Behaviour of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) in relation to various sizes of long-line bait

Tore Johannessen, Anders Fernö, and Svein Løkkeborg


The behaviour of cod (Gadus morhua L.) and haddock (Melanogrammus aeglefinus L.) in relation to various bait sizes was studied by simulating semipelagic long-lining in the laboratory. The fish were exposed to a hook baited alternately with mackerel baits of 10 g and 30 g. During the experimental period the behaviour of the fish gradually changed through learning. The behaviour during the first part of the experiment was therefore considered to be most relevant to field conditions. For both species the frequency of biting was significantly higher on small than on big baits. Haddock frequently bit at part of the big bait, leaving the hook outside the mouth, and would then jerk or rush to tear the bait apart, whereas hooks with small baits were usually completely ingested. In cod, on the other hand, there was little difference in behaviour towards the two bait sizes after biting. Owing to higher frequency of biting, one should expect small baits to give higher catch rates on semipelagic long-line than big baits for both cod and haddock. Furthermore, the complete ingestion of small baits should favour an increased catching efficiency for haddock. These observations are in accordance with the results from fishing experiments in the field.

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Introduction

Fishing experiments at sea with semipelagic long lines have shown that bait size has a significant influence on both catching efficiency and size selectivity for cod and haddock (Johannessen, 1983). Different bait sizes caught approximately the same number of cod >60 cm total length, whereas small baits were more efficient for smaller cod. For haddock, bait size only slightly influenced catch size selectivity. However, baits of 10 g caught more than twice as many haddock as 30 g baits. The results of the fishing trials provided no evidence about the cause of the observed differences. It was assumed that the variation in catch reflected the prey size preferences of cod and haddock, or that larger baits may result in less efficient hook engagement and capture.

This paper describes laboratory studies of the behaviour of cod and haddock towards different bait sizes. The main objective was to explain the observed catch difference between small and big baits in semipelagic long-lining. The paper also gives a detailed description of the behaviour of the fish in relation to a baited hook, and the results may be relevant to general prey size preferences of cod and haddock.

Material and methods

Experimental design

The behavioural studies were carried out indoors in a concrete tank which formed a 2 m wide circular channel with a circumference of 31 m along the inner wall and had a water depth of 2.3 m. The experiment with cod took place in October/November. The cod, 26 individuals with an average total length of 55.5 cm (range 46-72 cm), were caught in traps and gillnets on the west coast of Norway and kept for 21 days in the tank for
adaptation. Prior to the experiment more than half the cod were eating (except for test-feeding to examine how the adaptation improved, the fish were not fed). One cod died during the experimental period of 13 days.

The experiment with haddock took place in May/June. The fish were caught by beach seine three days prior to delivery. Thirty haddock with an average total length of 55.1 cm (46-61 cm) were transferred to the observation tank. The fish adapted quickly, and after a fortnight most of the haddock were eating (test-feeding only). Five haddock died during the experimental period of 24 days.

A monofilament, polyamide long line (4 m) was placed in front of an observation window. One barbless hook (Mustad Norway no. 5, qual. 7296) with a 40 cm gangion was attached to the test line. The line was rigged to simulate the performance of semipelagic long lines with respect to flexibility. Also factors such as bait type, bait dimension and baiting technique were in accordance with the fishing trials at sea. The light in the laboratory was kept on both day and night to simulate the conditions in the Barents Sea during the polar summer. The water temperature in the tank was 8°C (±0.3).

The experiments were carried out by comparing the behaviour of the fish towards mackerel baits of 10 and 30 g. The length and width of 10 g baits were 3.8 and 2.0 cm respectively, and of 30 g baits 8.3 and 2.3 cm. The thickness of the bait was adjusted to give the appropriate weights, and hence varied according to which part of the mackerel fillet the bait had been cut from. The two bait sizes were tested in alternating trials. Each trial lasted for 10 min or until a fish was hooked. There was a 5 min break between trials. The starting bait size was altered from day to day. The number of experiments per day varied between two and four, depending on the response of the fish. Seventeen trials with each bait size were conducted in the experiment with cod, and 20 trials with each bait size in the experiment with haddock. Hooked fish were carefully removed from the hook and released into the tank again.

**Behavioural patterns**

The behaviour of the fish was videotaped for later analysis. The observed behaviour was sorted into the following categories:

- **Approach (A)** - swimming towards the baited hook, but turning before touching the bait.
- **Taste (T)** - touching the bait with the lips or the barbel (if followed by another behaviour pattern, the taste had to last for at least 2 s to be recorded).
- **Incomplete bite (iB)** - sucking the bait into the mouth without closing the mouth.
- **Bite (B)** - biting the bait while part of the bait remained outside the mouth.
- **Complete bite (cB)** - sucking the whole bait into the mouth and closing the mouth.
- **Bite (B)** - either iB, bB or cB.
- **Chew (C)** - chewing on the bait.
- **Jerk (J)** - a rapid movement of the head with the bait in the mouth.
- **Slow jerk (sJ)** - a low-intensity jerk.
- **Rush (R)** - swimming rapidly with the bait in the mouth.
- **Pull (P)** - swimming slowly with the bait in the mouth (a slow rush).
- **Bait out of mouth (O)** - spitting out the bait or the bait being pulled out of the mouth.
- **Hooking (H)** - retaining the hook in the mouth for at least 30 s while the fish fought violently.

A behaviour sequence was defined as a series of these categorized behaviour patterns, starting with the fish approaching the bait and terminating when the fish became hooked or turned away from the bait. The behaviour of the fish was evaluated on the basis of three phases: (1) attacking phase (consisting of A, T, iB, bB, cB), (2) handling phase (C, J, sJ, R, P), and (3) terminating phase (O, H).

Owing to possible effects of learning, the experiments were split into four periods, with approximately the same number of behaviour sequences in each period.

Hence, the four periods were equal neither in time nor in number of trials. If there was no significant change in behaviour during the four periods (p > 0.05, chi-square heterogeneity test), the four periods were pooled to evaluate the behaviour of the fish. On the other hand, if behaviour changed significantly, only data from period 1 were included since the very first attacks probably are most relevant to actual fishing.

**Results**

**Cod**

There was a significant change in behaviour of cod during the four experimental periods in the attacking phase (p = 0.001, chi-square heterogeneity test). In period 1 the frequency of complete bite (cB) on 10 g baits was approximately 2.5 times as high as that on 30 g baits (Table 1). Cod more frequently approached and tasted the 30 g baits. In subsequent periods the frequency of complete bite dropped significantly and became the same on both bait sizes.

In the handling phase there was no significant change in the behaviour of cod during the experimental period (p = 0.303, chi-square heterogeneity test), and behaviour towards 10 and 30 g baits was similar (p = 0.413, chi-square contingency analysis). A total of 7 and 5 cod were caught on 10 g and 30 g baits respectively. These numbers are too low to evaluate the hooking probability on the two bait sizes. All hooking took place after a jerk or a rush, both being behaviour patterns of high-intensity movement.
Table 1. For cod, number of observations and the relative frequency (%) of the various behaviour patterns* in relation to 10 and 30 g baits in the attacking phase (period 1 only) and in the handling phase (all four periods), and the observed number of behaviour patterns in the terminating phase.

<table>
<thead>
<tr>
<th>Bait size</th>
<th>Attacking phase</th>
<th>Handling phase</th>
<th>Term. ph.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>A</td>
<td>T</td>
</tr>
<tr>
<td>10 g</td>
<td>57</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>30 g</td>
<td>59</td>
<td>48</td>
<td>27</td>
</tr>
</tbody>
</table>

* Behaviour patterns: A, approach; bB, bite the bait; C, chew; cB, complete bite; H, hooking; iB, incomplete bite; J, jerk; O, bait out of mouth; P, pull; R, rush; sj, slow jerk; T, taste. See text for definitions.

Haddock

The behaviour of haddock in the attacking phase did not change significantly during the experimental period (p = 0.950, chi-square heterogeneity test, Table 2). However, haddock attacked the two bait sizes differently (p = 0.001, chi-square contingency analysis). The frequency of complete bites of 10 g baits was more than twice as high as that of 30 g baits, whereas haddock bit the bait (bB) more often when attacking 30 g baits. Haddock also more frequently tasted big baits. After tasting, the fish swam away on 90% of occasions. Incomplete bite was only of minor importance and the number of approaches was about the same towards both bait sizes.

The handling behaviour of the haddock did not change significantly during the experimental period (p = 0.723, chi-square heterogeneity test). However, haddock handled small and big baits differently (p = 0.001, chi-square contingency analysis), with slow jerk being more frequent for 10 g baits and jerk more frequent for 30 g baits. The frequency of rush was similar for both bait sizes, whereas pull and chew were of minor importance. The catch rates were significantly higher on small baits than on big baits when estimated on the basis of the number of bites (B, p = 0.049, chi-square analysis).

Discussion

During fishing experiments with hooks and lines, several authors have reported a decreased catchability of various species (Beukema, 1970a, 1970b; Hackney and Linkous, 1978; O'Grady and Hughes, 1980). This is believed to be due to the development of hook avoidance. Fernö and Huse (1983) observed the behaviour of cod towards a baited hook and found that the intensity of the response was highest initially, with a modification of behaviour after experience with the baited hook. This is in accordance with the present findings. Consequently, the behaviour of cod when attacking the baited hook as observed in period 1 is probably the most relevant to behaviour in the field.

The behaviour of fish towards a single baited hook may differ from that in commercial long-lining, where many hooks are used. Fish caught on a semipelagic long line located above the seabed can swim some distance, and neighbouring hooks will therefore be moving rather than hanging still. Furthermore, cod making rapid and intensive movements seem to stimulate the feeding behaviour of other cod (Brawn, 1969), and fish fighting vigorously after hooking have been observed to stimulate other fish to attack neighbouring hooks (Fernö et
al., 1986; Løkkeborg et al., 1989). Thus, fish attacking a single hook in the laboratory will have more time to judge the "quality of the prey organism". Therefore, the most likely effect of laboratory conditions is that behavioural differences towards the two bait sizes would be overestimated.

However, there is good agreement between the present study and fishing experiments with different bait sizes at sea (Johannessen, 1983). In the fishing experiments at sea, small baits gave higher catches of small cod (<60 cm), whereas the catches of larger cod were not affected by the bait size. The present study indicates that this effect probably was caused by small cod ingesting (cB) small baits more frequently than big baits.

For haddock, bait size has been shown to influence catch size selectivity only slightly, but, baits of 10 g caught more than twice as many haddock as 30 g baits (Johannessen, 1983). This may be explained by haddock attacking small baits more often than big baits, and also by more frequently ingesting (cB) small baits. When attacking 30 g baits, haddock often bit the bait (bB) and then usually jerked or rushed to tear the bait apart. This finding is in accordance with the fishing experiments at sea, where observations of the state of the bait at the end of fishing indicated that haddock nibbled on big baits but not on small baits (Johannessen, 1983). Løkkeborg et al. (1989), when observing behaviour towards a baited hook in the field, also reported that haddock more frequently bit the bait (bB) than did cod.

The present study indicates that haddock may attack food particles that are too big for its small mouth, and then try to tear it apart. Cod, on the other hand, only seem to attack food particles of appropriate size. This difference in behaviour of cod and haddock may explain why bait size influenced selectivity for cod but not for haddock.

References


