction of trips (July-Dec.)	1037.0	27064.7	9468.0	15192.7	2404.0	3575.9	1795.6	700.4
4day reduction of trips (July-Dec.)	1382.7	36086.2	12624.1	20256.9	3205.3	4767.8	2394.2	933.8
	% of reduction in the annual current levels							
10% July-Dec. effort reduction	5.5%	6.2%	5.3%	6.9%	6.4%	6.3%	6.7%	5.1%
15% July-Dec. effort reduction	8.2%	9.3%	7.9%	10.3%	9.7%	9.4%	10.0%	7.6%
20% July-Dec. effort reduction	10.9%	12.4%	10.6%	13.7%	12.9%	12.5%	13.4%	10.2%
2 day reduction of trips (July-Dec.)	4.5%	5.1%	4.4%	5.6%	5.3%	5.2%	5.5%	4.2%
3 day reduction of trips (July-Dec.)	6.7%	7.6%	6.6%	8.4%	8.0%	7.8%	8.3%	6.3%
4day reduction of trips (July-Dec.)	9.0%	10.2%	8.8%	11.2%	10.7%	10.4%	11.1%	8.4%

Table 5. Current values estimated from the average values calculated by considering the entire year and only the last six months of the year.

	Estimated values		
	All year (A)	July-December (B)	B/A
cyft/s.d.	9.00	9.14	101%
cskj/sf.d.	10.88	14.70	133%
cbet/s.d	1.80	2.26	123%
yf1/s.d.	2.73	3.38	116%
bet1/s.d.	1.29	1.68	126%
c/s.d.	21.68	26.09	120%
l/s.d.	0.71	0.66	94%
Average trip length	27.87	24.76	86%
Days at sea by boat	245.49	141.29	55%
Number of trips	9.03	5.86	60%
Total days at sea	15405.77	8417.75	58%
Total catch	354486.79	219262.04	69%
Yft catch	143676.81	75993.74	59%
Bet catch	180807.20	123925.80	76%
Skj catch	30003.26	19342.67	70%
yft1 catch	45945.77	28786.02	66%
bet1 catch	21609.00	14444.27	72%
Total number of sets	11150.42	5685.99	55%

Table 6. Changes in yield per recruit and spawning biomass per recruit resulting from reduction in effort of the PS, LL and PS+LL fleets.

Changes in YPR and SSBPR resulting from different effort strategies			
	Effort reduction	**YPR**	**SSBPR**
PS	10%	0.76%	4.62%
	15%	1.15%	7.01%
	20%	1.53%	9.46%
LL	10%	-1.57%	5.26%
	15%	-2.48%	8.15%
	20%	-3.48%	11.24%
PS+LL	10%	-0.90%	10.16%
	15%	-1.54%	15.82%
	20%	-2.35%	21.93%

Table 7.- Catch by set, species and number of sets on FADS, by time interval, considering 0 as sunrise time.

Time interval	-1	0	1	2	3	4	5	6	7	8	9	10	11	TOTAL
Nº sets	32	207	30	19	32	33	24	21	28	20	11	12	6	475
YFT (t)	202	898	127	85,5	160	162	52	108	139	65	7,8	22,4	1,3	2030
SKJ (t)	653	2501	202	288	230	360	150	147	136	161	41	50,2	64	4983
BET (t)	420	1576	217	237	181	242	86	61	74	88	32	14,5	16	3244
Total (t)	1276	4975	546	611	570	764	288	316	350	314	81	87,1	81	10257
Catch by set (t)	39,9	24,0	18,2	32,2	17,8	23,1	12,0	15,0	12,5	15,7	7,4	7,3	13,5	21,6

Table 8.- Species composition, in percentage, of FAD associated catches by time interval (Atlantic ocean, Patudo Project).

Proportions of each species (%)														
	-1	0	1	2	3	4	5	6	7	8	9	10	11	
YFT	15,9	18,0	23,2	14,0	28,0	21,2	18,0	34,3	39,9	20,7	9,6	25,7	1,6	19,8
SKJ	51,2	50,3	37,0	47,2	40,3	47,1	52,2	46,4	39,0	51,4	50,7	57,7	78,8	48,6
BET	32,9	31,7	39,8	38,8	31,7	31,7	29,8	19,3	21,1	27,9	39,7	16,7	19,6	31,6

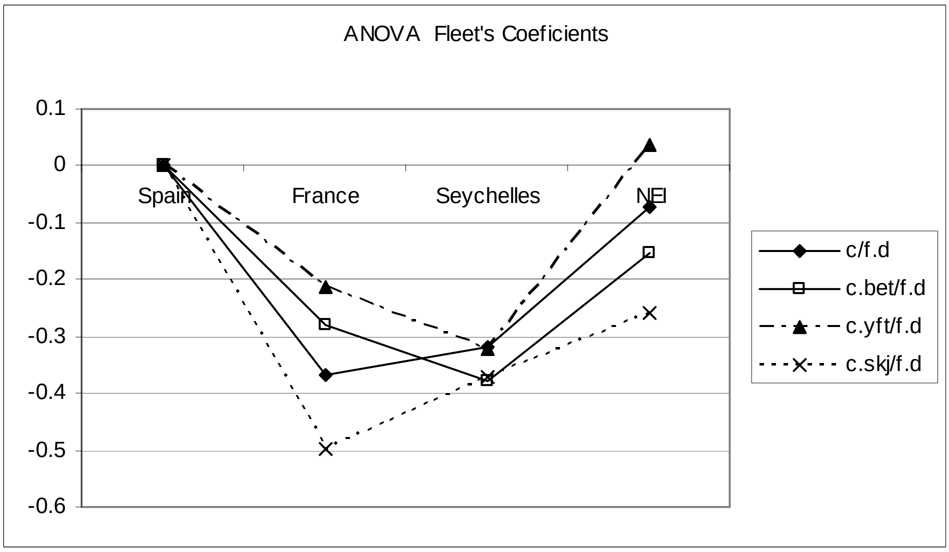

Figure 1. Fleet coefficients estimated by ANOVA considering different catch rates as response variables.

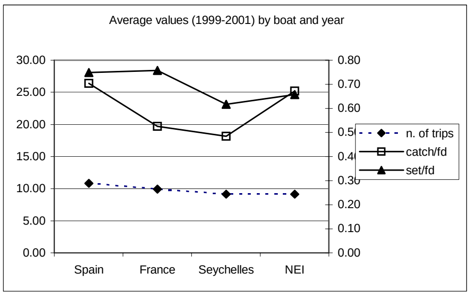

Figure 2. Annual number of trips, catch and number of set by fishing day by boat and fleet.

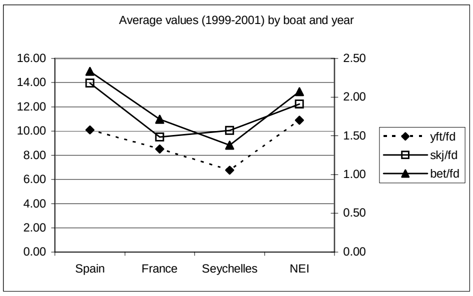

Figure 3. Yellowfin, skipjack and bigeye annual catch rate by boat and fleet.

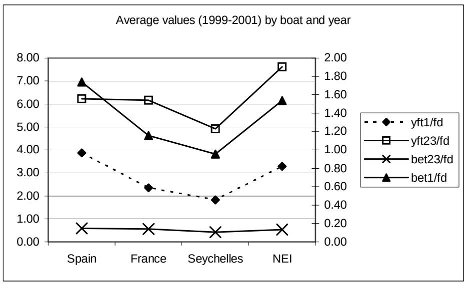

Figure 4. Small (less 10 Kg.) and large (10 Kg. and more) yellowfin and bigeye annual catch rate by boat and fleet.

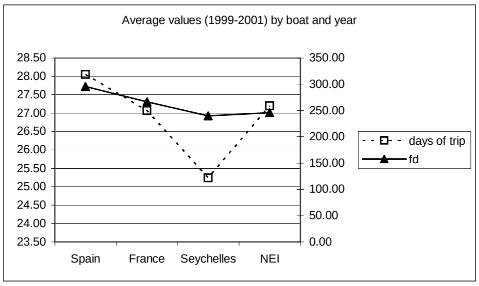

Figure 5. Average number of days by trip and number of fishing days by boat and year for the Spanish, French, Seychelles and NEI fleets.

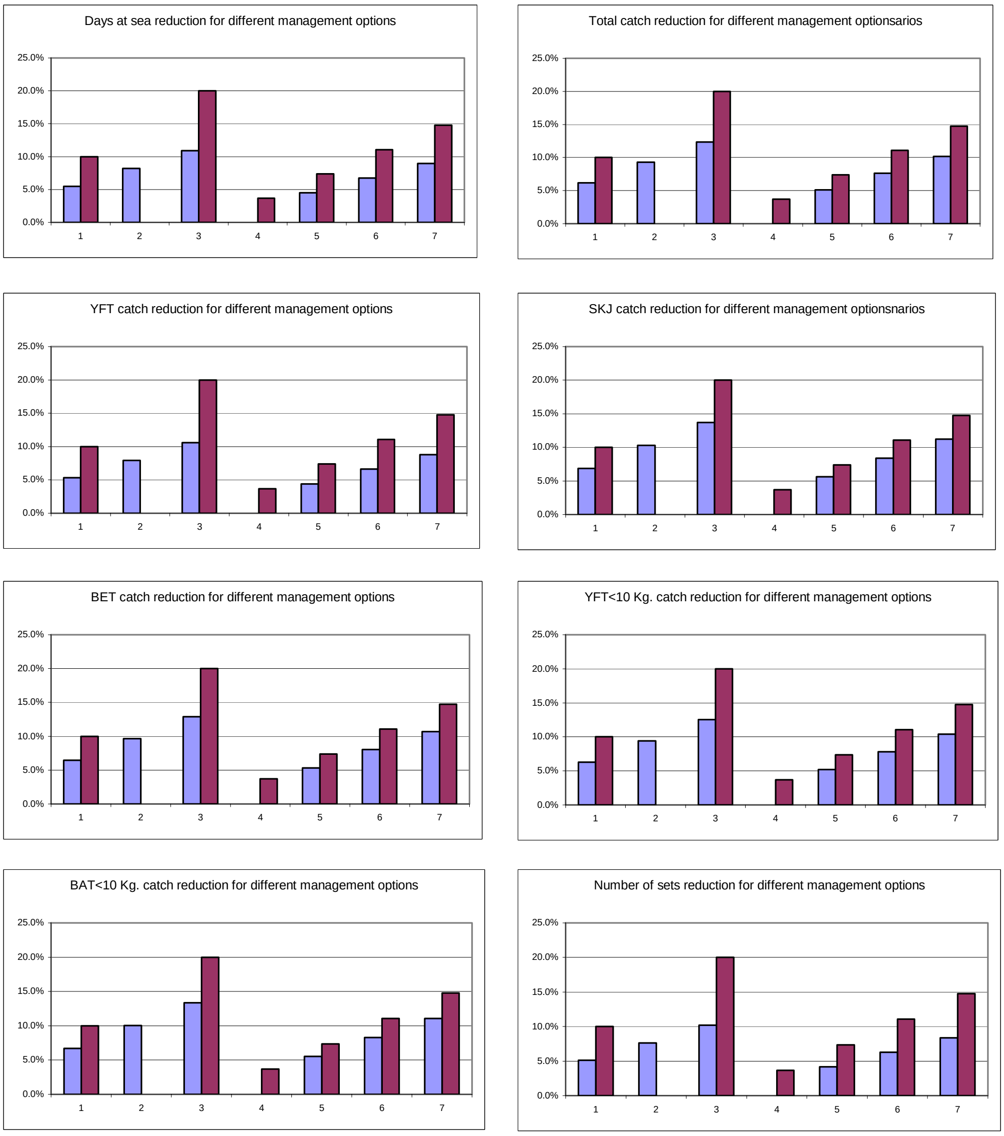

Figure 6. Percentage of total annual reduction in catches and effort resulting from the application of different effort control scenarios to the annual and to the second six-month period of the year (1 = 10% effort reduction; 2 = 15% effort reduction; 3 = 20% effort reduction; 4 = reduce all trips in 1 day; 5 = reduce all trips in 2 days; 6 = reduce all trips in 3 days; 7 = reduce all trips in 4 days). The dark bars correspond to annual calculations, the light one to six-monthly calculations.

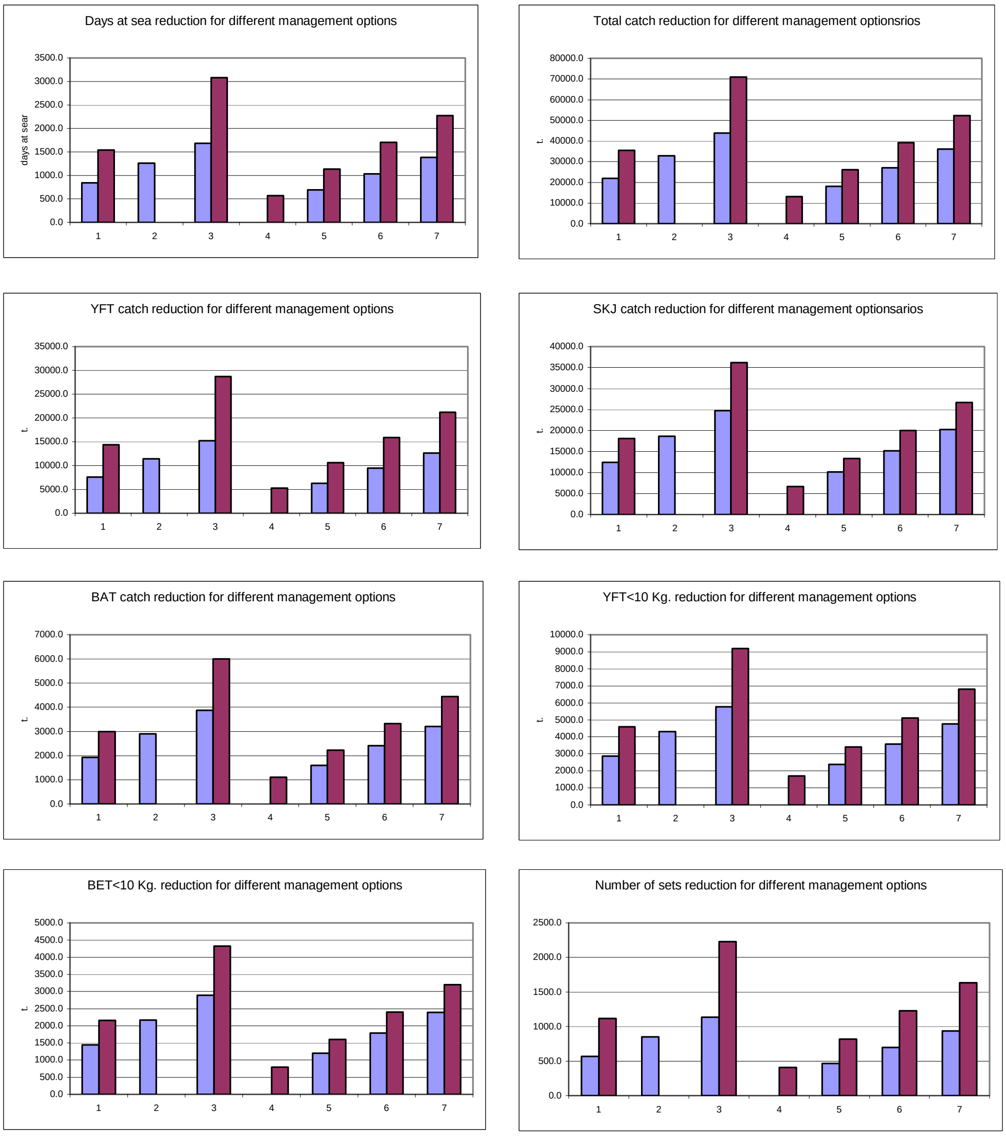

Figure 7. Reduction in catches and effort resulting from the application of different effort control scenarios to the annual total and to the second six-month period.

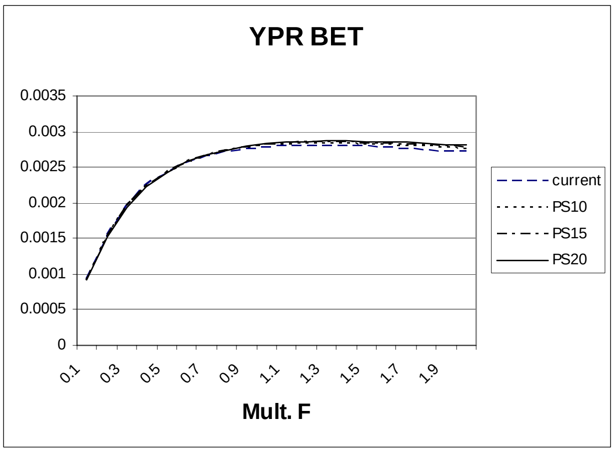

Figure 8. Yield per recruit resulting from different levels of reduction in the PS effort compared with the current values.

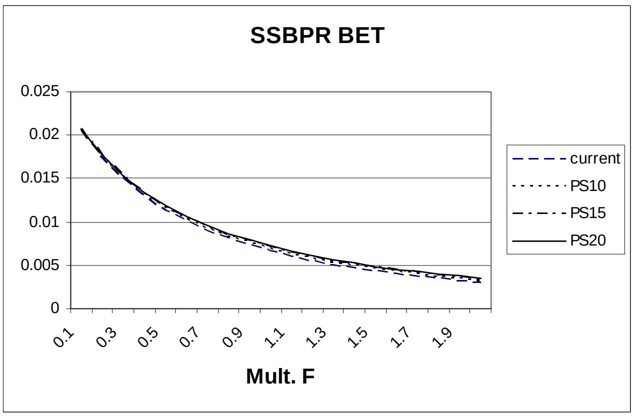

Figure 9. Spawning biomass per recruit resulting from different levels of reduction in the PS effort compared with the current values.

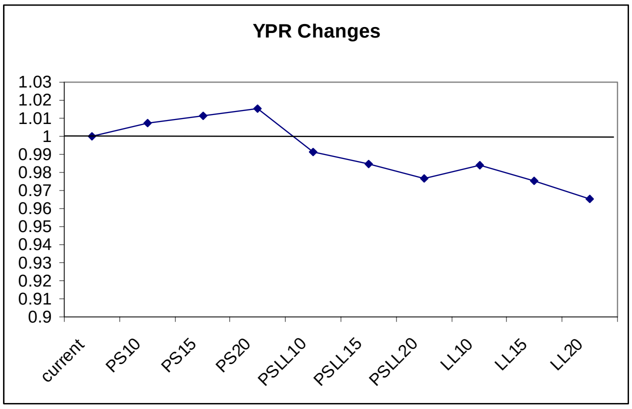

Figure 10. Yield per recruit resulting from different management strategies based on the reduction of fishing mortality of PS, LL and PS+LL.

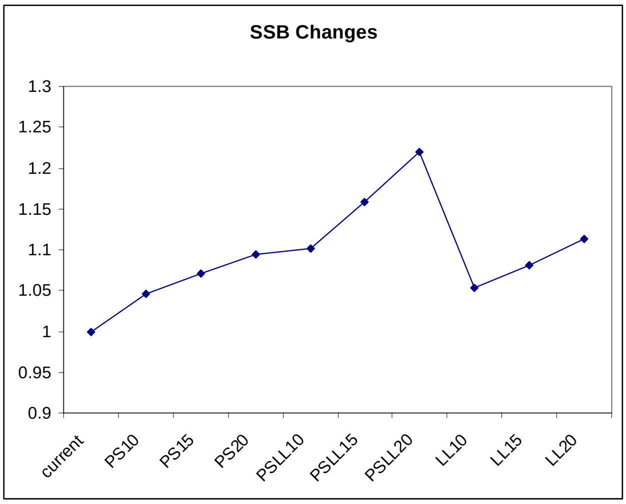

Figure 11. Spawning biomass per recruit resulting from different management strategies based on the reduction of the fishing mortality of PS, LL and PS+LL.

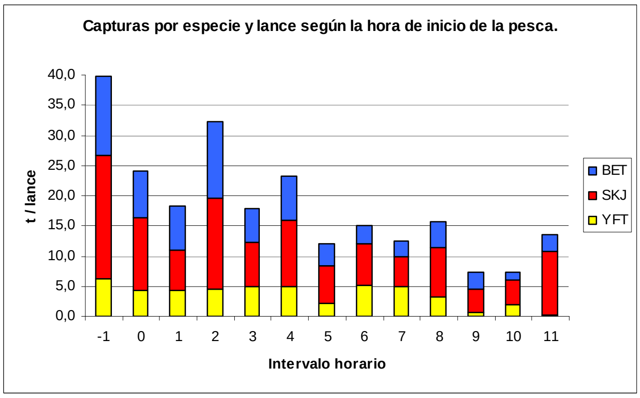

Figura 12.- FAD associated catch by set and species by time interval. Atlantic ocean, Patudo Project.

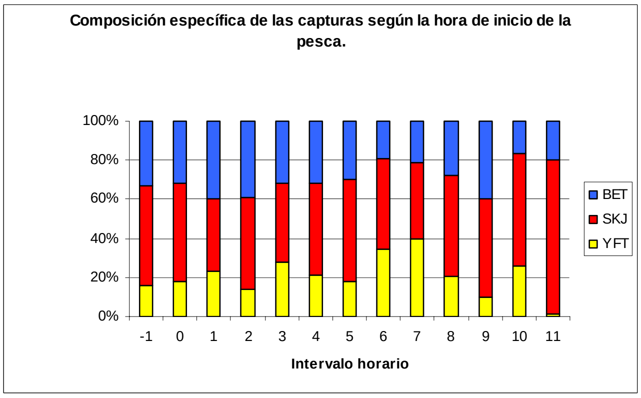

Figura13.- Proportion of each species in FAD associated catches by time interval. Atlantic ocean, Patudo Project.

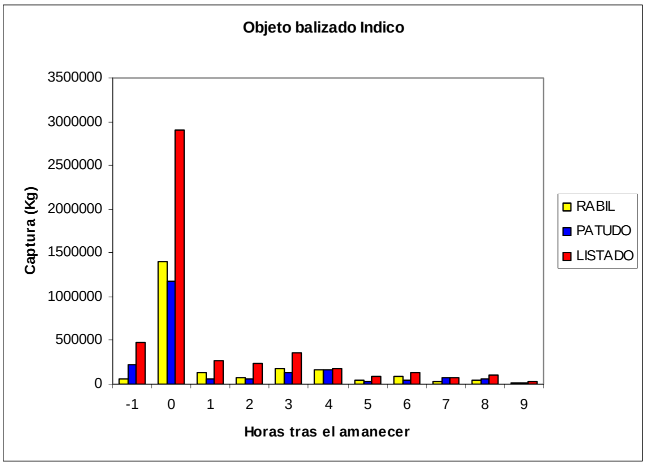

Figura 14.- Catch distribution by time interval and species. Data from 928 fishing operations in the Indian ocean.

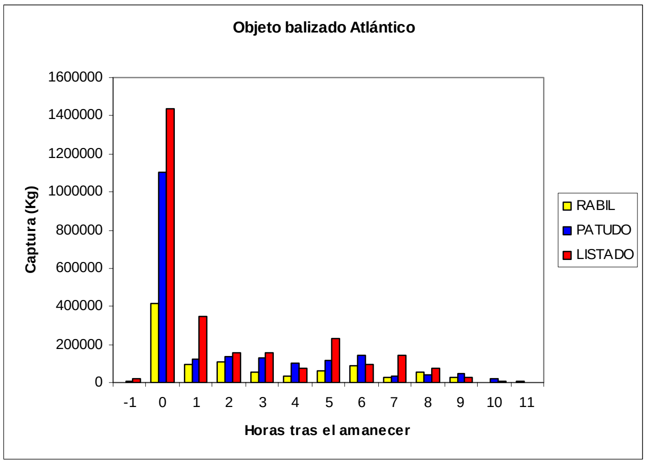

Figura 15.- Catch distribution by time interval and species. Data from 581 fishing operations in the Atlantic ocean.