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Engineering and fish reaction aspects of longlining - A review

by

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ABSTRACT

This paper reviews works on the different aspects of longlining: Behavioural aspects including interaction between fish and gear, selectivity and survival of and damage to fish after escapement, and engineering aspects including materials, rigging, hooks, bait, selection, mechanization, energy requirements and gear competition. Present results indicate potentials for improvement in longlining, both regarding CPUE, effort, size and species selection and energy consumption.

1. INRODUCTION

A longline consists of a number of snoods (branch lines) with baited hooks, connected to a mainline at fixed intervals. It is classified as a passive or fish active gear. The catching process may be divided in 3 main stages: 1) Long distance attraction by olfactory stimuli from the bait, 2) Hooking, 3) Escapement. The combined probabilites of attraction, hooking and escapement give the total catching probability of a longline.

The catching success in longlining is highly dependent on an interplay between several methodical, physical and behavioural factors: The physiological state of the fish, migration, swimming depth, current direction/strength, competition between different species, bait (type and size), hooks (shape and dimension), snood-length, hook spacing, material of mainline and snoods, rigging, methods of operation, soak time and weather conditons.

Ideally, the longline should have high probabilities of attraction and hooking for a certain size-range of the desired species of fish - and no escapement. If this could be achieved, further increase of total catch may be obtained by increased effort, especially through mechanization of the gear handling.

2. FISH REACTION ASPECTS

2.1 Interaction fish/gear.

The latest years there has been an increasing effort in the field of fish behaviour studies in relation to longline, especially on the aspects of attraction and hooking.

Methods for testing smell response of fish in laboratory and/or field is described by WARDLE et.al (1973), SOLEMDAL et.al. (1974), TILSETH et.al. (1977), HUSE (1979a) and JOHNSTONE et.al. (1981)

Some of the authors define behaviour sequences in the attraction and hooking stages. SOLEMDAL and TILSETH found the following bait preference, from high to low, for cod (length 40-70 cm): krill, shrimp, squid, herring, capelin, mussel and mackerel. After feeding the fish on a specific type of bait, the preference for this bait increased, which show that the fish may adapt to certain smell stimuli. JOHNSTONE et.al. (1981) found a somewhat different attraction range for cod using different baits: Mackerel, squid, mussel and salted herring. This may be caused by specific smell adaption, but possibly also by difference in size distribution of the experimental fish, as shown for eel captured in baited pots (ALLEN, 1963).

Following attraction, the next stage of the catching process is the attack of the baited hook and hooking. Detailed studies of the fish behaviour in this stage are conducted by HUSE (1979) and FERNØ & HUSE (1981), with description of various behaviour patterns. The found that the attracted fish not necessarily attack the hook an bait, and if so the general hooking rate is low even after severa attacks. The attacking activity decreases with time, which is explained as an effect of experience. These results are supported by several authors (KAWAMURA et.al. 1973, BEUHEMA 1970, FERNØ et.al. 1977 and JOHNSTONE et.al. 1981). FERNØ et.al. (1981) summarize earlier results on factors influencing attraction and hooking in longline.

2.2 Selectivity.

Underwater TV observations have revealed specific behaviour for different fish species when rushing with the baited hook in the mouth: Cod rush downwards while the whiting generally show a sideways/upwards movement (SOLEMDAL, pers.comm.). The directivity of this behaviour pattern has not been studied extensively, but the preliminary observations indicate that this effect might cause the species selectivity of different hook patterns, (See sect.3.6).

Type of bait is shown to have both species and -size selective effects (see 2.1). The selective effect may be caused by adaption (similarities of stimulus character between bait and major food organisms). Size and shape of the bait is also shown to have size-selective properties (JOHANNESSEN, 1980).

2.3 Survival and damage to fish after escapement.

Information on damage and survival of fish after escapement is scarce. Fish that is caught on longline in shallow water and de-hooked to keep alive for experimental use, does not seem to have increased mortality from hooking injuries, which may indicate that the mortality of fish after escapement at fishing depth is fairly low. In deep water longlining for fish with physoclist swimbladder like cod, tusk and ling, the fish is usually damaged by swimbladder expansion during hauling. Fish that escape during hauling may therefore have low probability of survival.

3. ENGINEERING ASPECTS.

3.1 Methods of operation.

There are mainly 3 different methods of setting the longline: 1) on the bottom, 2) semipelagic (floated from bottom) and 3) pelagic.

SKUD (1978), gives a general review on the operation of halibut longline in the NE-Pacific, while BROTHERS (1975) gives a short description of the cod and halibut longlining on the east coast of Canada. SHINGU et.al. (1974) review the Japanese tuna longlining in the eastern Pacific, BJORDAL (1981b) gives a short description of the existing longline fisheries in Norway, while AGUSTSSON et.al. (1981) describe the longline gear and methods of operation in Icelandic waters.

To prevent chafing of monofilament line the Norwegian fishermen use alternate sinkers and floats to lift the line from the bottom (KARLSEN, 1976).

3.2 Materials.

In modern longlining, synthetic materials are widely used, both in mainline and snoods. Traditionally 3-strand and 2-strand twisted multifilament is used as mainline and snoods, respectively. Braided multifilament lines is also in use, but KARLSEN (1976) did not find any difference in catching performance between the two types of mainline construction.

Monofilament longline has been used for some years with great success in coastal longlining, especially in Norway and Portugal, but this material is also at the introduction stage in other longline fisheries.

In the Norwegian longlining for cod and haddock, the use of monofilament mainline and snoods has proven to give significant catch improvements. The advantage of monofilament is most pronounced in semipelagic longlining with high light level (summer), with reported catch increase close to 400%, (KARLSEN, 1976 and 1977; HUSE & KARLSEN, 1977 and HUSE, 1979a). These results are supported by similar experiments in Newfoundland (HEARN & WARREN, 1980).

In multifilament line the snoods are knotted directly to the mainline, while in monofilament line they are connected to the mainline by a swivel. HUSE & KARLSEN (1977), state that the difference of rigging contributes little to the catch improvement of monofilament line - the effect is mainly obtained by the difference of material. This effect is explained by the lower visibility and hence reduced repeeling force of the monofilament mainline.

3.3. Rigging.

There are various ways of rigging longline for different fisheries, especially on variables like snoodlength, hook spacing and connection of snoods to mainline. Swivel-connected snoods seems to be beneficial. HUSE & KARLSEN (1977) indicate that the swivel have some impact on improved catch rates for monofilament line, but the main benefit of the swivels is elimination of snood entanglements which reduce the labour of gear handling.

KARLSEN (1976 & 1977) showed that decreased snood length gave significantly decrease of catchrates, while HUSE (1979a) found that the catchrate increased, using longer snoods on monofilament line. Shortening of the snoods by entangling (twisting around mainline) also give reduced catchrates (PARK, 1976). The reduced catchrate with short snoods is explained by increased repellant force from the mainline, as the baited hook gets closer, and higher escapement (from the assumption that the fish more easlity will break loose from or twist off the hook on a shorter and less flexible snood).

In longlining it would be desireable to increase the hook spacing with decreased fish density. Increased hook spacing has been shown to give a relative increase of catchrates, (KARLSEN, 1976; HAMLEY & SKUD, 1978). However, increased hook spacing usually give a decreased effort (number of hooks hauled pr. unit time), so the total catch may decrease. The question of hook spacing must therefore be a judgement of effort, cost of bait and fish density. In most existing longline fisheries, except where clip on snoods are used, the change of hook spacing according to fish density would involve too many problems on the gear rigging. However, the establishment of an average optimum hook spacing in various longline fisheries should be considered.

3.4 Hooks - effect on catchrate.

Through laboratory studies and field observations with underwater TV camera, several authors have found that the hooking rate of normal longline hooks is low. Based on the number of attacks on the baited hook, FERNØ et.al. (1977) observed the actual hooking frequency for whiting to range from 3 to 12 %, while JOHNSTONE et.al. (1981) reports hooking a frequency of 14% for cod, with escapement frequency as high as 60%.

That the bait frequently is stolen is another fact that demonstrates the low effectivity of normal fish hooks (PARK, 1979). This phenomenon is also observed in Norwegian longlining, as hooked fish often have several pieces of bait in the stomach.

These results show that there is a potential of improvement of the standard hook designs, to increase the hooking rate and lower the escapement. BJORDAL (1981a) discuss the effect of hook shape and dimensions on longline catchrates, based on recent results and previous investigations (AASEN, 1965; FOSTER, 1973; HAMRE, 1968; HUSE 1979b and KARLSEN, 1976). Several experimental hook designs tested, gave significant catch improvements, some as high as 50-60%.

3.5 Bait.

The importance of a good bait for attraction of the fish and acceptance of the baited hook was discussed in Sect. 2, and it is clear that the bait is a vital component of the longline gear. Only natural baits are used in longline fishing and traditionally these are species that are valuable for human consuption, like herring, mackerel, sardines, saury, horse-mackerel, squid, shrimp and mussels. Both the increasing cost of the bait and the fact that several thousand metric tons of bait that is suitable for human consumption are used annually (around 15000 MT of mackerel is used in the Norwegian longlining only) have originated research on alternative artificial baits. SUTTERLIN et.al. (1981) discuss the bait problem in modern longlining, describes the desired properties of a good natural bait and review the works on development of artificial baits. The paper also includes an extensive bibliography on the bait aspects of longlining.

3.6 Selection.

Longline is considered to be a selective fishing gear. The hook-design is probably the most important selective part of the gear, but the bait and material of mainline/snood contributes to the selection process.

Size selection

Selection curves for longline- and trawlcaught cod and haddock are given by McCRACKEN (1963). Trials with different hook sizes clearly show the importance of hook size for size selection in longlining, as the small hooks catch a higher proportion of small fish. A similar study is done by SÆTERSDAL (1963). This effect may be explained by feeding ecology: The big hooks (and bait) are above the normal size of the prey eaten by the small fish. Or, if the small fish actually attack the big hook and make a rush it will not fasten as well as a big fish that is able to produce a greater pulling force. This assumption is based on the studies by ONSHIMA (1953), that found a proportional relationship between the pullforce of a hooked fish and its bodyweight.

FRENCH (1969) compared the performance of purse seine, gill net and longline in the Pacific salmon fishery: "In summary there is little difference between the age and species composition of salmon caught by gill nets and purse seines, but longlines are selective for older sockeye and chum salmon".

Species selection

By testing experimental hook patterns against standard hooks, several authors have shown that the hook shape is important in species selection (HUSE, 1979a,b; KARLSEN, 1976; BJORDAL, 1981a and FOSTER, 1973). The reasons are not clear, but the results show that specific hook designs can improve the species selection in longlining.

The influence of a bait on species selection is demonstrated by IMAI (1972) and JOHNSTONE et.al. (1981). Different bait types gave clear differences in catchrate for different species.

Testing monofilament line against multifilament for cod and haddock (HUSE & KARLSEN, 1977 and HUSE 1979a) found much higher catch increase on the monofilament line for cod than for haddock, which indicate a species selection due to the line material, (cod being more sensible to the repelling force of mainline than haddock).

3.7 Mechanization of gear handling.

Compared to most other gear types the handling of longline gear is relatively labourous and time consuming. Mechanical or hydraulic haulers are now widely used to haul the gear, but the following operations are still done manually in most longline fisheries: de-hooking of fish, twist-removal of snoods, removal of bait residue from hooks, baitcutting, rebaiting and recoiling the line, handling of line units (baskets, tubs) onboard/ashore.

Through the last 10-15 years, different systems are developed to eliminate most of the manual gear handling, including: hook cleaners, twist removers, splitting machines (catch the hooks and guide it on to magazine racks) and baiting machines.

The main characteristics of different handling systems are given in Table 1.

The existing systems are based on two main ways of line storage (magazine-racks and drums) and two main ways of baiting (random and precise). Magazine-racks: The hooks are stored on racks, with snoods and mainline hanging freely underneath. This way of storing may cause entanglements during setting, but has the advantage that the line can be inspected and maintained when stored. Drum storage: In the Marco TiLiner and NN(10) and NN(11) systems both hooks, snoods and mainline are stored on drums, while for the Mustad Miniline, Autoclip and Delta systems, only the mainline is stored on drums. The hooks/snoods are automatically detached and attached to the mainline during hauling and setting. Random baiting: During setting the hooks and line are drawn through a container of precut bait. This way of baiting seems to work satisfactory, especially with bait of uniform consistence like squid. Precise baiting: During setting the hook is drawn through the baiting unit, where the hook is orientated and the bait is precisely positioned on the hook.

3.8 Energy requirements:

With the raising fuel prices, fuel saving has become important in all fisheries. Among several areas of fuel saving ENDAL (1980), mentions: Choise of fishing method and improved fishing gear. To exploit a certain fish-species it is therefore of importance to choose the present gear of lowest fuel consumption pr. unit catch. One should also bear in mind to choose the gear that have the greatest fuel consumption potentials, through gear, vessel and strategic improvements.

ENDAL (1979, 1980) give the fuel consumption ratios (kg fuel/kg fish) for different gear types in Norway, and shows that longline has relatively low ratios (0.18 - 0.30 kg fuel/kg fish) compared to (0.6 - 1 kg fuel/kg fish) for bottom trawling.

AUGUSTSSON and RAGNARSSON (1980) give fuel consumption values for the different stages of the fishing operation in trawling, purse seining, gill netting and other gear types in the Icelandic fishery.

4. COMPETITION WITH OTHER FISHING METHODS.

The trends in modern fisheries policy and -economics, lead to a strategy that will favour types of fishing gear that give maximum catch pr. unit effort (and unit energy consumption) of high quality fish of the right size and species.

In the tuna fisheries, purse seine is the main competing gear to longline, while in the fisheries for groundfish, gill net and bottom trawling are the main competitors.

SUTTERLIN et.al. (1981) mention several reasons why passive gears and especially longlining is preferable to trawling: Lower energy costs, gear effectiveness less dependant of bottom topography, catch quality often superior, no ghost fishing and greater size- and species selectivity.

We may also expect that longline has a relative great potential for improvements compared to gears like gill nets and trawls:
1). Increased effort: By further mechanization
2. Increased CPUE: By new hook designs, bait and line materials.

5. RECENT AND PLANNED RESEARCH AND DEVELOPMENT ACTIVITES

In general it seems to be a growing interest for longline fishing. The research on gear parameters will be continued and intensified for further improvements of selection and hooking performance. The development activites on mechanized gear handling is extensive, especially on systems at relatively low cost both for vessel- and shorebaiting. In future longlining there will be a growing demand for adequate bait and the important research on the development of artificial bait will be continued.

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Table 1 - Different mechanichal longlining systems - Main characteristics

	System		Hook cleaner	Twist Rem.	Splitting	Storage (Magazines)	Baiting	State of development No of units in operation in parenth.	Reference
CANADA	Gillbaiter (Jennex)	1	Autom.	Manual	Manual	Racks	Random	In operation (not known)	
	Burry baiter	2	"	"	"	"	"	" "	
	Simplex longl.syst.	3	"	"	"	"	"	" "	
	Colwell " "	4	"	"	"	"	"	" "	
GB	Autoclip	5	"	(5)	"	Rack/Drum	Precise	Devel.compl/not in operat.	(Hopper 1979 Moore 1979, Anon 1980 a)
IRELAND	MFC Speedoline	6	"	Autom.	"	Racks	Random	In operation (2 +)	(Anon 1980 c)
NORWAY	Mustad Autoline	7	"	"	"	"	Precise	In operation (100 +)	(Anon 1980 a)
	Mustad Miniline	8	"	(8)	(8)	Drum	Precise	Developm.compl/not in operat.)	(Anon 1979 b)
	Java longline syst.	9	"	Autom.	Autom.	Racks	Precise	In operation (1)	
	N.N. 10	10	"	Manual	Manual	Drums	Manual	Under developm.	
	N.N. 11	11	"		Autom.	Drums		Under developm.	
USA	Alaskan longl.syst.	12	"	"	Manual	Racks	Random	In operation (60 +)	
	Marco Ti-liner	13	"	"	"	Drums	"	In operation (25 +)	(Anon 1980 a)
	Delta	14		(14)	(14)	Rack/drum	Precise	Under development	