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REVIEW OF TUNA FISHERIES ON FLOATING OBJECTS IN THE INDIAN OCEAN

by

J.P. HALLIER[1]

and

J.I. PARAJUA[2]

(1) ORSTOM tuna biologist with Seychelles Fishing Authority (SFA)
P.O. Box 570, Victoria, SEYCHELLES

(2) Oficina de Pesca de Espana en Seychelles
Secretaria General de Pesca Maritima

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Stequert and Marsac (1986), in a review of the tuna surface fisheries of the Indian Ocean do not mention the use of floating objects by the large artisanal tuna fisheries. Therefore, this document is limited to the tuna fishing on floating objects by the purse seine fishery. Some analysis have already been published by Hallier (1986, 1991) on this topic.

This document is an update version of the paper presented by Hallier at the Indo-Pacific Tuna Programme (IPTP) Expert Consultation on Stock Assessment of Tunas in the Indian Ocean held in Bangkok, Thailand from the 2nd to the 6th of July 1990 (IPTP, 1991).

1. THE INDIAN OCEAN TUNA PURSE SEINE FISHERY

Tuna catch in the Indian Ocean has been increasing dramatically since 1982 (figure 1), most of the catch and almost all this increase have taken place in the Western part of the ocean (East of 80° East = FAO area 51).

In the Western Indian Ocean, this increase is mostly due to the occurrence and development of the purse seine fishery (figure 2) and secondly to the development of the artisanal fisheries of Maldives and Sri Lanka.

The purse seine catch by flag country is given in figure 3; France and Spain are catching the bulk of the catch even if their share is slightly decreasing for the past two years as some of their vessels returned to Atlantic Ocean and vessels from USSR and Japan tended to come in greater number.

2. FISHING FOR TUNAS ASSOCIATED WITH FLOATING OBJECTS

The association of tunas with floating objects is very well known by purse seine fishermen.

In this report "floating objects" when not especially built by fishermen will be called logs and the associated school of tuna, log school, to be opposed to free school when no association is noted. Likewise, we will write small cetacean school, whale shark school, whale school, etc...

When the log is man made, it will be called artificial log to differenciate it from log or natural log.

In the beginning of the eighties fishermen started to use radio beacons tied up to logs in order to help to locate them at sea. In 1984/85, this practice was widely used in this fishery.

2.1. DATA SOURCES

The purse seine fishery of the Western Indian Ocean is surveyed by using several sources of data :

* fishing forms are filled by every vessel and collected in port in order to get the catch and effort data;
* unloading catches are recorded in port or at canneries;
* fishes caught are sampled for species composition and for sizes in port, at canneries and at sea;
* more detailed data are collected at sea by the SFA Observer Programme.

The computer file, which contains the fishing forms, is made of 87,967 lines of data where more than 21,000 nil sets and 34,000 successful sets are documented (16,400 on log schools and 17,600 on free schools).
More than 524,000 fish have been measured including 245,000 yellowfins, 229,000 skipjacks and 50,000 bigeyes.
The observer file contain informations on 2,343 sets (1,096 sets on log schools and 1,247 sets on free schools) and measurements on more than 60,000 tunas.
In this document, most of the time, data from the French purse seine fleet will be used to illustrate the characteristics of fishing for tunas associated with floating objects as more data on this fleet are available to us. Futhermore, the exact number of sets and consequently the catch per set is not always available for the other fisheries.

2.1. LOG SCHOOL CATCH

In the Western Indian Ocean, tuna catch on log makes up half of the purse seine catch of the French, Spanish and USSR vessels (Table 1 and figure 4). Japanese vessels as Mauritius vessels (not represented in figure 4) are fishing almost exclusively on artificial logs. The total tuna catch for Mauritian purse seiners was 6,847 mt. in 1988 and 8,592 mt. in 1989. This Mauritian fishery is described in Cayre *and al.* (1991).

2.2. LOG SCHOOL SETS

Since 1984, on average, 33% of the sets were made on log schools (table 1 and figure 5). For the French purse seiners, this percentage fluctuates from 25% in 1988 to 39.6% in 1987.

2.3. FISHING SUCCESS

The fishing success is defined as the percentage of positive sets among the total number of sets; a positive or successful set corresponds to one resulting in a catch equal or greater than 0.5 metric tons.
The higher fishing success on log schools than on free schools (table 1 and figure 6) explains why fewer sets on log schools than on free schools (figure 5) yield as many tons of tuna on log schools as on free schools (figure 4). Overall, on log schools 9 sets out of 10 are successfull (91.8%) while less than 5 sets out of 10 (47.2%) are successful on free schools.

2.4. SET SIZES (OR CATCH BY POSITIVE SET)

The catch by total set (nil + positive sets) is not studied as its values are directly related to the fishing success.

There is no important differences in set size between log and free school sets (Table 1, figure 7 and 8). The average for the French fleet is 35.6 mt for log school sets and 31.0 mt for free school sets from 1984 to 1990. For each year but 1989, the set size is lower for free sets than for log sets (some years it is even 10 t lower); in 1989, the French fleet achieved 42.6 mt for free sets compared to 34.5 mt for log sets. Overall, 1985 and 1989 were the worst fishing year in the Western Indian Ocean purse seine fishery.

2.5. LOG SCHOOL SEASON

Figure 9 displays the monthly catch between log and free schools.

It shows that :

- almost every month there are some, even if small, catches on log schools,
- there are generally two peaks of log school fishing, a smaller one in April/May and a main one in September/October,
- the seasonnality between log and free school seasons is more evident since 1988.

The two log school seasons correspond to the change in the Indian Ocean monsoon system :

- in April/May one goes from the North-West monsoon (winds blowing from the North-West in the Southern hemisphere) to the South-East monsoon (winds from the South-East in the Southern hemisphere)
- in September/October, one goes the other way round from SE monsoon to NW monsoon.

Seasonnality is also discussed in the following chapter.

2.6. LOG SCHOOL FISHING GROUNDS

Figure 10 illustrates by squares of 1° latitude x 1° longitude the average catch from 1984 to 1989 of French purse seine fishery on log (figure 10a) and on free schools (figure 10b).

Several comments can be made :

. almost in every 1° x 1° square both types of catch (log and free) occur,

. the main fishing zones are somewhat different :
+ log school fishing is especially dominant in the area :
0°-8°N/48°E-59°E
+ free school fishing is especially dominant in the areas :
3°S-6°S/56°E-66°E
4°S-11°S/46°E-52°E

. however certain areas yield almost as much catch on log schools than on free :
+ 0°-5°S/50°E-55°E
+ 4°S-8°S/65°E-70°E
+ 12°S-18°S/42°E-48°E (Mozambique Channel)

2.6.1. Total catch by quarter and area

The total catch combine for all purse seine fisheries except the Mauritian purse seine fleet from 1984 to 1990 have been distributed by 5° x 5° square, by quarter and by type of school (figure 11).

From figure 11a the third and fourth quarters appear to be the main fishing season for log schools while the first and fourth quarter are the main free school season (figure 11b). This is not in opposition with data of figure 9 as September belongs to the third quarter and October to the fourth quarter, these two months being the best month for log fishing their catch is divided between both quarters. Fishing is then located off Somalian Coast and North and East of Seychelles Plateau.

In the figure 11a the log school season of the Mozambique Channel is still visible during the second quarter.

From figure 11, the general pattern of the fisheries can be described :

- during the first quarter, the fishery is mainly located East, South-East and South of the Seychelles Plateau : (between 0°-10°S/50°E-65°E),
- during the second quarter, vessels shift their operations West of Seychelles (0°-10°S/45°E-55°E) and in the Mozambique Channel (10°-20°S/40°E-50°E),
- during the third quarter, purse seiners are fishing off the Somalian Coast, West and North of Seychelles Plateau (5°N-5°S/45°E-60°E),
- during the last quarter, fishing is taking place in the same area as during the third quarter but also East of Seychelles Plateau (10°N-5°S/45°E-60°E and 0°-10°S/55°E-65°E).

There is some sort of clockwise movement of the fishery around the Seychelles Plateau starting East of Seychelles during the first quarter, South and West of Seychelles during the second quarter, West and North during the third and North and East during the fourth quarter.

2.6.2. Yellowfin Catch by quarter and area (Figure 12)

Yellowfin is caught predominantly on free schools, this is obvious from data in figure 12. However, yellowfin catch on log schools occur during all quarters but primarily during the third and fourth quarters and secondly during the second quarter in the Mozambique Channel (figure 12a).

2.6.3. Skipjack catch by quarter and area (Figure 13)

Skipjack is predominantly caught on log schools, during the third and fourth quarter of the year and off the Somalian Coast and North of Seychelles Plateau. There is a secondary skipjack season during the second quarter in the Mozambique Channel.

2.6.4. Bigeye catch by quarter and by area (Figure 14)

Bigeye is mainly caught on log schools during the third and fourth quarters. Some bigeye catches also occur in the Mozambique Channel during the second quarter. Overall, bigeye catches are small compared to yellowfin and skipjack catches.

2.6.5. Consequences

Despite the fact that log and free school fishing grounds are more or less separate, the mingling between the two types of schools in the same time-area strata is still too important to make it possible to decide on some sort of fishing effort allocation on one or the other type of school for each time-area strata. Consequently this situation make it difficult to allocate fishing effort to each of the two main species, yellowfin and skipjack.

2.7. LOG VERSUS FREE SCHOOL SPECIES COMPOSITION

Table 2 gives the species composition of tuna catch from log and free schools for the different purse seine fisheries of the Western Indian Ocean.

On log schools, the catch is mainly made of skipjack (71%), yellowfin is second with 24%, bigeye is third with 5.5% and albacore are almost never caught.

On free schools, the catch is mainly made of yellowfin (68%), skipjack is second with 29%, bigeye is third with 2.5% and albacore is sometimes caught (0.4%).

For the French, Spanish and Japanese fleets of the Western Indian Ocean :

- 27% of yellowfin are caught on log schools and 73% on free schools, (figure 15),
- 72% of skipjack are caught on log schools and 28% on free schools (figure 16),
- 69% of bigeye are caught on log schools and 31% on free schools (figure 17),
- 8% of albacore are caught on log schools and 92% on free schools (figure 18).

Log school species composition between French and Spanish purse seine fisheries are very similar, almost identical, however it is somewhat different on free schools (Table 2).

This difference can have its origin in the species correction method or in some different fishing strategy between the two fleets when fishing on free schools.

Japan log school species composition differs from France and Spain especially for bigeye proportion which is much higher : 9.6% for Japan instead of 5.2% for France and 5.5% for Spain. However, the species composition correction method has been seriously improved since 1989. Table 3 gives the log, free and general species composition of French purse seine catch before and after correction from 1984 to 1990.

Therefore, if only data for 1989 and 1990 are used, the percentage of bigeye is respectively of 8.6% for Japan, 6.6% for France and 6.8% for Spain. Japanese purse seiners are still catching a higher proportion of bigeye but the difference is not so great. It could be the result of the use of deeper nets or a better use of the net or different fishing grounds or even the use of different methods to estimate the proportion of bigeye.

The average depth of French purse seine is 210 metres with little variability from vessel to vessel. For the Spanish purse seine the average depth is slightly greater (230 meters) but with more variability as some vessels have net depth of 250 m and two even have nets of over 300m depth.

Japanese vessels, but the JAMARC Nippon Maru, do not have deeper nets. However they have better electronic equipments and especially captors of pressure, current and temperature onto their nets which give them the possibility to obtain better results from their sets.

Of the Japanese purse seine catch, 98% is located in the area 5°S-10°N/50°E-70°E. In this area, 8.7% of their 1989-90 total catch is bigeye. For the same time-area strata, the percentage of bigeye on log schools is 4.3% for France and 6.3% for Spain.

If the species composition correction method used is reliable, it seems that Japanese are achieving a higher proportion of bigeye in their catch by a better use of their nets.

2.8. TUNA SIZE DISTRIBUTIONS

Fish sizes used in this document are those from the French purse seine fishery as actually, no size or unreliable sizes exist for the other fisheries. That is why catch by size for all purse seine fisheries of the Indian Ocean are established by using the French purse seine sizes.

The only exception is the Mauritian purse seine fishery for the two last years and the Spanish fishery since July 1990.

2.8.1. Skipjack

Size distributions (in % of total number) of skipjack caught on log and free schools are quite similar (figures 19 and 20) : the mode is the same (figure 19 and table 4), there is only a few more fish greater than 70 cm in free schools than in log schools.
Distribution by weight given in metric tons (figure 20) demonstrates the importance of skipjack catch on log schools compared to free schools; the bulk of the catch is made of skipjack between 45 and 70 cm fork length for both type of fishing (log and free schools) : the shape of the distribution by weight is very similar (figure 20).

2.8.2. Yellowfin

Size distribution is very different between yellowfin caught on log or on free schools (figure 21 and table 5) :

- a majority of small fish (81% of yellowfin less than 70 cm FL) on log schools
- a majority of big fish (58% of yellowfin more than 100 cm FL) on free schools
- two different modes for small yellowfin between log and free schools
- an extra mode for big fish (126-130 cm) on free schools but absent on log schools.

Catch distribution by weight (figure 22) is very different between the two types of schools :

- catch on free schools is by far the most important part of yellowfin catch and it is mostly made of fish greater than 100 cm (90 % of the total yellowfin catch on log schools).
- catch on log schools is distributed half and half between yellowfin smaller than 94 cm FL and yellowfin greater than 94 cm FL.

2.8.3. Bigeye

Bigeye size distribution is very different between log and free schools (figure 23 and table 6). It is quite similar to the yellowfin situation with smaller bigeye on log schools than on free schools : very few fish are greater than 114 cm FL on log schools.
The catch distribution by weight (figure 24) shows that bigeye are mostly caught on log schools.

2.8.4 Lonliner size distribution

Longliners from far-east Asian countries are active in the Indian Ocean since 1952 and they are still fishing (figure 2). They are catching primarily bigeye, yellowfin, albacore and soutern bluefin tuna. Their catch is made of very few skipjack while the purse seine fishery is catching a small proportion of bigeye, therefore yellowfin tuna is the only species which is caught in large numbers by both fisheries.
Yellowfin sizes from the Japanese longline fishery are given in figures 25 and 26 for the two main fishing areas of the purse seiners :

- the large size yellowfin fishery East of Seychelles, figure 25
- the predominantly log school fishery north-west of Seychelles, figure 26.

From these figures, it is obvious that longliners from Japan are starting to catch yellowfin at a length when purse seiners are started not to catch this size class anymore. Longliner size distribution is quite similar to the second half of the size distribution of yellowfin caught by purse seiners on free schools; the mode of 128-130 cm FL is found in both fisheries (figures 21, 25 and 26). Therefore, only when purse seiners are fishing on free school, did they exploit apparently the same size yellowfin as longliners from Japan.

2.9. FISHING STRATEGY

As the fishing success on log schools is much higher than on free schools (chapter 2.3) and the catch by positive set is somewhat higher on log schools than on free schools (chapter 2.4), one would think it is preferable to fish on log than on free schools. However, the catch species composition and the species sizes are quite different between the two types of schools (chapters 2.7 and 2.8). Then, when fish prices are set according to species and sizes, the fishing strategy follows by fishermen has to take into consideration these different factors. Therefore, until recently, EEC purse seiners were mainly targetting yellowfin as their sale price on the world market was almost double that of skipjack. In this situation, log school fishing seasons might reveal more the absence of free schools (rich in large yellowfin) than the real abundance of log schools (poor in large yellowfin).

A year ago, the price of yellowfin dropped down. Almost at the same time, Spanish purse seiners first, followed afterwards by French purse seiners, started to develop fishing on artificial drifting logs. The Spanish really started on a large scale in 1990, the French followed them more cautiously in 1991 (Table7). However, all catches made on artificial logs are not all recorded as such on logbooks. Some are just listed as "log school sets". Then, the proportion of artificial log school catch is most probably underestimate. This particular point is more developed in another document on the study of the different types of associations tuna schools are involved with at sea (Hallier, 1992). Other factors are also to be kept in mind (see following paragraphes 2.9.1 and 2.9.2).

2.9.1. Purse seine fishing according to the time of day

From figures 27 and 28, it appears that these two types of purse seine fishing are not performed at the same time during the day :

- log school fishing is an early morning activity (figure 27),
- free school fishing is taking place the rest of the day until sunset (figure28).

According to fishermen, tunas gather under and around floating objects at night and early morning. When the sun rises they tend to disperse and to get away from logs, then schools under logs become less vulnerable to purse seine fishing.

2.9.2. Purse seine set durations

Figures 29 and 30 illustrate the greater durations of sets made on log than those made on free schools.

This could be explained by several factors :

- by-catch is more important on log schools than on free schools (87% of by-catch observations are recorded on log schools) therefore crews are spending more time to sort the catch,
- species sizes are smaller therefore more tuna get gilled into the net mesh and crew must clean the net still spending for the same catch more time for a log school set than for a free school set.

3. THE DEVELOPPMENT OF PURSE SEINE FISHERY ON LOG SCHOOL

The importance of the development in the use of artificial log by the EEC purse seine fleet operating in the Western indian Ocean is illustrated by Table 7. It is remarkable for Spanish fleet that catches obtain from artificial log schools which were negligeable in 1989 represented in 1991 a maximum of 14.4% of the total catch. For French fleet, it is still a small fraction of the catch (2.9% of the 1991 total catch).

However for the Spanish fleet, the increase in the use of artificial logs is associated with a decrease of catch on natural logs from 51.5% in 1989 to 36.4% in 1991 (Table 7). Therefore the use of artificial log has not brought, as could be expected, an increase in the total catch on logs (natural and artificial).

An analysis at the level of time-area strata of 5° latitude x 5° longitude by month has given the results presented in Table 8.

Conclusions from Table 8 data are as follows :

- in strata where natural log schools are not present but unassociated schools are abundant (56 strata altogether), artificial log are set up in only 14 of them (or 25% of these strata),

- in strata where unassociated schools are present together with natural log schools (85 strata altogether), artificial logs are set up in 52 of them (or 61% of these strata),

- only 6 strata without any schools of any kind are set up with artificial logs.

Therefore, it appears that fishermen are setting artificial logs predominantly in areas where natural logs are already abundant. This practice does not result in an increase of overall log school catches. However when analysis is made at the level of strata with particular school type combinaision, results are as follows :

- in strata with associated schools, the use of artificial logs have yield 1,651 t compared to the 5,984 t fished on associated schools which represents an increase of 27.6% of the total catch for this strata.

- in strata with associated schools combined with natural log schools the catch increased from 63,665t to 75,637 t by using artificial logs (an increase of 19%).

However these increases correspond to the share of the catch attributed to artificial log schools, it cannot really be totally attributed to the artificial logs because one does not know what would have been fished in these strata if no artificial logs had been used. With artificial logs, either the tuna population in this area will have been distributed in smaller schools among natural and artificial logs or less logs (natural and artificial) would have been stocked with tuna.

4. CONCLUSIONS

The new purse seine fishery of the Western Indian Ocean rely on log school sets for half of its catch.

Log school fishing differ from free school fishing in many different ways :

- most of the sets are successful (90%) while less than half are successful on free schools,

- catch on log school are predominantly skipjack (71%),

- yellowfin which account for 24% on log school catch are mostly of small size while large yellowfins are mixed with small ones in free schools,

- bigeye are more abundant in log schools (5.5%) than in free schools (2.5%) and as for yellowfin small bigeye are predominant in log schools,

- log schools are almost exclusively fished early morning while free schools are fished the rest of the day until sunset,

- a log school set is generally taking more time to perform than a free school set.

Even in term of fishing technique and fishing strategy, purse seining on log or on free schools requires different expertise and know-how. This is so much the case that some fisheries such as the Japanese purse seine fishery of the Western Indian Ocean is practicing only one type of fishing : the log school purse seining. As log school fishing in this region is more or less seasonal, the Japanese purse seiners rely on artificial logs in order to fish all year round. The best area they found to perform this fishery all year round is the area from 5°S to 10°N and 50°E to 70°E, an area which is under the Equatorial Counter Current influence.

As most yellowfin and bigeye caught on logs (natural or artificial) are immature, the developpment of this fishery which is actually taking place in the Western Indian Ocean is to be monitored very closely.

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Table 1 : Catch, catch per set and fishing success on log and free schools. Western Indian Ocean purse seine fishery (1984-90)

Country		TOTAL CATCH		TOTAL NUMBER OF SETS		CATCH PER POSITIVE SET		FISHING SUCCESS %	
		LOG	FREE	LOG	FREE	LOG	FREE	LOG	FREE
FRANCE	mt	309 730	294 535	9 567	20 448	35.6	31.0	90.9	46.5
84-90	%	51.3	48.7	31.9	68.1	-	-	-	-
SPAIN	mt	254 710	239 513	7 231	15 824	37.9	31.5	92.9	48.1
84-90	%	51.5	48.5	31.9	68.1	-	-	-	-
JAPAN	mt	22 925	51	878	6	27.3	17.1	95.6	50.0
88-90	%	99.8	0.2	99.3	0.7	-	-	-	-
USSR *	mt	3 241	3 052	192	283	24.4	23.5	75.5	45.9
90	%	51.5	48.5	40.4	59.6	-	-	-	-
TOTAL	mt	590 606	537 151	17 868	36 561	36.0	31.1	91.8	47.2
AVERAGE	%	52.4	47.6	32.8	67.2	-	-	-	-

* distribution of catch statistics between log and free schools is only available for 1990.

Table 2 : Log and free school species composition of the Westerm Indian Ocean purse seine fishery (1984-1990)

SPECIES		YFT		SKJ		BET		ALB	
FLEET		yearly average mt	%	yearly average mt	%	yearly average mt	%	yearly average mt	%
FRANCE 1984 1990	LOG	11 056	25.0	30 886	69.8	2 280	5.2	4	0.0
	FREE	30 809	73.2	10 276	24.4	786	1.9	216	0.5
SPAIN 1984 1990	LOG	8 834	22.6	28 034	71.8	2 156	5.5	22	0.0
	FREE	24 699	62.6	13 363	33.9	1 297	3.3	88	0.2
JAPAN(1 1988 1990	LOG	1 524	20.1	5 327	70.3	725	9.6	0	0
	FREE	13	76.5	4	23.5	0	0	0	0
USSR(2	LOG	1 003	30.9	2 001	61.7	239	7.4	2	0.0
1990	FREE	2 161	64.4	1 073	32.0	121	3.6	0	0
TOTAL 1984 1990	LOG	144 800	23.8	430 425	70.7	33 467	5.5	190	0.0
	FREE	390 755	68.1	166 555	29.0	14 705	2.5	2 128	0.4

(1) One purse seiner started to fish in December 1987, she fished 9 months out of 12 in 1988, and in 1989; three vessels fished for 16 months in 1989, 5 vessels were active in 1990 for a total of 43 months vessels

(2) USSR purse seiners are fishing in the Indian Ocean since 1985 but catch by types of school is only available since 1990.

Table 3 : French purse seine catch composition* (in %) before and after correction (1984-1990

		LOG CATCH		FREE CATCH		TOTAL CATCH	
		BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
84	YF	23.4	23.6	78.1	77.9	54.1	54.1
	SJ	74.6	74.1	20.5	20.6	44.2	44.0
	BE	2.0	2.3	0.8	0.8	1.3	1.5
85	YF	20.8	22.5	86.3	86.1	46.3	47.2
	SJ	75.7	73.6	11.5	11.6	50.7	49.5
	BE	3.4	3.9	0.4	0.5	2.3	2.6
86	YF	13.5	16.9	74.6	75.4	39.5	41.8
	SJ	81.4	77.1	22.5	21.5	56.3	53.4
	BE	5.1	6.1	2.5	2.6	4.0	4.6
87	YF	24.1	28.5	57.3	58.2	38.7	41.5
	SJ	72.0	65.9	41.2	39.8	58.5	54.5
	BE	3.9	5.6	0.8	1.3	2.5	3.7
88	YF	16.5	20.9	77.4	77.7	50.8	52.9
	SJ	79.7	74.4	21.2	20.6	46.7	44.1
	BE	3.8	4.7	1.1	1.3	2.3	2.8
89	YF	21.5	34.1	50.0	57.6	34.9	45.1
	SJ	75.8	59.8	49.1	40.3	63.2	50.6
	BE	2.8	6.1	0.9	2.1	1.9	4.2
90	YF	17.0	30.2	81.4	78.8	53.0	57.4
	SJ	78.6	62.6	16.0	16.7	43.6	36.9
	BE	4.4	7.2	2.5	4.4	3.4	5.6
AVERAGE	YF	19.5	25.0	72.3	73.2	45.2	48.5
	SJ	76.8	69.8	25.9	24.4	52.0	47.7
	BE	3.7	5.2	1.3	1.9	2.5	3.6

* Albacore is not listed as quite uncommon but it is taken into account in the calculation of the species composition

Table 4 : Skipjack size distribution from French purse seiners 1984-90. (% of total number of skipjack)

SIZE RANGE (FL)	LOG SCHOOLS	FREE SCHOOLS
SJ < 50 cm 50 cm < SJ < 60 cm SJ > 70 cm	45.2 42.9 0.6	35.0 50.2 1.4
Size class with the highest size frequency	50-52 cm	50-52 cm

Table 5 : Yellowfin size distribution from French purse seiners, 1984-90. (% of total number of yellowfin)

SIZE RANGE (FL)	LOG SCHOOLS	FREE SCHOOLS
YF < 40 cm	2.6	0.0
40 cm < YF < 70 cm	78.6	28.6
70 cm < YF < 100 cm	9.8	13.8
120 cm < YF < 150 cm	3.7	39.7
YF > 150 cm	0.1	3.4
Size class with the highest size frequency	46-50 cm	50-54 cm & 126-130 cm

Table 6 : Bigeye size distribution from French purse seiners, 1984-89. (% of total number of bigeye)

SIZE RANGE (FL)	LOG SCHOOLS	FREE SCHOOLS
BE < 40 cm	2.9	0
40 cm < BE < 80 cm	86.9	54.3
80 cm < BE < 130 cm	9.9	35.5
BE > 130 cm	0.3	10.2
Size class with the highest size frequency	58-62 cm	50-54 cm

Table 7 : The development of artificial log use in the EEC purse seine fishery of the Western Indian Ocean (1989-1991)

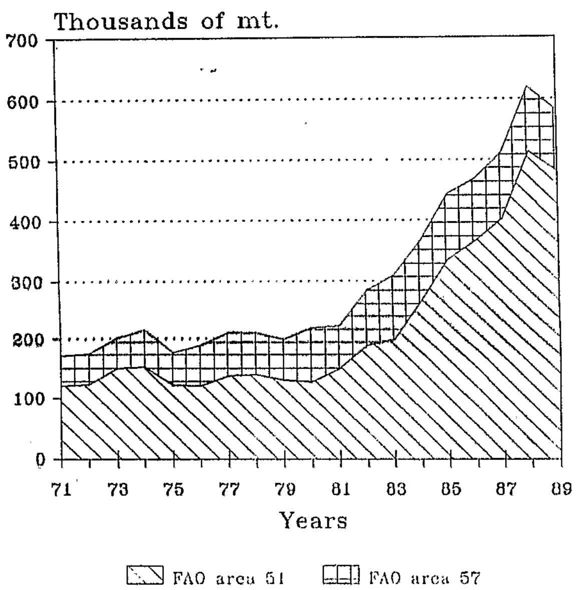
	FRANCE & associated				SPAIN & associated			
	NATURAL LOG		ARTIFICIAL LOG		NATURAL LOG		ARTIFICIAL LOG	
	CATCH mt.	%	CATCH mt.	%	CATCH mt.	%	CATCH mt.	%
1989	44 441	52.2	269	0.3	63 870	51.5	141	0.1
1990	34 112	43.2	543	0.7	55 717	46.2	7 678	6.4
1991*	41 222	53.7	2 210	2.9	35 730	36.4	14 174	14.4

* data are incomplete (1½ month data are still missing)

Table 8 : The occurrence of natural and artificial log schools by time-area strata
Spanish logbooks, 1991, Western Indian Ocean

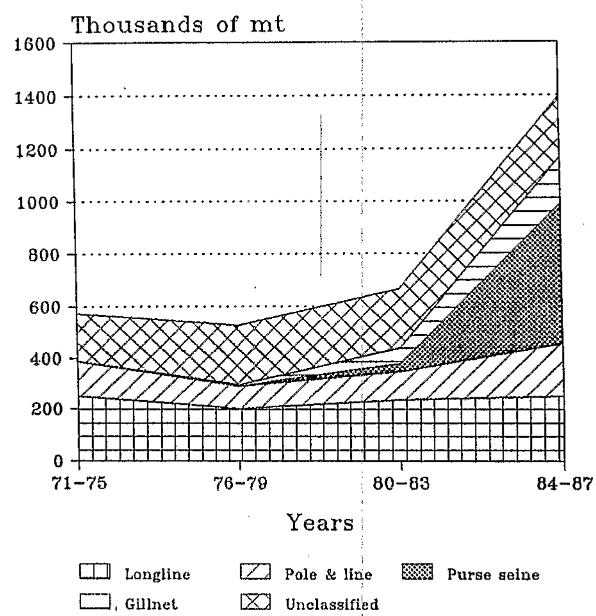
Type of schools fished in each time-area strata	Number of 5°x5°/month time area strata concerned	
	Number	% of Total
Unassociated schools only	42	27.6
Unassociated schools + artificial log schools	14	9.2
Unassociated schools + natural log schools	33	21.7
Unassociated schools + natural log schools + artificial log schools	52	34.2
Natural log schools only	5	3.3
Artificial log schools only	6	3.9
TOTAL	152	100.0

FIGURE 1: INDIAN OCEAN TUNA CATCH IN FAO AREAS 51 AND 57 FROM 1971 TO 1989 (80 E is the limit between the 2 areas)



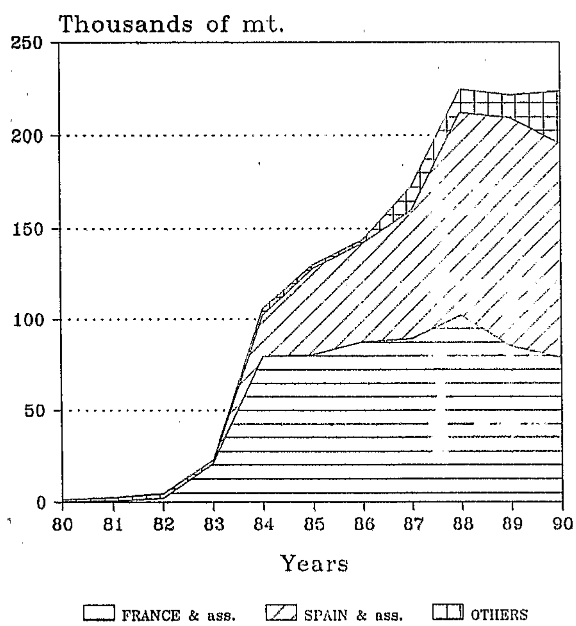
Source: FAO

FIGURE 2: WESTERN INDIAN OCEAN TUNA CATCH BY GEAR (1971 – 87)



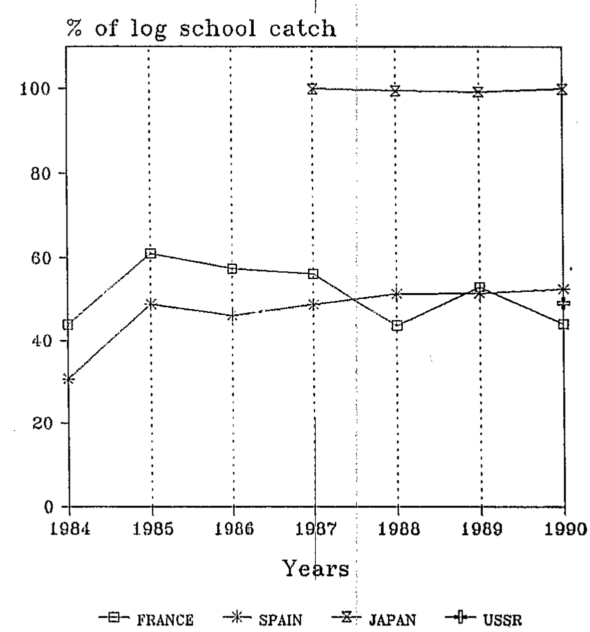
Source: FAO

FIGURE 3 : PURSE SEINER TOTAL CATCH BY COUNTRY IN FAO AREA 51 (1980 – 90)



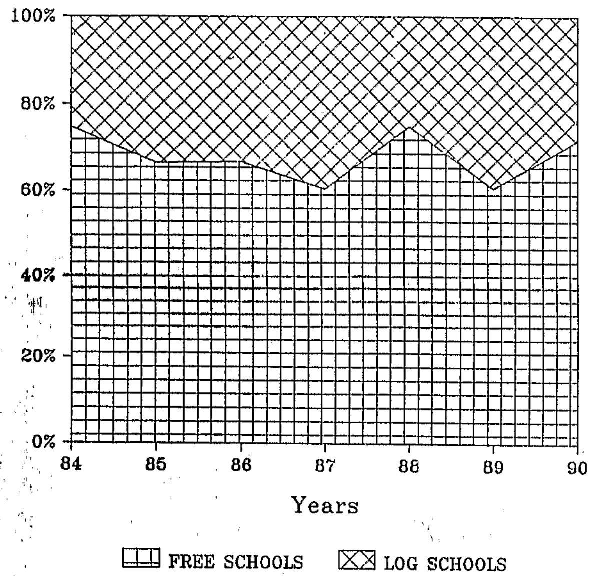
Source: ORSTOM, SFA

FIGURE 4 : PERCENTAGE OF LOG SCHOOL CATCH BY COUNTRY (1984 – 90)



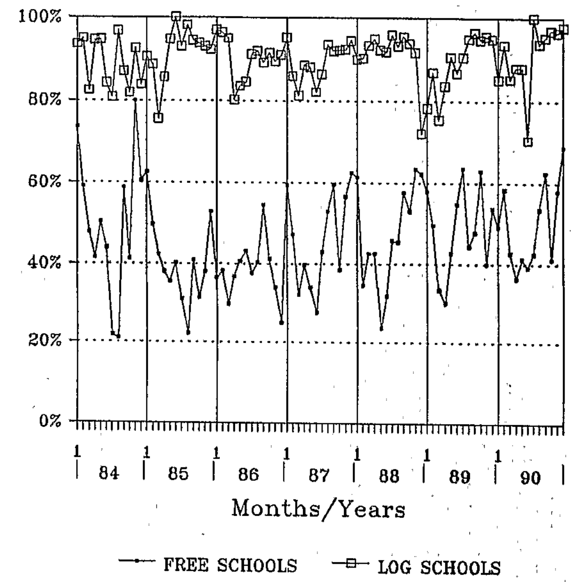
No data for USSR before 1990

FIGURE 5 : YEARLY DISTRIBUTION OF PURSE SEINE SETS ON LOG AND FREE SCHOOLS (1984 – 90)



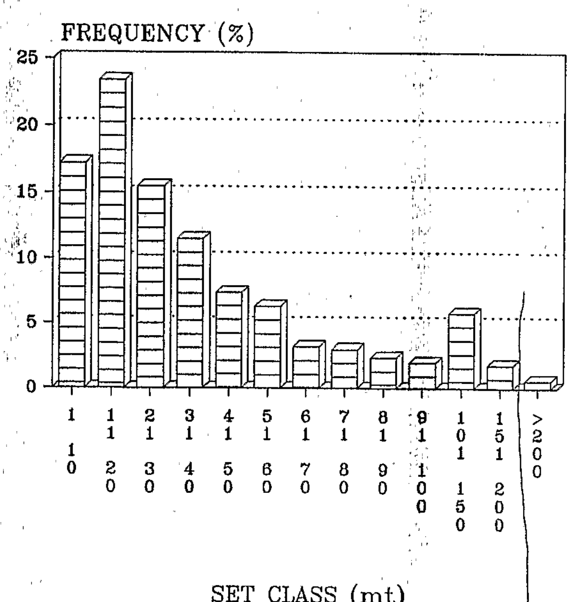
French purse seiners,
Western Indian Ocean

FIGURE 6 : FISHING SUCCESS ON LOG AND FREE SCHOOL SETS (1984 – 90)



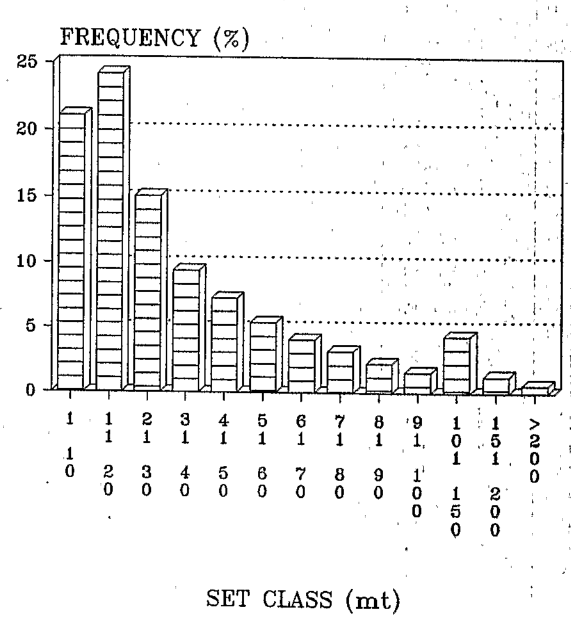
French purse seiners,
Western Indian Ocean

FIGURE 7 : SET SIZE DISTRIBUTION (IN MT) FOR LOG SCHOOLS French fleet (1984 – 89)



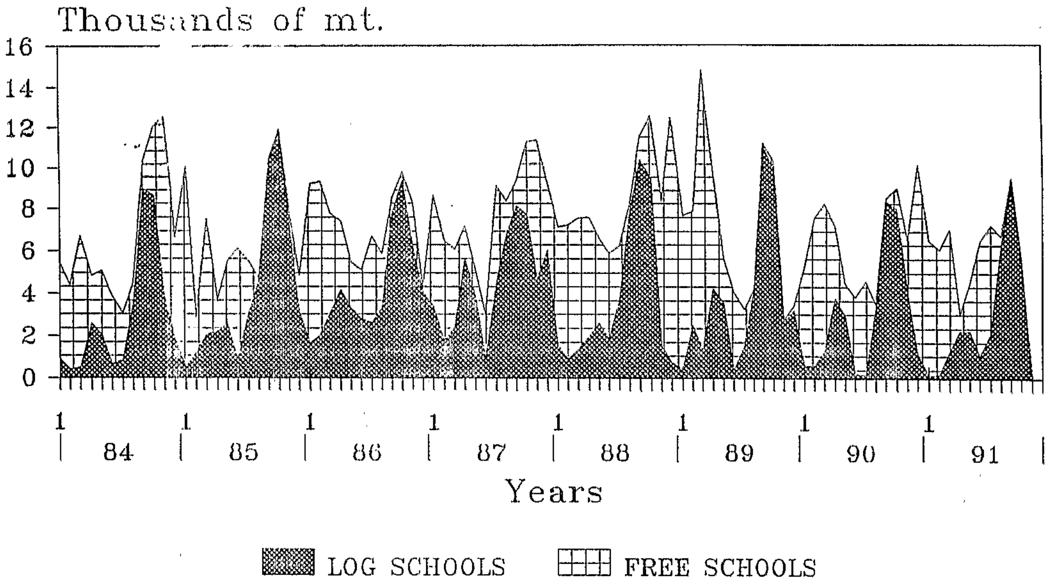
6794 positive sets
(not including 757 nil sets)

FIGURE 8 : SET SIZE DISTRIBUTION (IN MT) FOR FREE SCHOOLS French fleet (1984 – 89)



5720 positive sets
(not including 9241 nil sets)

FIGURE 9 : MONTHLY CATCH DISTRIBUTION
ON LOG AND FREE SCHOOLS
French fleet (1984 - 91)



For 1991, data uncorrected & uncomplete.
Western Indian Ocean

LOG

a

FREE

b

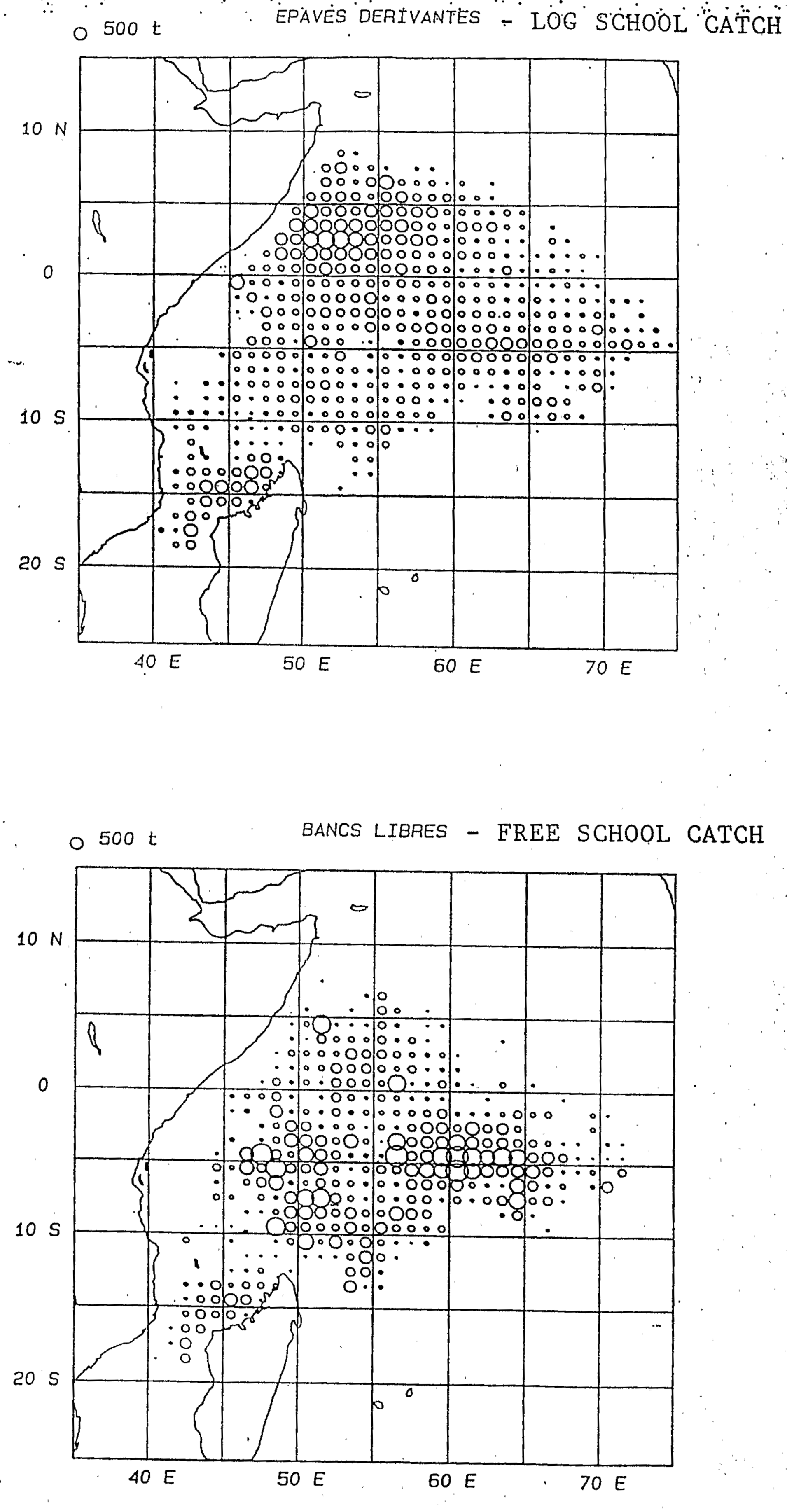


Figure 10 : Average catch per 1°x1° square (1984-89) per type of school.
French purse seine fleet, Western Indian Ocean.

LOG

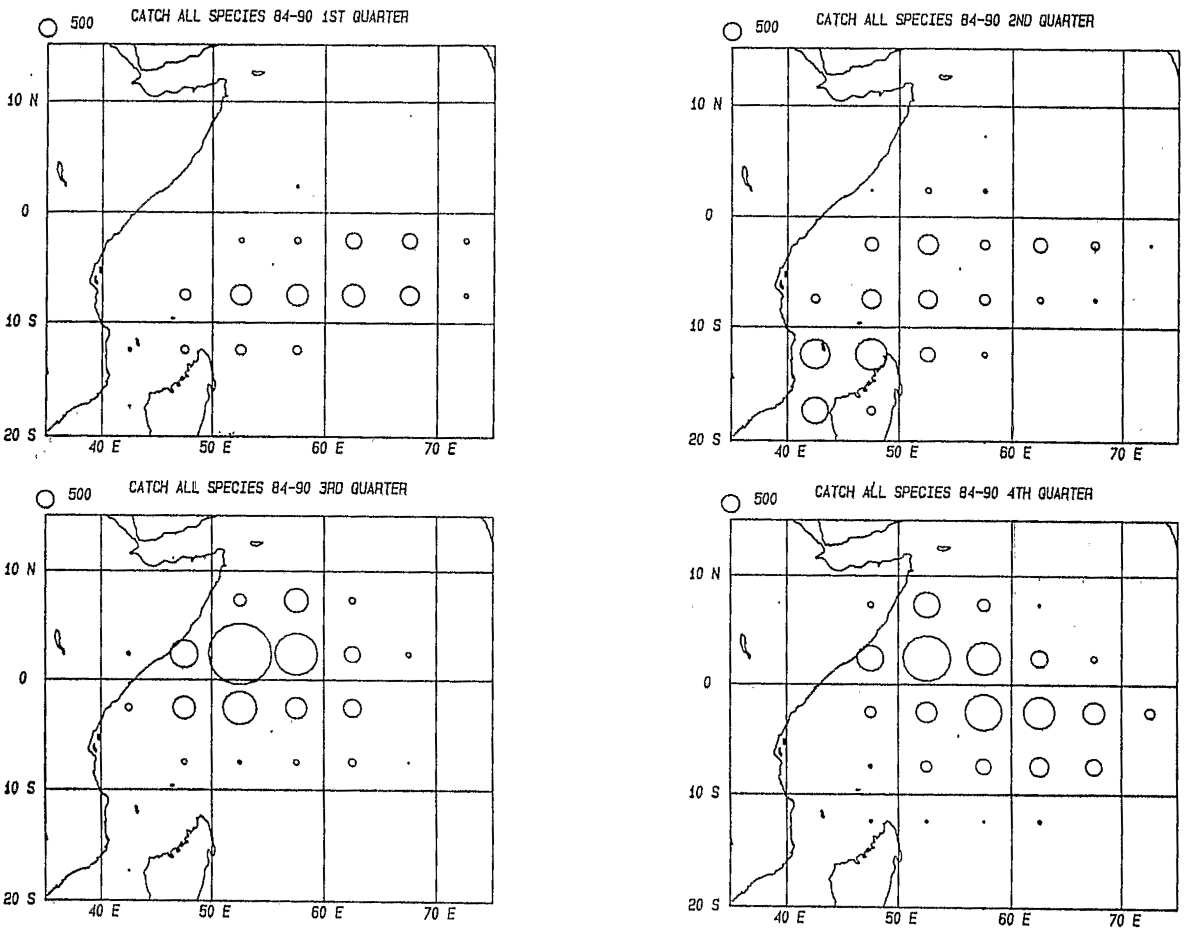
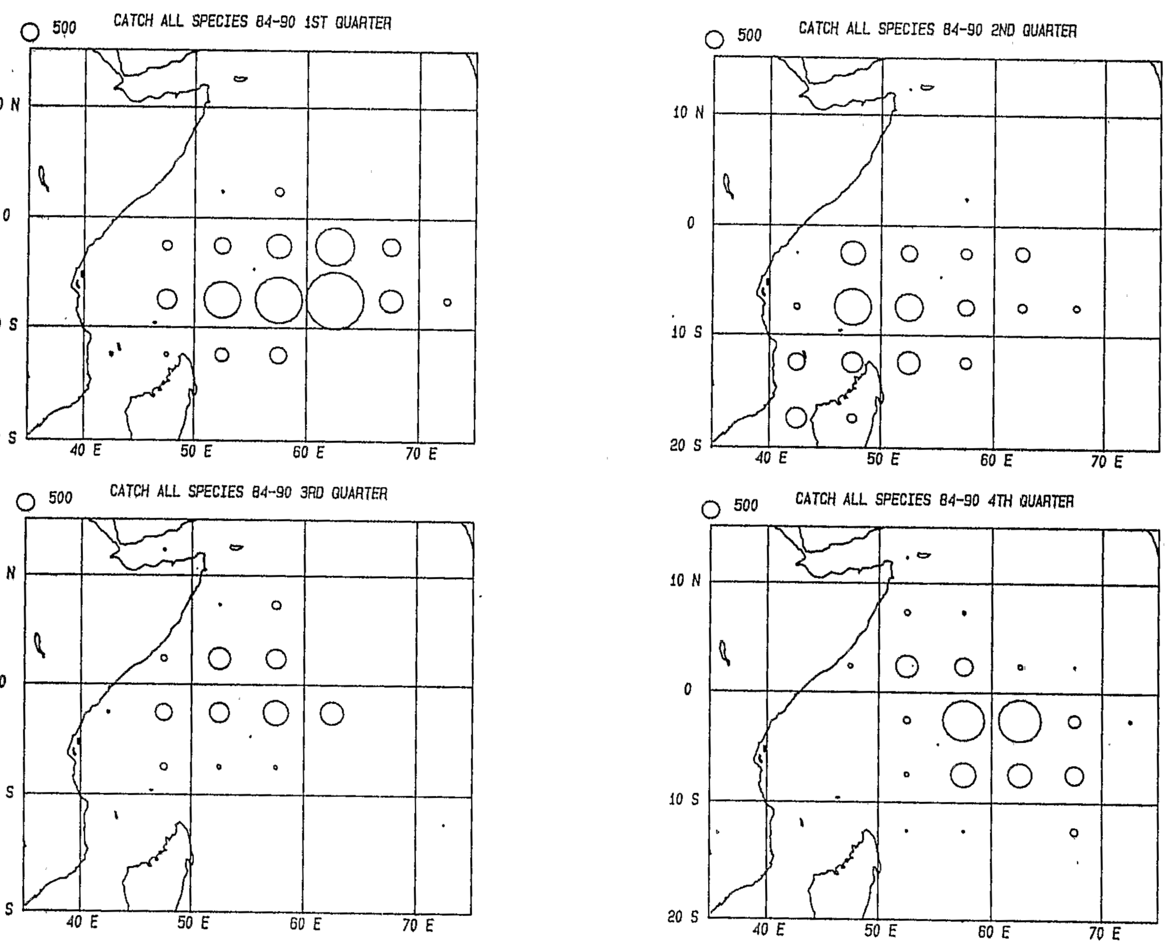


Figure 11 : Average catch per 5°x5°/quarter (1984-90) per type of school. Overall purse seine fleet, Western Indian Ocean.

FREE



LOG

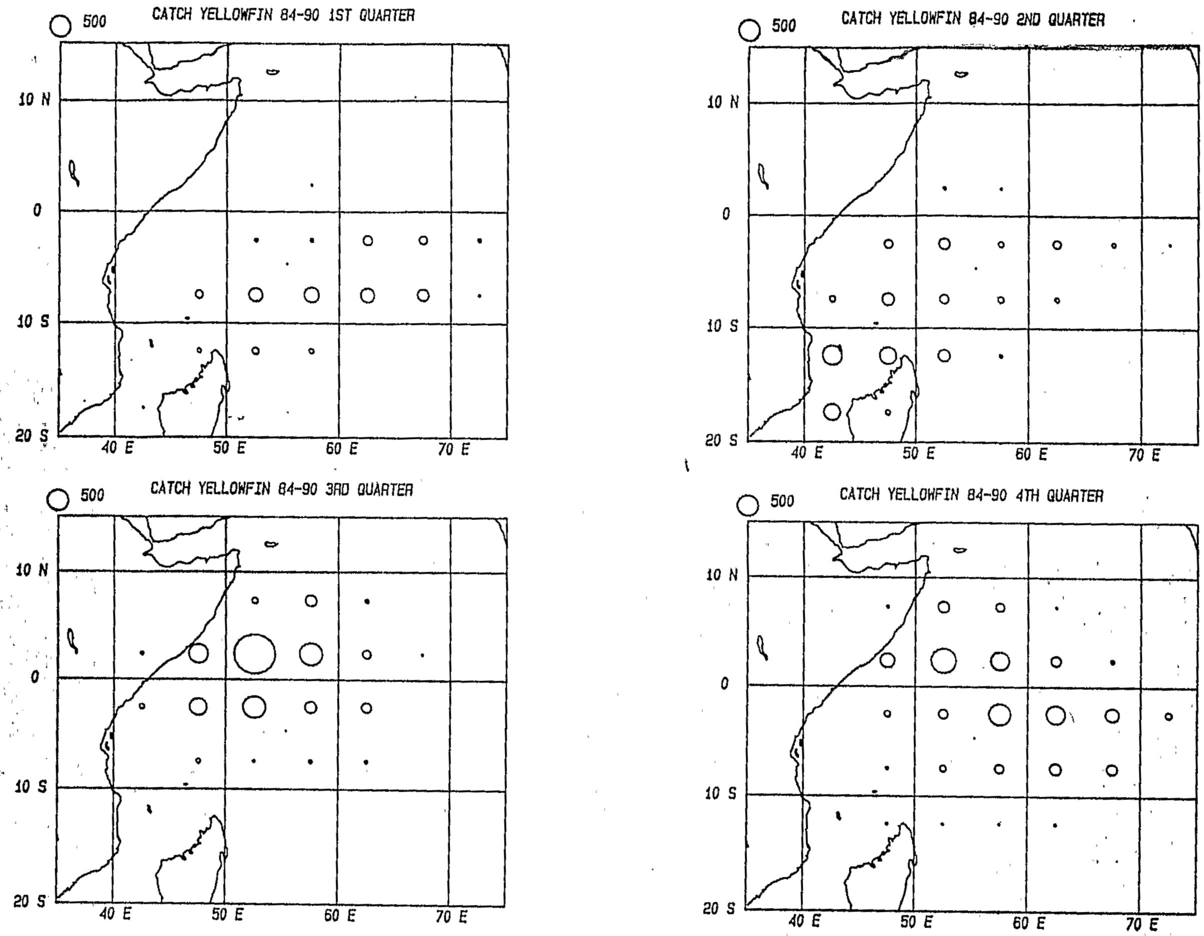
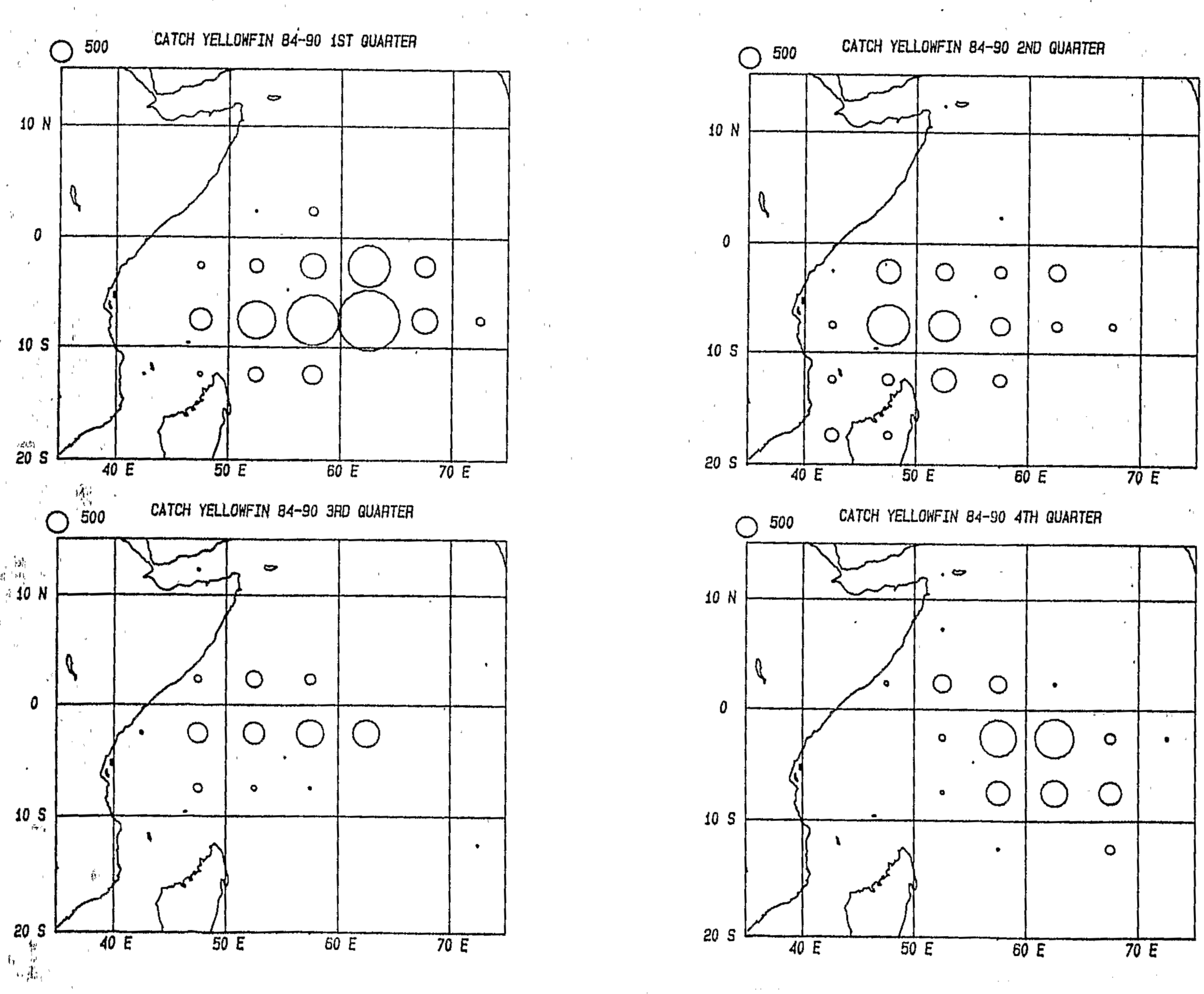


Figure 12 : Yellowfin average catch per 5°x5°/quarter (1984-90) per type of school. Overall purse seine fleet, Western Indian Ocean.

FREE



LOG

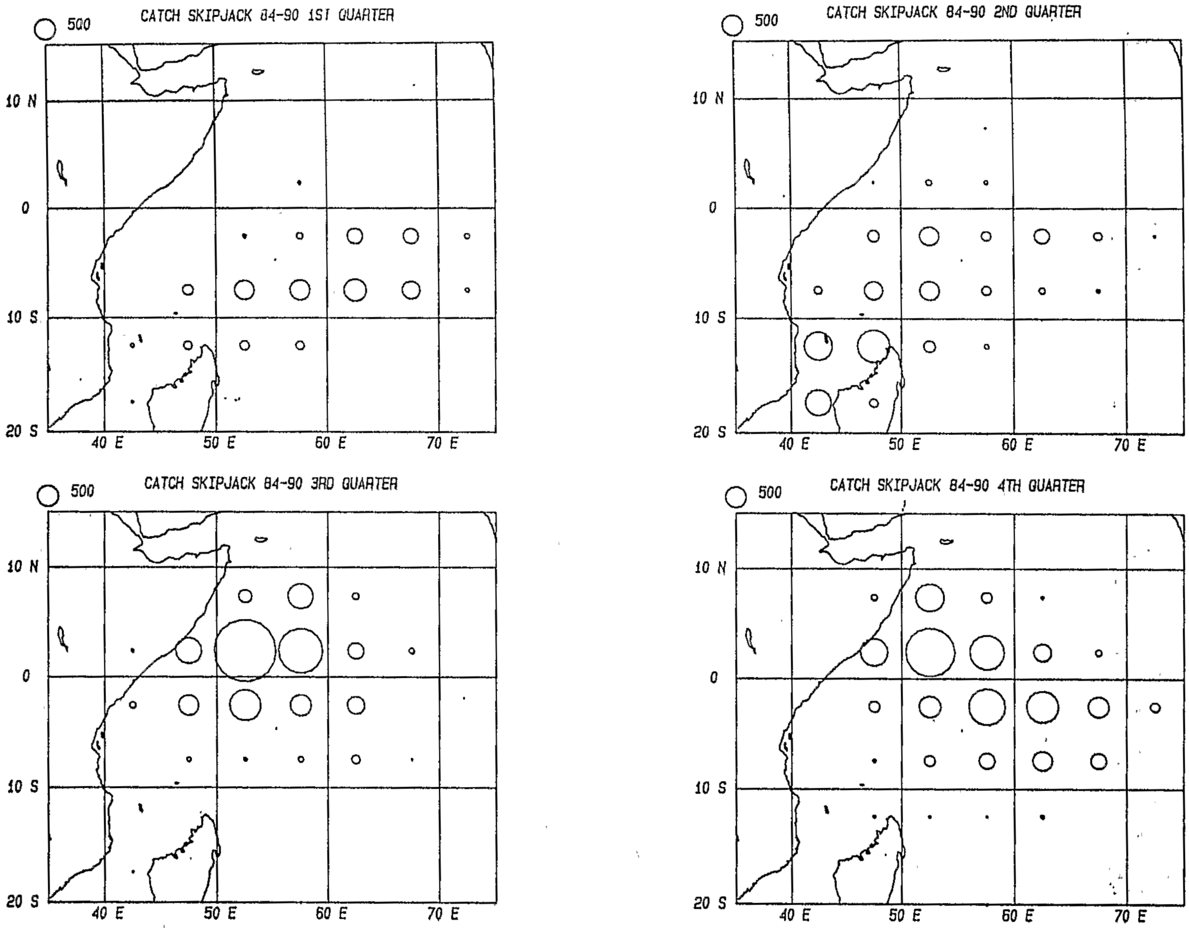
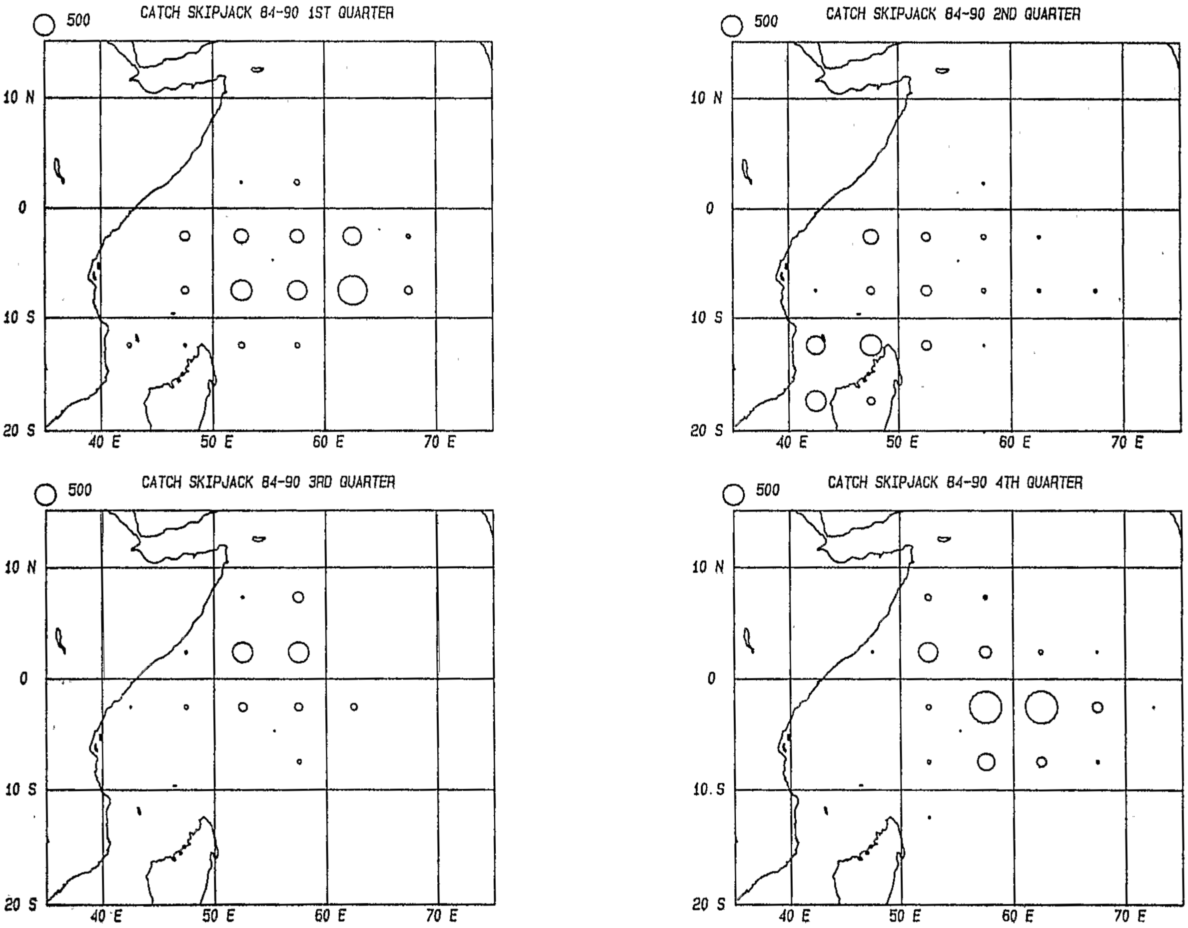


Figure 13 : Skipjack average catch per 5°x5°/quarter (1984-90) per type of school. Overall purse seine fleet, Western Indian Ocean.

FREE



LOG

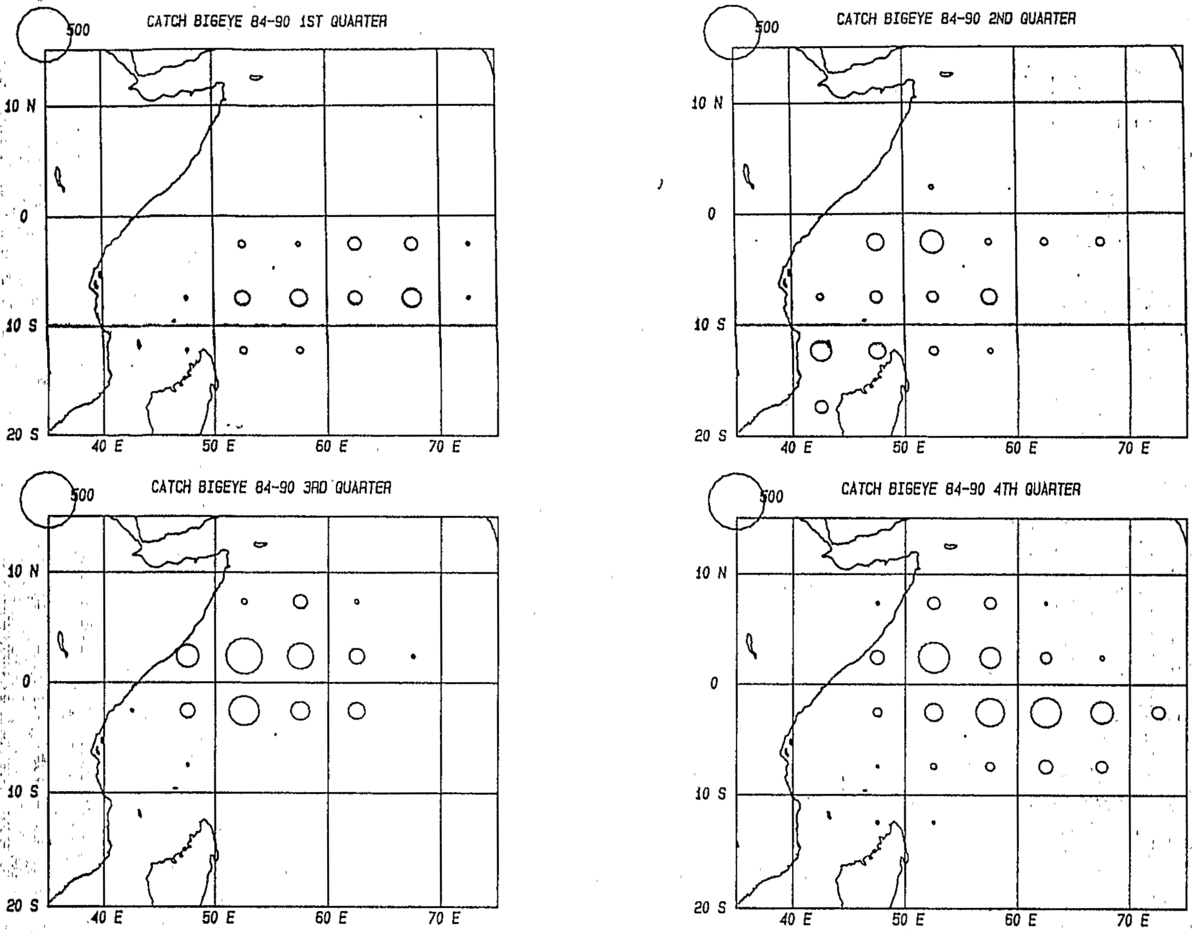


Figure 14 : Bigeye average catch per 5°x5°/quarter (1984-90) per type of school. Overall purse seine fleet, Western Indian Ocean.

FREE

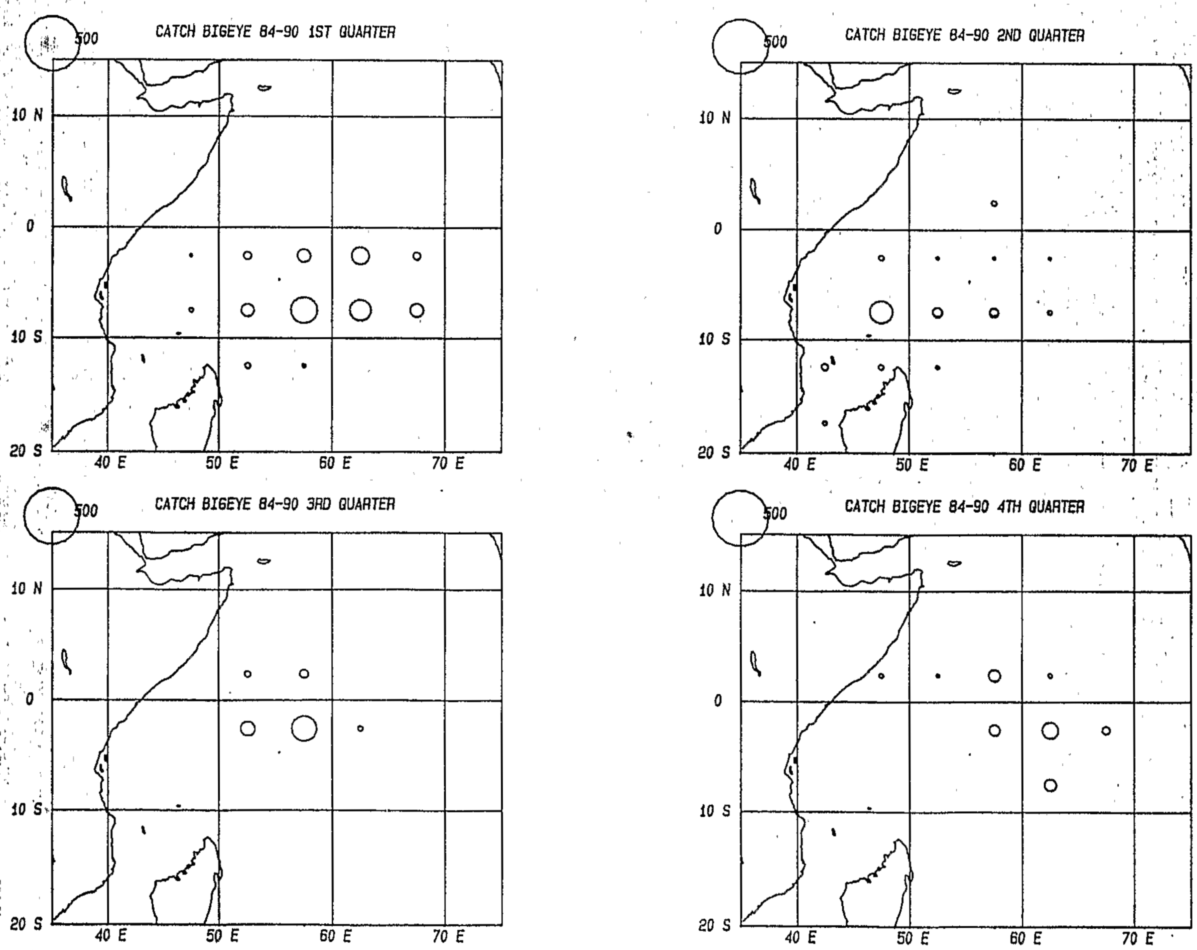
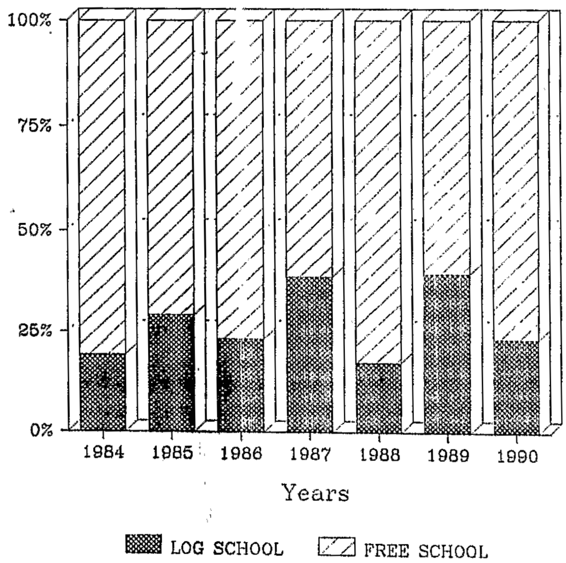
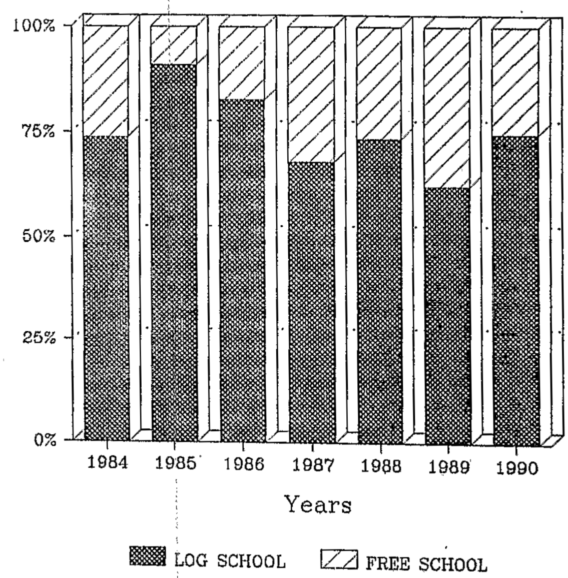


FIGURE 15:YELLOWFIN CATCH DISTRIBUTION BETWEEN LOG AND FREE SCHOOLS (1984 - 90)



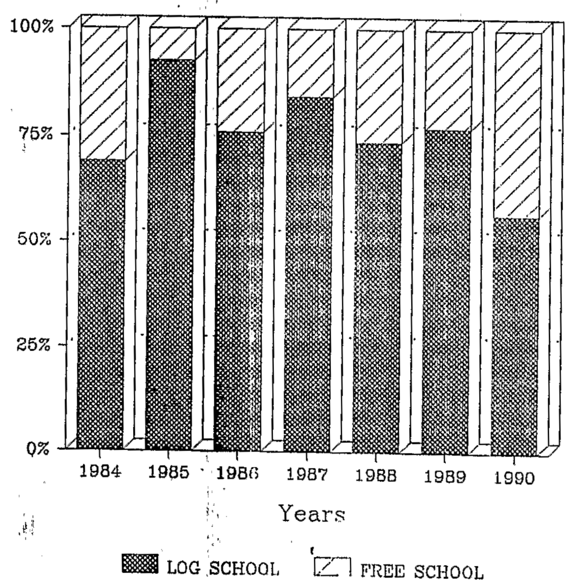
French purse seiners,
Western Indian Ocean

FIGURE 16 : SKIPJACK CATCH DISTRIBUTION BETWEEN LOG AND FREE SCHOOLS (1984 - 90)



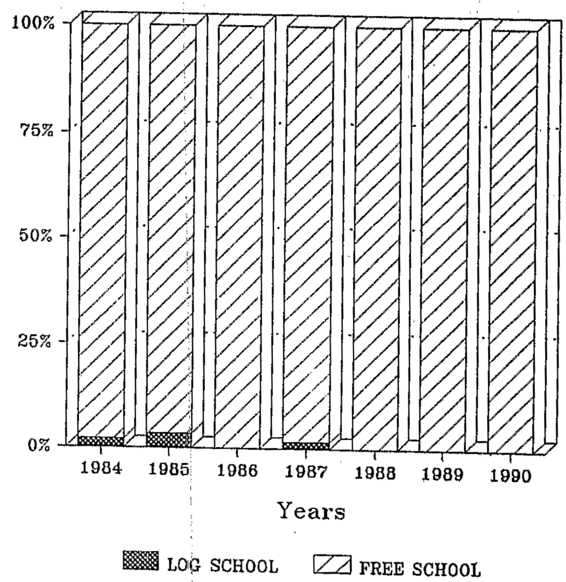
French purse seiners,
Western Indian Ocean

FIGURE 17 : BIGEYE CATCH DISTRIBUTION BETWEEN LOG AND FREE SCHOOLS (1984 - 90)



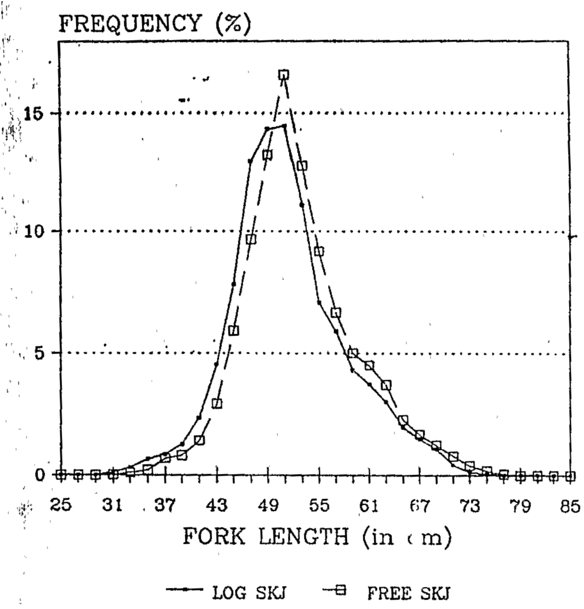
French purse seiners,
Western Indian Ocean

FIGURE 18 : ALBAÇORE CATCH DISTRIBUTION BETWEEN LOG AND FREE SCHOOLS (1984 - 90)



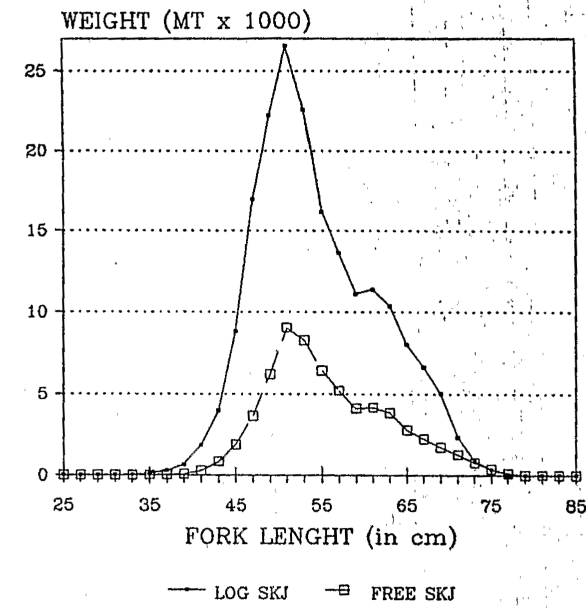
French purse seiners,
Western Indian Ocean

FIGURE 19 : SIZE FREQUENCY DISTRIBUTION OF SKIPJACK FROM LOG AND FREE SCHOOLS



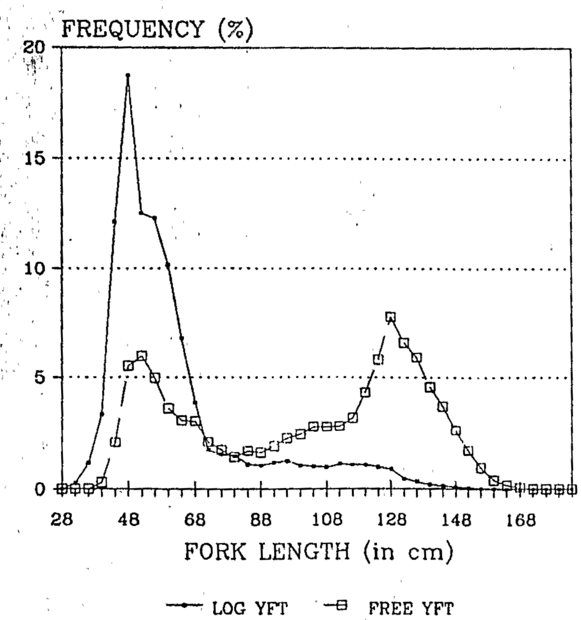
French purse seiners,
Western Indian Ocean, 1984–90.

FIGURE 20 : WEIGHT OF SKIPJACK BY SIZE CLASSES OF 2CM ON LOG AND FREE SCHOOLS



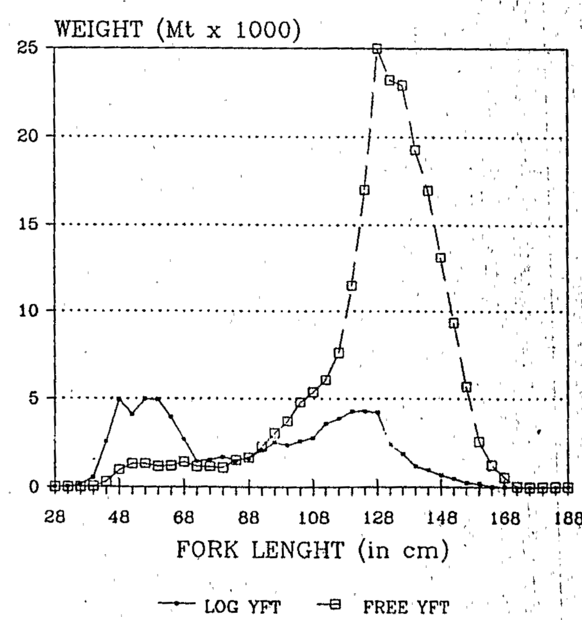
French purse seiners,
Western Indian Ocean, 1984–90.

FIGURE 21 : SIZE FREQUENCY DISTRIBUTION OF YELLOWFIN FROM LOG AND FREE SCHOOLS



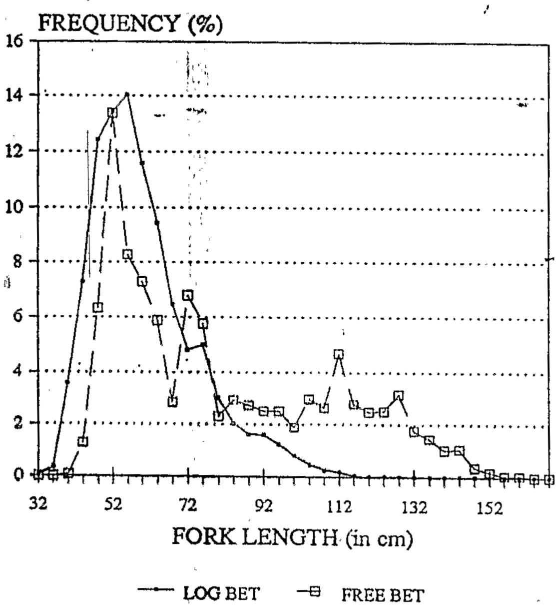
French purse seiners,
Western Indian Ocean, 1984–90.

FIGURE 22 : WEIGHT OF YELLOWFIN BY SIZE CLASSES OF 4CM ON LOG AND FREE SCHOOLS



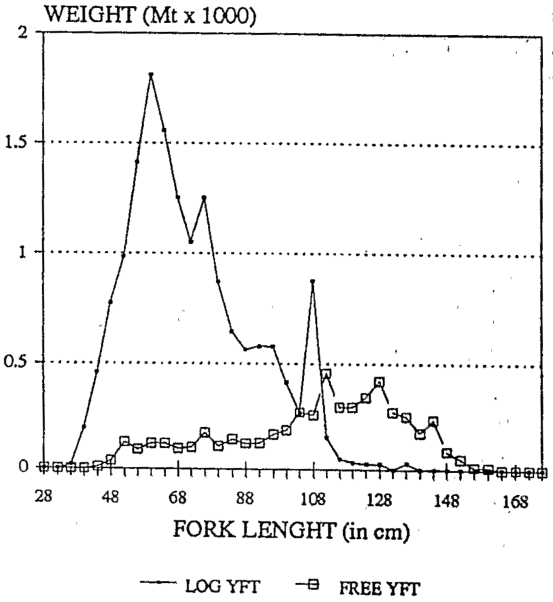
French purse seiners,
Western Indian Ocean, 1984–90.

FIGURE 23 : SIZE FREQUENCY DISTRIBUTION OF BIGEYE FROM LOG AND FREE SCHOOLS



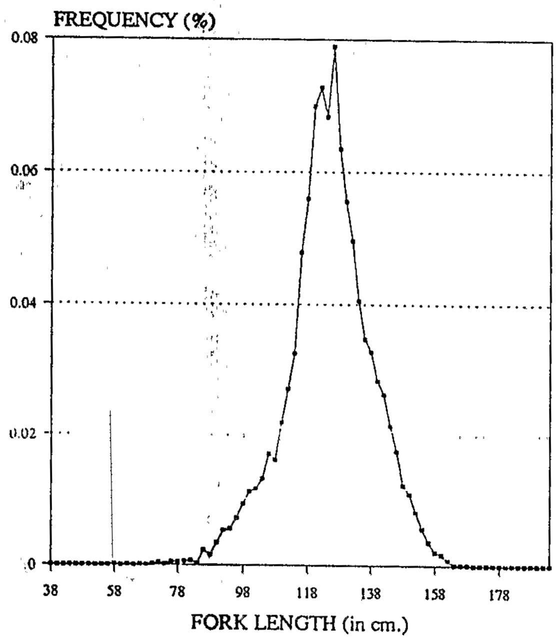
French purse seiners,
Western Indian Ocean, 1984-90.

FIGURE 24 : WEIGHT OF BIGEYE BY SIZE CLASSES OF 4CM ON LOG AND FREE SCHOOLS



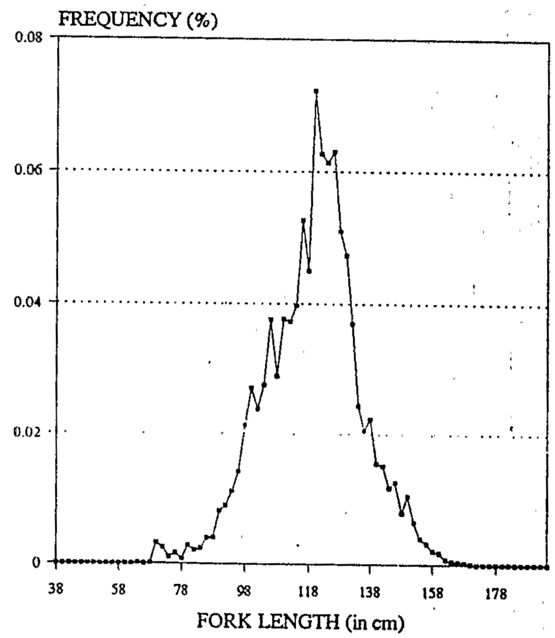
French purse seiners,
Western Indian Ocean, 1984-90.

FIGURE 25 : SIZE FREQUENCY DISTRIBUTION OF YELLOWFIN CAUGHT ON JAPAN LONGLINERS BY 2 CM CLASSES (1976 - 1989)



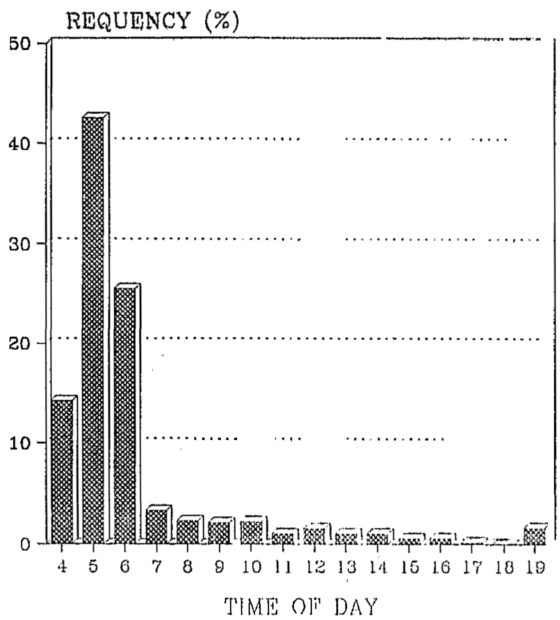
Western Indian Ocean 05°N-05°S/55°E-75°E

FIGURE 26 : SIZE FREQUENCY DISTRIBUTION OF YELLOWFIN CAUGHT ON JAPAN LONGLINERS BY 2 CM CLASSES (1976-89)



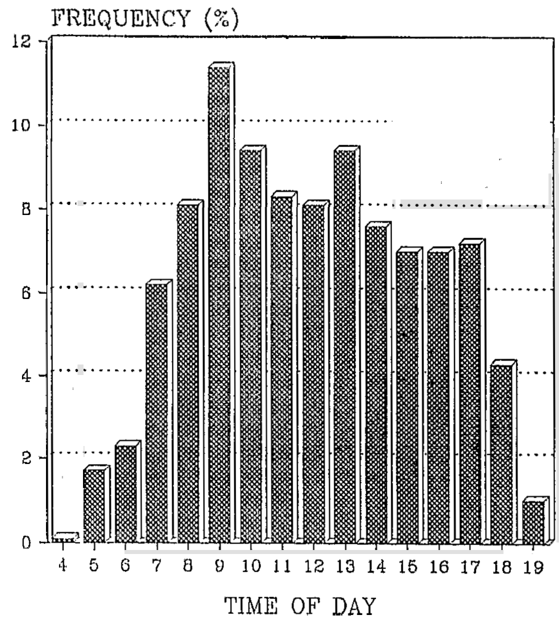
Western Indian Ocean 15°N-00 /45°E-55°E

FIGURE 27 : SETTING TIME FOR LOG SCHOOL SETS



Western Indian Ocean purse seiners, 1981–89

FIGURE 28 : SETTING TIME FOR FREE SCHOOL SETS



Western Indian Ocean purse seiners, 1981–89.

FIGURE 29 : DURATION AGAINST CATCH FOR FRENCH POSITIVE SETS ON LOG AND FREE SCHOOLS

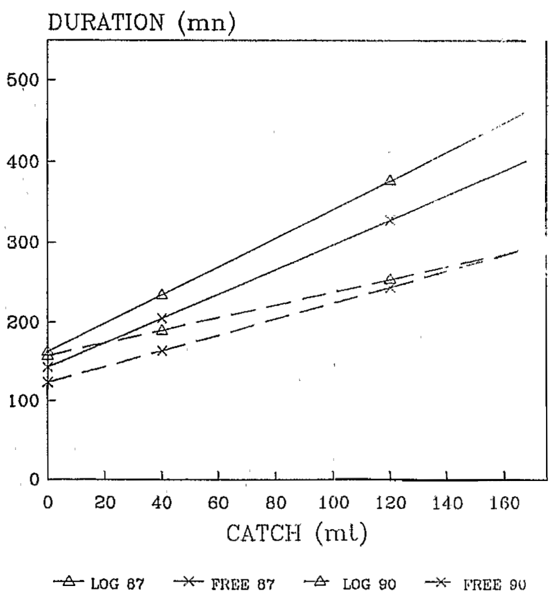


FIGURE 30 : DURATION AGAINST CATCH FOR SPANISH POSITIVE SETS ON LOG AND FREE SCHOOLS