ELSEVIER

Fisheries Research 32 (1997) 213–222

FISHERIES RESEARCH

Effects of setting time, setting direction and soak time on longline catch rates

Svein Løkkeborg [a,*], Teresa Pina [b]

[a] *Institute of Marine Research, P.O. Box 1870, N-5024 Bergen, Norway*
[b] *Universidade do Algarve, Campus de Gambelas, P.O.Box 322, 8004 Faro, Portugal*

Accepted 28 July 1997

Abstract

Most studies of factors affecting catch 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). 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. Such 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 affect the catch rates of either species significantly, indicating that other factors have a more pronounced effect on longline catch rates and may therefore mask the effect of soak time. © 1997 Elsevier Science B.V.

Keywords: Longline; Setting time; Setting direction; Soak time; Cod; Haddock

1. 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 catch performance has been improved through gear improvement programmes, there is still potential for improving catch efficiency and selectivity (Løkkeborg and Bjordal, 1992).

Catches of longlines are affected by several technical, biological and environmental factors (Olsen and 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. There have been few studies on how the operation of the gear affects catchability and selectivity.

Studies of the effects of setting time, setting direction and soak time on catch rates can generate

* Corresponding author. Tel.: +47 55236826; fax: +47 55236830; e-mail: svein.lokkeborg@imr.no.

PII S0165-7836(97)00070-2

further information on the longline catch process and thus can be of interest both to workers in stock assessment and to commercial fishers. 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 have a potential use in absolute stock assessment (Fernö and 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 and Olsen, 1994). It is therefore important to assess the relative magnitude of these effects, so as to make approximate corrections in abundance estimates. Furthermore, better understanding of these effects would be beneficial to fishermen, because 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 catch 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), although 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 and 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 increase at a constant rate with soak time (Sloan and 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 were much higher than at any other time, catches at sunset moderately high, catches during the day low, and almost no catches were made at night (Anonymous, 1969; Takagi, 1971 *in* Shepard et al., 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 best of the authors' knowledge, no studies have been carried out to verify the effect of setting direction on the efficiency of longlines. However, as attractants are dispersed over a larger area when baited lines are set across the current than when lines are set in the same direction as the current, lines set across the current should attract and catch more fish.

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.

2. Materials and methods

2.1. 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 3:1. 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 03:20 and 22:05, 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, to obtain data for

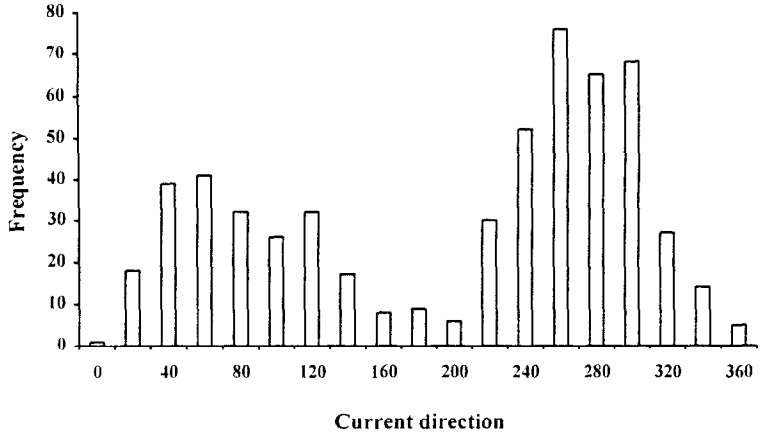

Fig. 1. Prevailing current direction during the March trial. Current meter suspended 215 cm above seabed.

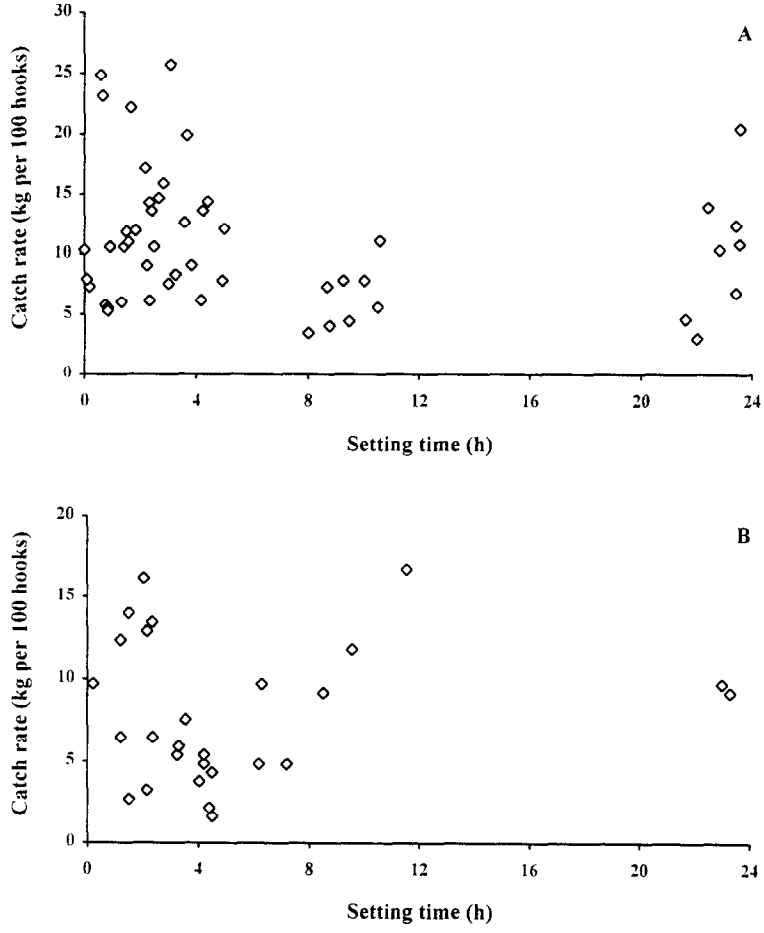

Fig. 2. Relationship between setting time (clock time, 0:00–24:00) and catch rates of haddock observed during the February (A) and March (B) trials. Note differing vertical scales.

Table 1
Mean catch rate (kg/100 hooks) of lines set at night and after dawn (SE and number of longline fleets in brackets)

Trial	Setting time	Haddock		Cod	
		All lines	Lines retrieved before dusk	All lines	Lines retrieved before dusk
Feb.	Set at night	11.8 (0.9, 42)	12.9 (1.7, 19)	25.8 (1.4, 42)	23.2 (2.2, 19)
	Set after dawn	6.4 (0.9, 8)	6.1 (1.0, 5)	20.3 (3.8, 8)	17.8 (2.4, 5)
	P^a	< 0.001	< 0.01	NS	NS
March	Set at night	9.1 (1.1, 14)	10.4 (0.9, 4)	7.1 (0.7, 14)	6.3 (1.3, 4)
	Set after dawn	6.7 (1.2, 13)	5.7 (0.8, 9)	9.1 (0.8, 13)	9.1 (1.0, 9)
	P^a	NS	< 0.01	NS	NS

[a]Two-sample *t*-test.

very short soak times. The soak times, therefore, varied between 01:20 and 20:40.

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 3 h, the mean soak time is actually 1.5 h longer than the soak time used. The total catch was estimated by multiplying the weight of the headed

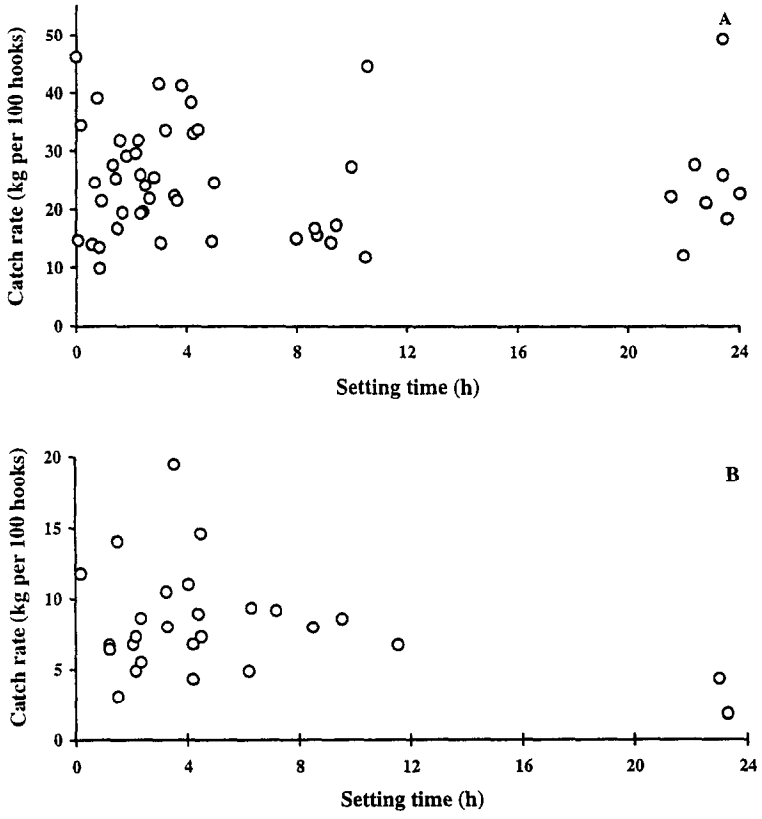

Fig. 3. Relationship between setting time (clock time, 0:00–24:00) and catch rates of cod observed during the February (A) and March (B) trials. Note differing vertical scales.

and gutted catch by a conversion factor of 1.4 for haddock and 1.5 for cod, which are the factors used by the Norwegian fisheries management.

During the second trial, the current speed and direction were recorded every 10 min by two current meters (SD 6000, Sensordata) suspended 65 and 215 cm, respectively, above the seabed. The current meter suspended 215 cm above the seabed showed that the prevailing current directions were east and west (Fig. 1), and longlines were therefore set in the east/west and north/south directions to study the effect of setting direction. There were larger variations in the measurements recorded closest to the seabed, probably due to near bottom turbulence.

2.2. Data analysis

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

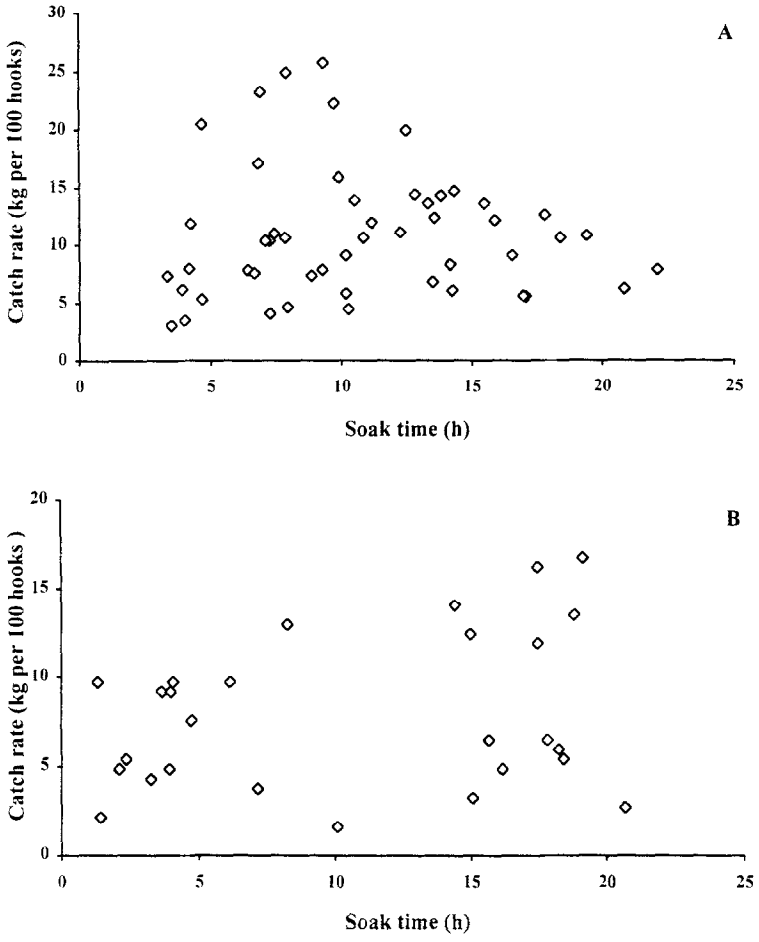

Fig. 4. Relationship between soak time and catch rates of haddock observed during the February (A) and March (B) trials. Note differing vertical scales.

with increasing soak time (Løkkeborg, 1994). The soak times were therefore log-transformed in order to obtain a linear relationship (Zar, 1974).

3. 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 06:30 (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 h (i.e., lines retrieved before dusk) (Table 1). The sunrise was about 3 h earlier in the end of March than in the middle of February when the two trials were conducted respectively. 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

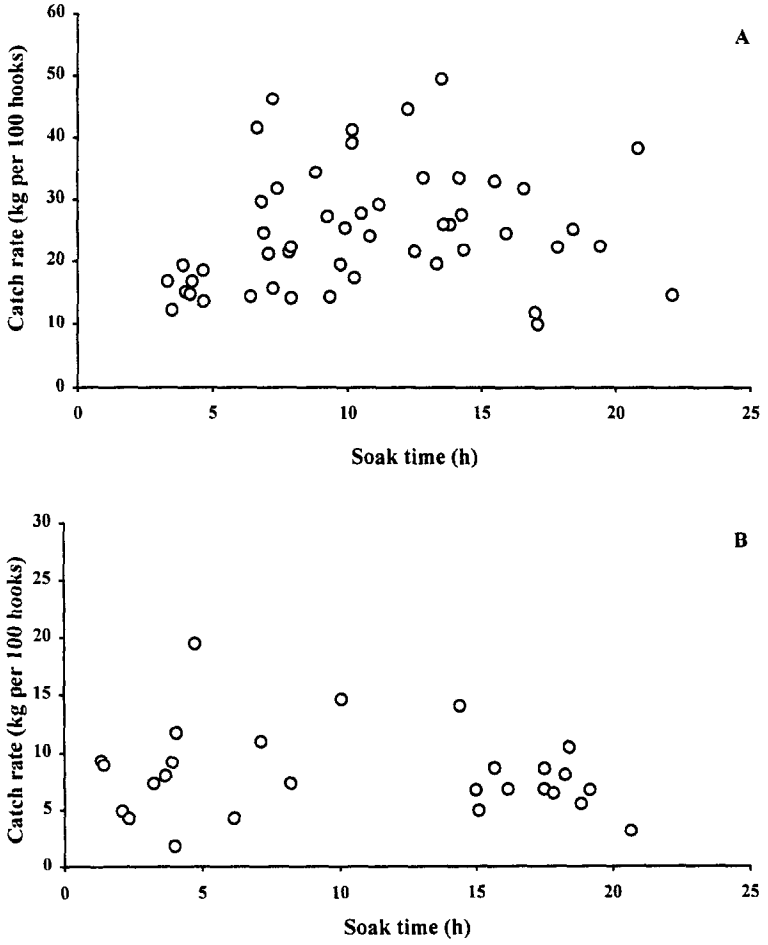

Fig. 5. Relationship between soak time and catch rates of cod observed during the February (A) and March (B) trials. Note differing vertical scales.

Table 2
Mean catch rate (kg/100 hooks) of lines set in north/south and east/west directions (SE and number of longline fleets in brackets) (second trial)

Setting direction	Haddock	Cod
North/south	9.9 (1.0, 17)	8.2 (0.8, 17)
East/west	4.6 (0.5, 10)	7.8 (1.5, 10)
P^a	0.001	NS

[a]Two-sample t-test.

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) than for east/west lines, 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: $y = 8.92 + 2.06x$; $r^2 = 0.006$; $P > 0.05$; and in the second trial: $y = 5.16 + 3.11x$; $r^2 = 0.077$; $P > 0.05$. Similarly, no significant relationship was found between the logarithm of soak time and catch rates of cod in the second trial ($y = 8.56 - 0.54x$; $r^2 = 0.003$; $P > 0.05$). However, in the first cod trial, a significant relation was found ($y = 12.60 + 12.54x$; $r^2 = 0.079$; $p = 0.05$) (see Fig. 5).

4. 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 effect was 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; Wilson and Smith, 1984; Fernö et al., 1986). 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). Furthermore, the importance of chemical stimuli in longlining has been demonstrated in fishing trials for torsk where baits soaked in sea water for 24 h prior to baiting gave a 50% reduction in catch rate compared to fresh bait (Løkkeborg and Johannessen, 1992).

The lack of conclusive results regarding the effects of setting time and setting direction on catch rates of cod may be explained by interspecific competition for the available baits. The explanation might have been that haddock responded to the bait more frequently than cod, and so became 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 rates of haddock were three times as high as those of cod (Løkkeborg et al., 1989). Engås et al. (1996) showed that longlines were about six times as effective in catching haddock as in catching cod. In addition, haddock often bite the baits without becoming hooked, which means that one haddock may take several baits (Løkkeborg et al., 1989). Furthermore, behavioural studies have

shown that haddock responded one hour earlier in the morning than cod (Løkkeborg et al., 1989), reflecting the fact that this species starts feeding earlier in the morning. Thus, the potential superiority of longlines set before dawn and across the current in catching cod might have been counteracted by the higher catch rates of haddock for these lines compared to lines set after dawn and in the same direction as the current.

No significant relationships between soak time and catch rates of haddock and cod were found, although in the first 10 h of soak time there was a tendency for catch rates to increase with time at a gradually diminishing rate (see Figs. 4 and 5). Ogura et al. (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 2 h 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 (Skud, 1978; High, 1980). In pelagic (Murphy, 1960) and vertical longlining (Matsuoka, 1990; Matsuoka et al., 1992), which differ from bottom longlining both in gear performance and catching process, 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. A similar effect was demonstrated in studies with traps (Sloan and Robinson, 1985). In 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 catch efficiency and soak time is caused by a rapid decrease in the rate of release of attractants from the bait (Whitelaw et al., 1991; Løkkeborg, 1994) 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 been shown to be highest during this period (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). Bait loss 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 reduce the number of baits available with time. Gear saturation and decreased probability of successive capture are thus likely to occur (Engås and Løkkeborg, 1994). Furthermore, as Ogura et al. (1980) suggested, factors such as escape and dislodgement from the hooks should be taken into consideration if the longline is set for a long period.

The results of this study indicate that most fish were hooked within the first 2.5 h. This finding is most likely explained by a higher initial rate of release of chemical stimuli, low bait loss and therefore 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 so as 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. Because we may be dealing with masking effects, further research on this effect should be done.

Acknowledgements

We are grateful to the captains and crews of 'Geir' and 'Skarheim' for their helpful cooperation and assistance in the collection of the data, and to Elen Hals who assisted with manuscript preparation.

References

Anonymous, 1969. Progress in 1967 in Canadian research on problems raised by the Protocol. Int. North. Pac. Fish. Comm. Annu. Rep., 1967, pp. 29–53.

Bjordal, Å., 1989. Recent developments in longline fishing—catching performance and conservation aspects. Proceedings of the 1988 World Symposium on Fishing Gear and Fishing Vessel Design. Newfoundland and Labrador Inst. of Fisheries and Marine Technology, St. John's, NF, Canada, pp. 19–24.

Bjordal, Å., Løkkeborg, S., 1996. Longlining. Fishing News Books, Oxford, 156 pp.

Engås, A., Løkkeborg, S., 1994. Abundance estimation using bottom gillnet and longline—the role of fish behaviour. In: Fernö, A., Olsen, S. (Eds.), Marine Fish Behaviour in Capture and Abundance Estimation. Fishing News Books, Oxford, pp. 134–160.

Engås, A., Løkkeborg, S., Soldal, A.V., Ona, E., 1996. Comparative fishing trials for cod and haddock using commercial trawl and longline at two different stock levels. J. Northwest Atl. Fish. Sci. 19, 83–90.

Fernö, A., Olsen, S., 1994. Introduction. In: Fernö, A., Olsen, S. (Eds.), Marine Fish Behaviour in Capture and Abundance Estimation. Fishing News Books, Oxford, pp. 1–8.

Fernö, A., Solemdal, P., Tilseth, S., 1986. Field studies on the behaviour of whiting (*Gadus merlangus* L.) towards a baited hook. Fiskeridirektoratets Skrifter Serie Havundersøkelser 18, 83–95.

Fogarty, M.J., Borden, D.V.D., 1980. Effects of trap venting on gear selectivity in the inshore Rhode Island American lobster, *Homarus americanus*, fishery. Fish. Bull. US 77, 925–933.

Grimes, C.B., Able, K.W., Turner, S.C., 1982. Direct observation from a submersible vessel of commercial longlines for tilefish. Trans. Am. Fish. Soc. 111, 94–98.

High, W.L., 1980. Bait loss from halibut longline gear observed from a submersible. Mar. Fish. Rev. 42 (2), 26–29.

Hirayama, N., 1969. Studies on the fishing mechanism of tuna longline: IV. Theoretical analysis of fishing effectiveness of the gear. Bull. Jpn. Soc. Scientific Fish. 35, 635–640.

Kennelly, S.J., 1989. Effects of soak-time and spatial heterogeneity on sampling populations of spanner crabs, *Ranina ranina*. Mar. Eco. Prog. Ser. 55, 141–147.

Løkkeborg, S., 1990. Rate of release of potential feeding attractants from natural and artificial bait. Fish. Res. 8, 253–261.

Løkkeborg, S., 1991. Fishing experiments with an alternative longline bait using surplus fish products. Fish. Res. 12, 43–56.

Løkkeborg, S., 1994. Fish behaviour and longlining. In: Fernö, A., Olsen, S. (Eds.), Marine Fish Behaviour in Capture and Abundance Estimation. Fishing News Books, Oxford, pp. 10–24.

Løkkeborg, S., Bjordal, Å., 1992. Species and size selectivity in longline fishing: a review. Fish. Res. 13, 311–322.

Løkkeborg, S., Johannessen, T., 1992. The importance of chemical stimuli in bait fishing—fishing trials with pre-soaked bait. Fish. Res. 14, 21–29.

Løkkeborg, S., Bjordal, Å., Fernö, A., 1989. Responses of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) to baited hooks in the natural environment. Can. J. Fish. Aquatic Sci. 46, 1478–1483.

Matsuoka, T., 1990. Fish-catching mechanism in vertical longline fishing. In: Hirano, R., Hanyu, I. (Eds.), The Second Asian Fisheries Forum. Asian Fisheries Society, Manila, pp. 801–803.

Matsuoka, T., Kasu, J., Nagaleta, H., 1992. Capture process in vertical longline fishing. Bull. Jpn. Soc. Scientific Fish. 58, 213–222.

Miller, R.J., 1983. How many traps should a crab fisherman fish?. North Am. J. Fish. Manage. 3 (1), 1–8.

Müller, K., 1978. Locomotor activity of fish and environmental oscillation. In: Thorpe, J.E. (Ed.), Rhythmic Activity of Fishes. Academic Press, London, pp. 90–104.

Murphy, G.I., 1960. Estimating abundance from longline catches. J. Fish. Res. Board Can. 17 (1), 33–40.

Ogura, M., Arimoto, T., Inoue, Y., 1980. Influence of the immersion time on the hooking rate of a small bottom longline in coastal waters. Bull. Jpn. Soc. Scientific Fish. 46, 963–966.

Olsen, S., Laevastu, T., 1983. Factors affecting catch of long lines, evaluated with a simulation model of longline fishing. Proc. Rep. Northwest and Alaska Fisheries Centre, Seattle, 50 pp.

Pawson, M.G., 1977. The responses of cod *Gadus morhua* (L.) to chemical attractants in moving water. J. Conseil Int. l'Exploration Mer 37, 316–318.

Robertson, W.D., 1989. Factors affecting catches of the crab *Scylla serrata* (Forska) (Decapoda: Portunidae) in baited traps: soak time, time of day and accessibility to the bait. Estuarine, Coastal Shelf Sci. 29, 161–170.

Sheaves, M.J., 1995. Effect of design modifications and soak time variations on antillean-z fish trap performance in a tropical estuary. Bull. Mar. Sci. 56, 475–489.

Shepard, M.P., Roberts, R.F.A., Aro, K.V., Turner, C.E., 1975. Effect of bait loss on catching power of floating longline gear. Int. North Pacific Fish. Commission Bull. 32, 71–77.

Sivasubramaniam, K., 1961. Relation between soaking time and catch of tunas in longline fisheries. Bull. Jpn. Soc. Scientific Fish. 27, 835–845.

Skud, B.E., 1975. Revised estimates of halibut abundance and the Thompson–Burkenroad debate. Int. Pacific Halibut Commission Scientific Rep. 56, 36 pp.

Skud, B.E., 1978. Factors affecting longline catch and effort: III. Bait loss and competition. Int. Pacific Halibut Commission Scientific Rep. 64, 66 pp.

Sloan, N.A., Robinson, S.M.C., 1985. The effect of trap soak time on yields of the deep-water golden king crab *Lithodes aequispina* Benedict in a Northern British Columbia fjord. J. Shellfish Res. 5 (1), 21–23.

Sundberg, P., 1985. A model for the relationship between catch and soak time in baited fish traps. Océanographie Trop. 20 (1), 19–24.

Sutterlin, A.M., Solemdal, P., Tilseth, S., 1982. Baits in fisheries with emphasis on the North Alantic cod fishing industry. In: Hara, T.J. (Ed.), Chemoreception in Fishes. Elsevier, Amsterdam, pp. 293–305.

Takagi, K., 1971. Information on the catchable time period for Pacific salmon obtained through simultaneous fishing by longlines and gillnets. Bull. Far Seas Fish. Res. Lab. 5, 177–194.

Wathne, F., 1959. Summary report of exploratory longline fishing

for tuna in Gulf of Mexico and Caribbean Sea, 1954–1957. Commercial Fish. Rev. 21 (4), 1–26.

Whitelaw, A.W., Sainsbury, K.J., Dews, G.J., Campbell, R.A., 1991. Catching characteristics of four fish-trap types on the North West Shelf of Australia. Aust. J. Mar. Freshwater Res. 42, 369–382.

Wilson, R.R., Smith, K.L., 1984. Effect of near-bottom currents on detection of bait by the abyssal grenadier fishes *Coryphaenoides* spp., recorded in situ with a video camera on a free vehicle. Mar. Bio. 84, 83–91.

Zar, J.H., 1974. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, NJ, 718 pp.