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SURVIVAL OF LESSER SPOTTED DOGFISH (*Scyliorhinus canicula*, L.) DISCARDED BY TRAWLERS.

by

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ABSTRACT

Discards of up to 35% represent a significant percentage of the catches in the trawl fishery. The estimated average annual dogfish catch in ICES area VIIIc is approximately 1,500 tn, from which 80% is discarded. Different experiments have been carried out in order to estimate the survival rate of the lesser spotted dogfish caught by trawlers in the Cantabrian Sea (North of Spain). Survival estimates based on tagging surveys have provided a mean value of 90% while estimates based on commercial trawlers gave 78%. No significant differences were found between males and females, and with the currently available data there was no strong relationship between survival rate and depth, sorting time or haul duration. Also, survival rate was not dependent on the length. The survival rate was estimated to be close to 0.42 based on length distributions from the total catch mortality (Z) caused by trawlers.

INTRODUCTION

The trawl fishing fleet lands an average of 55,165 tn of fish a year from ICES area VIIIc. Of this quantity 1,197 tn corresponds to elasmobranchs in general and 265 tn specifically to lesser spotted dogfish. Nevertheless, almost 90% of the catch of this species from an estimated catch of 2,747 tn is discarded during the fishing operations, since this species does not have any commercial interest. In the case of the long line, practically 100% of the catch of this species, approximately 229 tn, is discarded, whereas in the net fishery the discard represents 23% from an estimated catch of 407 tn. From these figures it is concluded *a priori* that the largest mortality from fishing is produced by trawling, which is the gear that catches most fish (fig. 1). Nevertheless, this species, in contrast to the majority of other species of commercial interest and other elasmobranchs, possesses a great survival capacity and can resist prolonged emersion periods and the fishing operations themselves. Therefore, it was considered of great interest to carry out a study aimed at estimating the survival of this species subjected to trawling, both from the point of view of tagging carried out on research cruises and from the discard produced on commercial trawling boats.

It is generally assumed that the animals die as a result of the trauma of being caught (the fishing operation) and exposed to air (Maclean, 1972; Saila, 1983; Daan, 1991). However, several studies have shown that some animals survive trawling. Survival is affected by several factors, such as the duration of the trawl and the size of the catch (De Veen *et al*., 1975; Van Beek *et al*., 1990), the time spent out of the water on the deck (De Veen *et al*., 1975, Neilson *et al*., 1989), the extent of damage from the gear (Kaiser and Spencer, 1995), the damage produced by other animals or objects in the catch (e.g. spines, teeth, rocks) and the depressurisation as the catch is brought to the surface, among others.

Many experiments have been carried out to estimate the mortality caused by the fishing gear. These have been based mainly on commercial species such as cod, plaice, sole and halibut, among others, and have focused on animals escaping from the net. On the contrary, fewer experiments have been performed with non-commercial species (Wassenberg and Hill, 1989; Kaiser and Spencer, 1995) and no literature has been found with respect to dogfish.

MATERIAL AND METHODS

a) Scientific bottom trawl surveys

In order to determine the survival rate, 10 specimens of both sexes were selected and placed on deck for different time intervals, after which they were transferred to a tank with running water. Five experiments were undertaken for each time interval. The criteria used to determine if an individual was alive were to look for respiratory movements and response to stimuli. The dogfish that started to recover and swim actively after a certain period were recorded, and those which remained on the bottom upside down were considered as dead for purposes of the experiment, although they sometimes kept on breathing and moving (animals returned to the sea may recover or continue to die but this could not be determined, so for this experiment they were considered to be dead). A pilot experiment was carried out on two bottom trawl surveys ("Demersales 2000 and 2001") where the speed (2 knots) and trawl time (30 minutes) remained constant during the haul (Sánchez, 1993) (fig. 2). The air temperature range was between 15 ºC to 20 ºC during the whole experiment. In order to observe if the dogfish were affected by fishing activities over a longer time interval, a total of 36 tagged specimens (length range from 25 to 62 cm) from bottom trawl surveys in 1995 were kept in an aquarium for up to one year and length and weight measurements were taken periodically.

b) Commercial trawl vessels

The same experiment was carried out on two commercial vessels with 320 hp, 21 m length, 256.36 grt and 400 hp, 21 m length, 135 grt, respectively, where the time of trawling varied (from 3 up to 6 hours) according to the extension of the fishing ground. The trawl speed remained more or less constant at around 2-3 knots, and the time interval fish were exposure on the deck for the survival experiment also varied according to the time spent on sorting the catch (from 18 minutes up to 1.25 h). The procedure and criteria used to determine the survival of an individual were the same as mentioned previously. However, in this case, a higher number of specimens was selected (table I).

In both cases specimens were sexed and measured to the lowest cm. To test for differences between sex and survival an analysis of a 2 x 2 contingency table was performed. To compare the length frequency distributions of dead and alive dogfish the Mann-Whitney U test was applied. Linear regression analysis was performed to measure different relationships between the survival percentage and time of trawling, time spent on sorting the catch and haul depth, respectively. On board the commercial trawlers, the length distributions of dogfish discarded and landed were also obtained. Total mortality was estimated by the empirical equation from Beverton and Holt (1956).

RESULTS

Results obtained from trawl survey data (fig. 3) indicated that survival was rather high and reached up to 90% after 40 minutes of exposure on deck, although the hauls only lasted 30 minutes. For tagging purposes dogfish were always transferred to tanks immediately they appeared on the deck, and this operation could last as long as 10 to 20 minutes.

Results from commercial trawlers provided an average survival estimation of 78% considering a mean trawl time of 4.5 hours (table I). With the available data there was no relationship between survival and haul duration. A very weak correlation existed between survival and sorting time and survival and depth (fig. 4). However, although the survival estimate was 78%, it ranged from 47.1% to 90.5%. No significant differences ($P<0.05$) were found in the survival rate between males and females from each of the commercial hauls, for 15 out of the 16 hauls analysed (fig. 5).

The length distributions of the specimens caught by both commercial vessels are shown in Figure 6. Similar length distributions were found on bottom trawl surveys. Almost the whole population was well represented with the exception of young individuals less than 20 cm. In both cases, the number of live specimens was higher than the dead ones, but no significant differences were found ($P<0.05$) between the length distributions in each case.

Based on the length distribution of the catch of both commercial trawlers (fig. 7) and using a $K=0.15$ and $L_{inf}=75$ we obtained a $Z=0.37$.

DISCUSSION

Indirect mortality caused by trawling is an important parameter very often ignored in fish stock assessments and it is difficult to quantify. Many experiments have been carried out in order to assess fish damage and survival after escape from trawl cod-ends (Anon, 1994; Main and Sangster, 1989; Sangster *et al*., 1996).

When discards data are included in fish stock assessments, it is generally assumed that all discarded animals die. This is the case for the majority of species, especially fishes, but there are some exceptions such as the lesser spotted dogfish (Kaiser and Spencer, 1995), which is a very hardy species and can withstand long periods of emersion. Experiments carried out on bottom trawl surveys demonstrated that almost all the specimens survive if they are returned to the sea in less than 30 minutes after tows of 30 minutes duration.

Wassenberg and Hill (1993) suggested that the appropriate duration for discard survival experiments should be four days since most deaths occurred within three days of capture. Unfortunately, long experiments on board commercial trawlers are rather difficult to carry out. Millner *et al*. (1993) demonstrates that short term-survival of plaice discards is high compare to estimates of longer survival derived from the recapture rate of tagged discards. Tagged specimens from trawl surveys kept in captivity for more than 7 months had an average survival rate after this period of 86.9% (fig. 8). *A priori*, we can affirm that the mortality due to tagging is quite low, although indirect effects caused by tagging have not been measured.

In commercial trawling, where haul duration is much higher (from 1 to 6 hours), survival rates of this species vary from 47.1% to 98%. Contrary to what happens in other species (De Veen *et al*., 1975; Van Beek *et al*., 1990) no relation was found between survival and haul duration, although this could be due to the low number of observations and the range covered (3 to 6 h). While this relationship is probably representative of some fishes (e.g. sole, plaice) it may not be the same for elasmobranch species, especially dogfish, and some invertebrate species (Kaiser and Spencer, 1995). No comparisons with other areas or fisheries can be made since similar studies on this species have not been found.

The other studied parameters such as time spent in sorting the catch and depth have a slight influence on the survival rate but not as much as was expected. Probably there is no single factor that affects the survival rate but the combination of them all and possibly some others not reflected in this study, such as fish damage produced by the fishing gear or the catch (e.g. stones), would have the greatest influence.

De Veen *et al*. (1975) found a slight decrease in the average amount of damage with increasing length in plaice. In the same vein, Neilson *et al*. (1989) found a positive correlation of survival with fish length for Atlantic halibut. Juveniles of lesser spotted dogfish have a higher standard metabolic rate than adults (Sims, 1996) and consume more oxygen. Therefore, it could have been expected that juveniles would have a higher mortality. In this experiment, no significant differences were found between the length distributions of the dead and live specimens, suggesting that length is not a major factor in determining the survival. Also, no significant differences were found between sexes, thus mortality due to discards equally affects both sexes although they are higher in juveniles.

In calculations of total fishing mortality, it is generally assumed that the mortality of discards is approximately 100% (Daan, 1991). A preliminary estimate of mortality based on the catch length distribution of commercial trawlers gives a Z=0.36. Mortality estimations based on survival experiments on board commercial trawlers provide a Z= 0.24. However, in this case the value of Z could be said to correspond to the fishing mortality F. Based on simulation models (Ecopath and Ecosim) in the Cantabrian ecosystem Sánchez and Olaso (2001) obtained a Z=0.40.

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Figure 1. Catch and discard percentage of lesser spotted dogfish in VIIIc ICES division (based on Pérez *et al*., 1996).

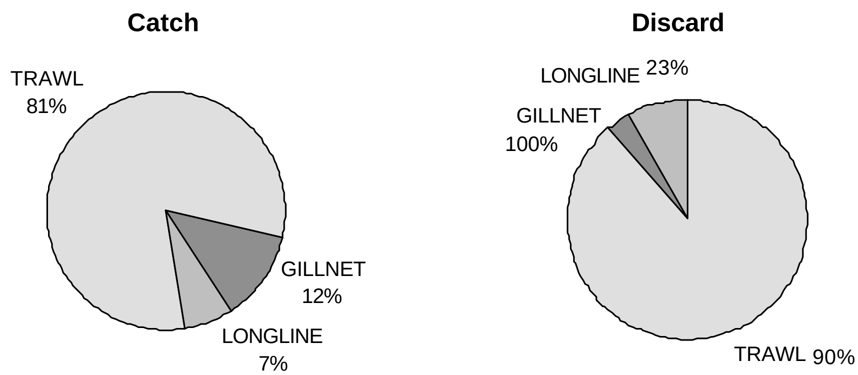


Figure 2. Area of the study and haul positions.

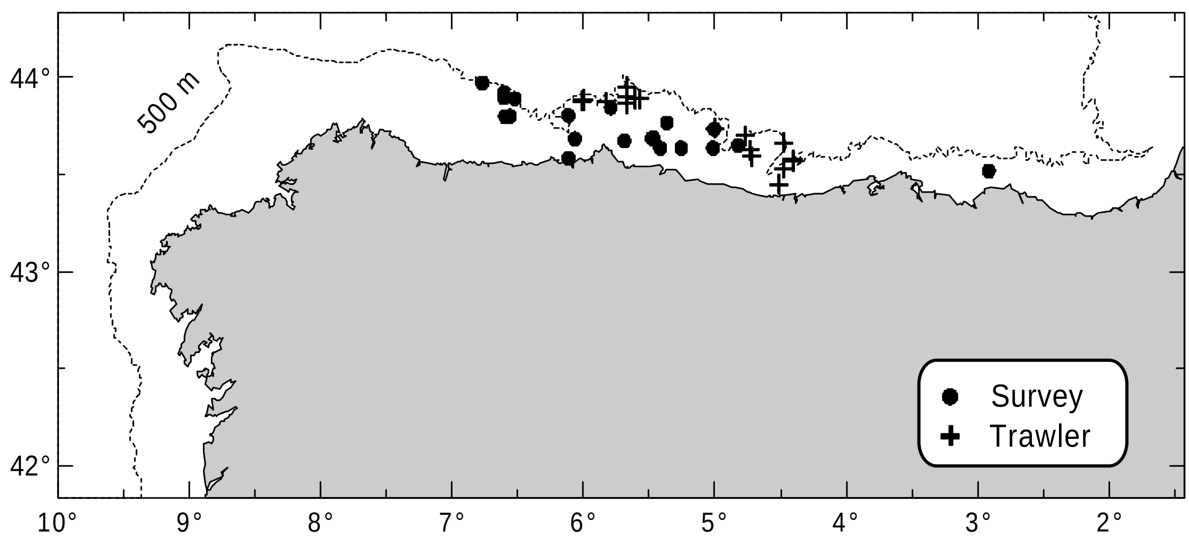


Figure 3. Relationship between number of specimens alive and time spent on sorting the catch during bottom trawl surveys.

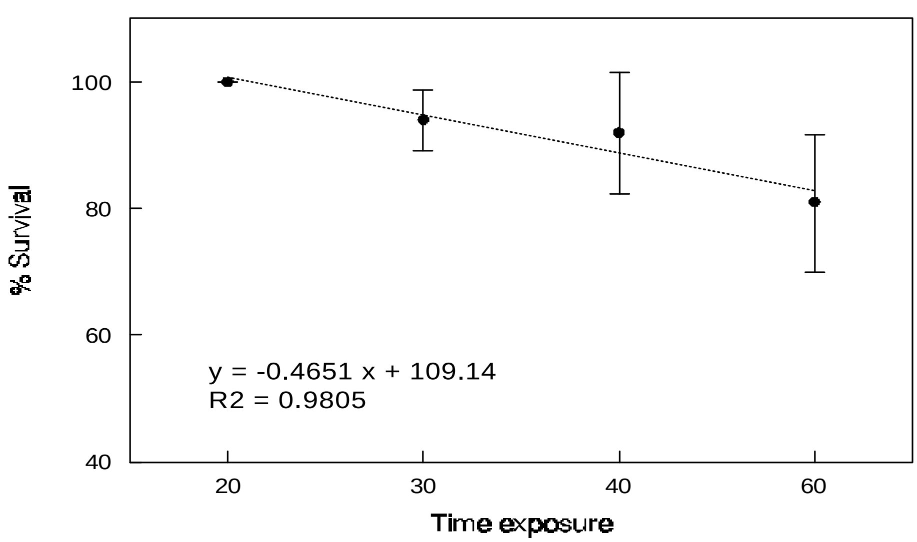
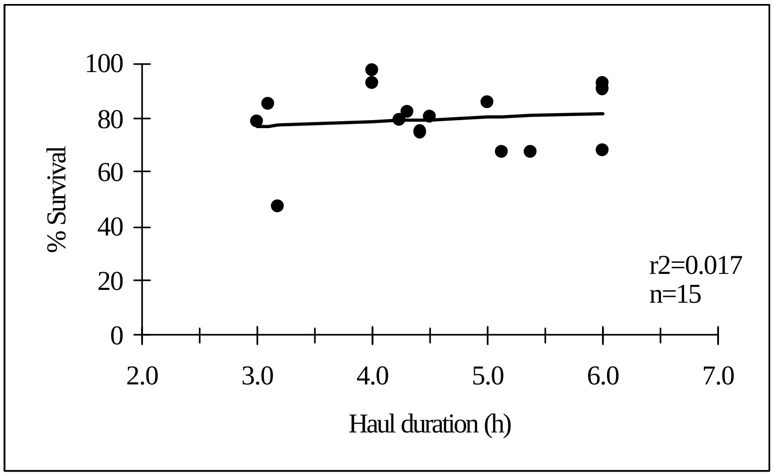
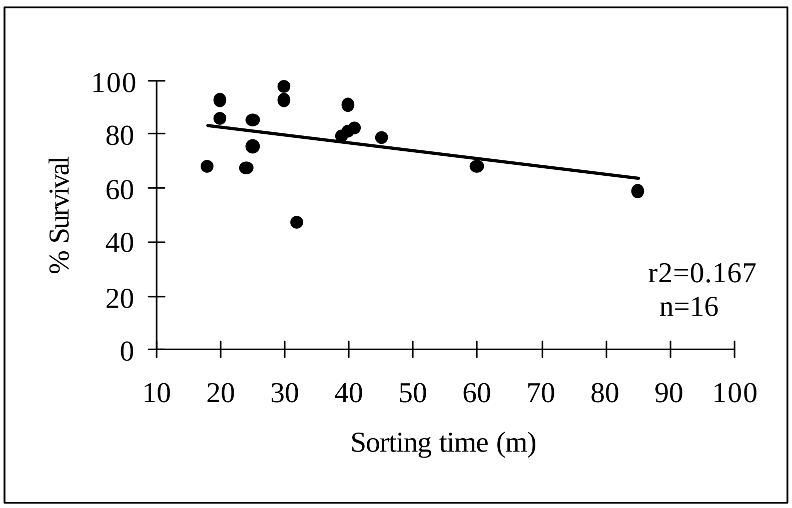


Figure 4. Relationship between the percentage survival and different parameters: a) Haul Duration (hours) b) Sorting time (minutes) and c) Depth (meters).





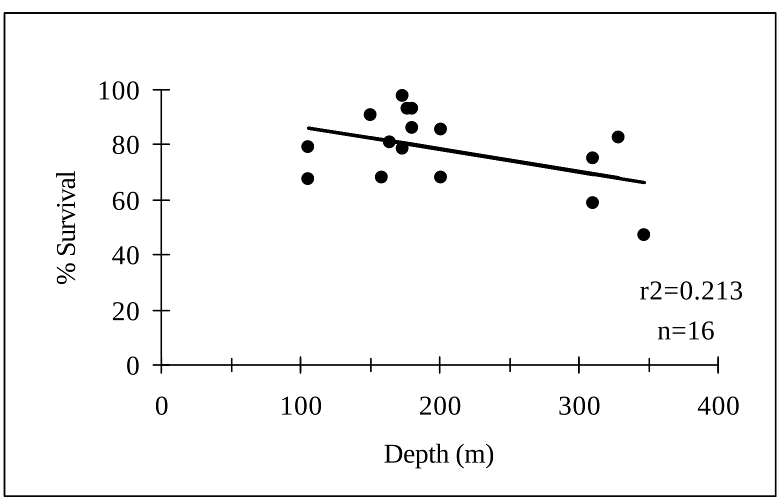


Figure 5. Proportion of males and females alive in each haul. In all cases the hypothesis that the proportion surviving is the same for both sexes was accepted (P<0.05) except for haul 15 (Z=2.41).

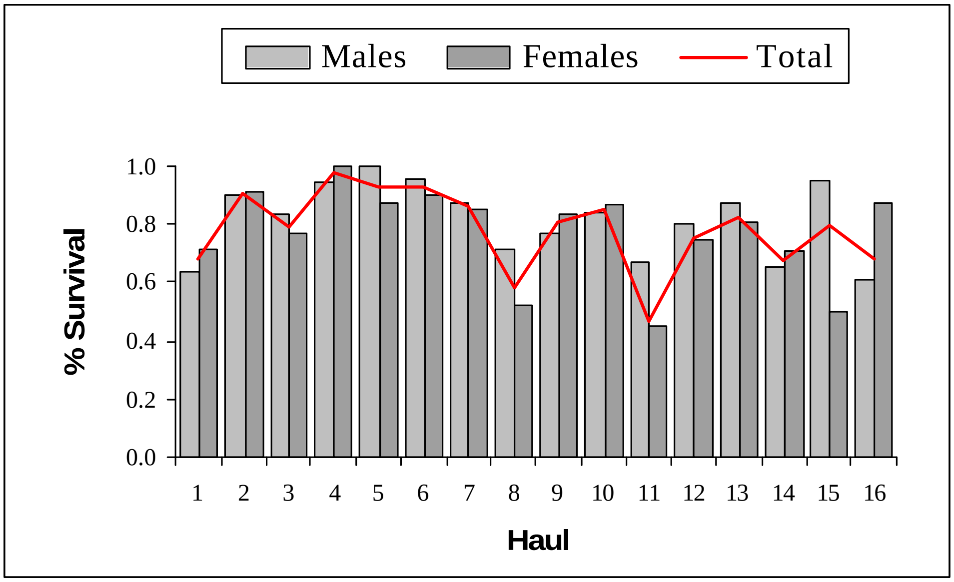


Figure 6. Comparison between the length distribution of dead and alive specimens in both commercial trawlers.

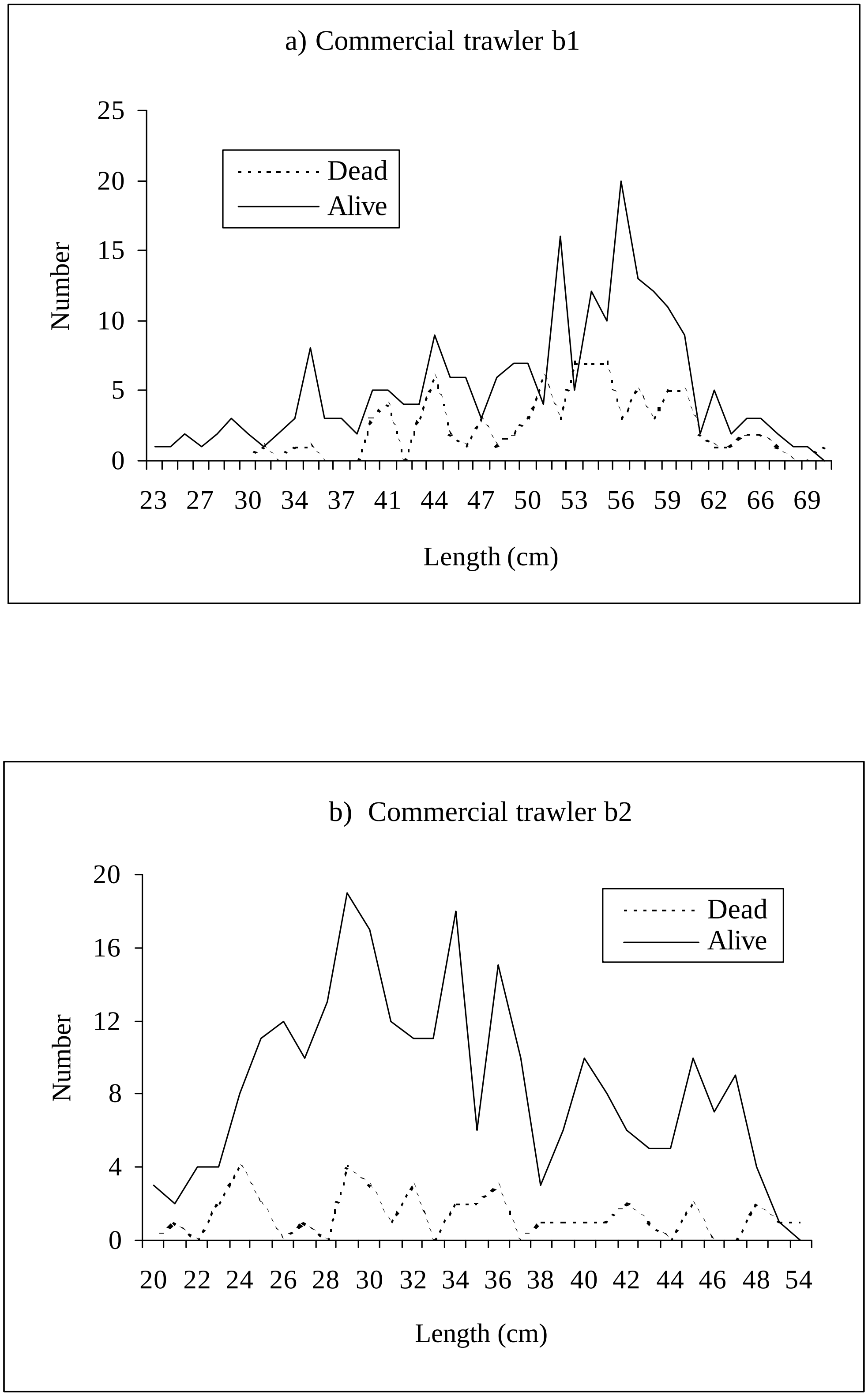


Figure 7. Length distribution of the individuals caught and discarded on commercial trawlers.

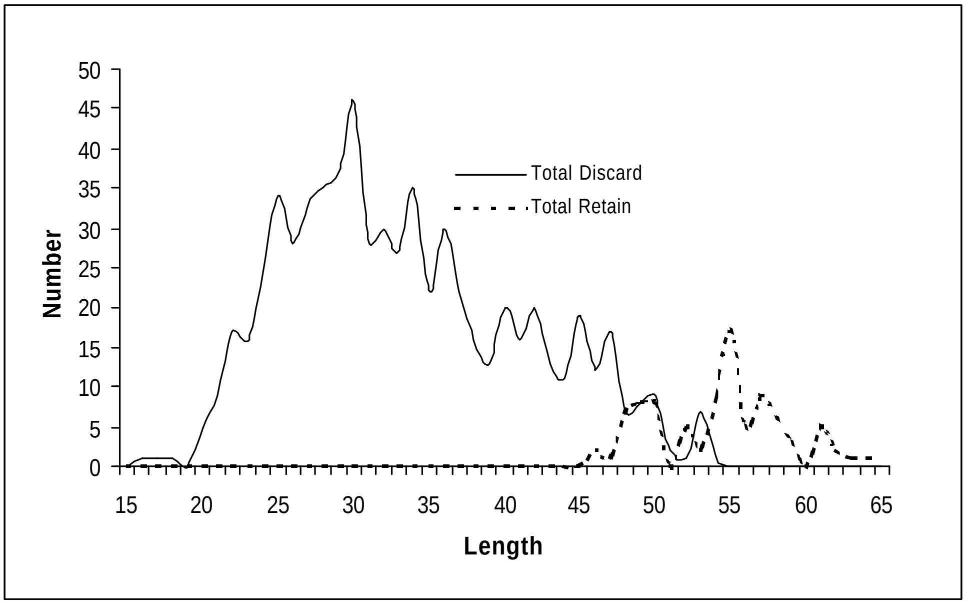


Figure 8. Survival rate of 36 specimens kept in captivity for a period of eight months.

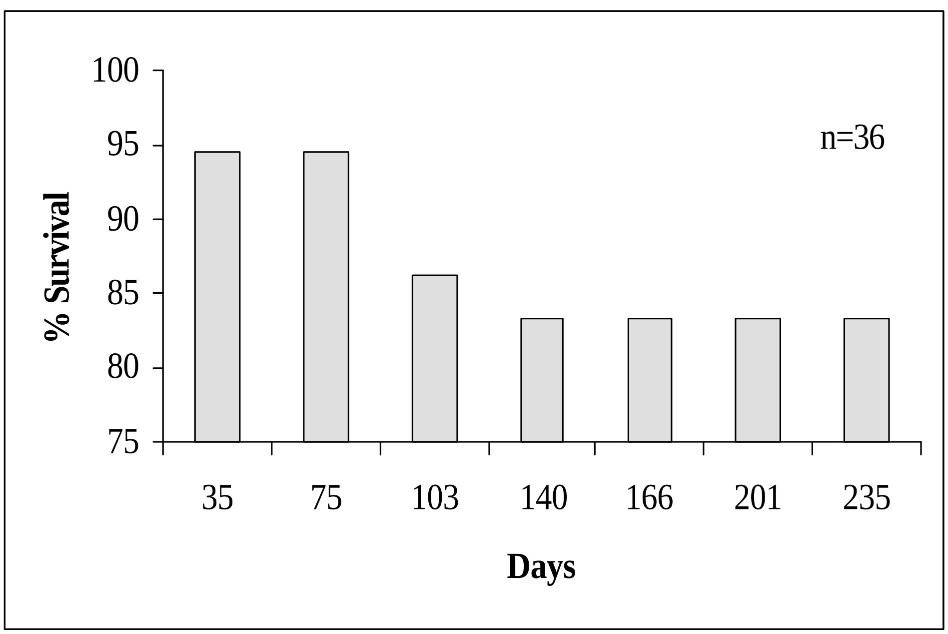


Table I. Summary of data obtain for the survival experiments from a) Bottom trawl surveys
b) Commercial trawl vessels.

a)

		Number		Time (h)		%
Haul	**Depth (m)**	**Catch**	**Sample**	**Trawling**	**Sorting**	**Survival**
76	286	7	7	00:30	01:00	100.0
78	232	12	10	00:30	00:30	100.0
79	177	12	10	00:30	00:20	100.0
80	139	108	11	00:30	01:00	81.8
82	174	14	10	00:30	00:30	90.0
85	137	24	10	00:30	00:20	100.0
88	93	9	9	00:30	00:20	100.0
89	117	19	10	00:30	00:40	100.0
91	180	88	10	00:30	00:40	80.0
97	187	63	11	00:30	00:40	100.0
113	132	29	10	00:30	00:40	80.0
70	66	10	10	00:30	01:00	90.0
71	110	45	11	00:30	01:00	81.8
72	226	52	10	00:30	01:00	60.0
77	141	80	10	00:30	00:30	100.0
78	138	20	10	00:30	00:30	90.0
82	154	51	10	00:30	00:30	90.0
83	143	35	10	00:30	00:40	100.0
84	114	18	10	00:30	01:00	90.0
92	404	10	10	00:30	00:20	100.0

b)

		Number		Time (h)		%
Haul	**Depth (m)**	**Catch**	**Sample**	**Trawling**	**Sorting**	**Survival**
1	311	120	41	----	01:25	58.5
2	165	176	31	04:50	00:40	80.6
3	201	360	41	03:10	00:25	85.4
4	347	104	34	03:18	00:32	47.1
5	311	100	32	04:42	00:25	75.0
6	329	34	34	04:30	00:41	82.4
7	106	45	46	05:38	00:24	67.4
8	106	50	29	04:24	00:39	79.3
9	201	54	31	05:12	00:18	67.7
10	159	139	111	06:00	01:00	68.1
11	150	54	54	06:00	00:40	90.5
12	174	136	136	03:00	00:45	78.6
13	174	630	126	04:00	00:30	97.7
14	177	232	116	04:00	00:30	92.9
15	181	258	129	06:00	00:20	92.9
16	181	188	94	05:00	00:20	86.0