

Review and evaluation of three mitigation measures - bird-scaring line, underwater setting and line shooter - to reduce seabird bycatch in the Norwegian longline fishery

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Seabirds scavenge baits from the hooks of commercial longlines, resulting in incidental seabird mortality and bait loss. As interactions between seabirds and longline fishing may cause decline in seabird populations and reduced gear efficiency, the potential for solving this problem by means of various mitigation measures has been tested. Four fishing experiments were conducted in commercial longlining in the north Atlantic to investigate the effectiveness of a bird-scaring line, underwater setting and a line shooter in reducing seabird bycatch during longline setting. These results are reviewed and the performance of the mitigation measures is evaluated. Accidental catches of birds were reduced by all three methods, most clearly by the bird-scaring line that had an efficiency of 98-100%. The experiments also produced a reduction in bait loss and raised the catch rates of target species, which are important incentives for fishermen to employ mitigation measures.

Introduction

Seabirds are accidentally killed in longline fishing (Brothers, 1991; Cherel et al., 1996; Kalmer et al., 1996; Weimerskirch et al., 1997; Løkkeborg, 1998). During setting, they take baits from hooks floating on or near the surface and birds are occasionally caught. The solution of this problem would make longlining a wholly environmentally friendly fishing method as the operation of longline gear has no destructive effect on bottom habitats, vessel fuel consumption is low and ghost fishing or marine mammal bycatch are not regarded as problems. Incidental bycatch of seabirds in longlining is a twofold problem as it also reduces gear efficiency due to the associated bait loss, and a solution to the problem is thus likely to raise fish catches.

Several mitigation measures capable of reducing the likelihood of seabird bycatches have been described (Brothers et al., 1999). In addition to being efficient, a mitigation measure should be practical and easy to implement in commercial fishing. The greatest potential for solving this problem in the north Atlantic fisheries thus lies in modifications that either make the baited hooks less available to seabirds or devices that deter birds from taking baits (Løkkeborg, 2000).

In the north Atlantic, interactions between seabirds and longline fisheries are regarded merely as a problem for longline efficiency as the species mainly caught, the northern fulmar (*Fulmarus glacialis*), shows no sign of population decline (Lloyd et al., 1991; Løkkeborg, 1998). Four fishing experiments have been conducted in commercial longlining in this region to investigate the effectiveness of mitigation measures that fulfil the requirement of practical applicability (Løkkeborg and Bjordal, 1992; Løkkeborg, 1998; 2000; Løkkeborg and Robertson, in prep.). These were a bird-scaring line to deter birds from the area where the baited hooks emerge in the water, an underwater setting funnel to guide the lines down to a certain depth and a line shooter to set lines with slack (no tension) to increase the sink rate. Here, I review these results and evaluate the performance of the mitigation measures on the basis of their effectiveness in reducing seabird bycatch and bait loss and increasing target fish catches.

Methods

The four experiments were conducted on commercial longliners operating on fishing grounds off the coast of Norway (Table 1). The vessels were equipped with the Mustad autoline system, and used 7 or 9 mm longlines rigged with EZ-baiter hooks and baited with a combination of mackerel and squid baits.

The bird-scaring line was deployed astern during line setting and had floats (gillnet float rings or a punctured buoy) attached to its after end. Twelve 8 cm-wide streamers of yellow tarpaulin were attached at intervals of 5.0 – 5.5 m and increasing in length from 0.5 m at the free end to 3.0 m at the end secured to the stern of the vessel (Fig. 1). The setting funnel tested was designed to set lines underwater so that the baited hooks first emerge in the water out of sight of seabirds (see Fig. 1 in Løkkeborg, 1998). It guided the lines down to about 1 m beneath the surface, the exact depth being dependent on the pitch angle of the vessel. A line shooter is designed to set lines at a speed slightly faster than the vessel's speed during setting. It is placed behind the baiting machine, and ensures that the line is set slack (no tension) into the water.

Each day during the experiments, one fleet of longlines was set using each of the mitigation measures tested. Another fleet of longlines was set as a control without using any mitigation measure. The fleets were set in the morning and retrieved during the day and night, as is typical of this commercial fishery. Most of the lines were set in daylight. During hauling, the numbers of marketable species and seabirds caught were counted for each fleet of longlines.

Bait loss due to seabirds was determined by setting lines without anchors and retrieving them immediately in order to prevent fish and scavengers at the seabed from taking baits. Lines baited with both mackerel and squid were set, and lost baits were counted during retrieval. This test was also carried out on control lines set without any mitigation measure and for lines using the measures tested. Details of the experimental procedure and statistical testing of results have been described in the following publications: Løkkeborg and Bjordal, 1992; Løkkeborg, 1998; 2000; Løkkeborg and Robertson, in prep.

Results

There were significant differences in the numbers of seabirds caught using the various setting methods in all experiments (Table 2). The bycatch of seabirds was reduced by all the mitigation measures tested, most definitely with the bird-scaring line. Seabird catch rates (number of birds per 1000 hooks) ranged from 0.55 to 1.75 for the control lines and from 0 to 0.49 for the lines set when one of the measures was employed. The great majority of the birds caught were northern fulmars.

All the experiments also produced significant differences in bait loss using the various setting methods (Table 3). Fewer baits were lost when lines were set using the bird-scaring line than with the control and the other two mitigation measures. Bait losses for lines set through the setting funnel increased in Cruise no. 2, but decreased in Cruise no. 3.

The catch rates of target species were higher with lines that were set using one of the mitigation measures than with those set without any measure (Table 4). However, the difference in catch rates were significant only in Cruise no. 3 where lines set with the bird-scaring line gave a 32% catch increase compared with the control. The catches consisted mainly of torsk (*Brosme brosme*), but ling (*Molva molva*) and haddock (*Melanogrammus aeglefinus*) were also taken.

Discussion

The problem of incidental bycatch of seabirds in longline fishing should be solved by mitigation measures that are effective in preventing birds from taking baits and that can be implemented in commercial fishing without causing restrictions in or practical problems to fishing operations. In addition, there should be incentives for fishermen to employ such mitigation measures, otherwise compulsory measures will have to be enforced. Various mitigation measures are capable of reducing interactions between seabirds and longline fishing (see Brothers et al., 1999), but they do not all fulfil the above requirements.

Fishing area or seasonal closures and limiting line setting to nighttime, which have been proposed in other regions, are less acceptable to fishermen operating in the north Atlantic as

such restrictions affect profitability. Area and seasonal closures may exclude vessels from operating at attractive fishing grounds. Although studies on feeding activity rhythms have shown that longlines set at or before dawn increase catch rates (see Løkkeborg et al., 1989; Løkkeborg and Pina, 1997; Løkkeborg and Fernö, 1999), line setting at night (in darkness) is impossible during the polar summer. Discarding fish offal during line setting in order to lure birds away from the baited hooks has been shown to reduce greatly the incidental capture of seabirds in the longline fishery in Kerguelen waters (Cherel et al., 1996), but this method is not possible in the north Atlantic where lines may be set continuously for several hours. Weighting the lines to increase the sink rate is a suitable method in manual longlining, but involves practical complications in mechanized longlining. Furthermore, when fishing in deep waters and rough weather, lines are more easily broken if they are weighted. Dyeing the bait to make it less visible has reduced bird interaction (i.e. number of contacts) by about 90% (Boggs, 2000). However, in mechanized longlining the baits are cut during setting, and this approach is therefore feasible only for artificial baits that can be dyed during manufacture. Mitigation measures such as acoustic deterrents, water cannon and magnetic deterrents have not been effective due to habituation or short range (Brothers et al., 1999).

The results reviewed in this paper demonstrate that bird-scaring lines, underwater setting and line shooters are all capable of reducing incidental catches of seabirds in the north Atlantic longline fishery. Seabird catch rates ranged from 0 to 0.49 birds per 1000 hooks for the mitigation measures tested, compared with 0.55 to 1.75 when no measures were employed. The bird-scaring line almost eliminated seabird catches that were reduced by 98 – 100% for lines set using this device. A bird-scaring line with narrowly spaced streamers works as both a visual and physical deterrent that hits birds as they approach the baited line, and a decrease in efficiency due to habituation is therefore unlikely (Løkkeborg, 2000). The results reviewed showed that the bird-scaring line was still efficient at the end of a 12-day period. This mitigation measure is acceptable to fishermen, and it is likely that it can be successfully implemented in the north Atlantic fishery as fishermen in this region frequently use bird-scaring lines without streamers. Furthermore, large increases in catch rates were observed even under conditions of relatively low bait loss due to seabirds compared to the 70% bait loss documented by Løkkeborg and Bjordal (1992). This potential for increased catches and profit is an incentive for fishermen to employ seabird mitigation measures, which is of particular importance for a region where the seabird mainly caught has undergone massive increases of range and number rather than declining (Lloyd et al., 1991; Løkkeborg, 2000).

The underwater setting funnel reduced seabird bycatch by 72% and 92% in Cruises nos. 2 and 3, respectively. Different pitch angles due to the loading of the vessel are the most likely explanation for this difference (Løkkeborg, 2000). Cruise no. 3 was conducted when the vessel was unloaded (i.e. during the early part of a trip) and the funnel was at its maximum depth, whereas Cruise no. 2 was conducted during the last part of a trip when the freezing room (midships/forward) was filled with catch and lines set through the funnel emerged closer to the surface. In this condition, the vessel's wake and the turbulence created by the propeller may bring the baited hooks to the surface. It is thus likely that this measure could be improved by using a funnel whose length can be adjusted with changes in the pitch angle. The performance of the setting funnel can be further improved as my results indicated that some baits are thrown off the hooks as they pass through the funnel (Løkkeborg, 1998; 2000; Table 3). This mitigation measure is practical in use, and of all known measures, underwater setting is the only with the potential to avoid incidental catch of seabirds (Brothers et al., 1999).

Seabird bycatch was reduced by 59% for lines set with the line shooter. This device does not seem to be as efficient as the bird-scaring line or the setting funnel in reducing seabird bycatch. The line shooter is believed to increase the longline sink rate and thereby make the baits less accessible to seabirds. However, the results indicate that birds were still able to take baits. The simultaneous use of weighted lines is one possible way of improving the efficiency of the line shooter, and it is likely that less weight would be needed when the lines are set slack with no tension.

The development of responsible fishing methods through the reduction or elimination of the effects on the ecosystem of current fishing operations has become an important topic.

Although the species mainly caught in the north Atlantic longline fisheries has undergone massive increases of range and number, and these fisheries do not seem to be the cause of declines in seabird populations, efforts should be made to solve the seabird bycatch problem for this region too. The solution of the problem would make longlining a wholly environmentally friendly fishing method. On the basis of our current knowledge, this review has documented that of all known mitigation measures, the bird-scaring line is the most feasible and effective one.

References

- Boggs, C.H. 2000. Deterring albatross from taking baits during swordfish longline sets. In: Proceeding of the Pacific Seabird Group Symposium: Seabird Bycatch: Trends, Roadblocks and Solutions. In press.
- Brothers, N. 1991. Albatross mortality and associated bait loss in Japanese longline fishery in the Southern Ocean. *Biol. Cons.* 55: 255-268.
- Brothers, N.P., J. Cooper and S. Løkkeborg. 1999. The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO Fisheries Circular No. 937. FAO, Rome. 100 pp.
- Cherel, Y., H. Weimerskirch and G. Duhamel. 1996. Interaction between longline vessels and seabirds in Kerguelen waters and a method to reduce seabird mortality. *Biol. Cons.* 75: 63-70.
- Kalmer, A.K., R.B. Fujita and C.F. Wurster. 1996. Seabird bycatch in longline fisheries. *Pacific Seabirds* 23(2): 3-6.
- Lloyd, C., M.L. Tasker and K. Partridge. 1991. The status of seabirds in Britain and Ireland. T. and A.D. Poyser, London.
- Løkkeborg, S. 1998. Seabird by-catch and bait loss in long-lining using different setting methods. *ICES J. Mar. Sci.* 55: 145-149.
- Løkkeborg, S. 2000. Reducing seabird bycatch in longline fisheries by means of bird-scaring lines and underwater setting. In: Proceeding of the Pacific Seabird Group Symposium: Seabird Bycatch: Trends, Roadblocks and Solutions. In press.
- Løkkeborg, S. and Å. Bjordal. 1992. Reduced bait loss and bycatch of seabirds in longlining by using a seabird scarer. Document to Working Group FSA-92 CCAMLR, Hobart, Australia. 5 pp.
- Løkkeborg, S., Å. Bjordal and A. Fernö. 1989. Responses of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) to baited hooks in the natural environment. *Can. J. Fish. Aqua. Sci.* 46: 1478-1483.
- Løkkeborg, S. and T. Pina. 1997. Effects of setting time setting direction and soak time on longline catch rates. *Fish. Res.* 32: 213-222.
- Løkkeborg, S. and A. Fernö. 1999. Diel activity pattern and food search behaviour in cod, *Gadus morhua*. *Env. Biol. Fish.* 54: 345-353.

Weimerskirch, H., N.P. Brothers and P. Jouventin. 1997. Population dynamics of Wandering Albatross *Diomedea exulans* and the Amsterdam Albatross *D. amsterdamensis* in the Indian Ocean and their relationships with long-line fisheries: conservation implications. *Biol. Cons.* 79:257-270.

Table 1. Periods and areas of longline fishing experiments conducted to test various mitigation measures to reduced incidental catch of seabirds.

Cruise no.	Period	Area	Mitigation measures tested	No. hooks set
1	17 May, 1992	Barents Sea	Bird-scaring line	812*
2	9 – 22 May, 1996	Mid-Norway	Bird-scaring line, setting funnel	56 700
3	13 – 24 Aug., 1998	Mid-Norway	Bird-scaring line, setting funnel	70 200
4	10 – 20 Aug., 1999	Mid-Norway	Bird-scaring line, line shooter	58 420

*Only bait loss due to seabirds was recorded in this experiment.

Table 2. Numbers and catch rates (number per 1000 hooks in parentheses) of seabirds caught by longlines set with no mitigation measure, bird-scaring line, setting funnel and line shooter. For details of individual cruises see table 1.

Mitigation measure	Cruise no. 2	Cruise no. 3	Cruise no. 4
No measure	99 (1.75)	74 (1.06)	32 (0.55)
Bird-scaring line	2 (0.04)	0 (0.00)	0 (0.00)
Setting funnel	28 (0.49)	6 (0.08)	*
Line shooter	*	*	13 (0.22)

*Not tested.

Table 3. Bait losses (percentage of hooks without bait) of mackerel and squid bait for longlines set with no mitigation measure, bird-scaring line, setting funnel and line shooter.

Mitigation measure	Cruise no.1		Cruise no.2		Cruise no. 3		Cruise no.4	
	Mackerel	Squid	Mackerel	Squid	Mackerel	Squid	Mackerel	Squid
No measure	69.9	18.2	19.5	21.1	30.9	22.5	14.5	1.6
Bird-scaring line	26.3	13.0	13.1	17.2	15.2	15.6	2.1	0.9
Setting funnel	*	*	22.7	26.0	26.6	16.7	*	*
Line shooter	*	*	*	*	*	*	12.7	3.7

*Not tested.

Table 4. Total catches of target fish species for longlines set with no mitigation measure, bird-scaring line, setting funnel and line shooter. The catches are given in number in Cruise nos. 3 and 4, and in kg in Cruise no. 2.

Mitigation measure	Cruise no. 2	Cruise no. 3	Cruise no. 4
No measure	4895	5434	2461
Bird-scaring line	5549	7173	2805
Setting funnel	5218	6360	*
Line shooter	*	*	2712

*Not tested.

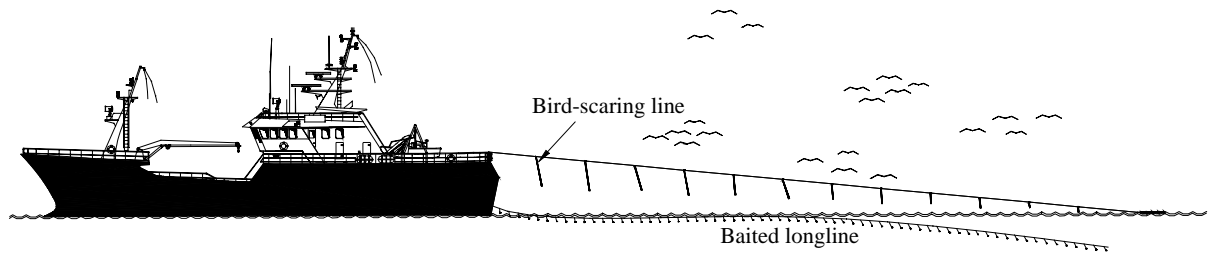


Figure 1. The bird-scaring line. (Redrawn after Løkkeborg, 1998.)