A METHOD TO ASSESS THE SET TIME OF THE PURSE SEINERS IN THE INDIAN OCEAN

by

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RESUME

La durée des coups de filet effectués au moyen de 3 types de sennes qu'utilisent les thoniers dans l'ocean Indien, sont analysées et leurs efficacités respectives sont comparées. Les données ont été collectées à bord des senneurs français et ivoiriens (FI) par des observateurs scientifiques. En l'absence d'informations concernant les thoniers espagnols qui emploient un gréement particulier, l'efficacité de cet équipement peut être appréciée au travers des résultats obtenus par un senneur français qui en est pourvu. La relation entre le temps de sennage et la capture est linéaire, quel que soit le type de greement. La comparaison des 3 ajustements confirme que 1) le gréement utilisé sur les senneurs espagnols et sur un senneur français permet de réaliser plus rapidement des calées, et 2) que l'équipement récent à anneaux ouvrants dans la flottille FI se relève plus performant que le gréement classique à anneaux fermés. Lorsque les captures par coup de filet ne sont pas précisées, un modèle est proposé, qui permet d'estimer le temps global de sennage. L'intérêt de ces calculs est de parvenir à une estimation plus fine de l'effort de pêche des senneurs.

SUMMARY

The set times relevant to 3 types of tuna purse seine gears used by tuna boats in the Indian Ocean are analysed and their respective efficiencies are compared. The data were collected on board French and Ivorian (FI) seiners by technical officers. Since data from the Spanish vessels which deal with a specific equipment are not available, the results reported by a French seiner using this kind of equipment were considered in order to assess its efficiency. The relationship between the set time and the catch is a linear model, whatever the purse seine gear may be. They confirm that 1) less time is required for setting with the equipment used by Spanish vessels and the French vessel considered; 2) that the recently introduced equipment, with opening ring nets, among the FI fleet, provides a greater efficiency when compared with the previous one fitted with closed ring nets. When catch for several sets are grouped together, a model is presented, which gives an estimation of the total set time. The purpose of these calculations is to provide a better estimation of the purse seiner fishing effort.

1 INTRODUCTION

Measuring tuna abundance can be achieved using direct evaluation technics or analysis of the yields of the fishing vessels. The first method, based on aerial spotting or observations at sea along line transects, has the great advantage to provide abundance indices not related to the fishing effort. The second way requires accurate and detailed data on the fishing power of the vessels, the fishing effort, the catch and the probability of sighting and capturing schools. These parameters have been included within a wider concept of fishing effort by GREENBLATT (1976), who proposed a three component structure : a hardware component, or the physical capabilities of the ship, a software component or the skill of the skipper, an environment component, or the atmospheric conditions, the sea state, the time of the day, the occurence of tuna sensors (birds, floatsom, small pelagic schools ...). This approach is more complete but rather complex.

At this stage of our study, we will only assess a part of the first component. LAUREC and LE GUEN (1977), referring to the two concepts of fishing effort, the day at sea and the searching time (which excludes the time spent for setting), point out the higher accuracy of the second one which allows the use of the corresponding CPUE as a rather reliable index of abundance. Thence estimating the set time appears as a prime necessity for the assessment of tuna abundance, a topic which will be studied in the forthcoming months in the Western Indian Ocean.

During the latest years, the purse seine gears were modified in order to increase their fishing efficiency. Until 1984, most of the French and Ivorian fleet (called FI) used nets whose pursing line was running through closed rings (C.R.), while the Spanish vessel nets were fitted with opening rings (O.R.). This latter equipment could provide more safety in retrieving the net in case of bad weather, and could save some time during the retrieval process since it is no longer necessary to interrupt the operation to back the pursing line off the rings. After 1984, all the C.R. equipped nets were changed into O.R. equipped nets among the FI fleet. However, some important differences still remain between Spanish and FI fleets. On Spanish vessels, the windlass has a greater power and the net has a different structure which allows a quicker retrieving process; furthermore,during the loading process, they can carry on board more fish at a time than the FI vessels.

The purpose of this paper is, first, to compare the set times of three types of purse seine gears based on information recorded in the Western Indian Ocean and, second, to present a model estimating the total set time resulting from several sets grouped together, when the catch by set is not detailed.

2 SOURCES OF DATA

The set is an operation starting when the net skiff is released into the water, and ending with the lift out of the skiff on board the seiner, after the net has been completely restacked onto the deck. The time spent between these two events is what we call the "set time"; obviously, during this operation, the scouting effort is null.

This kind of data is rarely provided by the skippers. They have been collected on board different purse seiners by scientific observers from the Seychelles Fishing Authority (SFA) and the ORSTOM station based in Seychelles. These observations are still going on; the data analysed in the paper were gathered during the period 1982-86. Three groups of data are considered:

- data group no.1 : FI fleet with C.R. nets (data collected between 1982 and 1984)
- data group no.2 : FI fleet with O.R. nets (data collected in 1985-86)
- data group no.3 : Spanish equipment, used by a single French vessel (data collected in 1984)

Since Spanish set time data are not yet available in the Indian Ocean, we considered separately the single French vessel using the Spanish equipment in order to give a preliminary estimate of its efficiency. General information on the three groups of data is given below.

Table 1 : General information regarding the groups of data analysed.

Data group	Purse seine gear	Sampling period	No. of boats sampled	No. of sets		
				Unsuccesful	Successful	Total
1	C.R nets (FI fleet)	Nov 1981- Sep 1984	4	79	198	277
2	O.R nets (FI fleet)	Aug 1985- Sep 1986	10	52	77	129
3	Spanish equipment	Mar 1984- Nov 1984	1	33	51	84

Due to lack of data, it is not possible to study the efficiency by vessel sizes. Two sizes of vessels are operating among the FI fleet : 51 - 55m length, 400 to 500 MT loading capacity (class 5), and 70m length boats, 800 MT (class 6). It is likely that differences may exist both in terms of capability of the vessels in pursuing and encircling the schools (due to different cruising speed) and in terms of time spent for setting. FONTENEAU et al (1983) have statistically rejected the hypothesis of homogeneity of set times between class 5 and 6 boats in the Atlantic Ocean.

3 RESULTS

3.1 Set time for unsuccessful sets

This event needs to be considered separately since it contributes to a significant proportion of the sets (36%, the mean for the period 1982-85 by the FI fleet).

The frequency of sets by 15mn interval is plotted in fig.1. There is a continuous decrease of the mean time from the C.R. nets to the Spanish equipment. Two tests were done to compare the three distributions and their means (SCHERRER, 1984).

1. As the whole distribution for each equipment (plotted in fig.1) does not fit a normal distribution, we used distribution-free statistics (Wilcoxon-Mann-Whitney test) : they prove the distributions are statistically different at the level <1%.

2. When we exclude the longer set times, the distribution is then normal. These long set times are due to problems which occur sometimes during bad weather conditions or equipment breakdowns. The time level exclusion, on the right side of the distribution, was set at the frequency level 5%, i.e. 3.25 h with the C.R. nets, 2.75 h with the O.R. nets and 2.25 h with the Spanish equipment. In this case of normality, the means were compared with a t-test and were found different at a risk level lower than 1%.

Both test lead to the conclusion that a decrease of the setting time was obtained in the FI fleet with the introduction of O.R nets (2.43 to 2.00 h). However, the Spanish equipment remains the more efficient (1.54 h). A comparison with the Atlantic Ocean shows a great similarity of the results (Table 2). The O.R. nets were not considered by FONTENEAU et al (1983) as they were not yet introduced among the FI fleet.

The proportion of excluded sets is also different between C.R. nets (11%) and other equipments (O.R.: 7%, Spanish equipment: 6%).

Table 2 : Comparison of set times for unsuccessful sets between Indian and Atlantic Oceans, according to the purse seine gear (time in decimal hours).

		FI Fleet		Spanish Equipment
		Closed Rings Nets	Opening Rings Nets	
I	Whole distribution:			
N				
D	N	79	52	33
I	mean set time	2.70	2.07	1.68
A	standard error	0.90	0.38	0.62
N				
	Filtered distribution			
O	(longer set times excluded)			
C	N	70	48	31
E	mean set time	2.43	2.00	1.54
A	95% C.I. for mean	(2.35-2.51)	(1.91-2.08)	(1.46-1.64)
N	standard error	0.34	0.28	0.24
A	N	137	-	68
T	mean set time in Atlantic Ocean	2.43	-	1.66
L.	(Fonteneau et al, 1983)			

3.2 Set time versus the size of the catch

The set times for successful sets which catches range from 1 to 180 MT are displayed in fig. 2 (a, b, c) for the three purse seine gears. First, a great heterogeneity of the density of points appears in the two first diagrams (the big sets, over 80 MT are not so common than the small ones), so that fitting a curve with such data would be highly biased. Second, some points are located quite far from the main distribution : similarly to unsuccessful sets, they are relevant to unfavourable conditions and should not be considered as regular set times.

According to these observations, two processing methods were used on the original data:

- for the three data group, we excluded the uncommon sets. The time level was set at 7h (1 to 40MT) and 9h (over 40MT) for the first group of data, and at 7h for the two others. So, 8 sets, 4 sets and 1 set have been excluded respectively from the three data groups.

- for the two first groups of data (C.R. and O.R. nets), we computed the mean set time within catch intervals. These mean times and the corresponding mean catch were then used for the regression process.

The choice of the catch intervals were based on two criteria : no correlation between the set time and the catch, and a minimum of 30 points in each interval. When both criteria were not satisfied simultaneously, the first one was considered as sufficient. We used a rank correlation (Kendall Tau) since the normality along x and y within each interval is not satisfied. Thence, 5 catch intervals were selected in the first data group and 2 intervals in the second. The results are presented in Table 3.

Two kinds of linear regressions (least squares method) were computed:

model 1 = only considering the successful sets (Fig 3a,b,c)

model 2 = fixing the intercept, i.e. the set time for a zero catch. This is calculated by the formula $y = a + b x$, y and x is given by the model 1. So, since the intercept "a" is known, the slope "b" can be found.

The time (T) is given in decimal hours, the catch (C) in metric tons. The results are as follows:

- C.R. nets :

model 1 : $T = 3.54 + 0.025 . C$ ($r = 0.765$; $n = 36$)

model 2 : $T = 2.43 + 0.042 . C$

- O.R. equipped nets

model 1 : $T = 3.46 + 0.018 . C$ ($r = 0.651$; $n = 44$)

model 2 : $T = 2.00 + 0.045 . C$

- Spanish equipment :

model 1 : $T = 2.41 + 0.015 . C$ ($r = 0.598$; $n = 50$)

model 2 : $T = 1.54 + 0.040 . C$

These relationships were compared each one with the other (Table 4). First, we used a slope test, which proved the three slopes were not statistically different. Then, a position test was made to compare the intercepts. The calculations made from the model 1 showed no statistical difference between the C.R. and O.R. nets; on the other hand, the Spanish equipment always remains different. The conclusions are slightly different with the model 2: the O.R. net is an intermediate gear between the two others, and it shows no statistical difference with them. However, this gear would have an efficiency closer to the one of the C.R. equipment.

Table 3 : Analysis made on the two first groups of data to calculate the sizes of the catch intervals and the corresponding mean set times.

	C.R. NET					O.R. NET	
Metric tons :	1-5	6-10	11-17	18-25	26-40	1-8	9-17
N	32	36	31	30	30	14	17
X: mean (catch)	3.4	8.9	14.6	22.2	34.4	4.1	12.9
stand. error on x	1.3	1.5	1.5	2.6	4.5	2.7	2.3
y: mean (time)	3.7	3.6	4.0	4.1	4.5	2.7	3.4
stand. error on y	1.1	0.7	0.8	1.0	0.9	0.6	0.7
no of concord. pairs	179	213	114	152	160	48	61
no of discord. pairs	214	160	200	119	179	34	50
correlations coef (Tau)	0.071	0.084	-0.185	0.076	-0.025	0.154	0.081
Z Tau	0.57	0.72	-1.46	0.57	0.18	0.71	0.41

The null hypothesis (no correlation) is accepted when $|Z\ Tau| < Z\ \alpha/2$
($Z\ \alpha/2 = 1.96$ with $\alpha = 0.05$)

Table 4 : Results of slope test and position test between the linear regressions of each purse seine gear. (a significant difference between the slopes or the position, at the risk level $\alpha = 5\%$, is obtained when the test value exceeds 1.96).

model	test	C. R. nets versus O. R. nets	O. R. nets versus Spanish equipment	C. R. nets versus Spanish equipment
1	slope	0.90	0.77	1.69
	position	0.30	5.14**	4.51**
2	slope	0.43	0.68	0.27
	position	1.03	1.42	2.62*

* : 1%   ** : 1%.

According to the homogeneity of the set times versus the size of the catch within the FI fleet, a mixing of the data could be considered. However, this would require no differences between variances and means. A log-anova test resulted in differences between the three variances, but no difference between the C.R. and O.R. nets distributions. This confirms the Spanish equipment should be analysed separately. A t-test to compare the means between C.R. and O.R. equipments resulted in a significant difference at the risk level α = 1% along the y axis, i.e. the set times (Zcy = 2.93). Thence, each of the three gears has a specific efficiency and mixing data within the FI fleet is not possible.

As a comparison, the linear models obtained by FONTENEAU et al (1983) in the Atlantic Ocean are the following:

- C.R. nets :

model 1 : T = 2.57 + 0.027. C   n = 194
model 2 : T = 2.43 + 0.042. C

- Spanish equipment

model 1 : T = 1.78 + 0.028. C   n = 122
model 2 : T = 1.66 + 0.030. C

The model 2 for C.R. nets is the same as we calculated in the Indian Ocean. However, detailed data from the Atlantic Ocean would be necessary to compare the slopes of the equations between the two oceans.

3.3 Estimation of the set time with no available catch per set data

When detailed information on the catch of each set is not available, the previous equations cannot be used. This occurs when skippers mention on their log books the total catch of the day resulting of more than one successful set. So, we have investigated a relationship taking into account the additional time according to the number of sets reported. This surplus of time coefficient explains that two x M.Ton sets require more time than a single 2.x M.Ton set. This was achieved through a simulation on different values of multiple sets, ranging from 2 to 5 sets. We consider that 5 sets is the maximum number of sets which can be made during one fishing day. The surplus coefficient Q is defined by:

$$Q = \frac{Tn}{Ts}$$ with

Tn = n. (set time for a catch of C/n MT)

Ts = set time for a single catch of C MT

The model proposed assumes that the surplus time coefficient is a linear function of the catch C. Furthermore, different values of multiple sets lead to different linear functions.

So, the surplus of time required by multiple setting process is described by a function g (n,C). Its values are presented in Table 5 for the two different models described in section 3.2.

The generalised relationship between the set time (T) and the size of the catch (C) is given by the equation :

$$T = f(C) \cdot g(n,C)$$

The robustness of the model can be tested by calculating the mean relative error between the observed and the expected set times. The sets to be grouped are chosen at random, then the total catch and the total set time are calculated (observed set times). The expected set time is obtained by using the appropriate g (n,C) values, according to the number of sets grouped and the total catch. The comparison is made on 10 arrangements, for groups of sets ranging from 2 to 4. The relative error is given in percent by :

$$e_i = \frac{(\text{Expected set time} - \text{Observed set time})}{\text{Observed set time}} \cdot 100 \quad \text{and} \quad \bar{e} = \frac{\sum |e_i|}{n}$$

The results are presented in Table 6. Most of the mean relative errors are below 12%. It also appears that the model 1 fits the data better than the model 2. With the present data, these results suggest a rather good robustness of the model, keeping in mind that improvements could be achieved with stratified data (seasons, size of boats...).

4 DISCUSSION

The availability of equations relating set times and size of catch by purse seiners in Indian Ocean is not an absolute issue to the assessment of the effective searching time. Usually, this searching time is the difference between the fishing time and the set times of the day :

$S = F - \sum_{j=1}^{n} Tj$ with

S : searching time
F : fishing time (usually 12 h)
Tj : set time of each of the n sets performed during the day

It is possible that a set could be made at sunset, when scouting is no longer possible. Therefore, it is necessary to introduce a correction factor taking into account the fraction of the set occurring during the potential scouting time. This corrective factor is computed as follows:

- if $hj2 > h$, $pj = \frac{h - hj1}{Tj}$
- if $hj2 \leqslant h$, $pj = 1$
- if $hj1 \geqslant h$, $pj = 0$

with h : hour when scouting process is stopped (usually 6 p.m. in tropical regions)
hj1 : hour when the set is started
hj2 : hour when the set is completed

Consequently, $S = F - \sum_{j=1}^{n} Tj \cdot pj$

Table 5 : The function g (n,C) according to the number of sets (linear model : y = a + bx, with x = catch in metric tons)

NUMBER OF SETS (n)	C.R. Nets		O.R. Nets		Spanish Equipment	
	a	b	a	b	a	b
1	1	0	1	0	1	0
2	1.8993	$-27.25.10^{-4}$	1.9303	$-24.16.10^{-4}$	1.9113	$-25.87.10^{-4}$
3	2.7951	$-54.19.10^{-4}$	2.8602	$-48.47.10^{-4}$	2.8256	$-52.05.10^{-4}$
4	3.6955	$-81.50.10^{-4}$	3.7896	$-72.54.10^{-4}$	3.7360	$-77.94.10^{-4}$
5	4.5912	$-108.3.10^{-4}$	4.7177	$-96.78.10^{-4}$	4.6496	$-104.0.10^{-4}$

-MODEL 1-

NUMBER OF SETS (n)	C.R. Nets		O.R. Nets		Spanish Equipment	
	a	b	a	b	a	b
1	1	0	1	0	1	0
2	1.7520	$-31.41.10^{-4}$	1.6990	$-31.20.10^{-4}$	1.6651	$-30.72.10^{-4}$
3	2.5043	$-62.66.10^{-4}$	2.3927	$-62.17.10^{-4}$	2.3304	$-61.33.10^{-4}$
4	3.2562	$-94.06.10^{-4}$	3.0906	$-93.36.10^{-4}$	2.9949	$-92.03.10^{-4}$
5	4.0067	$-125.3.10^{-4}$	3.7880	$-124.5.10^{-4}$	3.6598	$-122.7.10^{-4}$

- MODEL 2 -

Table 6 : Mean relative errors (in %) between observed and expected set times when sets are grouped

NUMBER OF SETS	C.R. Nets		O.R. Nets		Spanish Equipment	
	model 1	model 2	model 1	model 2	model 1	model 2
2	11.2	9.2	12.0	17.7	10.9	18.7
3	8.9	11.5	8.7	8.0	11.4	12.3
4	11.2	14.0	8.9	13.5	9.6	9.8

So, this correction requires detailed data on the setting process. One can see that ignoring this fact could lead to a bias in the estimation the searching time of the whole fleet.

According to a poor sampling of high levels of catch, the set time-catch relationships presented there should be used with care for sets greater than 100 MT, until further data is gathered.

In the Indian Ocean, where the oceanic conditions are closely related to the monsoon system, it could be interested to stratify each gear into 2 time strata : the southwest monsoon (June-September), with hard conditions at sea which can lengthen the set times; and the remaining months (October-May) when oceanic conditions do not seem to be a limiting factor of the seining activity. A stratification of the data according to the size class of the vessels should also be tried. This study will be carried out when more samples are available in each strata.

5. CONCLUSION

Among the FI fleet, the efficiency was increased with the introduction of nets fitted with opening rings. The mean set time required for unsuccessful sets have dropped from 2.43 h (C. R. nets) to 2.00 h (O.R. nets) and a significant difference is found between the set times of the two gears for successful sets.

Although the improvement of the FI purse seine gears, the Spanish equipment remains the most efficient. An unsuccessful set can be completed within 1.54 h. However, the slope of the equations, i.e. the increase of time along the catch, is not statistically different between the three gears. Finally, each gear has a specific efficiency : the O.R. nets of the FI fleet is intermediate between the C.R. nets and the Spanish equipment.

A major cause of the Spanish efficiency is a greater power of the windlass. Furthermore , in case of successful set, more time is saved by using the Spanish equipment during the loading process : 6 MT of fish is loaded at a time, when FI vessels carry 3 to 4 MT.

The models proposed to estimate the total time required by several sets when detailed catch by set data is not known, show mean relative errors in the order of 10%; it suggests that the model "set time versus catch" which only considers the successful sets, fits the data better than the model including the set time for a zero catch.

These results lead to a better estimation of the purse seiner fishing effort. This predictive model needs to be improved when more data is available.

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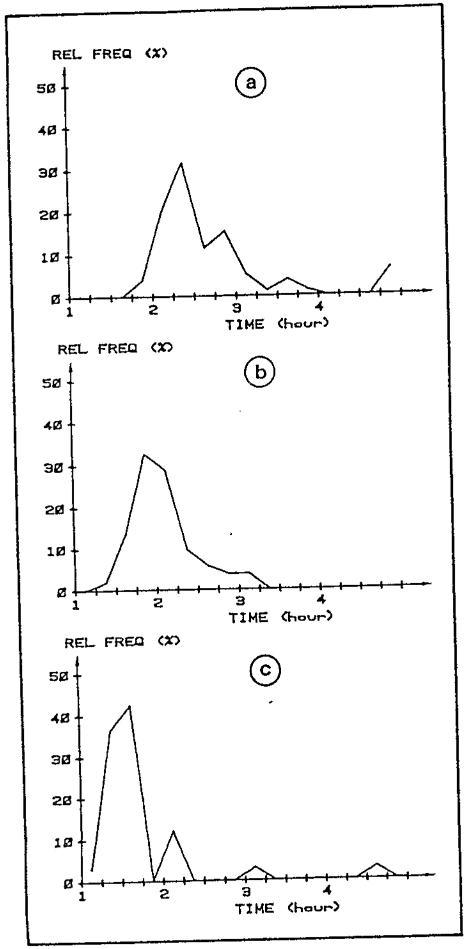

Fig.1 - Frequency of sets by 0.25 h intervals.
(a) C.R. nets
(b) O.R. nets
(c) Spanish equipment

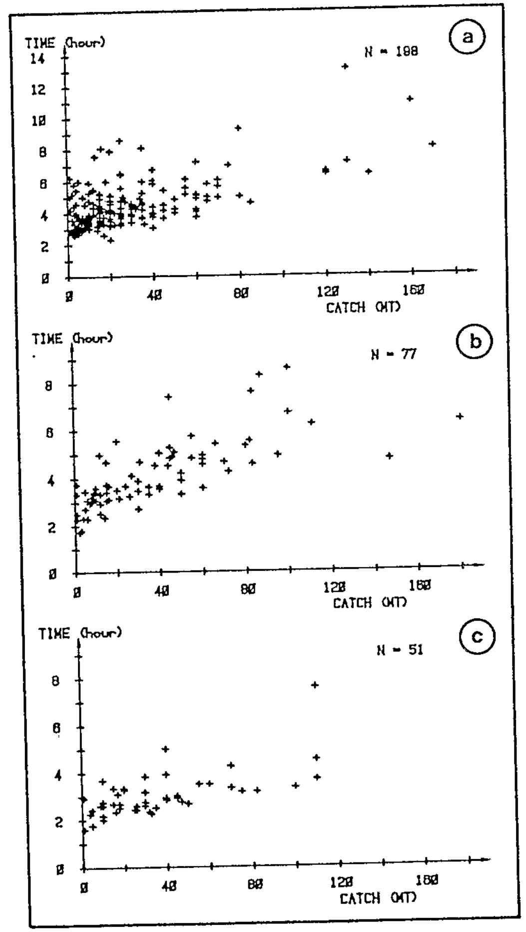

Fig.2 - Set times versus the size
of the catch.
(a) C.R. nets
(b) O.R. nets
(c) Spanish equipment

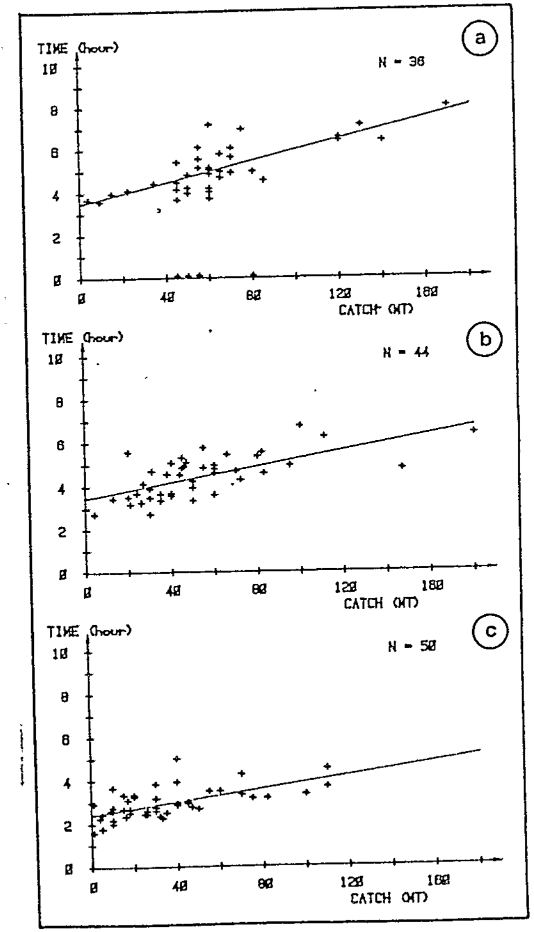

Fig.3 - Linear relations between
the set time and the catch.
(a),(b),(c) same as Fig.2