International Council
for the Exploration
of the Sea

C.M. 1977/B :44
Gear and Behaviour
Committee

# THE BEHAVIOUR OF WHITING (Gadus merlangus) IN RELATION TO LONG LINES

by

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## INTRODUCTION

Field studies on fish behaviour with underwater TV in Norwegian waters started in 1976 (Fernø et al. 1976).

The TV field studies form the link between the laboratory work and the comparative fishing experiments with the aim to analyze fish behaviour in relation to long lines.

The operation and design of long lines have developed over centuries. Still it is believed that both the operation and design of the long lines can be improved by systematic analysis, including behaviour studies.

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The crucial point in behaviour studies is the definition of easily observable behaviour relevant for the specific problem in focus. The results from 1976 was based on behaviour patterns defined in the laboratory (Solemdal and Tilseth 1974), and the method showed to work well under field conditions. The present paper aims to demonstrate the effects of some environmental factors on the behaviour of fish in relation to long line, specially the effects of currents and the diurnal cycle. Understanding of these effects is important in the analyses of fish behaviour in relation to the catch efficiency of long line. It was necessary to improve and increase the number of behaviour patterns to obtain relevant informations.

## MATERIALS AND METHODS

Observations on the behaviour of fish in relation to a test section of long line were carried out in the Borgenfjord, north of Trondheim, during the period 26/6 - 1/7 1977. A total of 51 experiments were conducted at two different sites at depths of 42 m and 25 m respectively. The main species of fish observed in the area were whiting (Gadus merlangus), cod (Gadus morhua), haddock (Melanogrammus aeglefinus) and dab (Limanda limanda). The dominant species was whiting and only observations on this species are presented in this paper.

The underwater equipment was an improved version of the system used in 1976 (see FERNØ et al. 1976). The underwater television camera (Hydro products TC-125 SIT-W) was mounted at a fixed angle in an aluminium frame with a distance of 1.5 m between the line and the camera. The line was drawn out between two aluminium poles on the frame and could be set on the bottom or with the bait 30 cm above the bottom. The whole system was shot and hauled in one unit. A 500 W halogen lamp with a Kodac wratten 29 filter was attached to the camera frame. A current meter was mounted to one of the aluminium poles, (this instrument was a prototype of a current meter now under development).

The observation period was generally 60 minutes long. However, when comparing the effect of the line on the bottom with the line above the bottom the observations lasted for 30 minutes.

The swimming direction of fish relative to the current direction was recorded in three categories: ($A_1$) with a component against the current, ($A_2$) with a component in the direction of the current and (A) perpendicular to the current.

Four 40 cm long snoods were attached to the line 40 cm apart. Two Mustad hooks No. 8 and two smaller Mustad hooks No. 10 were used, one of each was sharpened and the other one blunted. The points of the hooks were measured with a microscope 11 times during the course of the experiment and corrected if necessary. The mean difference concerning the shortest side of the point between the two hooks No. 8 was x 4.7 and between the two hooks No. 10 x 7.8. The mean difference concerning the area of the point between the hooks No. 8 was 26.2 and between the hooks No. 10 x 29.4. The difference in the point between hooks of different sizes was relatively small. In all experiments the hooks were baited with mackerel.

The reactions of the fish to the bait were divided according to behaviour patterns observed during laboratory studies of cod, these will be presented in the following.

The fish were considered hooked if the baited hook was retained in their mouths for more than 30 seconds while they were violently fighting to get free, and recorded caught if still hooked at the end of the experiment. The number of fish that came free during hauling was also recorded.

## RESULTS

### Description of the behaviour patterns

Generally, whiting approached the line rapidly retarding in the immediate vicinity of the bait. The fish might then touch the bait with the snout and take it into the mouth (bite). It might spit out

the bait and take it into the mouth several times. When biting with low intensity, the fish took only a part of the bait in the mouth, alternatively did not close the mouth when biting.

After biting, the fish generally swam slowly forward with the bait in the mouth. Suddenly the swimming speed would increase and the fish would make a rush. A rush could also follow directly after a bite. Sometimes, after making a bite or a rush, the fish repeatedly shake its head rapidly from side to side, making a jerk. Rushes, and to some extent jerks, were considered often to lead to hooking. If a fish was not hooked after a rush, the bait was pulled out of the mouth and the fish left the area or made a new try.

The frequencies of all these behaviour patterns were recorded. In the present paper, rushes and jerks will be dealt with in particular.

Influence of time of day and the current

The number of whiting attacking the bait at different times of the day is presented in Fig. 1. There were two periods of high activity during the 24 hour cycle, one from about 6 a.m. to 10 a.m. and the other from about 7 p.m. to 10 p.m.

The current speed was measured during the first 5 minutes of each observation. The lowest current speed was measured at 0.4 cm/sec. and the highest at 16.7 cm/sec.. The Borgenfjord has a complicated current system, yet there did not seem to be any obvious relationship between current velocity and the number of whiting attacking the bait. ($r = -0.14$, $p > 0.1$)

Swimming direction

The swimming direction of the fish relative to the current has been separately calculated for fish making any kind of behaviour pattern towards the bait, and for fish showing no interest in the bait at all. The results are presented in Table 1.

Fish attacking the bait approached the line significantly more often against the current than fish showing no interest ($p < 0.001$).

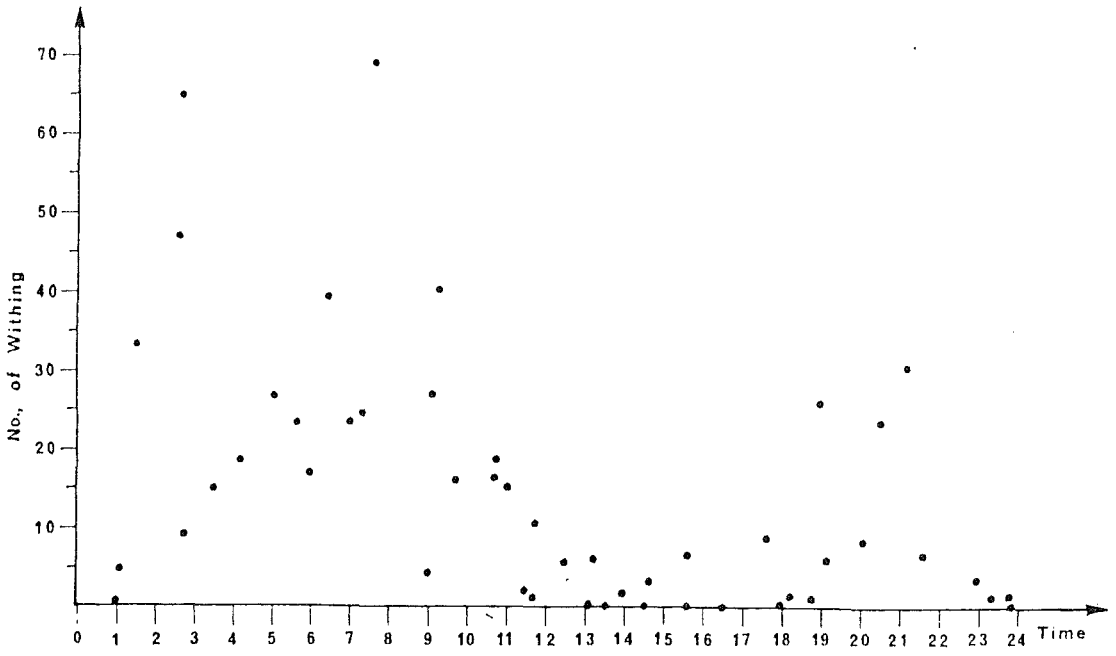


Fig. 1 The number of whiting making any kind of behaviour pattern towards the bait during the first 30 minutes of observation shown against the time of day. The figure is based on experiments with the bait situated above the bottom.

Table 1 Swimming direction of fish attacking bait, and fish showing no interest in bait, respectively.

| | Fish attacking bait | | | Fish showing no interest in bait | | |
|---|---|---|---|---|---|---|
| Swimming in relation to the current | A | $A_1$ | $A_2$ | A | $A_1$ | $A_2$ |
| No. of fish | 51 | 589 | 22 | 81 | 420 | 34 |
| % of total | 7.7 | 89.0 | 3.3 | 15.5 | 78.0 | 6.5 |

Line above and on the bottom

On comparison of a line above the bottom to a line on the bottom (table 2), no significant differences were found, either in number of fish observed or number of rushes and jerks. Ten fish were hooked on a line above the bottom while seven fish were hooked on a line on the bottom.

Table 2 Experiments with the line on the bottom and the line above the bottom. The material consists of 10 pairs of two successive tests of each kind.

| Test | No. of fish observed | | No. of rushes and jerks | |
|---|---|---|---|---|
| | Above bottom | On bottom | Above bottom | On bottom |
| 1 | 48 | 62 | 20 | 16 |
| 2 | 55 | 29 | 22 | 21 |
| 3 | 72 | 59 | 35 | 6 |
| 4 | 21 | 34 | 15 | 11 |
| 5 | 8 | 50 | 1 | 21 |
| 6 | 40 | 59 | 6 | 11 |
| 7 | 100 | 10 | 12 | 0 |
| 8 | 57 | 72 | 26 | 12 |
| 9 | 4 | 18 | 1 | 1 |
| 10 | 1 | 5 | 1 | 2 |
| Total | 406 | 398 | 139 | 101 |

Changes in activity within the observation period

With no fish on the hook, there was a decreasing number of rushes and jerks during the course of one hour (Fig. 2). The mean number of these behaviour patterns in one hour was 10.6. When one or more fish were hooked, there was more than twice as much activity of this kind (mean number = 23.3) and the activity did not decrease until after about 30 minutes of observation time. A similar, although smaller, difference exists if those 5-minute intervals when fish become hooked are disregarded. This shows that there is actually an effect of an earlier hooked fish, and that the difference can not only be explained by the fact that high activity during a period leads to hooking.

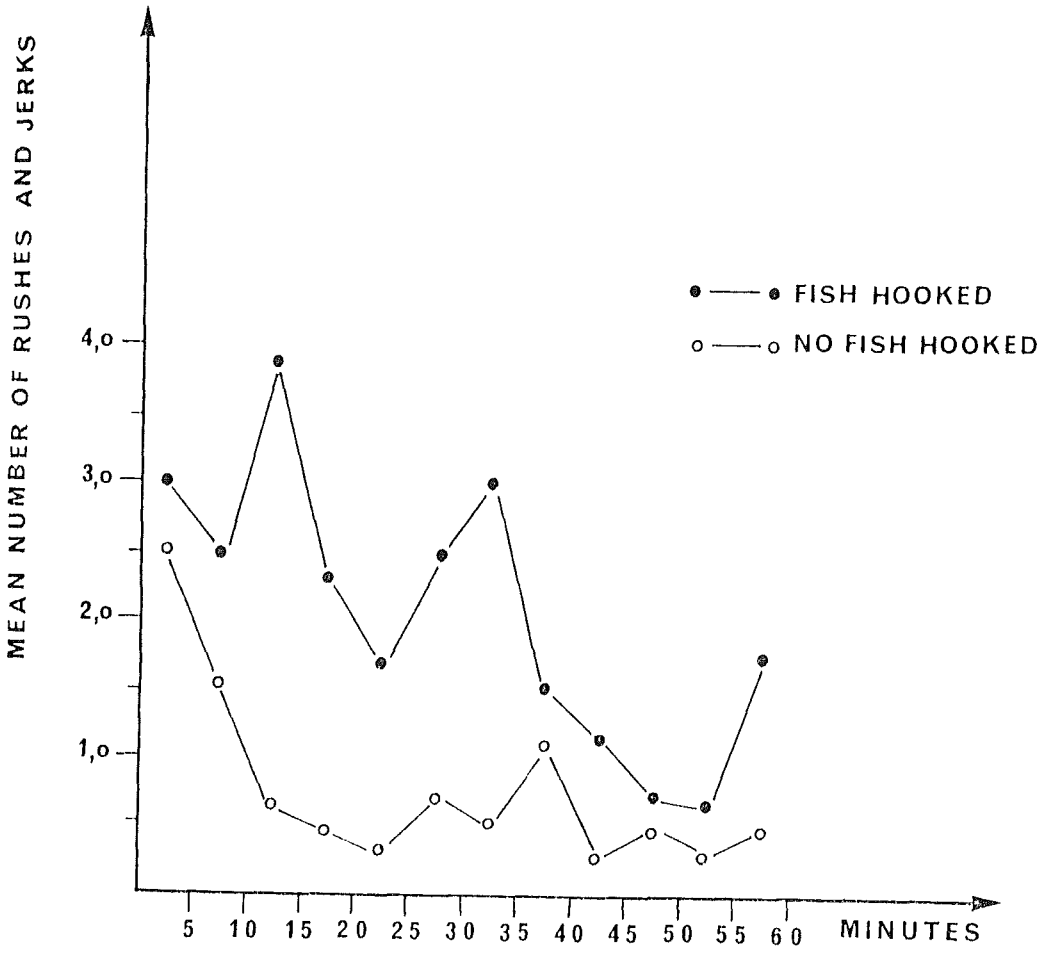


Fig. 2 The mean number of rushes and jerks of successive 5-minute intervals during the course of one hour. The activity when no fish were hooked is compared with the activity when at least one fish was struggling on the line.

Hooking probability

Throughout the experiment a total of 53 whiting were hooked, out of which six broke loose and two were lost during hauling. The mean length was 38 cm (29 - 56 cm). Thirty-eight fish were hooked in the mouth and seven fish had swallowed the hooks.

Stomach analyses showed that only 10 out of 47 fish had any stomach contents at all. These fish had eaten euphausids, amphiphods and small fish, most probably sprat. Only one whiting had a full stomach. The rest of the fish with stomach contents contained only a few euphausids or amphipods.

Because of the difficulty in assessing the exact moment of hooking, it was not possible to determine with certainty which behaviour pattern preceeds hooking in every case. As either a rush og a jerk always occurred in connection with hooking, these behaviour patterns are, however, regarded to be the main cause of hooking. In some cases a rush or a jerk might not occur as a cause of hooking but as an effect of a previous bite, but as a rush or jerk occurred alone in connection with the vast majority of hookings, other behaviour patterns are disregarded when estimating the hooking probability.

Calculated from the number of rushes and jerks in relation to the number of hooked fish, the hooking probabilities for the different hooks are given in Table 3. The sharpness of the hook did not significantly influence the hooking probability, but a small hook (No. 10) was about twice as effective as a bigger hook (No. 8). The hooking probability based on the tests with the line on the bottom alternating with the line above the bottom is similar to that based on the rest of the material.

Table 3 The hooking probability of different hooks based on the number of hooked fish in relation to the number of rushes and jerks. The tests with the line alternating on and above the bottom (I) are given separate from the rest of the material (II).

| | | No. of rushes and jerks | No. of hooked fish | Ratio |
|---|---|---|---|---|
| Sharpened hook No. 8 | I | 71 | 2 | 0.028 |
| | II | 152 | 12 | 0.079 |
| Blunted hook No. 8 | I | 57 | 3 | 0.053 |
| | II | 150 | 6 | 0.040 |
| Sharpened hook No. 10 | I | 61 | 6 | 0.098 |
| | II | 97 | 12 | 0.124 |
| Blunted hook No. 10 | I | 39 | 4 | 0.103 |
| | II | 87 | 8 | 0.092 |

Apart from the stimulatory influence of a hooked whiting on the activity on others, other biological observations relevant to long line fishing were also made. Several whiting seemed to increase eachother's activity through competition, sometimes leading to attacks in the area of the bait. Interspecific relationships were also observed. Cod often chased away whiting from the bait and bites were also directed at hooked whiting. The presence of one species could therefore influence the efficiency of a long line in catching another species.

## DISCUSSION

Whiting swam with a component against the current in 80 - 90 % of the cases. Due to the relatively small observation field the same fish was probably often observed more than once. This means that some of the fish swimming in other directions than against the current are attacking the bait a second or third time, and that possibly even a higher proportion swam against the current during the initial attraction.

As the current determines the swimming direction, one might suspect that current velocity acts on whiting food searching behaviour. We observed two periods of high activity during the 24-hour cycle, but could not correlate the activity with changes in tide or current velocity. This may be due to the complicated current system in the Borgenfjord which has a narrow and shallow inlet. The tides of the Trondheimfjord, to which the Borgenfjord is an appendage, create a turbulent jet stream at the inlet. (McCLIMANS 1973). The present observations were made in close vicinity to the small island of Rolsøy, and according to McCLIMANS (1973) there is a large eddy of turbulent water around Rolsøy.

No difference in number of fish observed, or in the activity of the fish, was found between a long line placed on the bottom and one above the bottom. This is in contrast to findings on haddock and dab (FERNØ et al. 1976), where the greater effectiveness of a line above the bottom was thought to be caused by increased visibility. It is possible that the disagreement in this context reflects differences in the relative importance of visual and olfactory stimuli for different species. The observed ability of whiting to remove seastars from a bait on the bottom may also reduce the significance of the placing of the line in relation

to the bottom.

The decreasing tendency for fish to be attracted and further react to the bait in the course of one hour is in accordance with results from previous experiments on haddock and dab (FERNØ et al. 1976). This decrease may be caused by the washing out of olfactory stimuli from the bait, or that fish initially attracted when the line is shot, gradually leave the area. The effect may alternatively be due to changes within the fish, provided that, to some extent, the same fish return to the long line during an observation. Repeated unsuccessful attempts to pull the bait off the snood may produce response waining due to habituation or the hooks may cause pain in the fish and give negative reinforcement, decreasing the possibility of new attempts.

When fish are already hooked, a new factor is introduced, leading to a smaller decrease in activity during the course of one hour. Fish have been observed to react both to the struggle of a hooked fish and to the movement of the bait caused by the struggle. These visual stimuli are probably only effective from a relatively short distance away, on fish already attracted to the general area by the smell of the bait. As a matter of fact, activity towards the bait was relatively low after 30 minutes even if other fish were hooked. After this time the olfaction from the bait had presumably decreased considerably.

(SUMMARY)

1) Eighty-ninety % of the fish swam against the current.

2) The maximum number of fish attacking the bait was observed between 6-10 a.m. and 7-10 p.m. No correlation was found between the current velocity and the fish activity.

3) Activity towards the bait decreased considerably during the course of one hour. If fish were hooked on the line the decrease was not so pronouneed and occurred later in the period.

4) No difference in activity was observed between a line on the bottom and a line above the bottom.

5) The number of fish hooked in relation to the number of rushes and jerks was about 0.05 for hook No. 8 and about 0.10 for hook No. 10. The sharpness of the hooks did not influence the hooking probability.

REFERENCES

FERNØ, A. JOHANNESSEN, A. OLSEN, K.A. SOLEMDAL, P. TILSETH, S. and VALDEMARSEN J.W. 1976. Fish behaviour in relation to long lines observed by TV. Coun. Meet. int. Coun. Explor. Sea, F:33 7 pp. (Mimeo).

McCLIMANS, T.A. 1973. Physical oceanography of Borgenfjorden. K. norske Vidensk. Selsk. Skr., 2, 1 - 43.

SOLEMDAL, P. TILSETH, S. 1974. Reactions of cod (Gadus morhua L.) to smell stimuli from bait. Coun. Meet. int. Coun. Explor. Sea, F:40 19 pp. (Mimeo).