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EFFECTS OF SETTING TIME, SETTING DIRECTION AND SOAK TIME ON LONGLINE CATCH RATES

by

Svein Løkkeborg[1] and Teresa Pina[2]

1) Institute of Marine Research, P.O. Box 1870, N-5024 Bergen, Norway

2) Universidade do Algarve, Campus de Gambelas, P.O.Box 322, 8004 Faro, Portugal

ABSTRACT

Most studies of factors affecting catching efficiency and selectivity in longlining have focused on various gear parameters (mainline and snood material, hook design and size, rigging) and on the bait (type and size), and few studies have investigated how catch rates are affected by the way the gear is operated during fishing. We carried out fishing experiments to study the effects of setting time, setting direction (relative to the current direction) and soak time on catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Lines set before dawn and lines set across the current gave higher catch rates of haddock than lines set after dawn and in the same direction as the current, respectively. Similar effects were not found for cod, and these differences between haddock and cod were explained by differences in behaviour and interspecific competition for the available baits. Soak time was not found to significantly affect the catch rates of either species, indicating that other factors have a more pronounced effect on longline catch rates and may therefore mask the effect of soak time.

INTRODUCTION

The use of longlines is being encouraged by fisheries management authorities for its conservation-orientated aspects (Sutterlin *et al.*, 1982); fuel consumption is low, fishing grounds are not damaged, the fish captured are of good quality and discards of undersized fish and non-target species are low (Bjordal, 1989; Bjordal and Løkkeborg, 1996). Although longline design has evolved over centuries and its catching performance has been improved through gear improvement programmes, there is still potential for improving catch efficiency and selectivity (Løkkeborg & Bjordal, 1992).

Catches of longlines are affected by several technical, biological, and environmental factors (Olsen & Laevastu, 1983). Most studies aimed at improving efficiency and selectivity of longlines have focused on the configuration of the gear, e. g. on bait type and size, hook design and size, hook spacing, materials, dimensions and rigging. Studies on how the operation of the gear affects catchability and selectivity are few.

Studies of the effects of setting time, setting direction and soak time on catch rates can generate further information on the longline catching process and thus be of interest both to workers in stock assessment and to commercial fishermen. Longline fisheries provide indices that are accepted as linear estimates of stock abundance (Murphy, 1960). Therefore, catch data from longlines are used for relative stock assessment of several stocks (e.g. Pacific halibut (*Hippoglossus stenolepis*), sablefish (*Anoplopoma fimbria*)), and also have a potential use in absolute stock assessment (Fernö & Olsen, 1994). Longline catch rates may be influenced by changes in soak time (Skud, 1975), and by the feeding habits of the fish in relation to time of setting (Shepard *et al.* ,1975), leading to great variation in stock size estimates (Fernö & Olsen, 1994). It is therefore important to assess the relative magnitude of these effects, in order to make approximate corrections in abundance estimates. Furthermore, better understanding of these effects would be beneficial to fishermen, since this might enable them to obtain higher catches and increase their profits by choosing the best way of operating their gear. Finally, the study of these effects can generate new knowledge of the behaviour of target species.

The relationship between soak time and catching efficiency of longlines is influenced by attractant release rate, bait loss and local fish density; changes in all these factors modify efficiency over time (Løkkeborg, 1994). Thus, the total catch should increase with time at a gradually decreasing rate, and such a relationship has been demonstrated in bottom longlining for Pacific halibut (Skud, 1978). However, Ogura *et al.* (1980) stated that, for bottom longlining, this relation would not be expected beyond the feeding period of the fish. Results obtained in pelagic longlining for tuna are not consistent (Murphy, 1960; Hirayama, 1969), though Sivasubramaniam (1961) stated that there was no significant variation in yellowfin tuna (*Thunnus albacares*) catches with increasing soak time.

A number of studies have been made of the effects of soak time on fishing efficiency of traps. Some authors suggest that the catch rates may become asymptotic with increasing soak time (Fogarty & Borden, 1980; Kennelly, 1989; Robertson, 1989), others that shorter soak times give considerably higher catches (Whitelaw *et al.,* 1991; Sheaves, 1995), while yet others claim that catches increased at a constant rate with soak time (Sloan & Robinson, 1985).

Studies of the effects of setting time have shown that longline catches of Pacific salmon varied markedly with time of the day; catches at sunrise being much higher than at any other time, catches at sunset being moderately high, while catches during the day are low, and almost no catches are made at night (Anonymous, 1969 and Takagi, 1971 *in* Shepard, 1975). In studies with traps it was shown that there were no consistent differences in catch rates of traps set at different times of day (Miller, 1983; Kennelly, 1989; Robertson, 1989). To the author's knowledge, no studies have been carried out to verify the effect of setting direction on the efficiency of longlines.

Cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) are two important target species in the Norwegian longline fishery (Løkkeborg, 1991). The objectives of this study were to verify the effect of setting time, setting direction and soak time on the catch rates of bottom longlines for these species.

MATERIALS AND METHODS

Fishing trials and gear

Fishing trials were conducted from 7 to 17 February and from 18 to 29 March 1996, on commercial autoliners operating on Tromsøflaket (Northern Norway) at 143-327 m depth. The longliners chartered for the trials used mainlines (7 and 9 mm) rigged with swivels and Mustad EZ-baiter hooks (quality 39974 and 39975, no. 12/0) at a hook spacing of 1.4 m. The baits used were squid and mackerel in the proportion of about 1.5:1. In the first trial, the longline fleets, each with 6300 or 8230 hooks, were set between 21:35 and 10:35. The soak time varied between 3h 20min and 22h 05min, which is a normal range of times in commercial longlining. In the second trial, each longline fleet had about 5720 hooks and was set between 23:00 and 11:55. In this trial some fleets were retrieved shortly after setting in order to obtain data for very short soak times. The soak times therefore varied between 1h 20min and 20h 40min.

Time of setting and hauling and total catch of cod and haddock were noted for each fleet. The soak time was considered as the time elapsed between the start of setting and the start of hauling of the fleet. This means that with a hauling time of about three hours, the mean soak time is actually 1.5 hours longer than the soak time used. The total catch was estimated by multiplying the weight of the headed and gutted catch by a conversion factor of 1.4 for haddock and 1.5 for cod.

During the second trial the current speed and direction were recorded every 10 minutes by two current meters (SD 6000, Sensordata) suspended 65 and 150 cm respectively above the seabed. The prevailing current directions were east and west (Fig. 1), and longlines were therefore set in the east/west and north/south directions in order to study the effect of setting direction.

Data analysis

In order to investigate the differences between the catch rates of different setting times and setting directions, a two sample *t*-test was used (Zar, 1974). When testing the effect of setting time, a test including only lines retrieved before dusk was also run. This excludes variations in catch rates caused by fish caught at dusk, which has also been shown to be a period of high feeding activity (Fernö *et al.,* 1986; Løkkeborg *et.al.*, 1989).

The effect of soak time on catch rates was tested by simple linear regression. Catch rates were expected to increase at a progressively decreasing rate with increasing soak time (Løkkeborg, 1994). The soak times were therefore log-transformed in order to obtain a linear relationship (Zar, 1974).

RESULTS

The catch consisted mainly of cod and haddock, but other species such as torsk (*Brosme brosme*), Atlantic catfish (*Anarhichas lupus*), redfish (*Sebastes marinus*), and ling (*Molva molva*) were also taken.

The relationship between setting time and catch rates of haddock is shown in Fig. 2. Lines set at night produced higher catch rates than those set during the day, and the results indicated that the decrease in catch rates occurred later in the morning in the first trial (February) than in the second trial (March). In the first trial, a significant difference was found in haddock catch rates between lines set before and after 04:30 (Table 1). In the second trial, lines set before 03:30 made significantly higher haddock catches than lines set later, but only when soak times were shorter than 10 hours (i.e. lines retrieved before dusk) (Table 1). No differences were found in catch rates of cod between lines set at night and during the day in either of the trials (Fig. 3, Table 1).

In the second trial, catch rates of lines set in the north/south direction were compared with lines set east/west. The catch rate of haddock was significantly higher for north/south lines (i.e. across current), whereas there was no difference for cod (Table 2).

The relationship between the catch rate of haddock and soak time is shown in Fig. 4. No significant relation was found between the logarithm of soak time and the catch rates of haddock. This relation was tested by applying a simple linear regression. (In the first trial: $Y = 8.922 + 2.057x$; $r^2 = 0.006$; $p > 0.05$; and in the second trial: $y = 5.158 + 3.109x$; $r^2 = 0.077$; $p > 0.05$). Similarly, no significant relationship was found for cod between the logarithm of soak time and catch rates in the second trial ($y = 8.561 - 0.537x$; $r^2 = 0.003$; $p > 0.05$). However, in the first trial a significant relation was found ($y = 12.599 + 12.541x$; $r^2 = 0.079$; $p = 0.05$) (Fig. 5).

DISCUSSION

This study showed that lines set before dawn produced higher catches of haddock than lines set after dawn, suggesting that haddock has a diurnal rhythm of feeding activity. However, similar effects were not found for cod. Several species of fish have been shown to exhibit diurnal rhythms of activity (Müller, 1978), and behavioural studies have shown that responses of cod, haddock and whiting (*Merlangius merlangus*) to baited hooks increase at dawn and decrease at dusk in correspondence with the seasonal photoperiod (Fernö *et al.*, 1986; Løkkeborg *et al.*, 1989). This diel rhythm in activity has been explained as reflecting variations in feeding motivation. The setting time of lines giving higher catches was shown to be different between February and March; in February, high catches were obtained for lines set later in the morning than in March. This finding may be explained as a reflection of changes in diurnal activity rhythm, corresponding to changes in the photoperiod. Similar changes in activity peaks of cod and haddock were observed from September to December in the North Sea (Løkkeborg *et al.*, 1989).

Lines set across the current resulted in larger catches of haddock than lines set in the same direction as the current, whereas no difference was found for cod. When lines are set across the current, the odour plume is dispersed over and "activates" a larger area. The baited lines may therefore attract a larger number of fish. Thus, the higher catches of haddock of lines set across the current indicated the importance of chemical stimuli in longlining. A general tendency of fish to swim upstream towards baits has been demonstrated in the course of several behavioural studies (Pawson, 1977; Fernö *et al.,* 1986; Wilson and Smith, 1984). Fish that responded to baits showed a greater tendency to swim upstream than non-responding fish, and this finding was explained by their feeding activity being stimulated chemically (Løkkeborg *et al.,* 1989).

The lack of conclusive results regarding the effects of setting time and setting direction on catch rates of cod might have been due to interspecific competition for the available baits. The explanation might have been that haddock responded to the bait more frequently than cod, being caught first, thus lowering the number of baits available to cod. Although more cod were observed (more than three times as many), more haddock responded to baited hooks, and catch rate of haddock were three times as high as those of cod (Løkkeborg *et al.*, 1989). Engås *et al.* (*in press*) showed that in comparison with trawls longlines were about six times as effective in catching haddock than cod. The higher haddock:cod ratio was explained by differences in the behaviour of cod and haddock towards baited hooks. Furthermore, behavioural studies have shown that haddock responded one hour earlier in the morning than cod (Fig. 1 *in* Løkkeborg *et al.*, 1989), reflecting the fact that this species starts feeding earlier in the morning. Thus, longlines, particularly those set before dawn, may be more effective in catching haddock than cod.

No significant relationships between soak time and catch rates of haddock and cod were found. However, as far as haddock are concerned, in the first 10 h of soak time there was a tendency for catch rates to increase with time at a gradually diminishing rate. Ogura & Arimoto (1980) stated that during the period of time immediately following the setting of longlines, the quantity of demersal fish caught was large, suggesting that after about two hours the catch would not be expected to increase in proportion to the soak time beyond the feeding period of the fish. In halibut longline gear, the catch of fish increased at a decreasing rate with soak time during the first three hours (High, 1980). In pelagic (Murphy, 1960) and vertical longlining (Matsuoka, 1990; Matsuoka *et al.,* 1992), increasing catches, rising to maximum followed by a decline were observed. In vertical longline fishing, these results were attributed to saturation and to a rising proportion of snoods broken by fish as soak time increased. In studies with traps a similar effect was demonstrated (Sloan & Robinson, 1985). In studies with baited traps, the asymptotic nature of catch curves was ascribed to two factors; a reduction in the population available to be fished, and saturation (Kennelly, 1989; Robertson, 1989).

The relationship between catching efficiency and soak time is caused by a rapid decrease in the rate of release of attractants from the bait (Løkkeborg, 1994; Whitelaw *et al.*, 1991) and by a rise in loss of bait (Løkkeborg, 1994). The gear is thus most effective shortly after it is set, and responses to baited hooks have thus been shown to be highest shortly after the gear is set (Fernö *et al.*, 1986; Løkkeborg, 1990). The length of time during which the gear remains active depends on the sensitivity of the target species to bait odour and on the distribution of the attractants in the environment (Sundberg, 1985; Løkkeborg, 1990). With regard to bait loss, it has been shown by several authors that this increases with soak time (Wathne, 1959; Shepard *et al.*, 1975; Skud, 1978; High, 1980; Grimes *et al.*, 1982; Løkkeborg, 1994). Grimes *et. al.* (1982) stated that predation, one of the factors affecting bait loss, began soon after the longline was set and increased linearly with soak time. In addition to the loss of bait, hooked fish, both target species and bycatches of unwanted species, reduce the number of baits available through time. Gear saturation and decreased probability of successive capture are thus likely to occur (Engås & Løkkeborg, 1994). Furthermore, as Ogura & Arimoto (1980) suggested, factors such as escape and dislodgement from the hooks should be taken into consideration if the longline is allowed to stand in water for a long period of time.

The results of this study indicate that most fish were hooked within the first 2.5 hours. This is most likely explained by a higher initial rate of release of chemical stimuli, low bait loss and greater response of fish to the baited hooks during that period. The lack of consistent results regarding the relationship between soak time and catch rates might have been due to masking effects caused by other sources of variability, such as differences between fishing sites and days, current conditions and in particular, setting time relative to feeding activity, which this study showed to have pronounced effects on catch rates of haddock.

According to our study, setting time and setting direction have a clear effect on catch efficiency of longlines. Therefore it is important to take these factors into consideration when using longline catch data in stock assessment. Furthermore, they should also be taken into consideration by fishermen in order to achieve higher catch rates, at least as far as haddock are concerned. Similar effects on cod are likely to be demonstrated in areas where the proportion of haddock is low. On the other hand, the effect of soak time on catch rates was not clear. Since we may be dealing with masking effects, further research on this effect should be done.

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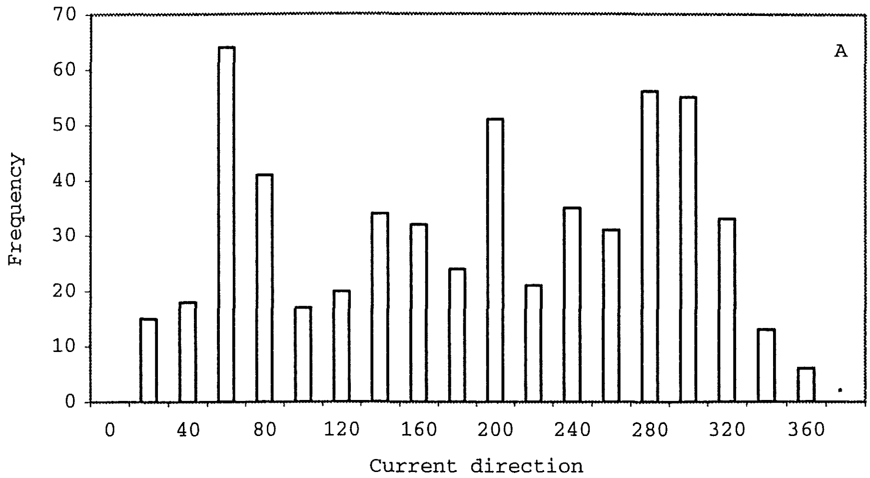
Table 1. Mean catch rate of lines (Kg/fleet) set at night and dawn (SE in brackets).

Trial	Species		Set at night	Set at dawn	P
First trial	Haddock	All lines	11.89 (0.91)	7.15 (0.91)	= 0.01
		Lines retrieved before dusk	12.92 (1.68)	6.09 (0.96)	= 0.05
	Cod	All lines	26.09 (1.49)	20.19 (3.09)	> 0.05
		Lines retrieved before dusk	23.21 (2.19)	17.83 (2.39)	> 0.05
Second trial	Haddock	All lines	9.11 (1.13)	6.67 (1.17)	> 0.05
		Lines retrieved before dusk	10.36 (0.86)	5.74 (0.84)	< 0.01
	Cod	All lines	7.10 (0.71)	9.13 (0.84)	> 0.05
		Lines retrieved before dusk	6.27 (1.25)	9.13 (1.01)	> 0.05

Table 2. Mean catch rate of lines (Kg/fleet) set in north/south and east/west directions (SE in brackets) (second trial).

Species	North/south	East/west	P
Haddock	9.88 (1.03)	4.63 (0.68)	= 0.001
Cod	8.24 (0.70)	7.81 (0.88)	> 0.05



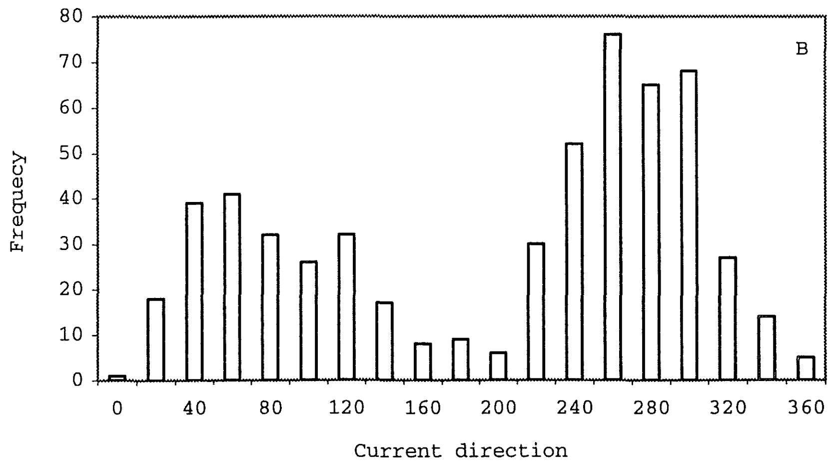
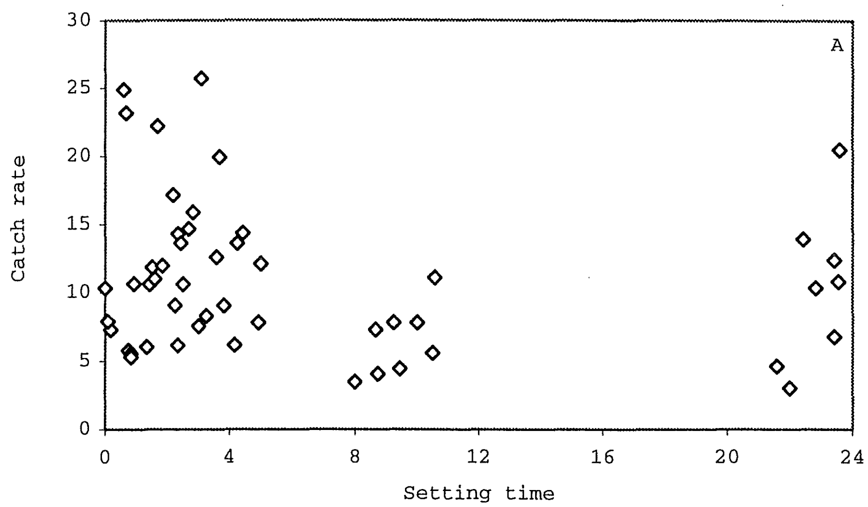


Figure 1. Prevailing current direction during the second trial.

Current meter suspended 65 cm (A) and 160 cm (B) above seabed.



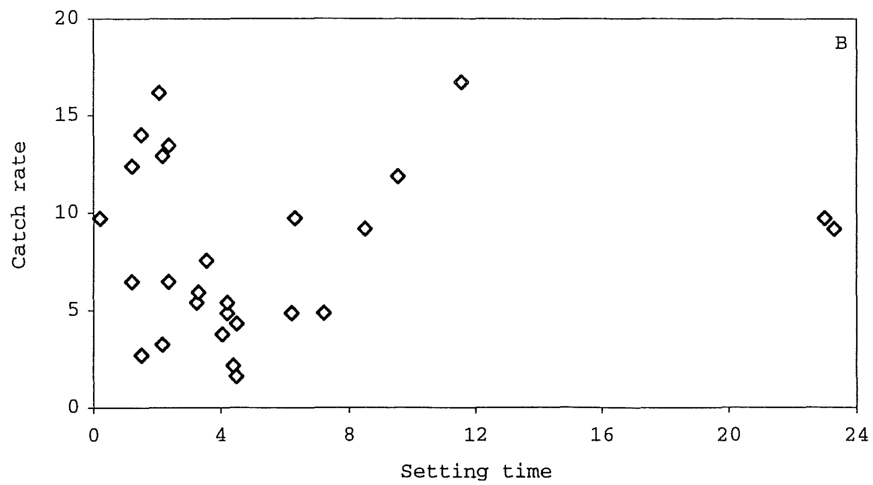


Figure 2. Relationship between setting time and catch rates of haddock observed during the first (A) and second (B) trials.

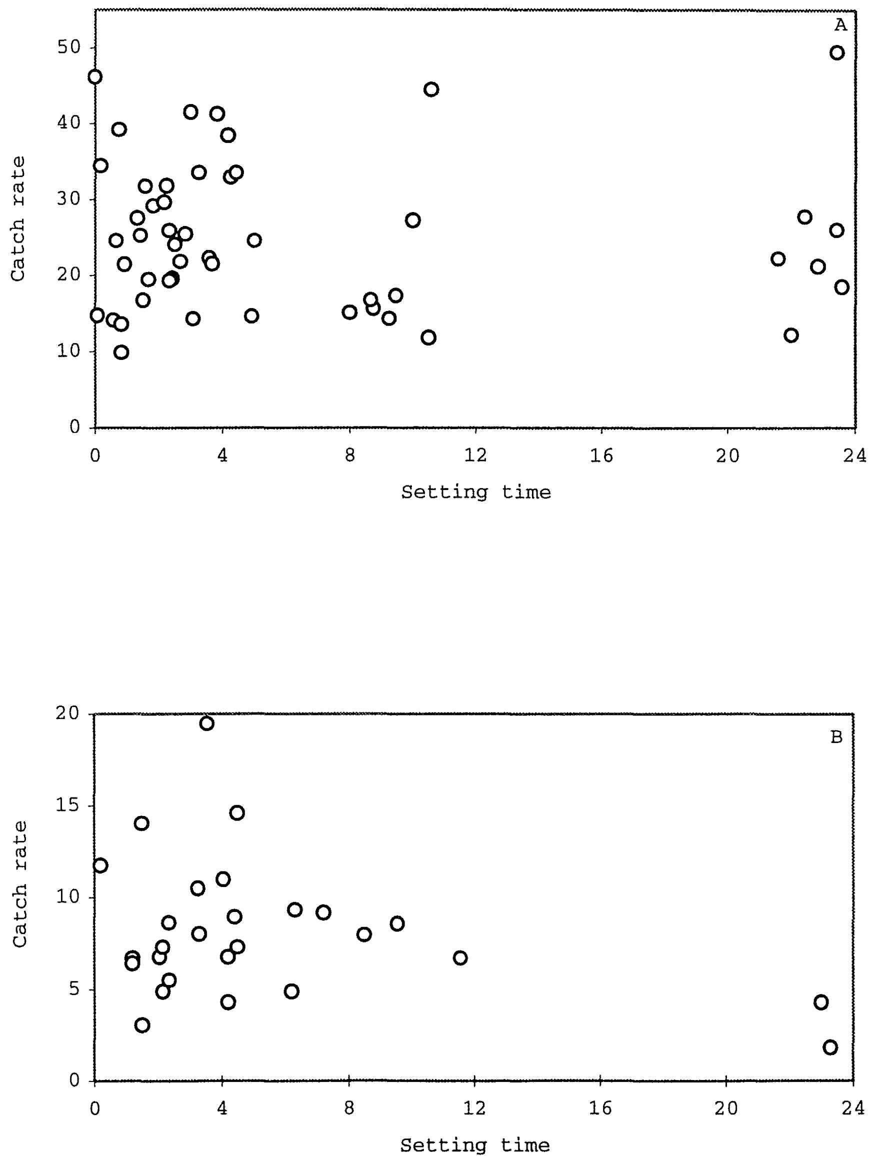
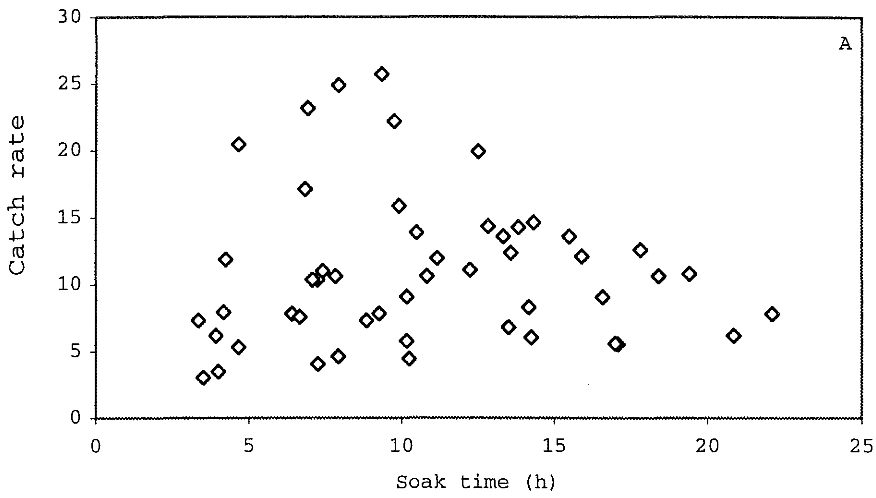


Figure 3. Relationship between setting time and catch rates of cod observed during the first (A) and second (B) trials.



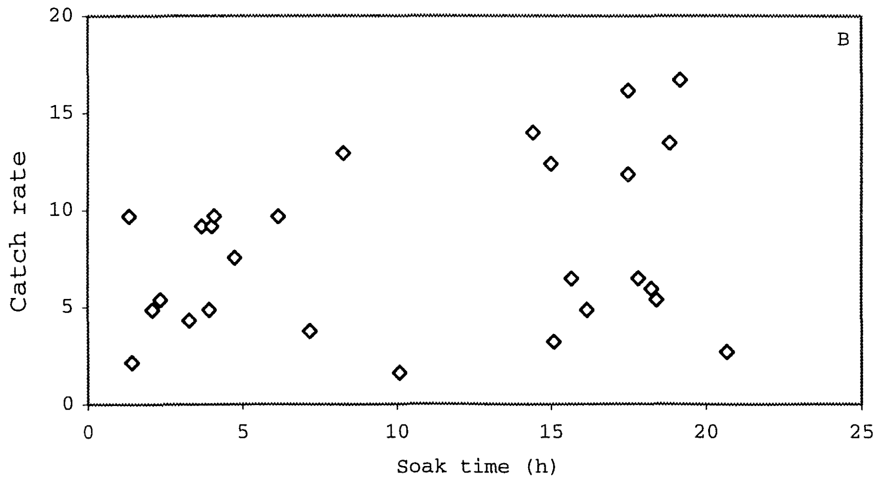


Figure 4. Relationship between soak time and catch rates (kg/100 hooks) of haddock observed during the first (A) and second (B) trials.

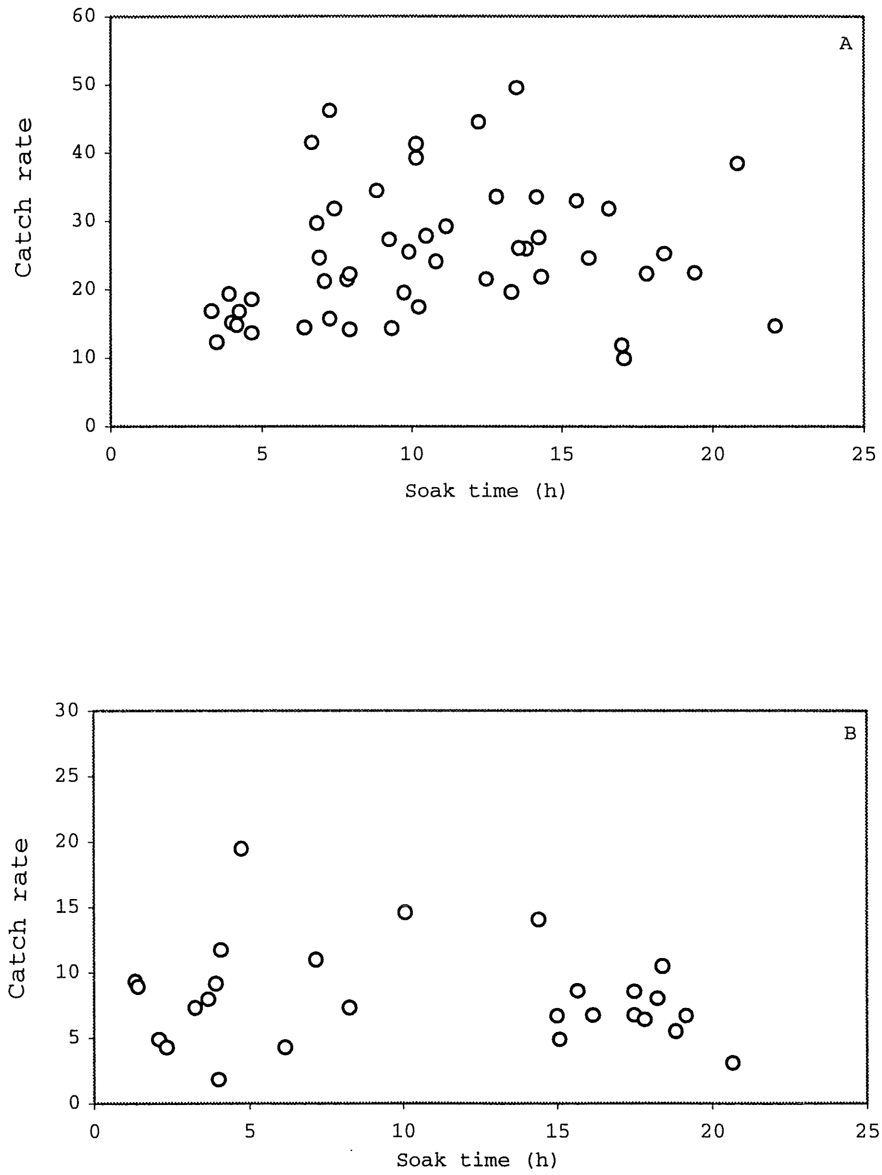


Figure 5. Relationship between soak time and catch rates (kg/100 hooks) of cod observed during the first (A) and second (B) trials.