LONGLINING

Longline gear - catching performance, selectivity and conservation aspects

by Mr Åsmund Bjordal,
Institute of Fishery Technology Research, Bergen, Norway

The following report is a summary of a paper presented in November by Mr Bjordal at the World Symposium on Fishing Gear and Fishing Vessel Design, organised by the Newfoundland and Labrador Institute of Fisheries and Marine Technology, St Johns, Newfoundland.

Åsmund Bjordal

During the last 15 years, the effectiveness of longline fishing has been significantly increased. This is achieved both by increased effort through mechanised baiting and gear handling, and by improved catching performance of the gear.

This paper describes recent developments of longline gear, with respect to the different gear components: hooks, gangions, swivels, mainline and bait.

The conservation aspects of longline compared with those of trawl gear are discussed.

1. Introduction

Longlining is a traditional fishing method all over the world. Although the rigging and methods of operation vary considerably, the longline is basically a very simple gear. However, the success of capture for longline gear depends on a complicated interaction between a series of biotic and abiotic factors (Olsen and Laevastu, 1983). The different aspects of longline fishing are reviewed by Skud and Hamley (1978) and Bjordal (1981a).

This paper focuses on the recent developments of the main longline gear parameters and on different conservation aspects of longline compared with those of trawl gear.

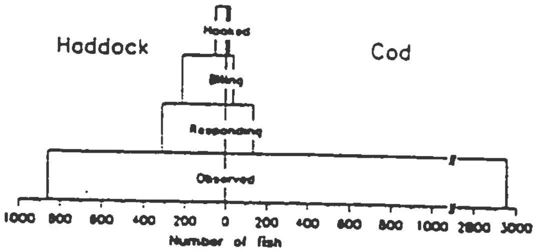
2. The longline catching cycle

The basic unit of longline gear consists of a baited hook connected by a gangion to the mainline. In a longline operation, the baited hook is the main daily investment, with a fish of high commercial value as the desired payback. The period from the when the hook leaves the fishing vessel until it is retrieved might be defined as the 'longline catching cycle', during which the hook goes through four major stages: shooting, sinking, in fishing position and retrieval.

3. Recent developments of longline gear

The longline is in general an inefficient gear, if gear efficiency is measured as success of capture relative to the number of fish actually attracted by the bait stimuli and number of fish attacking the bait (Fig 1).

Normal catch rates in the Norwegian longline fishery are from five to 30 fish (target species) per 100 hooks. Major reasons for this relatively low capture success are bait loss, low feeding motivation, low hooking probability, escapement of target species and the hooking of non-target species. Recent research- and development work has, however, shown that the gear efficiency of longlines might be significantly improved by apparently minor changes of the different gear parameters.



The behaviour of cod and haddock towards mackerel bait. Total number of observed fish and number of fish making a response, a bite or being hooked

3.1 Bait

A good longline bait should stay on the hook throughout the fishing period, during which it should effectively attract fish, either by chemical or visual stimuli, and by taste stimuli effectively entice the fish to ingest the baited hook.

The process of attracting fish by baits is not fully understood, although several authors have given valuable contributions within this field (Atema 1980, Ferno et al. 1981, Carr 1982, Sutterlin et al. 1982, Olsen & Laevastu 1983, Anon 1984, Løkkeborg 1985). However, the rather vast field of chemical sensing in fishes and fish attraction by baits is beyond the scope of this paper, so, given that the chemical properties of the bait are adequate, the following discussion will be focused on bait loss.

The catching efficiency of longline gear is inversely correlated to bait loss. The problem of bait loss is described by several authors (Shepard et al. 1975, Skud and Hamley 1978, High 1980), and according to type of bait, soak time and fishing depth, bait loss may vary from 20- to 100 per cent.

Bait loss from different reasons occurs during all stages of the catching cycle. During shooting of longlines, bait predation by sea birds might significantly reduce the number of effectively baited hooks, although crowds of sea birds in the wake of longliners during shooting of the gear is the familiar situation, this has never been looked upon as a severe cause of bait loss.

This problem varies with respect to fishing ground, time of day and seasonally, and according to Løkkeborg (1987), such bait loss might be as high as 70 per cent in extreme situations. Although little is known about the average bait predation by birds, the above investigation suggests that methods to prevent this type of bait loss might give a significant increase in catching efficiency.

Bait loss continues in the fishing position. For bottom-set gear in particular, severe bait loss might be caused by different bait predators like hagfish, sea lice (different isopods and amphipods), decepod crustaceans, snails, sea cucumbers and starfish (author's observations). In addition bait loss is caused by fish, either target or non-target species, that succeed in removing the bait without getting hooked. Due to bait loss, longline efficiency is thus gradually reduced during the first three stages of the catching cycle.

In some longline fisheries, a combination of bait is found to be more effective than either of the bait types used alone. Bjordal (1983) found that the traditional bait combination of mackerel and squid in the longline fishery for tusk and ling was significantly more effective that pure mackerel or pure squid. Franco et al. (1987) achieved the same effect using a combination of mackerel and sardine bait in the longline fishery for hake. The reason for this effect might be that one of the bait types is more attractive, but physically weaker than the other, and will therefore disappear quicker from the hooks, while the stronger bait will prolong the effective fishing time of the floats.

Gangion floats have been used as a method to prevent bait predation by bottom scavengers. Bjordal (1984) found that gangion floats of five- and eight-grams buoyancy reduced bait loss and improved the catching efficiency. These gangion floats were, however, never accepted by the fishermen because they made the gear handling more complicated.

Substantial effort is being made to develop artificial baits for longlining (Bjordal 1981a, Anon 1984). So far, this work has not led to a bait with sufficient efficiency for commercial longlining. A recent development based on a synthetic bait developed at the University of Florida has, however, given very promising results, with catch rates of cod equal to those of natural bait (Anon 1988a). Furthermore, this bait type gives only five per cent bait loss (Løkkeborg and Bjordal 1987).

3.2 Hook

The effectiveness of a longline hook is determined by a

Longlining Cont' from page 5

longline gear? McCracken (1963) and Saetersdal (1963) found that smaller hooks would select smaller fish. This is true to a certain extent but, in both these investigations, the bait size was reduced with decreasing hook size. Through a comprehensive study, Johannessen (1983) found that bait size had a much greater effect than hook size on the selective properties of longlines. A large fish will normally take both large and small bait, while a smaller fish will rather go for a small bait. A reduction in bait size will, therefore, give equal or increased catch rates, but a higher proportion of smaller fish (Bjordal 1983b).

Table 1.

Main target species	Catch rates (No. of fish per 100 hooks) Target species	Trash fish
Cod/haddock (1)	37.9	4.7
Cod/haddock (2)	16.6	1.2
Tusk/ling (3)	19.6	1.3

(1) Løkkeborg (1985) (2) Bjordal (1988) (3) Bjordal (1987b)

The information on species selectivity of different fishing gears is rather scarce. Table 1 is based on different Norwegian longline investigations, just to give an indication of the trash fish catch rates versus catch rates of the target species. The catch of non-commercial species will vary in different longline fisheries, but it is normally fairly low.

5 Conservation aspects of trawl- and longline gear

5.1 Conservation-oriented fishing

The following discussion on the conservation aspects of longline- and trawl gear is based on different aspects:

a) The species and size selectivity of the gear:
b) Survival after escapement;
c) Fish quality:
d) Effects on environment (eg bottom fauna):
e) Energy budget.

Ideally, a conservation oriented fishing gear should effectively catch only target species of legal size and high quality at minimum energy costs, with no harmful effects on the environment. According to the aspects above, different methods of exploiting marine resources may be classified from little- to highly conservative.

5.2 Selectivity

5.2.1 Size selectivity

In trawling, selection takes place at different stages of the catching process, from the doors and sweeps to the codend. For small (undersized) fish, codend selection is most important. In principle, a certain mesh size should give a good size selection. Clogging of meshes (eg by flatfish or rockfish) or large catches that stretch (close) the meshes are factors that may give very poor selection properties.

As mentioned above (4), longline gear might also catch small fish, and the length frequency distributions of longline and trawl catches might be fairly similar when the proportion of small fish in the fishing area is low.

The fact that longline gear has a definite saturation level also affects the tactics of operation in a conservation oriented direction. The profit in longlining depends on a maximum yield or payback per invested hook, and it is inversely correlated to the number of small fish in the catches. With an increasing proportion of small or undersized fish in the longline catch, the catch value will eventually reach a break-even level. The skipper then has the choice, either to stop fishing or to move to fishing grounds with less small fish. In addition to gear selectivity, the skipper's choice of fishing grounds regarding the possibilities of catching large fish is, therefore, an inherent mechanism in longlining towards exploitation of larger size groups of fish.

In comparison, trawl fishing has no definite level of gear saturation or catching capacity. As is the case for longlining, the profit in trawl fishing will also be reduced with an increasing proportion of small fish in the catches. There is, however, an important difference: as long as each haul produces adequate quantities of larger size groups for profitable fishing, there is no need to stop fishing or change fishing ground - even if there might be large quantities of small- and undersized fish in the catches. Unlike longlining, there is, therefore, no strong inherent mechanism in the operation tactics of trawling that prevents exploitation of young fish.

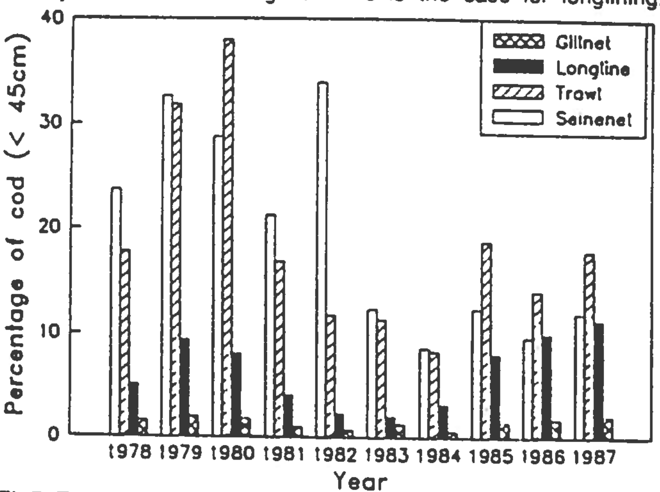


Fig7. The proportion of cod less than 45cm (deheaded) for different fishing gears. Based on landing statistics in northern Norway.

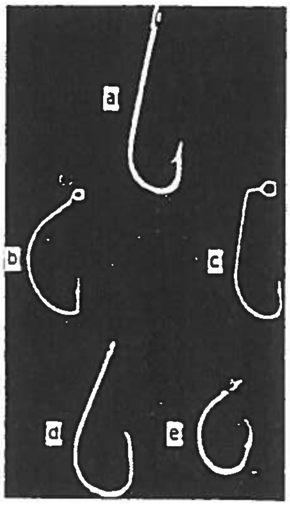
Compared with longline gear, the trawl is, however, a much more powerful tool for catching smaller, undersized fish. This is based on fundamental differences between the two gears regarding gear saturation, catching capacity and operational tactics.

Longline gear has a clearly defined level of gear saturation and catching capacity, defined as the daily catch in number of fish, which is limited upwards to the number of hooks operated per day. In Norwegian longlining, this ranges from a few thousand to 30- to 40,000 hooks, according to vessel size. With normal catch rates, ranging from 10- to 30 fish per 100 hooks and thereof five- to 10 per cent undersized fish, the exploitation of fish under legal size by longline is bound to be moderate.

The information available on the proportion of undersized fish in different trawl- and longline fisheries is too scarce to make a good comparison between the two gears. However, one rough measurement of the non-conservative nature of trawl gear is the closure of fishing grounds when the proportion of undersized fish in series of hook parameters, like sharpness of the point, barb width or strength. However, the hook size and general dimensions of the hook are regarded as the most important parameters for the catching efficiency.

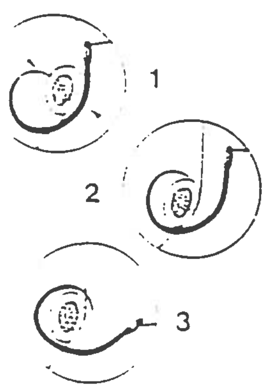
A small hook has a higher hooking probability than a larger one, and a slight reduction in hook size will normally give higher catch rates (Bjordal 1981b).

The most interesting developments are, however, on different new hook designs. At least in the western world, the J-hook (Fig. 2) has been the traditional longline hook design for centuries. Development of more effective hook

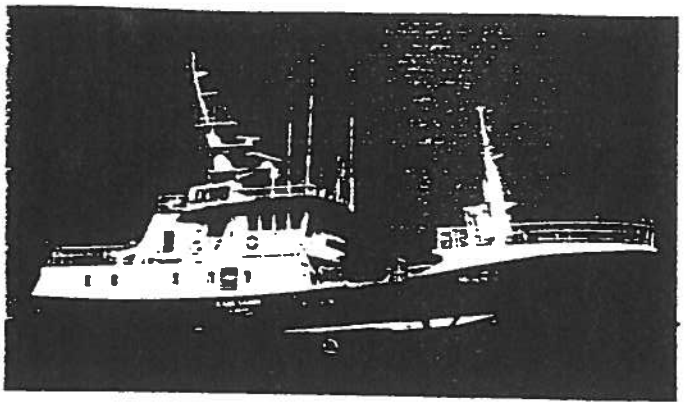


Traditional J-hook (a) and new hook designs: Wide gap (b), Spurt/O'Shaugnessy (c), EZ-baiter circle (d) and circle (e)

designs was initiated in the 1970's through fundamental studies of fish hooking behaviour and longline field trials. Huse (1979) found that the catch rates of the Wide Gap and Spurt/O'Shaugnessy hooks (Fig. 2) were superior to those of J-hooks in the order



How a circle hook works: **As** the in-curved hook is pulled over fish's jaw the gape expands and compresses the flesh on the jaw bone of the fish and then snaps back over the jaw, so the point acts as a one way gate



The *Karl Vadøy*, one of the most modern Autoline vessels

of 20- to 30 per cent according to target species (cod, haddock, tusk and ling). Today, these hook designs are dominant in the longline fisheries in northern Norway.

In the North American longline fisheries, the circle hook (Fig. 2) has proved to give significantly better catch rates, especially for halibut, but also for other species (Peeling & Rodgers, 1985). Compared with the traditional J-hook, the circle hook is reported to give a 50- to 100 per cent increase in catch rates of halibut, and this hook design is now used for halibut longlining in several countries. The circle hook is historically the traditional hook in certain Pacific islands and Johannes (1984) describes the catching principle of circle or rotating hooks (Fig. 3).

The most recent major hook development is the EZ-Baiter circle hook (Fig. 2), which is a hybrid design between the traditional J- and circle hooks. Compared with traditional J-hooks, this new hook design has given 20- to 40 per cent catch increase in comparative fishing trials for tusk, ling, cod and haddock (Skeide et al. 1986, Bjordal 1987a, b), and it is now being used by several Autoline vessels.

The increased catching power of the new hook designs, which all have incurved points or shanks bent towards the point, is believed to be caused by a combination of better hooking efficiency and lower probability of escapement after hooking. A characteristic of the new hook designs is that they all give a higher proportion of fish caught by the mouth or jaw compared with the J-hook design.

3.3 Gangions

Experimental fishing has shown that the material and length of gangions have an effect on longline catch rates. Compared with multifilament, monofilament gangions give higher catch rates in the order of 10- to 20 per cent in longlining for cod, haddock, tusk and ling (Bjordal 1985a, b).

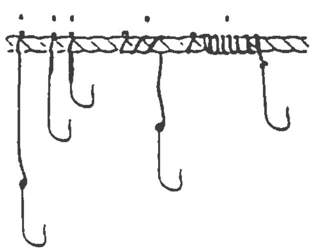
Within the range determined by the practical operation of longline gear, it has been shown that a reduced gangion length gives decreased catch rates. Karlsen (1976) obtained a significant decrease in catch rate of 28 per cent for tusk and 17 per cent for ling, by shortening the gangion length from 40- to 15cm. This is explained by lower escapement from a hook on a long gangion, since this can take a lot more twist before it loses its elasticity.

3.4 Swivels

On monofilament gear, gangions are normally connected to the mainline by swivels, and the generally high effectiveness of monofilament gear can partly be explained by this feature. The swivel will to a large extent prevent the twisting of gangions, and the catch rates are improved by the lower escapement of fish during retrieval of the gear.

During the last years, different arrangements for swivel connection of gangions on multifilament gear have been developed. Testing in different fisheries (cod, haddock, tusk and ling) has shown that the swivel gives a catch increase of 15 per cent minimum (Bjordal 1985b, 1987c).

On traditional longline gear, two types of gangion twist occur: around the gangion axis and around the mainline (Fig. 5). Compared with traditional



Gangion twist, (a) untwisted, (b&c) gangion twist, (d&e) mainline twist.

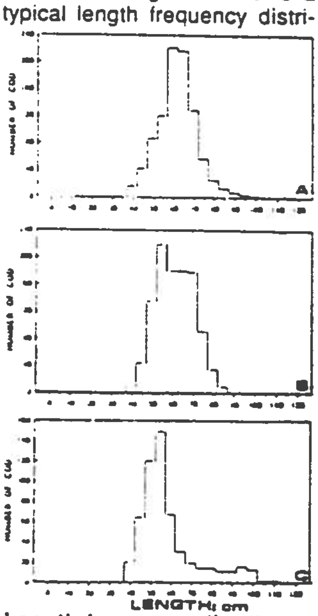
gear, both types of swivel give a significant reduction of 'gangion twist', while 'maintaining twist' is only significantly reduced by the 'two plane swivel' (Bjordal 1988).

3.5 Mainline

Several investigations have shown that the catching power of monofilament longlines is superior to that of multifilament gear (Karlsen 1976, Huse & Karlsen 1977, Hearn & Warren 1989). This might be partly explained by the lower visibility of monofilament material, but also because the monofilament absorbs little bait odour. There are also several other reasons for the high efficiency of monofilament gear. As mentioned above, swivels will partly increase the catching power of monofilament gear. Further, monofilament lines are thinner and are normally floated off the bottom. Movements by hooked fish will, therefore, more easily be transplanted to other parts of the gear, adding movement as an additional stimulant for fish attraction (Johannessen 1983).

4 Selectivity of longlines

The longline is regarded as a size-selective fishing gear. This is true to a certain extent. A longline will, however, catch fish over a fairly wide length range, but normally very few small fish. Figure 6 shows a typical length frequency distri-



Length frequency distributions of cod caught by longline off Norway in 3 different periods, A April 1987, B December 1987, and C April 1988

bution of cod caught by longline off northern Norway, where in these cases only 0.9- to 3.8 per cent of the fish are under the legal size (42cm).

What is the most important factor for size selectivity of

Cont'd on page 6