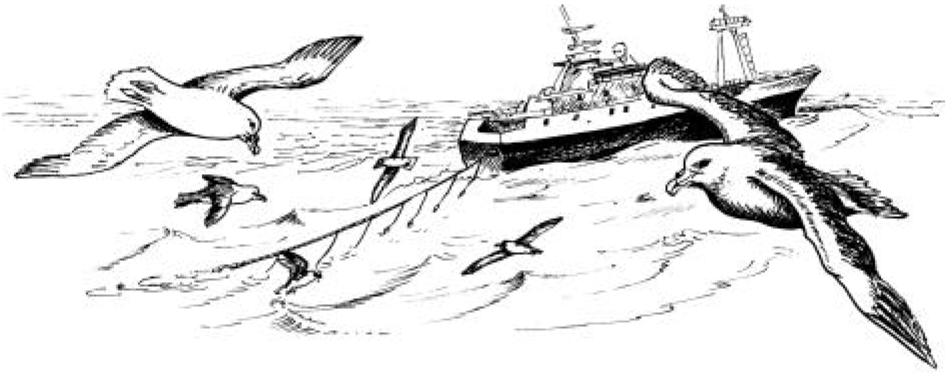

The impact of longline fishing on seabirds in the north-east Atlantic: recommendations for reducing mortality

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Illustration (this page) by Euan Dunn (RSPB)

Contents

Preface and Acknowledgements

This is a joint project between the UK's Royal Society for the Protection of Birds (RSPB), Norwegian Ornithological Society (NOF), both of which are partners of BirdLife International, and the UK's Joint Nature Conservation Committee (JNCC). The nominated officers are: for RSPB, Dr Euan Dunn, Senior Marine Policy Officer; for NOF, Dr Christian Steel; for JNCC, Mark Tasker, Head of Marine Advice. The RSPB is the leading partner in the study and is responsible for the project's initiation, overall supervision, and core funding. Apart from helping to fund the study, JNCC provided marine expertise and training. NOF have shared with RSPB the mainstay of the project's administration and planning, have provided personnel for the fieldwork as well as making all the operational arrangements in Norway, notably with the Norwegian longlining industry.

In this regard, the Norwegian longlining gear company 'Mustad' (particularly Terje Duklæt, sales manager) has given invaluable assistance in arranging access to longliners willing to participate in this study, and generally for emphasising the positive aspects of this study to the fishing industry. We acknowledge the co-operation and assistance given by the vessel owners and their skippers (Noralf Gjerset, Svein Ove Myrbø, Willy Nyvoll, Endre Søviknes and Jan Einar Søviknes) for permitting access to our two NOF observers, Terje Lislevand and Per Inge Værnesbranden who showed great commitment and skill in their work. These observers provided the information on which the Results section of this report is based. We are also grateful to the longliner crews for making the observers' stay on board such a pleasant and rewarding experience (for details of crews, 1997, see Appendix 2).

Andy Webb (Seabirds at Sea Team, JNCC) kindly provided training in counting seabirds at sea for our two observers. We are grateful to Mr Dag Romslo, managing Director of Color Line Ferries, for facilitating access to the bridge for this training exercise on the Bergen-Newcastle Ferry, and Capt Berger for his co-operation on board. We thank Canon (UK) Ltd, and particularly Anthony Sherreck, for providing us with 2 pairs of Canon 10x30 IS binoculars for field testing by observers on board the longliners. We are grateful to Ingvar Byrkjedal, curator of the Zoological Museum in Bergen (Norway), for kindly agreeing to store and analyse seabird corpses collected as by-catch.

For RSPB, the Conservation Science Department played a central role in designing the field sampling methodology. For valuable discussions in the preparatory stages, we are also indebted to the advice and generous encouragement given by Svein Løkkeborg (Institute of Marine Research, Bergen, Norway) who pioneered the study of underwater setting as a device to mitigate bait loss in longlining, and without whose experience this project would have been difficult; for valuable help and discussions, we also thank Åsmund Bjordal of that same Institute, Arne Farstad ('Marintech', University of Trondheim), Dr John Croxall (British Antarctic Survey), Christopher Chevasse, Janice Molloy (Dept of Conservation, New Zealand), Sandy Bartle (Dominion Museum, NZ), Dr John Cooper and Peter Ryan (both University of Cape Town), Graham Robertson (Australian Antarctic Division) and Ed Melvin (Washington Sea Grant Program), Berger Olsen (Faeroes) and Jákup Reinert, Head of Fisheries Dept, Faeroes.

English summary

This report describes an on-board observer study of the seabird bycatch taken by Norwegian offshore longline fishing vessels in the Norwegian Sea in 1997 and 1998. By establishing by-catch rates and extrapolating to the known fishing effort, we estimate that overall the Norwegian fleet takes a significant by-catch of northern fulmar *Fulmarus glacialis*, as must also the longlining fleets of Iceland and the Faeroes in their regional waters.

The total Norwegian longlining fleet (including the inshore fleet of smaller vessels) is conservatively estimated to take ca. 20,000 northern fulmars annually, but the actual total may easily be 50,000-100,000. The combined activities of the Norwegian, Icelandic and Faeroese longlining fleets are conservatively estimated to take a by-catch of 50,000-100,000 northern fulmars annually, but the true figure could be significantly higher (depending, e.g., on the deployment of mitigating measures).

While northern fulmars are caught in significant numbers by longlining, the estimated annual mortality is not thought to be status-threatening given that the north-east Atlantic breeding population of northern fulmars is ca. 2-4 million pairs, and the overall population much higher when non-breeding adults and immatures are included.

Nevertheless, the application of some simple technical devices and procedures could easily minimise this needless incidental mortality of seabirds. The fieldwork included an evaluation of the mitigating measures used by the Norwegian fleet, including an underwater setting tube and streamer lines. This assessment leads to recommendations for improvements in longlining gear and practices that would substantially reduce seabird by-catch, thereby also reducing bait loss and improving fishing efficiency.

The study was carried out to give impetus to the development and implementation of FAO National Plans of Action (NPOAs) for Reducing Incidental Catch of Seabirds in Longline Fisheries. The report makes recommendations for the content of the NPOA that Norway is currently undertaking, and presents evidence that Iceland and the Faeroes also need to undertake a NPOA.

Norwegian summary

Denne rapporten beskriver et feltstudium av bifangst av fugler i norske havgående linefiskefartøy i Norskehavet i 1997 og 1998, der observatører var ombord i ordinære fartøy. Ved å etablere bifangstrater og ekstrapolere til den kjente fiskeinnsatsen, estimerer vi at den totale norske flåten tar en betydelig bifangst av havhest Fulmarus glacialis, noe også de islandske og færøyske linefiskeflåtene må gjøre i sine regionale farvann.

Den totale norske linefiskeflåten (inklusive kystflåten med mindre båter) er konservativt estimert til å ta omkring 20.000 havhester årlig, men totalen kan godt være 50.000-100.000. Den kombinerte innsatsen til de norske, islandske og færøyske linefiskeflåtene er konservativt estimert til å ta en bifangst på 50.000-100.000 havhester årlig, men det faktiske antallet kan være betydelig høyere (avhengig blant annet av bruken av avbøtende tiltak).

Selv om det fanges betydelige antall havhest ved linefiske, er den estimerte årlige dødeligheten ikke antatt å true artens status, i og med at den nordøst-atlantiske hekkepopulasjonen av havhest er 2-4 millioner par, og den totale populasjonen er mye høyere når ikke-hekkende voksne og ungfugler tas med.

Ikke desto mindre kunne bruk av noen enkle tekniske hjelpemidler og prosedyrer enkelt minimere denne unødvendige dødeligheten hos sjøfugler. Feltarbeidet inbefatter en evaluering av avbøtende tiltak i bruk i den norske flåten, inklusive et undervanns setterør og skremmeliner. Denne vurderingen leder til anbefalinger for å forbedre linefiskeutstyret og arbeidsmåtene, noe som i betydelig grad ville redusere bifangsten av sjøfugler og dermed også redusere agntap og forbedre effektiviteten i fisket.

Studiet ble gjennomført for å sette fart i utarbeiding og iverksetting av FAOs nasjonale handlingsplaner (NPOAs) for å redusere uønsket fangst av sjøfugler i linefiske. Denne rapporten gir anbefalinger for innholdet i en NPOA som Norge i øyeblikket arbeider med, og presenterer opplysninger som viser at også Island og Færøyene trenger en NPOA.

Conclusions and Recommendations

The main findings from Part 1 (1997) and Part 2 (1998) of this study are as follows:

Longlining impact of the Norwegian demersal autolining fleet in the Norwegian Sea

1 Seabird by-catch appears to be low in autumn-winter, higher in spring-summer.

2 Virtually all (> 99%) of the seabird by-catch in this and related studies was of fulmars. They were caught mainly during line-setting, with occasional captures during line-hauling.

3 The findings for other species in this study were as follows:
- Large gulls (*Larus*) are exceptionally caught.
- Kittiwakes showed no interest in the baited hooks (though S. Løkkeborg says they can be adept at stealing bait without getting caught).
- Skuas (all four species) were attracted to the vicinity of longlines, but mainly to cleptoparasitise gulls rather than to snatch bait from hooks. While no skuas were taken as by-catch in this study, great skuas feature in the by-catch of the Icelandic longlining fleet.
- Gannets plunge-dived near the line during setting but were never caught.

4 Counts of fulmars flying behind the vessel were significantly and positively correlated with numbers of fulmars bait-snatching on the surface. Higher fulmar densities therefore probably promote higher bait-snatching intensity.

5 Fulmar by-catch rate tended to be positively correlated with counts of fulmars flying behind the vessel, but the relationship was not statistically significant.

6 Most (71%, n=21) of the fulmars caught (Part 2 of the study) were foul-hooked (i.e. snared on parts of the body other than the bill), adding to observational evidence that most birds were caught while scavenging loose offal in the vessel's wake, rather than when trying to snatch bait directly from hooks.

7 Two conclusions follow from (6), namely that (i) fulmar by-catch rate does not equate simply to rate of bait loss (this relationship is further weakened by the fact that fulmars are good at snatching bait from hooks without getting caught: S. Løkkeborg, pers. comm.), and (ii) discharge of offal during line-setting evidently attracts fulmars and thus facilitates birds getting hooked.

8 The two vessels under study used a variety of mitigating measures, namely underwater setting (on one), streamer line, sounding the ship's horn, and shooting.

9 Shooting (with shotgun) was usually in the air but sometimes directly at birds when bird density was especially high, causing some fatalities. One skipper believed that such shooting, as a deterrent practice, is widespread in the Norwegian offshore fleet.

10 Although not quantified, the observer (in 1998) found that the streamer line definitely affected the birds' behaviour by keeping them away from the area immediately behind the vessel where the setting line was entering the water, instead forcing them to scavenge further behind the vessel than when the streamer line was not deployed.

11 The skipper's experience was that the Mustad underwater setting tube was an effective mitigating measure, comparable in effect with - but probably not better than - the streamer line in mitigating by-catch.

12 Fulmar by-catch rates (birds per 1000 hooks) in relation to applying the various technical mitigating measures (streamer line only, tube only, streamer line plus tube) were as follows:

October 1997	: 0.03-0.04 (streamer line)
	: 0.01 (tube)
June 1998	: 0.18 (streamer + tube)
	: 0 (streamer line)

These by-catch rates indicate that: (i) the use of the tube did not eliminate seabird by-catch, (ii) (at least in 1998), the streamer line may have been more effective than the tube in mitigating by-catch, although daily by-catch rate was too variable to prove this.

13 Løkkeborg's (1999) study indicated that the Mustad underwater setting tube and streamer line each (as stand-alone measures) greatly reduce seabird by-catch but that the streamer line was the more effective of the two mitigating measures.

14 The evidence from the present study does not support the view that the Mustad underwater setting tube performs better than the streamer line. This is consistent with the possibility that, as Løkkeborg found, the streamer line may actually be the more effective of the two measures, at least under certain conditions in this fishery.

15 On this basis, the current underwater setting tube does not represent the most practicable way forward for the longline industry in the north-east Atlantic, and while it may be improved with development, pragmatism suggests other and better solutions to reducing seabird by-catch in the short term for existing longline vessels in this fishery.

16 A review of mitigating measures elsewhere suggests that a combination of an approved streamer line (preferably paired) and line-weighting offer the best prospect of reducing seabird by-catch to acceptable levels in existing vessels in this fishery. This is not to say that underwater setting tubes do not confer benefits in other fisheries (cf Study of Mustad tube in South African waters).

17 With a view to the seabird-friendly longliner of the future, however, Norway should take a lead in developing longline vessels and gear with a view to integrating mitigating measures, and especially underwater setting, into the hull design and construction so as to prevent the propellor wash bringing the line to the surface.

18 The seasonal distribution of fish catches by the Norwegian offshore longlining fleet (61 vessels) shows that 71% of the catch is taken in Oct-May compared with only 29% in summer.

19 Estimates of by-catch by the Nordic fleets are hampered by lack of data, notably on (i) observations of seabird by-catch in longlining operations; (ii) fishing effort and risk to fulmars by the substantial Norwegian fleet sector which operates closer inshore than the large autolining fleet (iii) fishing effort of, respectively, the Icelandic and Faeroese fleets; (iv) mitigation measures deployed by all fleets other than offshore Norwegian longliners.

20 Based on the seasonal by-catch rates from this and other studies, and data on fishing effort (total hooks set in 1996), the Norwegian offshore autolining fleet may take as by-catch ca 10,000 fulmars annually, assuming it widely applies streamer lines as a mitigating measure. If mitigating measures are scarcely used, the estimate of by-catch could increase by ten times or more over this figure.

21 The total Norwegian longlining fleet (including the inshore fleet of smaller vessels) is estimated to conservatively take ca 20,000 fulmars annually but the actual total may easily be 50,000-100,000.

22 The combined activities of the Norwegian, Icelandic and Faeroese longlining fleets are conservatively estimated to take a by-catch of 50,000-100,000 fulmars annually, but the true figure could be significantly higher (depending, e.g., on the deployment of mitigating measures).

23 While fulmars are caught in significant numbers by longlining, the estimated annual mortality is not thought to be status-threatening given that the North-East Atlantic breeding population of fulmars is ca 2-4 million pairs, and the overall population much higher when non-breeding adults and immatures are included.

24 Notwithstanding the fact that longlining does not apparently pose any significant risk to the status of fulmars in the region, the Nordic countries which deploy significant longlining fleet capacity have international obligations, notably under the FAO Code of Conduct for Responsible Fisheries (1995), to minimise incidental by-catch of seabirds from their operations.

25 Recognising these obligations, the scale of the by-catch (significant, albeit not status-threatening), and the potential to reduce economically damaging bait loss by taking effective action, the assessment from this study is that Norway, and also Iceland and the Faeroes, have a problem with incidental by-catch of seabirds. Iceland and the Faeroes should address this, as Norway is currently doing, by developing and implementing a National Plan of Action (NPOA) under the International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, a FAO global strategy adopted by FAO-COFI in Rome in February 1999.

26 This study recommends that a NPOA in the case of Norway and other longlining fleets in the north-east Atlantic should include the following elements:

- Collect and package data on fishing effort (hooks deployed annually) in a way that enables seabird by-catch rates (birds per 1000 hooks) to be calculated for the overall effort of the whole fleet.

- Assess the deployment of mitigating measures by the fleet.

- Encourage the deployment of streamer lines (preferably paired) of approved, effective design.

- Assess the effectiveness of these and other mitigation measures under the spectrum of operating conditions.

- Advocate best practice to fishermen and raise awareness.

- Encourage the manufacturers of longline equipment (Mustad etc) to develop appropriate mitigating measures, especially effective streamer lines, integrally weighted lines, and line-shooting/slackening devices, and initiate research to experimentally test the effectiveness of these, individually and in combination, at sea.

- Devise a suite of measures of proven effectiveness as part of the statutory national fishing regulations, just as mesh size etc are part of statutory technical measures, and enforce them accordingly.

- With a view to the seabird-friendly longliner of the future, take a lead in developing longline vessels and gear with a view to integrating mitigating measures, and especially underwater setting, into the hull design and construction so as to avoid any effects of the propellor in bringing the line to the surface.

- Research and implement ways of minimising the discharge of offal into the wake of vessels, which attracts and aggravates the by-catch of seabirds.

- Legislate (at least in Norway) against the practice of shooting at birds as a 'mitigating measure' and enforce accordingly.

- Implement an observer scheme to better assess the scale of seabird by-catch by all sectors (inshore and offshore) of the longlining fleet, and compliance with mitigating measures.

Introduction

From the point of view of fish stocks, longlining is a fishing method with a relatively good conservation profile for catching the target species. Compared with bottom-trawling, it is much 'cleaner', taking a smaller by-catch of non-target fish, tends to capture older more mature individuals (rather than unwanted juveniles), and inflicts negligible damage on the seabed.

However, wherever longline fisheries overlap with the distribution of pelagic seabirds, there is evidence that they inflict mortality on those seabirds by snaring and drowning them as they try to intercept and consume bait from hooks before they sink. Recent research in the southern hemisphere has highlighted the high seabird mortality associated with such bait-snatching during the setting of lines. There is strong circumstantial evidence that this mortality is responsible for the declining status of certain albatross species, including some whose population survival is now seriously threatened (Alexander *et al* 1997, Robertson and Gales 1998, BirdLife International 2000). There is international pressure to develop technical solutions for reducing this incidental mortality and to have these solutions adopted by the fishing industry.

Further, there is evidence (although the knowledge base is poor) that such mortality is occurring in waters off Norway and Britain where longlining is a growth industry. Beyond the data already collected and publicised by the Norwegian longlining industry, work is needed to quantify the seabird mortality associated with longlining in the north-east Atlantic in order to assess the potential threat to seabirds.

A considerable number of mitigation measures designed to reduce the by-catch of seabirds by longline fisheries have been recommended (e.g. Brothers 1991, CCAMLR 1994, Alexander *et al*. 1997, Brothers *et al*. 1999, FAO 1999). These measures include setting lines at night; trailing bird-scaring lines and streamers behind vessels during line-setting ('tori poles' and 'tori lines'); using machines to cast baits clear of the vessel's wake during line-setting; weighting lines more heavily so that they sink more quickly; thawing bait; using bait that sinks more readily; closing fishing areas or seasons; and not dumping offal near the fishing lines during setting and hauling.

It is also a priority to evaluate such mitigating measures with a view to promoting solutions to the fishing industry. Bait-snatching handicaps the efficiency of longlining, inflicting a bait loss of up to 70 % in the Norwegian Sea at certain times of year (Bjordal and Løkkeborg 1996). Given this economic burden, many fishermen share the objective of eliminating bait-snatching and its associated seabird mortality. This project thus addresses a potential 'win-win' situation whereby elimination of bait-snatching serves the needs of both the fishing industry and seabird conservation.

A promising mitigating measure for both is a stern-mounted tube which sets the automatically-deployed line ca. 1.5 m below the sea surface (S. Løkkeborg, pers. comm.), where it is intended to be out of sight of - and inaccessible to - scavenging seabirds. Field study by the Institute of Marine Research, Bergen, on an earlier version of the tube (whose penetration was shallower than now), showed that, under the conditions tested off the coast of mid-Norway, the tube was only partially successful in reducing bait-snatching, and indeed it was less effective than another mitigating measure - a specially designed bird scaring line (Løkkeborg 1996, 1998). Various types of streamer lines are routinely used by longliners to scare birds away from longlines here and elsewhere in the world and their effectiveness, with or without the addition of the setting tube, is also of considerable interest. A key objective of this study was therefore to gauge the efficiency of these mitigating measures.

In the context of the present study, it is notable that Løkkeborg's trials were conducted with the priority of reducing bait loss to the longlining industry rather than reducing incidental mortality of seabirds, and as such were conducted with no knowledge of (e.g.) the ambient seabird densities around the vessel. The present study aimed to focus much more closely on this as one of the conditions which potentially influenced seabird by-catch rates. Environmental conditions could influence seabird by-catch rates in a number of ways. For any given time and place, environmental factors could change the probability of by-catch by influencing not just the number of seabirds in the vicinity of the vessel but also the proportions of different species, whether the birds are actively foraging, and the operating efficiency of mitigating measures, and so on.

With studies of this kind still in their infancy, the complexity of factors involved and the interactions between them (e.g. seabird distribution patterns, weather and sea state) have often defied attempts at finding patterns in by-catch rates and interpreting the causal factors behind variation (e.g. Brothers *et al* 1999). To that extent, this relatively modest study is seen as a pilot project to begin to get some understanding of the issue in the north-east Atlantic and the factors involved.

This study describes the results of the 1997 (Part 1) and 1998 (Part 2) pilot projects by RSPB/NOF. The report has been prepared by Euan Dunn (RSPB), closely assisted by Christian Steel (NOF), incorporating an adapted version of field results supplied by two NOF observers. Appendices and References for both are given after Part 2.

The aims and objectives of the study were:

1 To quantify the seabird mortality associated with long-lining in the north-east Atlantic in terms of species and numbers affected and to evaluate methods (mitigating measures) of reducing seabird mortality.

2 To investigate the variables influencing this incidental mortality, including - notably - the attractiveness of the baited longlines to different seabird species in relation to their density during the vessel's fishing activities and to develop and test appropriate methodology for carrying out these investigations.

3 To apply the findings of this study to the wider context of longlining as a global threat to seabirds. In this context, the study is a contribution to the 'Save the Albatross Campaign' of BirdLife International's Global Seabird Programme.

Part 1: 1997

1 Introduction

The Norwegian longlining fleet is the largest in the north-east Atlantic and, critically for this study, it includes the only vessel (*M/S Søviknes*) equipped with underwater setting of any national fleet operating in the north-east Atlantic. Norway's fleet will most likely only accept Norwegian-speaking observers, and fortunately this could be arranged through NOF. During 1997, therefore, arrangements were made to put a single trained observer aboard each of two Norwegian longliners, the *M/S Søviknes* and another another (*M/S Værland*) without the tube. The observers were selected by NOF for their suitability to undertake this work.

A particular focus of the work was to gather data on the efficiency of the setting tube, compared with longlining without such a tube. If the tube was highly effective in preventing bait-snatching, the expectation from the fieldwork was that the vessel equipped with the tube (hereafter 'VWT') would take substantially less seabird by-catch than the vessel without the tube ('VWOT'). A methodology was devised for randomly sampling line-setting, line-hauling, associated fish catch and seabird by-catch (Appendix 1).

The original timetable was to conduct the observer studies in late summer (August-September) when information from the fishermen suggested that by-catch of northern fulmars *Fulmarus glacialis* (by far the commonest species caught on longlines in northern waters) is significant. Due to unscheduled delays beyond the control of the project, however, observers were unable to join their longliners until October and the late season, combined with very northerly ports of departure (N of 68°N) at this time of year, and the nocturnal setting regime (especially of the vessel not fitted with underwater setting) resulted in most of the setting and hauling activities being conducted in darkness. These conditions limited the scope and products of this study (made observations difficult, reduced numbers of seabirds around the vessels and may indeed have reduced the birds' ability to see baited lines).

2 Key details of fishing trips observed

Observer	Per Inge Værnesbranden (PIV)	Terje Lislevand (TL)
Vessel	M/S Søviknes (vessel with tube: <u>VWT</u>)	M/S Værland (vessel without tube: <u>VWOT</u>)
Skipper[1]	Svein Ove Myrbø	Jan Einar Søviknes
Period	19 days Left Ålesund 29 Sep Arr. Tromsø 18 Oct	15 days Left Honningsvåg 19 Oct Arr. Mehamn 30 Oct
Fishing Grounds[2]	NW of Lofoten/Vesterålen – W of Senja (Troms) (68° 16'N, 13° 39'E 69° 58'N, 17° 17'E)	Porsangerfjord (ca 70° 54'N, 26° 09'E) N of Porsangerfjord (ca 71° 27'N, 26° 39'E) N of Nordkynnhalvøya (ca 71° 05'N, 28° 47'E)

[1] See Appendix 2 for details of crew

[2] Although both vessels operated in the northern Norwegian Sea at approximately the same time of year, it could not be arranged to have both vessels fishing on exactly the same fishing grounds, far less alongside each other.

3 Details of longlining operations

3.1 General

Norwegian longliners operating in these northern waters typically set 30,000 - 40,000 hooks over the 24-hour period. However, these are not set in one continuous line but in a series of shorter lines called 'stubs'. Although the pattern varies with depth and topography of sea-bed, the vessel typically sets 6-8 stubs, all being set one after the other before all are hauled in sequence (starting with the first to be set). It generally takes around 30 min to set a stub and 2-3 hours to haul it. Along the stub at short intervals (typically just over 1 m) are branchlines called 'snoods' to which the hooks, automatically baited by machine, are attached. The typical bait is mackerel or squid, used thawed or semi-thawed to facilitate rapid sinking (frozen bait is more buoyant). The line is set from the stern of the vessel and subsequently hauled up the side, about mid-ships, to retrieve the catch.

On the VWT, of an estimated total of around 100 stubs set, the observer watched the fate of 47 (17 set by day, 30 at night), although the by-catch was ascertained as far as possible for all 100. On the VWOT, the equivalent figures were: total 62 stubs set (all at night) and hauled, of which 27 directly observed; again by-catch was ascertained for all 62. The practice of setting exclusively at night, at least on the VWOT, was because this regime optimises the catch of haddock *Melanogrammus aeglefinus* which was the target species for the whole trip.

3.2 Fishing regime: Vessel with the tube (VWT)

The observer (PIV) left Ålesund on the VWT on 29 September 1997, arriving at the fishing grounds in the evening of 1 October. He left the vessel in Tromsø on 18 October (see **Appendix 3** for detailed itinerary).

Setting and hauling was carried out continuously, largely according to the operational details described in 3.1 (above). The M/S Søviknes typically set 8 stubs of (total) 45,000 hooks, one stub after the other, over a 4-hr period. Immediately after setting, hauling began from the starting point, each stub taking ca. 2 hrs to haul, so that total hauling time was ca. 16 hrs. According to topography (etc) the stubs could be separated and set in parallel, or 2-3 stubs could be linked together (Endre Søviknes, pers. comm.). Of a total 107 stubs set during the fishing trip, 47 (44%) were observed over a cumulative period of 45h 15 min. Setting took place both by day and night: of the 47 stubs seen being set, 17 were set by day and 30 by night. For roles of crew see **Appendix 2**.

The proportion of hooks baited in automatic longlining (autoliners) varies between 85% and 95% (i.e. a small proportion emerge from the automatic baiting machine without being successfully baited). It has been suggested that there may be additional bait loss incurred by friction as the line passes through the tube. When this was queried, the skipper told the observer that, after investigation, Mustad had concluded that there was virtually no additional bait loss from this cause.

The main target fish catch was haddock and tusk, with the following also taken in smaller numbers: catfish, cod, halibut, ling and saithe (see **Appendix 4** for scientific names).

Relevant information about all the stubs set and observed during the trip by the VWT are given in **Appendix 5**.

3.3 Fishing regime: Vessel without the tube (VWOT)

The observer (TL) joined the VWOT in Honningsvåg on the night of 19 October 1997. From 30 Oct, the vessel was confined to Mehamn by strong winds and TL finally left the vessel on 3 Nov. The vessel fished continuously up to the morning of 30 Oct, except from the afternoon of Saturday 25 Oct until the afternoon of Sunday 26 Oct due to weekend fishing in coastal waters being prohibited by Norwegian fishing legislation (so-called 'holiday preservation').

The target fish species on this trip was mainly haddock. The stubs were always set at night (in the dark) because this was said to increase the catch of this species. Cod was also caught, but the main quota for this fish species was saved for later in the winter when more cod appears in these waters.

Setting typically took place in the evening, from around 20.00 hrs until midnight, while hauling started immediately after setting was finished. Usually seven stubs were set (though six on two days). As hauling normally lasted about 2 hours 20 minutes per stub and setting about 30 minutes, the cycle of hauling and setting took approximately 20 hours. Thus, all the stubs could usually be set, hauled and set again within 24 hours.

The setting regime varied as expected according to the bottom topography. Stubs were often set consecutively in straight lines along the long axis of fjords. Sometimes they were also were set in parallel lines, but apparently never more than two side by side. At sea, however, single stubs were often set in parallel along the continental shelf. The standard distance between stubs when set in parallel was 1 nautical mile, but when two stubs succeeded each other they always seemed to be set very close to each other.

According to the skipper, the number of hooks was 4500 per stub, which remained constant during the whole trip. The crew sometimes mentioned setting shorter and longer stubs (length influenced by sea currents) but the length had no influence on the number of hooks. For more information about the fishing gear used on the VWOT, see Table 1. Note that on this vessel, an estimated 90-95% of hooks were baited by the automatic baiting machine.

Table 1. Technical data on fishing gear used on VWOT (M/S Værland)
There was no variation in type of gear used during the trip.

Number of hooks	4500
Type of hooks	EZ
Size of hooks	no. 7
Spacing of snoods	1.35 m
Snood length	40 cm
Bait type	mackerel (60%), squid (40%)
Hooks baited	90-95%

Relevant information about all the stubs set and observed during the trip by the VWOT are given in **Appendix 6.**

4 Mitigating measures

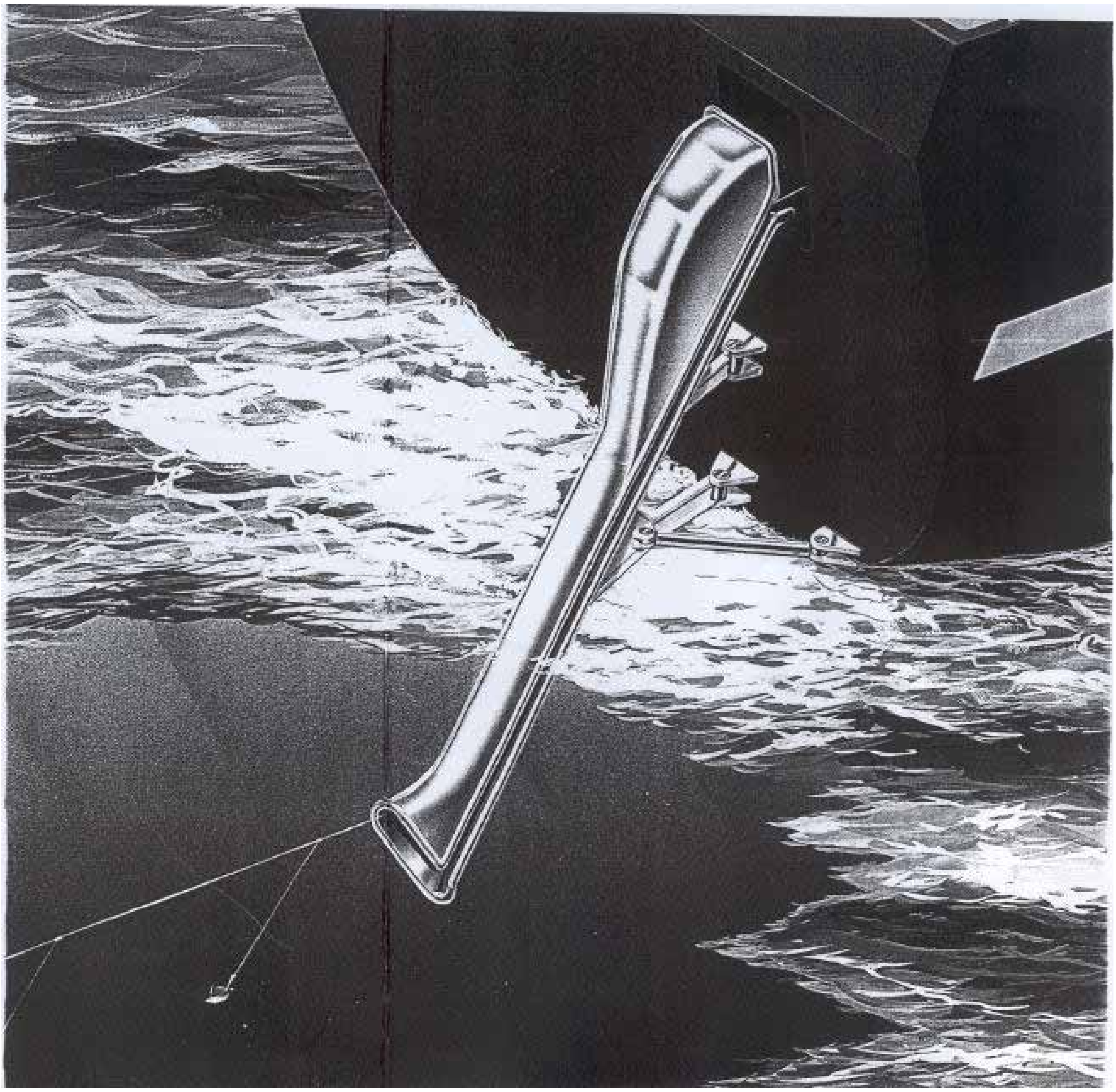
4.1 Mitigating measures on *M/S Søviknes* (VWT)

Mitigating measures consisted of the underwater setting tube, streamer line, hornblowing and shotgun. The observers were asked to record all mitigation measures deployed during line-setting.

Underwater setting tube

The underwater setting tube manufactured by O. Mustad & Søn, Gjøvik (Norway) is currently the only such setting device that is commercially available. As an attachment to the vessel's stern for use in single line demersal fisheries, the setting tube (**Figure 1**) is about 3 m long and extends about 1.5 m

Figure 1. The Mustad underwater setting tube in operation (reprinted by courtesy of O. Mustad & Søn A.S.)



below the water surface. It is manoeuvred hydraulically on hinges from its stern-facing operational setting position to stowing ('parking') position against the hull. The setting pipe or funnel is of sufficient diameter to allow the line (with hooks) to pass down it and exit, while having a slot running the length of the side for external deployment of buoys, weights etc.

The line was always deployed through the tube except on the odd occasion when it escaped going through the tube because of human error. This arose because the line does not automatically enter the tube, rather the front end of the line must be actively fed down the tube by a crew member. This is achieved by attaching a metal weight to the head of the line which a crew member is responsible for casting into the mouth of the tube. Occasionally his aim missed and the stub was then irretrievably set outside the tube, i.e. was fully exposed just as it always is in vessels not equipped with underwater setting. Lines may also jump through the tube's slot in heavy swell (S Løkkeborg, pers. comm.).

Streamer line

The VWT also deployed a streamer line during daylight setting, whenever there was a high density of birds following the vessel. The streamer line was often in use, sometimes simultaneously during setting with the tube. Details of the streamer line on this vessel are as follows:

> *Line length: 77 m from the stern.*
> *No. of streamers hanging from line: 9*
> *Streamers made of 30 cm long thick and pliable orange plastic strips*
> *Distance between streamers: 8.5 m*

The streamer line is the most prevalent mitigation measure currently in use, world-wide, in longline fishing and it is the main mitigation measure deployed by Norwegian longliners. The principle is a cord run behind the vessel from the top of the stern, with a number of streamers suspended at intervals along the cord. The idea is that the erratic movement of the streamers scares seabirds away from encroaching on the area where the baited hooks of the longline are entering the water.

The streamer line configuration is adjusted to suit the vessel size and its speed of setting and hauling. Although it does not deter all bird species equally effectively, such a line - when constructed and set properly - can reduce seabird bycatch by 30-75% (Alexander *et al* 1997). The value of the streamer line has long been recognised and its use is obligatory in CCAMLR (Commission for the Conservation of Antarctic Living Marine Resources), Australian and Alaskan waters.

In addition to these mitigating measures, the skipper of the VWT also regularly sounded the ship's horn and frequently fired a shotgun.

Taken together, the *M/S Søviknes* used a suite of mitigating measures and always had at least one measure in place. Thus, even when the line was accidentally set outside the tube, the vessel still had a streamer line in place, at least when the likelihood of by-catch was high. The combination of simultaneously using the tube and the streamer line complicated the observer's aim of evaluating the mitigating effect attributable to each measure individually. But it was not possible to evaluate this interference effect during the pilot study.

4.2 Mitigating measures on *M/S Værland* (VWOT)

The VWOT did not implement any mitigating measures because of the very low seabird by-catch expected due to setting lines exclusively in the dark.

5 Methods (for both vessels)

The methodology was issued to observers as a set of detailed instructions (**Appendix 1A**) which were specifically designed for this project by collaboration between staff in RSPB, NOF and JNCC. These instructions are summarised here, with some additional explanation for the approach adopted. Each observer was first asked to familiarise himself with the lay-out and operating procedures of his vessel. It was difficult for us or the observers to know this information in advance so the Methodology contains as much description as we could find of what they were likely to encounter on board. Information on the longline gear (including details such as type and condition of bait used) in each setting was entered on the **Line Setting Recording Form** (**Appendix 1B**), one sheet for each stub set.

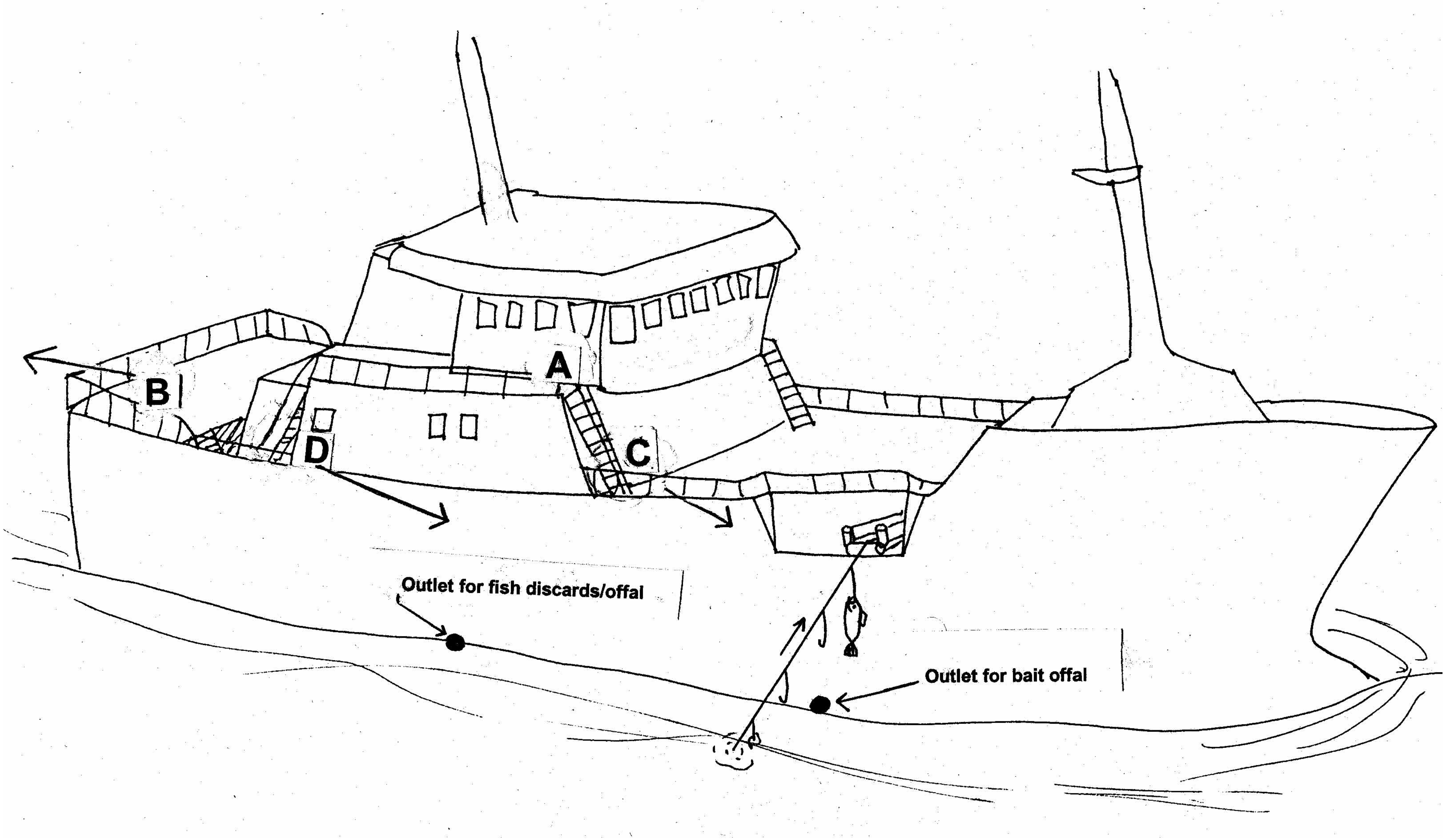
During transit to and from the fishing grounds, and during transit between fishing grounds, observers were asked to make transit counts of seabirds, using the methods learned during their pre-project training by the JNCC (and in accordance with Webb and Durinck 1992) in order to obtain background data on seabird density. For this purpose, observers were asked to find the most appropriate vantage points on the vessel. On the VWT, four observation locations were used during the trip: one for seabird counts during transit (A in **Figure 2**), one for observing line-setting (B), and two for observing hauling (C, D). On the VWOT, bird counts during line-setting were made from either the rear deck (3 m above sea level) or from the wheelhouse (ca 5 m above sea level).

The priorities for the study were to record: (i) the number of seabirds taken as bycatch, (ii) the number of baited hooks set daily which produced that bycatch, so that (iii) a bycatch rate of seabirds per 1000 hooks set could be derived for each day and for the fishing trip as a whole. The methodology for observing the setting and hauling of stubs was relatively complicated by various constraints. Firstly, the longliner sets and hauls round the clock: setting typically starts early in the morning, all the stubs being set one after the other, with hauling taking most of the rest of the day and night. As a result, the observer has to sleep etc for a certain time, so he cannot watch everything. Secondly, he must watch the same stubs being hauled as were set, but in order not to create systematic biases (e.g. of a diurnal nature), he had to randomise - from day to day - the groups of stubs he watched (recommended 4 stubs per block be observed). See methodology (**Appendix 1A**) for further randomisation safeguards.

Apart from all the characteristics of the setting of a particular stub, the **Line Setting Recording Form** (**Appendix 1B**) was used to record mitigating measures and how they were functioning, whether any discards or offal were discharged during setting, details of ship's course and position, depth to seabed, and ambient conditions (time of day - recorded as local Norwegian time - weather, sea conditions, state of moon, also any deck lighting). Each form was given a unique Setting Reference Number (SRN) so that it could be unambiguously cross-referenced to the same number on all other associated data sheets.

On the **Bird Count Recording Form** (**Appendix 1C**), which also carried the SRN, the observer entered 10-min snapshot counts of total number of birds species in the vicinity of the ship (according to JNCC Methods), and observers were also asked to gauge the rough accuracy of counts (to the nearest 10 or 50, etc). We also asked observers to take occasional photos of dense flocks to help calibrate these counts and to check if their counts 'drifted' during the course of the fishing trip. (After his field trip, on the VWT, the observer (PIV) suggested that the counting interval be extended to 15 min, mainly because he found it difficult to count adequately at a 10-min interval and also because, during line-setting, the counts tended to vary rather little).

Figure 2. Observer positions (A-D) on the Vessel fitted with the tube (VWT); see text for explanation of the positions.



We also asked them to make **behavioural observations** on different seabird species as to: level of attraction to baited hooks, susceptibility to capture, intensity of bait-snatching and distance behind vessel at which bait-snatching occurred; we anticipated, however, that these could be very difficult parameters to evaluate. It was hoped that some measure of bait-snatching intensity might yield an independent measure of the effectiveness of mitigating measures. While not expecting it to be easy, we asked observers to try and record, at least once during the setting of each block of stubs, the bait-snatching activity for each species on a qualitative scale of 1-5 (0 = zero, 1 = very little, 2 = some, 3 = moderate, 4 = quite a lot, 5 = intense). (After his field trip on the VWT, the observer (PIV) suggested that a better way to gauge bait-snatching intensity would be to count how many birds were snatching at a particular spot in the span of 5 min; such a count could be made for each stub.)

Again bearing in mind the SRN, the **Catch Sequence Recording Form** (**Appendix 1D**) was designed to record, on sequential hooks, the fish and birds brought on board during line-hauling. To facilitate recording, each entry was made by a code letter, thus 'F' for Fulmar, 'L' for Ling, 'T' for Tusk , etc. Special attention was to be paid to any rare fish bycatch (e.g. deepwater sharks and their fate). Observers were supplied with a comprehensive list (**Appendix 4**) of fish and bird names (in English and Norwegian, also scientific names), as well as fish and bird field guides, to cover all possibilities for the Norwegian Sea. If it turned out that the skipper was unhappy with fish being recorded in such detail, observers were to get a rough idea of the catch composition, e.g. number of boxes of each species. (As the observer on the VWOT noted during his trip, the catch is not stored in boxes but deep-frozen in blocks which are stored in the freezer room as soon as they are ready. This means that, in practice, assessing catch composition in detail is only feasible by watching the sequence of fish taken on board when the line is being hauled.) We also asked observers to record the fate of bait which had not been lost off hooks to fish or birds, e.g. do the fishermen throw it overboard during hauling or retain it on board? Later, the totals for each species (fish caught and birds by-caught) were added and entered in the **Catch Sums Recording Form** (**Appendix 1E**).

Observers were asked to make arrangements for on-board freezer storage of collected bird corpses (or - if very many were caught - a random sub-sample thereof) for subsequent examination at Zoological Museum in Bergen.

6 Results

6.1 Seabird composition and density during line-setting

6.1.1 VWT

Birds present in the areas of fishing operations of M/S Søviknes observed by Per Inge Værnesbranden (PIV) were, in declining order of abundance: northern fulmar (hereafter referred to as just 'fulmar'), herring gull, kittiwake, glaucous gull, great black-backed gull, gannet, sooty shearwater and arctic skua.

Table 2. Proportions of the seabird species present on the fishing grounds on successive days of the trip (from 2 - 17 Oct). The numbers shows the maximum number of each species each day, and percentage of the total number. Since the numbers of the most numerous species are a rather rough estimate, the total number is rounded to the nearest 5 or 10, and the percentage rounded to the nearest 1% in the largest numbers and to the nearest 0.5 or 0.25% in the lowest numbers.
F-Fulmar, HG-Herring Gull, K-Kittiwake, GG-Glaucous Gull, GB-Great Black-backed Gull, GAN-Gannet, SS-Sooty Shearwater, GSP-Gull sp., AS-Arctic Skua

Date	**02.10**		**03.10**		**04.10**		**06.10**		**07.10**		**08.10**		**10.10**	
Spec.	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%
F	300	86	500	97	500	93	450	92	200	83	100	38	3	11
HG	20	6	10	2	25	4.5	20	4	25	10.5	150	58	30	91
K	10	3	1	0.5	10	2	15	3	10	4	5	2		
GG					2	0.5	3	0.5	3	1.25	2	1		
GB	10	3	2	0.5	2	0.5	3	0.5	3	1.25	1	0.5		
GAN	5	1.5												
SS	2	0.5			1	0.25								
AS					1	0.25								
Total	350		515		540		490		240		260		33	

Date	**11.10**		**12.10**		**13.10**		**14.10**		**15.10**		**16.10**		**17.10**	
Spec.	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%
F	17	85	200	71	200	91	100	100	30	79	100	83		
HG	3	15			15	7			8	21			150	74
K					2	1							50	24
GG													2	1
GB													2	1
GSP			80	29							20	17		
Total	20		280		220		100		38		120		205	

6.1.2 VWOT

On the M/S Værland, the seabird background density could unfortunately not be assessed as planned because the vessel always moved between fishing grounds (or to and from land) during the hours of darkness (except once when the weather was too rough for observations). The birds had to be counted in the light from a stern-mounted searchlight. In this way it was possible to see the birds up to about 75-100 m behind the vessel although it was sometimes difficult to determine the species. Likewise, the observations of setting could not be carried out exactly as planned because the darkness made it very difficult to carry out the 'snapshot' counts of seabird density. Terje Lislevand therefore tried only to get a very rough estimate of the number of birds flying around the vessel.

He found that the fulmar was the dominant species, about 300-400 individuals regularly being counted behind the vessel. In the fjords and closer to land, herring gulls and kittiwakes were far more common. Herring gulls seemed to decrease in number when the vessel reached open sea. Kittiwakes also associated with the vessel at sea but not as numerously as fulmars. Glaucous gulls occurred in small numbers (from 5-20) in all areas, as did great black-backed gulls (never more than 5-6 individuals at the same time).

Thus, fulmars were roughly estimated to have constituted about 80% of the seabird total at sea, kittiwakes 15%, and the bigger gulls the remaining 5%. In the fjords, kittiwakes made up about 60%, herring gulls 35%, and the remaining gulls and fulmars together 5%.

The number of birds following the vessel at the time of setting remained fairly constant every night at usually 10-20 fulmars, but on 28 Oct there were up to 50 and on 29 Oct up to 100. When the vessel was fishing in the fjords, birds were almost absent, although a herring gull and some kittiwakes sometimes showed up.

7 Seabird behaviour

7.1 Seabird behaviour around VWT during line-setting

On the *M/S Søviknes*, the observer summarised daily diary notes as follows:

3 Oct: Most birds were ca. 100 m or more behind the vessel. Some bait-snatching (intensity scale 2). Some birds (fulmars) diving regularly, also a couple of gannets. One sooty shearwater present also dived occasionally.

4 Oct: Fulmars very active, gulls gradually increasing activity. Two glaucous gulls have been present since yesterday. The sooty shearwater seen again, diving once and submerged for 10 seconds. An arctic skua was seen, but showed no interest in the bait.

7 Oct: Because of problems with the tube, it wasn't in use during setting, and the line was set without the tube. The streamer line was used in the beginning, but was ripped off after a while, and replaced by a new streamer line, which was a little shorter. Before the new streamer line was in use, some fulmars were diving (4 on the scale of bait-snatching intensity). On the last stub (0710 F) there was rather intensive snatching (5 on the scale), mainly by fulmar, other species present were kittiwake, herring gull and glaucous gull.

17 Oct: Bait-snatching estimated at 4-5 on the scale. We were close to land, and fulmars had disappeared, but about 200 gulls were present (herring gull 150, kittiwake 40-50, great black-backed gull 2, and glaucous gull 2), arriving in large numbers as we approached land.

On **4 Oct** between 03.32-03.37 during setting I counted 20 fulmars diving at one spot where the searchlight beam lit the sea-surface.

7.2 Seabird behaviour around VWOT during line-setting

When the stubs were set, seabirds always flew behind the vessel, and over the line, in varying numbers. The gulls mostly followed behind the vessel while fulmars flew around the vessel in an apparently standard route, always ending over the line. The birds often landed on the sea near the line, but mostly quite far from the vessel. The line seemed to sink quite quickly beneath the sea surface. It was estimated to be visible only 20-30 metres from the vessel (although visibility was handicapped by the darkness).

The observer never saw birds snatching bait directly, but according to the fishermen this is certainly very common at times. According to them, the "problem species" is the fulmar, but "big" gulls (presumed by the observer to comprise glaucous gulls, great black-backed gulls, herring gulls and probably also lesser black-backed gulls) also occasionally get hooked. Kittiwakes, however, were scarcely ever known to be caught.

7.3 Seabird behaviour around VWT in relation to offal production and line-hauling

The amount of offal discharged during line-setting is unknown. During baiting of hooks, offal was flushed out through an outlet below the line outlet. Offal from gutting fish was produced regularly as the fish were cleaned shortly after it had been hauled, and this activity continued during hauling. Offal from gutting, and also discards, were flushed out through an outlet on the starboard side. Sometimes this attracted large, if variable, numbers of seabirds. Numbers were not quantified but often there were more birds present during hauling than during setting. A rough estimate of approximately 1000 fulmars was present on 4 Oct. On other days the numbers were typically lower, e.g. 250 fulmars and 50 gulls on 2 Oct. During line-setting, 1-3 glaucous gulls usually followed the vessel but during hauling this increased to 6 or more.

Fish continued to be gutted when hauling had ended, and when line-setting re-started. The resultant offal and discards were discarded on the starboard (right) side of the ship, and the line was deployed at the stern, only one metre from the starboard side of the vessel. When this activity coincided with the start of setting, it could be difficult to distinguish whether the birds snatched bait directly from the line, bait offal, or offal discarded from the gutting activity. The observer gained the impression that the birds were sometimes apparently bait-snatching far behind the point at which he assumed the line must have sunk beyond their reach.

<u>This is an important point because it has always been assumed that during line-setting seabirds are targeting the bait on the sinking hooks; the observations on the VWT show the target may actually, at least in some cases, be offal flushed from the outlet at the stern</u>.

The significance of the role of offal from baiting is as follows. Hooks can be hauled in still with their bait intact or retaining residual bait. During hauling, many birds were attracted by this bait as it was ripped off automatically from the hooks during hauling and flushed out below where the line was being hauled in.

If there were a lot of birds in the vicinity, many of them ventured very close to the line as it was being hauled, but generally they showed very little interest in the line itself or the fish or bait on the line during hauling. Only when the hauling was stopped because of some occasional problems with the line did some birds tried to catch residual bait on the line or peck at fish that was waiting to be hauled in. No birds were observed being hooked because of this, although once a fulmar was nearly hooked by the wing when it ventured too close to the line. Some times during hauling, when the sea was almost completely covered with fulmars clustered around the line, they were efficiently scared away by knocking with a gaff on the side of the vessel.

7.4 Seabird behaviour around VWOT in relation to offal production and line-hauling

In assessing the role of discarding fish waste in predisposing birds to capture, the observer on VWOT recorded that fish waste was flushed out through an outlet on the same side of the vessel as line-hauling, and that this often occurred during hauling.

The crew told him that fulmars can be attracted to this discharge in large numbers and occasionally, when the sea is calm, get caught on hooks (those which still have bait on) as they are hauled. The implication is that they accidentally snatch at residual bait on a hook when feeding on free-floating offal. No such incidents were witnessed by the observer who concluded that this source of by-catch must be rare because the line is typically hauled close in against the side of the vessel and is then exposed for not more than 2-3 metres (of the line's length). The observer confirmed that a calm sea is a prerequisite for birds approaching the line closely as it is hauled, and on one such occasion (when 100-200 fulmars were attracted), he succeeded in catching (by hand) 7 fulmars for ringing and subsequent release.

8 Seabird by-catch

8.1 By-catch rates

Table 3 shows a summary of the incidental mortality of seabirds in relation to the number of longlines (stubs) set on, respectively, the vessel with the tube (VWT) and the vessel not thus equipped (VWOT):

	VWT	**VWOT**
Birds known to be caught[1]	6 fulmars	9-10 fulmars
No. of stubs set/watched[2]	107/47	60/24
No. of days stubs watched	14	7
No. of hooks (total set)	481,500	279,000
By-catch rate		
birds/stub	0.06	0.15-0.16
birds/1000 hooks	0.01	0.03-0.04

The only species which suffered incidental mortality was fulmar. Even then, their overall by-catch rates (birds per 1000 hooks) were low: 0.01 for the VWT and 0.03-0.04 for the VWOT.

On the VWOT, 4 of the birds were caught on 2 successive stubs (2 on each stub), although the number of birds around the vessel did not appear to be much higher during these sets than during other sets when birds were not caught. This suggested that possibly the weather and sea state may have been additional factors affecting likelihood of by-catch, but the by-catch rate was generally too low to test this.

That the overall by-catch in both the VWT and the VWOT was so low in the present study was almost certainly attributable to the dominance of setting in the hours of darkness. The fishermen said that it was a great advantage to set the lines in the darkness compared to in daylight, because this drastically reduced bait-snatching. This was also the reason why it was not felt necessary to use any mitigating measures on the VWOT on this trip. The observer on the VWOT concluded that the darkness probably made it difficult for the birds to see the bait during setting (although the vessel used a searchlight almost continuously: see 8.2.2, below).

There was some evidence (though not conclusive) from the VWT that birds were more vulnerable to being caught in daylight. Thus, at the start of the trip on the VWT, the stubs were set in daylight, attracting "a couple of hundred birds, mostly fulmars" to follow the vessel. All the fulmar by-catch (6 birds) by the VWT was taken during day-setting.

To the mitigating effect of darkness on by-catch may be added the lateness of the season generally, although the input of these two factors is hard to separate. However, as the fishermen were anxious to confirm, there is little doubt that late autumn and winter (November-March) in sub-arctic waters is a period of low vulnerability for seabird by-catch from longlining. By contrast, they repeatedly told the observer on the VWOT that fulmars were a serious problem for their fishing activities in spring

[1] On the VWOT, 5 fulmars were seen caught by the observer. Another 2 stubs set, but not witnessed by the observer, yielded a by-catch of 4-5 fulmars which were not retained by the fishermen and only reported to the observer; the calculations are therefore based on a total known caught of 9-10; on the VWT the observer witnessed 3 birds caught on 47 stubs, the other 3 birds coming from stubs not observed. [NB: On both vessels, although the crew were instructed to report all birds caught during the periods when the observers were not on deck, the possibility cannot be discounted that a few birds may have been caught in addition to those witnessed by, or reported to, the observers.]

[2] "No of stubs set/watched" = total number (A) of stubs set on the trip/ number of 'A' that were actually monitored through setting and hauling by the observer

and summer, being caught in great numbers. The skipper on Værland, Jan Einar Søviknes, supposed the reason for this was that the birds needed food and energy to fulfil their breeding requirements, and therefore were more willing to take the bait from longlines. Perhaps in addition there are more fulmars available to be caught in spring/summer than in autumn/winter at which time the birds are more widely dispersed.

On the trip immediately previous to the one attended by our observer, the crew of the VWOT said they had caught huge numbers of fulmars and some "big" gulls (species unknown), the total by-catch estimated by one crewman to be at least 1000 birds during six weeks. Though suggestive, the speculative nature of this makes it inadmissible as evidence.

It was not possible, on the VWT, to distinguish to what extent the low by-catch was attributable to, respectively, (a) setting during dark/lateness of season and (b) any mitigating effect of the tube. However, the crew told the observer on the VWT that seabird by-catch had fallen significantly since the tube was fitted.

8.2 Other factors influencing seabird by-catch

8.2.1 Lines set outside the tube

In the case of the VWT, 3 of the birds caught were on 6 Oct. On that day, the observer noticed that some of the stubs were set such that the lines did not go down the tube (see 4.1, above). Too few birds were caught to establish conclusively whether this phenomenon led to the fulmar by-catch on 6 Oct. But it does suggest the way in which an effective controlled experiment could be conducted on the VWT alone.

8.2.2 Influence of searchlight

On the VWOT, a stern-mounted searchlight was constantly in use, around the clock. It's use evidently did not aggravate by-catch to any extent. On the VWT, the skipper and Mr. Søviknes said that they used the searchlight because they thought the strong light "blinds" the birds and prevents them seeing the bait below the surface.

On 13 Oct the observer made a rough comparison during setting to see how the birds behaved with and without the searchlight. Time: 18.00-20.30 (darkness).

<u>Stub A+ B: Searchlight + decklight (tube in use)</u> The birds seemed to be more concentrated around the searchlight, and several birds landed on the water. No bait-snatching by fulmars though some by gulls.

<u>Stub C: Without searchlight and also without tube</u> Watched the behaviour of the birds in more detail over 25 minutes. The birds seemed to be more dispersed than with the searchlight on. No bait-snatching observed, either by the 12-15 fulmars which landed on the water or by gulls. More birds closer to the ship and closer to the decklight at the stern, about 20-30 m from the vessel.

<u>Stub D: Searchlight + decklight (tube in use)</u> Watched over 25 minutes. About 60 fulmars landed on the water, but no bait-snatching. 10 herring gulls were snatching bait from the surface. Most of the birds were seen in the searchlight or behind the searchlight, about 100 m from the vessel.

Based on these observations, it seems that the seabirds are attracted by the light, and that they are able to see bait or offal floating on or near the surface. The theory that the seabirds are dazzled by the light may be true to some extent but only when they fly directly into the searchlight beam. Mostly, however, the searchlight would appear to enhance the opportunity for seabirds to snatch bait.

9 Fish catch

In neither the VWT not the VWOT were any rare or unusual fish species caught. This is a reflection of the relatively shallow depths (32-171m for the VWT; 26-183m for the VWOT) at which the lines were set.

9.1 Fish catch by VWT

Over half the catch (by number) was haddock, about one-third tusk, with much smaller numbers of saithe and cod. Other species each made up less than 1% of the catch.

Overall species composition of fish catch

Based on the fish catch totals from the **Catch Sums Recording Form**

Common name	Scientific name	No.	% of total
Haddock	*Melanogrammus aeglefinus*	7602	57
Tusk	*Brosme brosme*	4293	33
Saithe	*Pollachius virens*	398	2.1
Cod	*Gadus morhua*	328	2.5
Ling	*Molva molva*	70	0.54
Catfish	*Anarihichas lupus*	67	0.52
Halibut	*Hippoglossus hippoglossus*	67	0.52
Rays	*Raja* sp.	72	0.56
Redfish	*Sebastes marinus*	40	0.31
Spurdog	*Squalus acanthias*	11	0.08
Anglerfish	*Lophius piscatorius*	1	0.01
Herring	*Clupea harengus*	1	0.01
Dab sp	*Pleuronectidae*	1	0.01
Total		12951	100

9.2 Fish catch by VWOT

As in the VWT, about half the catch (by number) was haddock but the rest of the catch composition differed from that vessel. In the VWT, the next most important species was cod (one-quarter of the catch), with tusk the third most numerous. By comparison with these, other species comprised only minor proportions of the catch.

Overall species composition of fish catch

Based on the fish catch totals from the **Catch Sums Recording Form** (see **Appendix 7** for details)

Common name	Scientific name	No.	% of total
Haddock	*Melanogrammus aeglefinus*	4034	53.21
Cod	*Gadus morhua*	1916	25.27
Tusk	*Brosme brosme*	928	12.24
Rays	*Raja* sp	289	3.81
Catfish[1]	*Anarihichas* sp.	82	1.07
Redfish	*Sebastes marinus*	45	0.59
Saithe	*Pollachius virens*	37	0.49
Dab sp.	*Pleuronectidae*	9	0.12
Halibut	*Hippoglossus hippoglossus*	4	0.05
Ling	*Molva molva*	3	0.05
King crab	?	1	0.01
Unknown		252	3.32
Total		**7600**	**100 %**

[1] Two species of catfish were caught: lesser catfish (78) and blue catfish (4)

10 Fishermen's opinion of the 1997 study and of mitigating measures

10.1 General

Both observers enjoyed harmonious relations with the skippers and the crew who, at least after a little initial scepticism and suspicion, were extremely helpful and co-operative once the purpose of the project was explained to them. They openly shared information on seabird by-catch levels from other times of year and this strongly indicates that the fishing trips our observers attended were periods of low vulnerability for seabirds.

In the case of the VWT, the relationship of trust and openness with the observer certainly benefited from the confidence that the crew has in the tube as a major safeguard against seabird by-catch. In short, they felt they had little to hide. Interestingly, this perception does not translate into ready acceptance of the value of the tube by the rest of the Norwegian fleet (including by the crew of the VWOT) which is generally highly sceptical about mounting the tube on their vessels.

10.2 Mitigating measures: the VWOT perspective

This resistance to the tube arises mainly from a combination of cost and from uncertainty about its effectiveness; the latter began with a pilot study (Løkkeborg 1996, 1998) of a prototype tube which indicated that it did not significantly reduce bait loss. This may have been due to a variety of reasons, including that the design of that tube was probably intrinsically less effective at mitigating by-catch than the modified design we observed.

The crew of the VWOT said that the tube fitted to M/S Søviknes in 1997 had cost, in total, 500,000 NOK (ca £40,000) in terms of the initial purchase price, fitting, repairing, and design modifications. Part of the disenchantment arose from the tube's early operational difficulties; the skipper of the VWOT claimed that it had often caused 'a lot of mess with the line and thus more work for the crew'. (Mustad has since solved the technical problems associated with operating the tube and has shared the cost involved).

It is interesting that these views of the skipper of the VWOT differ so radically from the satisfaction with the tube expressed by Endre Søviknes, skipper of the VWT (and brother of the skipper on the VWOT). Nevertheless this shows the level of scepticism to be overcome in those skippers/owners whose vessels are not fitted with the tube and for whom a negative attitude to the potential of underwater setting is deeply entrenched.

The opposition to the tube by the crew on the VWOT was such that they advised the observer to concentrate on developing new mitigating measures (such as broadcast sounds) to scare the birds away from the line. However, other than streamer lines, birds are likely to habituate to this kind of scaring device.

10.3 Mitigating measures: the VWT perspective

The observer was impressed by the determination of the skipper to keep birds away from his line by whatever means possible. Even when line-setting through the tube, he often deployed a streamer line, regularly sounded the ship's horn and frequently fired off a shotgun.

The skipper and crew felt very positively about the tube, saying that it had greatly reduced seabird bycatch and bait-snatching. Nevertheless they voiced the same criticism as the VWOT about the cost of the tube, even to their own vessel, and feared it would be too expensive for many of the Norwegian longline fleet to buy and fit.

As for other possible mitigating measures, a crew-member on the VWT told the observer that dry lines and new lines float nearer the surface than wet lines or ones that have been used for a while, the latter sinking faster. This led the observer to suggest that, in order to facilitate rapid sinking, lines could possibly be sprayed with sea water before setting, especially if the lines are to be set in daylight. New lines could be reserved for setting in darkness until they had been worn in. Line-wetting could thus be a simple alternative (or addition) to weighting lines with, e.g., lead sinkers.

11 Effect of sea-lice on catch and by-catch

In the fulmar by-catch from both the VWT and VWOT, there was evidence when the lines were hauled that some of the snared birds had been attacked by bottom-living sea-lice (Amphipoda). Only one of the fulmars caught on the VWOT showed signs of attack, and only mildly so (not enough to prevent the bird making a good skin for the museum). However, one of the fulmars hauled by the VWT had been reduced to a skeleton. The observer on the VWT collected samples of the sea-lice species responsible.

Sea-lice may also attack hooked fish. The observer on the VWOT saw several fish showing signs of damage - some of which were still alive when hauled in. Sometimes the fish had been stripped to the bone, but more frequently they had attacked areas of the skin to expose flesh and in some cases the eyes. Bjordal and Løkkeborg (1996, p. 134) report that "Some line-caught fish may... be ruined as a result of attacks from bottom scavengers, a problem that is sometimes experienced in areas with high abundance of sea lice and hagfish." On the VWOT, the observer noted that, as Bjordal and Løkkeborg's statement implies, the severity of the problem seems to vary with local conditions. According to S. Løkkeborg, sea lice are particularly problematic in the North Sea in summer, causing significant damage to fish which then have to be discarded. A trial study of deepwater tangle-netting west of the Hebrides (Anon 1997) encountered serious damage from sea-lice to fish, the problem apparently increasing at greater depths, such that nets targeting ling had to be lifted every 12-24 hrs to minimise damage to the catch. Sea-lice damage to fish caught by longlining also occurs in New Zealand (N. Smith, pers. comm.)

12 Detailed conclusions and recommendations (1997)

12.1 Although few seabirds were caught by either vessel, the only species caught was the fulmar. The overall bycatch rates (birds per 1000 hooks) were very low: 0.01 for the vessel with the tube (VWT) and 0.03-0.04 for the vessel without the tube (VWOT).

12.2 Although only fulmars were caught in this study, the fishermen said that the large (*Larus*) gulls also sometimes get caught. Kittiwakes showed no interest in the bait, nor did one arctic skua. A sooty shearwater was seen diving behind the vessel during line-setting.

12.3 The finding that late-autumn/winter is a period of low vulnerability for the main victim (fulmar) of longlining in these northern waters is, in itself, a valuable contribution to understanding the seasonal influence on by-catch rates.

12.4 All the indications from this study, from Løkkeborg (1996), and from interviews with the fishermen, is that incidental mortality (chiefly fulmars) is much higher in spring and summer.

12.5 Line-hauling attracts fulmars close to the vessel in large numbers because offal is discharged at high density due mainly to the cleaning of fish, and to removing residual bait from hooks. Fulmars are occasionally caught on hooks in this way but the overall bycatch risk to fulmars during this hauling stage is judged to be minor.

12.6 Because hauling and setting are sequential operations, offal may continue to be discharged (as described in 7.3) when line-setting begins again. This makes it hard to distinguish whether birds behind the vessel are targeting baited hooks or free-floating offal. If discharging offal increases the likelihood of by-catch (as various other studies in the Southern Ocean have suggested), then discharging should be discouraged during line-setting.

12.7 There was some evidence that deck lighting facilitates bait-snatching in darkness by making it easier for the birds to see their surroundings and spot food in the sea surface.

12.8 The main fish catch by the VWT was haddock and tusk compared with haddock and cod by the VWOT. The overall prey spectrum (mainly finfish) of both vessels was quite broad but, given the relatively shallow depths at which lines were set (mostly 50-150m), no rare or unusual species were taken as by-catch.

12.9 On both vessels, the baited used was semi-thawed. In the case of the VWOT, the bait was mackerel and squid.

12.10 The percentage of hooks successfully baited on the VWOT was estimated by the skipper at 90-95%. It has been suggested that the friction of the line passing through the tube may incur further bait loss but, according to investigation by Mustad, there is virtually no additional bait loss from underwater setting.

12.11 The methodology devised for the study was found to be generally satisfactory by both observers, although both were handicapped by the darkness when required to count birds. On the basis of recommendations from the observers, some adjustment and simplification of the basic methods will be required in further fieldwork (see Part II) in order to adjust to the conditions (other than darkness) they encountered.

12.12 Each of the observers established an excellent relationship with the skipper and crew of their host vessels. This will help to facilitate not only future access to those vessels (especially the VWT) but this goodwill also helps us to spread generally our wider messages about seeking best practice to the Norwegian fishing industry.

12.13 The best focus for future research should be a programme of controlled experiments on the vessel equipped with the tube, such that rates of seabird by-catch are recorded when a proportion of lines are deliberately set outside the tube (as happened accidentally in a few cases in this study: see 4.1, above).

12.14 Controlled experiments are more likely to demonstrate the effectiveness of the tube when the overall level of potential by-catch (in the absence of mitigating measures) is higher. Clearly, therefore, the late autumn/winter months of fishing activity should be avoided and the study conducted earlier in the year.

12.15 There is a general reluctance by the Norwegian fishing industry to invest in the tube because they perceive it as too expensive and not convinced of its ability to reduce bait-snatching more than the (much cheaper) mitigating measures they already employ (notably streamer line). Currently, the *M/S Søviknes* is the only vessel in the Norwegian fleet of ca. 61 vessels that operates the tube. The skipper and crew of the *M/S Søviknes* are convinced of the effectiveness of the tube but still believe it is too expensive to buy and fit.

12.16 The experience of the crew on the vessel fitted with the tube suggested that incidental mortality of seabirds might be further reduced by wetting lines before setting or using lines that have been 'worn in'; in both cases, this is said to facilitate rapid sinking of the line below the surface during setting. This suggests a possible elaboration of weighting lines (with lead etc) which has been recommended elsewhere as a mitigating measure.

Part 2: 1998

The 1998 Project

Longlining and seabird by-catch on M/S *Søviknes* in June 1998

13 Introduction

The rationale behind the 1997 comparison of seabird by-catch on two vessels - with and without underwater setting - was that the differences observed might be so dramatic as to demonstrate the likely value of the tube, even though the vessels were operating at different times and in different places. Although much was learned about the factors influencing the likelihood of incidental mortality in 1997, this evaluation was rendered impossible by the low overall by-catch encountered so late in the year at such high latitudes when much of the line-setting occurred in the hours of darkness.

The key conclusions (see Part 1, above) from the 1997 pilot study were therefore:

12.13 *The best focus for future research should be a programme of controlled experiments on the vessel equipped with the tube, such that rates of seabird by-catch are recorded when a proportion of lines are deliberately set outside the tube (as happened accidentally in a few cases in the 1997 study).*

12.14 *Controlled experiments are more likely to demonstrate the effectiveness of the tube when the overall level of potential by-catch (especially in the absence of mitigating measures) is higher. Clearly, therefore, the late autumn/winter months of fishing activity should be avoided and the study conducted earlier in the year.*

These conclusions formed the rationale for the fieldwork planned for 1998. Terje Lislevand (who had observed on the M/S *Værland* in 1997) carried out 14 days of field work onboard M/S *Søviknes* in June 1998. The main goal was to test the effect of the Mustad tube by comparing seabird by-catch with and without underwater setting, and to collect other information about how longlining affects seabird mortality.

Apart from the methodology which was prepared in advance of the fieldwork, the results section of this account has been adapted and edited by E. Dunn from a report prepared by Terje Lislevand.

14 Itinerary, study area, and working conditions

In April 1998, Euan Dunn and Christian Steel visited the M/S *Søviknes* and its owners in Ålesund (Norway) where the vessel was in dock for repairs, to prepare the ground for the summer fieldwork. We first met John Ragnar Larsen, manager of Mustad's Ålesund Office, who confirmed that Mustad had accepted responsibility for meeting the cost of modifying the tube so as to prevent the tendency for the line to slip out of it during setting. He explained that they would make this modification by inserting a spring-loaded sleeve along the slot which runs down the tube.

At the shipyard, both owners of the M/S *Søviknes*, were present, namely Endre Søviknes and Noralf Gjerset. After discussion it was agreed with the owners that:

- Only one NOF observer (Terje Lislevand) would go on the M/S *Søviknes* (there was insufficient accommodation for two); the timing of the trip was discussed and (in the ensuing days) agreed that the observer would join the vessel on the last two weeks (approximately 1-15 June) of a 6-week trip. The opportunity to join the vessel would arise when the M/S *Søviknes* came ashore to re-fuel 4 weeks after the start of its trip; it would have been preferable to observe for longer but this was constrained by cost and by the observer's availability.

- One observer would still have plenty of time to carry out bird counts, watch the hauling of some of the lines, and the arrange for the crew to store bird by-catch during the observer's periods of rest and sleep.

- In order to properly evaluate the value of the tube, the need for control settings of lines outside the tube was accepted by Endre Søviknes although he expressed concern that if, as we had hoped, they set 2-3 stubs outside the tube daily, this could incur a significant loss of fish catch. The precise operational details should be discussed once the observer was on board with the skipper for that trip, namely Svein Ove Myrbø.

Because the M/S *Søviknes* enjoyed particularly good fishing during its trip in late May-early June, it was able to fish successfully, with below-average fuel consumption, in a relatively concentrated area of fishing grounds quite far off the Norwegian coast. As a result, it had no need to return to port for re-fuelling as scheduled, thus preventing our observer from joining the vessel in port as planned. This delayed his joining the vessel and thus the length of time he could remain on board, and forced contingency plans to be made for getting the observer aboard the M/S *Søviknes* at sea.

The observer arrived at Brønnøysund at about 17.00 on Sat 6 June where a rescue boat ("Kaptein Skaugen") was waiting to take him ca 120 nautical miles out at sea where the longlining vessel M/S *Søviknes* was fishing on grounds roughly 66° N and 06° E (see **Appendix 9** for details of locations, in relation to where stubs were set and observed).

The observer joined the vessel just after midnight on Sun 7 June and had to sleep shortly after, thus missing the setting for that day which was carried out a few hours later. The observer was also unable to watch the setting the following day (8 June) due to seasickness. He was able to start observations the next day (9 June), these continuing till the following Wednesday (17 June) although the rough weather placed constraints on the safety of observing line setting, as well as causing further seasickness which prevented the observer monitoring the setting of the last 6 stubs.

A further factor which affected the observer's work-plan and routine was that, although he shared a cabin with a crew -member, only one person at a time was allowed to sleep in the cabin. The reason for this was apparently that to double up would make the cabin too warm and increase disturbance to sleep. As the observer's work often had to be done simultaneously with the working hours of his room mate, the observer spent many hours trying to rest on a bench in the lounge. Consequently, he rarely got a full night's (or day's) rest. These difficulties are described in some detail here to emphasise the demanding conditions under which observers of seabird by-catch on longliners often have to operate.

The last 6 stubs of the trip were set early in the morning of 17 June, and hauling finished at about 09.00 the next day. With its storage rooms full, the M/S *Søviknes* headed home, a trip of around 24 hours. The observer left the vessel in the small fishing harbour of Elnesvågen near the town of Molde (Møre og Romsdal county) at 09.30 on Friday 19 June.

15 Fishing regime

In pursuit of its main target species, tusk, the M/S *Søviknes* typically set 6 stubs (separate longlines) during each setting. The length of each stub was measured by the number of hooks it carried, based on information from either the skipper or Endre Søviknes (**Appendix 9**). The precise number of hooks per stub, which ranged from 3700-6200 (mainly 5000-6200), was not exactly known but should not deviate markedly from the rounded-up figures presented.

The skipper varied the setting regime to a great extent during the trip and some days it was difficult to predict and plan work round the setting. This was not only unexpected by the observer, but also to some of the crew who indicated that it was rather uncommon practice for skippers. The daily time when setting started was thus variable (**Table 3**), the length of the whole cycle of setting and hauling, ranging from ca 17 to 25 hrs.

Table 3. Times when line setting of each set of stubs began on days of fishing trip monitored by observer

Date	Time	SRN*
8 June	08.08	0806
9 June	09.36	0906
10 June	06.34	1006
11 June	11.26	1106
12 June	12.10	1206
13 June	05.13	1306
14 June	01.56	1406
14 June	23.26	1506
16 June	01.59	1606

16 Methods

16.1 Instructions to observer

The observer, Terje Lislevand, was issued with a set of detailed instructions, specifically designed for the 1998 fieldwork, called **Field Methodology** and shown in **Appendix 8A** (this omits the **English-Norwegian Glossary** and the **Species list** as both of these are identical to the text supplied to observers in 1997: see respectively **Appendix 1A** and **Appendix 4**).

Accompanying the **Field Methodology** in 1998, as in 1997, were a number of recording forms. Two of these were exactly the same as in 1997, namely the **Line Setting Recording Form** (see **Appendix 1B**) and **Bird Count Recording Form** (see **Appendix 1C**). Refer to Part 1, sect 5 for the relationship between **Field Methodology** and these two recording forms.

However, the **1997 Catch Sequence Recording Form** (**Appendix 1D**) was abandoned in 1998 (see below for reasons), while the **1997 Catch Sums Recording Form** (**Appendix 1C)** was replaced in 1998 with a new **Catch Recording Form** (**Appendix 8B**; see below for details).

The 1998 **Field Methodology** was based largely on, and mostly replicated, the instructions supplied in 1997 (see Part 1, section 5 and **Appendix 1A**), but with some significant modifications. Generally, we asked the observer in 1998 to record rather less than in 1997, partly because there was no value in repeating certain information collected in 1997, partly to simplify and ease the workload, particularly as some of the tasks attempted in 1997 had proved difficult and not especially enlightening.

* Setting Reference Number: a unique coded number assigned to each stub which was set, allowing the observer to track its performance, and any associated by-catch from setting to hauling. 0806, for example, is the prefix for all the individual stubs set on that day, i.e. 0806a, 0806b, 0806c, etc

At the same time we asked the observer in 1998 to prioritise assessing the effect of the tube. The prime objective in 1998 was to set some stubs outside the tube every day (at least one per day but preferably more, at the skipper's discretion) and to compare the by-catch with stubs set through the tube, taking into account ambient seabird densities. The main differences in approach entailed by this, and by other methodology adjustments for the observer in 1998, were as follows:

i The observer was asked to give less priority to watching each and every individual stub being set (which – in 1997 - required randomising which block of stubs to track, which - in turn - made the observer's activity/rest cycle difficult to predict and regulate). However, whatever other stubs he watched, the observer was asked always to watch the <u>first</u> stub of the day being set, as this would give him time to make the necessary arrangements for storage of any seabird by-catch taken on subsequent hauling.

ii To prevent any systematic influences on the rate of seabird by-catch, the observer had to randomise which one (or ideally more) of the stubs should be set daily outside the tube. Naturally, this requirement needed delicate liaison with the skipper.

iii The observer was asked to watch the hauling of the first of the 6 stubs (i.e. the one he watched being set), then to get some sleep. He should also try to personally observe the hauling of the stubs which immediately preceded and followed the one set outside the tube, in order to provide the best comparison, in time and space, of the mitigating effect (if any) of underwater setting on seabird by-catch. Details of the statistical test the observer was to use for comparing by-catch with and without the tube are given in **Appendix 8A** (IV).

iv To ensure that the seabird by-catch could be matched to the particular stub from which it derived, the observer was to try and set up 6 boxes numbered 1-6, so that the crew could (in the observer's absence) assign by-catch from each of the 6 successive stubs to the correspondingly numbered box.

v Bait-snatching intensity during line-setting. In line with recommendation by the observer (PIV) on the M/S *Søviknes* in 1997, the crude and subjective 0-5 scale of bait-snatching intensity used in 1997 was abandoned for 1998. Instead the observer was required to enter, on the Bird Count Recording Form, the number of birds bait-snatching, over a 5-minute period, at a fixed spot of his choosing about 100m behind the vessel or the nearest spot to there where birds were bait-snatching.

vi To further simplify the observer's activity regime, he was not required (unlike in 1997) to watch the detailed sequence of birds and fish as they were hauled in (this had proved very labour-intensive in comparison to the meaningfulness of the results it produced). This in turn meant that the 1997 Catch Sequence Recording Form was not used in 1998. At the same time, the 1997 Catch Sums Recording Form was replaced in 1998 by the **Catch Recording Form** (**Appendix 8B**). This form requires only 1 line to be entered for each stub (watched by the observer or crew) and only needed entering in detail for the stubs which the observer personally watched being hauled. The information to be entered was **Date**, **SRN** (= Setting Reference Number: as in 1997, assigning a unique coded number to each stub set allowed the observer to track its performance, and any associated by-catch from setting to hauling), **Start Time** and **Stop Time** (= in each case for observing the haul**), Vessel light** (= use of searchlight, if any, during hauling), **Bait snatching** (= any seen during hauling), **Unused bait** (= fate of bait still attached to hooks when hauled), **Fulmar tally** (= total number of fulmars caught per stub), **Other birds tally** (= number of any other bird species caught per stub), **Fish catch tally** (= overall proportions of fish caught per stub, and any unusual non-target fish taken).

16.2 Experiment to test settings with/without the tube: application of the Field Methodology

A combination of the observer's seasickness, the skipper's lack of enthusiasm for the experiment and the understandable reluctance of the observer not to push the skipper too hard, especially at the beginning, delayed the start of the experiment until Thursday 11 June, 1998.

As described above, each stub was given a setting reference number (SRN) consisting of day, month and a letter (a-h) according to the sequence of setting. Stubs were assigned a SRN even if no observations of the setting were made.

To get a rough overview of the fish catch on the trip, the observer watched the hauling process of one stub per day. Observations were divided into periods of five minutes, and samples were taken every ten minutes after finishing the preceding observation bout. Normally hauling of the first set stub was observed, but this standard pattern of observations had to be altered sometimes in order to follow the daily routines of eating and sleeping.

Most of the dead birds were collected by the fishermen and put in labelled plastic bags by the observer before storing them in the freezer rooms. At the end of the trip these birds were sent to the Zoological Museum in Bergen.

To relate seabird bycatch to the intensity of bait-snatching behind the vessel when the lines were set, the observer followed the prescribed methodology by counting, every 5-10 minutes, the birds flying or sitting on water in a 180° zone behind the vessel. Such counts are referred to as "snapshots" hereafter. Three snapshots were available for most stubs.

As instructed, the frequency of bait-snatching or scavenging was recorded by counting the number of seabirds landing in a fixed area behind the boat during a period of 5 minutes. This period always started after having finished the second snapshot. The observer used a pole on the rear deck as a marker for the fixed area (ca 10x25m of sea surface) which was located behind the streamer line about 75-100m behind the boat. As the vessel rolled in the sea, however, this area was not constant - the position often changing relative to the vessel from day to day. When necessary, a pair of binoculars (7x50) was used to identify the bird species.

17 Results

17.1 Observations of mitigating measures

See Part 1, section 4.1 for details of underwater setting (the tube) and other mitigating measures routinely used on the M/S *Søviknes*. The hope and intention was that the skipper would continue to use traditional mitigating measures (notably the streamer line), in addition to using the tube, so that any mitigating effect of the tube could be compared with the 'normal' situation for other Norwegian longliners not fitted with the tube. At the start of the 1998 fishing period activity watched by our observer, there was no streamer line on board, and this had to be made before the experiment to compare by-catch with and without the use of the tube (see 16.1, above) could start.

Although it was virtually impossible to quantify, the observer found that the streamer line was definitely an effective scaring device. Birds dived and pecked on the surface further behind the vessel when the streamer line was in use that when it was not. The observer does not recall birds flying under the streamer line. Some may occasionally have landed near it but in smaller numbers than at the same distance behind the vessel when the streamer line was not in use. The streamer line, however, was sometimes less effective when a cross-wind blew it away from the longline.

As additional deterrents (see **Appendix 9**) the skipper regularly sounded the ship's horn and occasionally resorted to shooting (with a shotgun), usually into the air but sometimes lethally. Shooting killed 3-4 birds (one fulmar, one great black-backed gull and one or two unknown) during the setting of two stubs. The skipper was more likely to resort to shooting directly at birds when exceptionally large numbers (e.g. > 1000) of seabirds were following the vessel. While not condoning shooting birds (rather than shooting generally in the air), the observer tried to explain to the skipper that it was important to keep the intensity of bird scaring constant in order to avoid influencing the experiment. This may have explained why the skipper did not fire his shotgun on every stub set outside the tube. Careful notes on frequency of shooting and horn-blowing were taken for each stub.

It may be a little surprising that the skipper shot some birds in order to scare away the others, as he only fired some shots in the air without aiming at any particular individual when Per Inge Vernæsbranden was the onboard observer in autumn 1997. Svein Ove said that it was most effective to shoot one or two birds, especially big gulls and that this normally kept the other birds at a distance for some time. The observer's impression, however, was that shooting *per se* and killing had very little effect on the birds which quickly habituated and reached the same density behind the vessel only a few minutes after shooting occurred.

The skipper also told the observer that "everybody" on longlining vessels employs shooting to reduce bait-snatching, and he believed the number of birds killed in this way may actually be higher than the number of birds killed by drowning on the line. He did not shoot many birds himself, because it was not necessary when using the tube. The skipper alleged that vessels not fitted with a tube, however, more often combine shooting, horn-blowing and a streamer line. If this is correct, using the technique of underwater setting has at least one obvious benefit to bird conservation.

Appendix 9 presents data on mitigating measures, number of hooks, position, sea state, swell and wind speed for the 40 stubs which the observer monitored during setting. In total, 12 stubs were set outside the tube (along with the streamer line). In addition, two stubs slipped out of the tube at the start of setting (only one of these while the observer was watching), and these were set without using the streamer line. The skipper used horn-blowing, however, to scare away the birds from at least one of these two stubs.

The day-to-day variation in use of mitigating measures (shooting and horn-blowing excluded) is summarised in **Table 4** for all stubs, also for the first day when no observations were made and – on other days - for stubs which the observer did not personally watch.

Table 4. Number of stubs (including those which observer did not personally watch) and the main mitigating measures (tube, streamer line) used each day on M/S Søviknes. See Caption to Table 3 for explanation of SRN. [If the vessel's horn or if shooting were used, these are not included as mitigating measures in this Table.]

SRN only	Tube only	No mitigating	Tube + streamer	Streamer only
0806	?	-	-	-
0906	6	1	-	-
1006	5	-	-	-
1106	-	-	6	2
1206	3	-	1	2
1306	2	-	2	2
1406	-	-	3	2
1506	1	-	3	2
1606	1	-	2	2
1706	5	1	-	-
Total	**23**	**2**	**17**	**12**

17.2 Flock composition and behaviour

As expected, the fulmar was always the most numerous bird species around the fishing vessel. Other species included great black-backed gull (15 - 80 at any one time), a few lesser black-backed gulls, kittiwakes and 1-2 herring gulls. Of these, fulmars showed the greatest eagerness in bait-snatching and scavenging of offal when the lines were being set.

At the time of hauling, however, only fulmars and great black-backed gulls (in small numbers) came close to the vessel to scavenge on discards. Up to about 400 fulmars could then surround the vessel and fight for food when offal or unused bait was flushed out into the sea. When a lot of birds were swimming near the line a few of them got accidentally hooked and pulled aboard. Normally the fishermen managed to release them and throw them overboard. Otherwise, the birds would have been seriously injured or killed in the hauling winch. Apparently birds were often trapped in this way by accident, not because they tried to snatch bait from the line during hauling. To avoid such accidents, the skipper often sounded the vessel's horn to scare the birds away from the line when the fulmars got too numerous. The observer ringed three of the fulmars which were trapped in this way.

All four species of skua were regularly seen around the vessel. The great skua occurred in numbers varying from one to six individuals at a time. Pomarine skuas were also quite regularly observed, especially in the first week. Long-tailed skuas and arctic skuas were seen on only two or three occasions - singly or two birds together. Skuas clearly showed less interest in the line than gulls and fulmars. Great skuas and pomarine skuas seemed often to be kleptoparasitizing the gulls rather than snatching bait or scavenging offal on the sea surface.

A few gannets, guillemots (flying past) and common or arctic terns were also observed when the lines were being set. Of these, only the gannets followed the boat and plunge-dived near the line.

17.3 Seabird by-catch

In the first week, only a few birds were caught. However, during the second week, a relatively large by-catch was taken on some stubs. A total of 31 fulmars and one great black-backed gull was caught during these two weeks **(Table 5)**. The skipper told the observer that only a few (probably not more than 4-5) birds had been caught during the first four weeks of fishing prior to the observer joining the vessel. The skipper reported that on some days, no birds at all had been seen around the vessel before the observer joined the vessel. This absence of birds, he said, was very uncommon, so much so that most of the fishermen had noticed it. He was therefore quite surprised that the by-catch had increased significantly towards the end of the fishing trip.

Against all expectations, the only stubs on which birds were caught were ones which were set through the tube, with or without the streamer line. Excluding the by-catch data from stubs where the observer had no information about number of hooks etc, the by-catch rate on lines set through the tube (± streamer) was found to be 25 fulmars on 139,100 hooks (0.18 birds per 1000 hooks), and 0 birds on 62,200 hooks set outside the tube. By-catch rate is far from constant, however, the variation between stubs being considerable (Table 5). As the sample sizes are already limited, no attempt is made here to break down the data further to take account of the effect of whether using a streamer or not had any separable effect on by-catch for stubs set through or outside the tube. By the same token, the possibly complicating influence of other mitigating measures (horn-blowing, shooting) which accompanied the use of the tube and streamer line to varying degrees is not addressed here.

Table 5. Number of fulmars caught in relation to the use of mitigating measures. * = the stub where one of the birds caught was a great black-backed gull. Stubs where no data are available on geographical position, number of hooks, environmental data and snapshot counts (see 16.2), are marked with an x suffix in the SRN.

SRN	Mitigating measure	No. of birds
0806x	tube only	2
1006c	tube only	1
1306x	tube only	1
1406b	tube and streamer line	5
1506b	tube and streamer line	3
1506c	tube and streamer line	1
1506d	tube and streamer line	5
1606x	tube only	3*
1606a	tube only	6
1606e	tube and streamer line	4
1706x	tube only	1
Total		32

Most of the 32 birds caught got hooked by the wing, foot or other part of the body (n=15), some had the hook stuck in the bill (n=6) and the rest (n=11) were caught in an unknown way. In total, 29 fulmars and a great black-backed gull were collected and sent to the Zoological Museum of Bergen.

Of the several factors which may influence the by-catch rate, the number of birds behind the vessel at the time of line-setting seems to be important (**Figure 3**), although this factor was not statistically significant. The number of birds associating with the vessel was highest in the last part of the trip, but estimated numbers rarely exceeded 300 fulmars. As expected, an increase in bird density also increased the bait-snatching or scavenging of offal and discards behind the boat, as the number of fulmars landing on the sea during each 5-minute period of observations is positively correlated with the average 'snapshot' counts per stub ($R^2 = 0.28$, $p = 0.001$, $n = 33$; **Figure 4**).

Figure 3. Number of fulmars caught per day (= 'Bycatch') in relation to the daily snapshot averages. Except for 8 and 17 June, no birds from stubs where snapshots are lacking are included in the figure. [See text, 16.2, for explanation of 'snapshot' counts.]

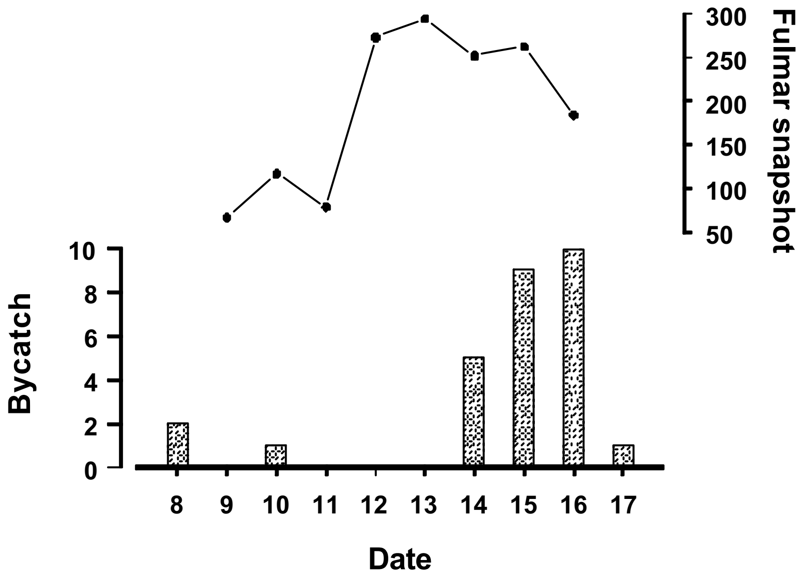
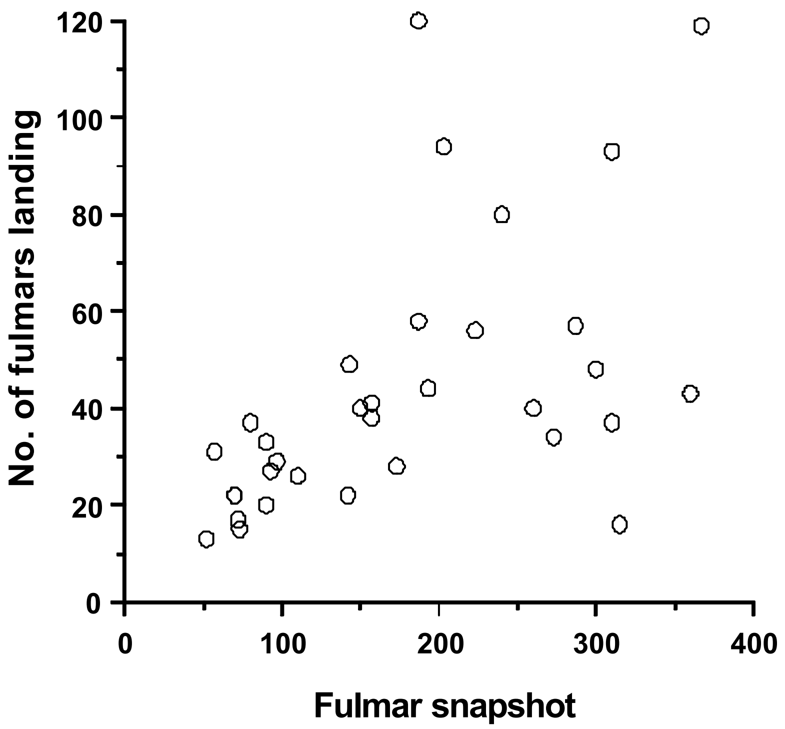


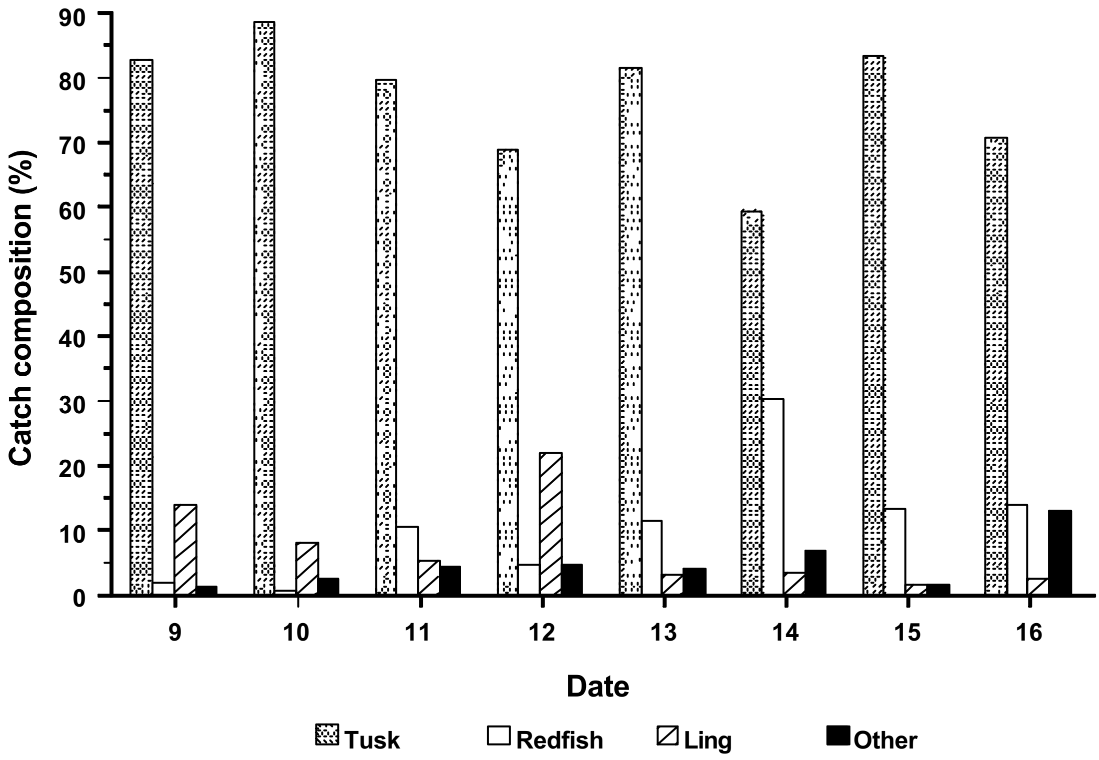
Figure 4. The relationship between snapshot counts (see 16.2 for details) and the frequency of birds landing on the water. Only counts of fulmars are shown.



17.4 Fish catch

Tusk was the target fish species on this trip and typically made up 70-80% or more of the catch. Although much less commonly caught, ling and redfish were also caught in significant numbers (**Figure 5**). Less commonly caught species included in the 'Other' category of Figure 3 were cod, haddock and saithe. Rays (not identified), *Chimaera monstrosa* and *Etmopterus spinax* were also caught in smaller numbers, but these species were all discarded.

Figure 5. Composition of the fish catch on M/S Søviknes during eight days of June 1998.



18 Discussion

18.1 Evaluation of the results

The aim of this study was to evaluate the effect of the Mustad underwater setting tube on the by-catch rate of seabirds. Unfortunately the results are too few to give a statistically clear answer. A clearer understanding requires a resource-demanding long-term study of the tube in a variety of waters, at different times of year and in a wide spectrum of environmental conditions.

Nevertheless, through the 1998 work we have - as in 1997 - gained some interesting insight into the different factors influencing by-catch rates and the role of mitigating measures. Moreover, some general indications about the efficiency of different mitigating measures emerge when these results are taken together with those from related studies.

There may be several reasons for the great variation in daily by-catch rate reported in the present study:

18.1.1 Setting time

There were too few data to test the significance of the start of setting time; this was variable and did not have an obvious influence on observed by-catch rate.

18.1.2 Seabird density

The number of birds associating with the vessel was not constant, and an increase in bird numbers also showed a tendency, albeit not statistically significant, to be associated with an increase in by-catch rate. The relationship between bird numbers and by-catch rate does not explain the whole picture, however, because no birds were caught in the two days when bird numbers were highest (12 and 13 June, 1998).

18.1.3 Availability of offal

According to the observer, the baiting machinery apparently generated a lot of offal (small-sized bait remnants) which either fell into the sea when the lines were set or was thrown overboard by the fishermen. In New Zealand demersal longline fisheries, N. Smith (pers. comm.) believes that most of this offal derives from bait falling off hooks, rather than from the Mustad baiting machine. As in 1997, the observer in our study reported that most of the birds seemed to be scavenging this offal rather than snatching bait directly from hooks and, if so, seabird by-catch rate is probably related to the amount of offal floating in the sea. We discussed this possibility with S. Løkkeborg. He agrees that bait in the wake could cause foul-hooking but believes that, at least on the M/S *Søviknes*, rather little of this comes from the baiting machine, and the main source is probably bait dropping off hooks into the sea, shortly after line-setting. It would be possible to quantify the role of the baiting machine in generating bait loss by using a counter to log baiting success of hooks.

Indirect evidence for birds getting hooked while taking free-floating bait derives from the manner of ensnarement: of the 21 birds caught where the part of the body hooked was known; 15 (71%) were hooked by the wing, foot or some other part of the body, the other 6 by the bill or deeper in the alimentary tract. This may well indicate that birds were more often accidentally snagged when diving to reach offal floating near the line than when deliberately trying to snatch bait off hooks.

It was noted that birds often got ensnared on hooks quite close to one another (although this was not quantified). This grouping may arise from the patchy dispersion of offal floating in the sea, as birds concentrate on patches with higher food density. Another explanation, or reinforcing factor, is that when a bird has been caught, it will - as the crew confirmed - keep the line floating higher in the sea for a while, and thus facilitate the capture of more birds around it.

18.1.4 Weather conditions

Weather probably has the great influence on both bird numbers and on their eagerness to snatch bait. Sea state may have a great impact on how the tube works, because rough sea may cause the line to float higher in the sea than in calmer conditions. Moreover, fulmars tend to be more mobile and dispersive in windy conditions and spend less time sitting on the sea (M. L. Tasker, pers. comm.), thus perhaps enhancing their opportunities to follow and forage behind longliners. Moreover, natural foods may also be less accessible in rough weather, increasing the attraction of fulmars to the artificial food source generated by longlining.

In the four weeks which preceded the observer joining the M/S *Søviknes*, the sea state was relatively calm, with few days of strong wind and rough seas. In this first two-thirds of the fishing trip, the crew described seabird numbers as unusually low and they reported very few caught. After the observer joined the vessel, however, there were 2-3 days with quite rough seas. Indeed the skipper said that he had never experienced such rough sea conditions at that time of year as long as he had been a fisherman. Weather conditions and apparently low seabird density around the longliner could therefore explain why so few birds were caught in the first two-thirds of the trip.

18.1.5 Variation in use and efficiency of mitigating measures

Variation in the type and intensity of mitigating measures could explain the variation in by-catch rates. However, there were no obvious differences in use of horn-blowing or other methods to keep the birds away from the lines (**Appendix 9**). The observer discussed with Endre Søviknes (vessel co-owner) the marked increase in seabird by-catch during the second week of the observer's spell on board. Søviknes suggested that a higher seabird by-catch on stubs set with a combination of tube and streamer line, compared to only the streamer line, could be attributable to the birds being forced to forage behind the streamer line (see 17.1, above, for qualitative evidence that the streamer line had this effect). He argued that, in contrast to near the vessel where the offal was floating on or near the surface and where the birds could take it without getting hooked, the birds forced by the streamer line to forage further behind the vessel where the offal was sinking had to dive to reach it and thus could face a greater risk of being accidentally hooked (this would also explain why so few birds were hooked by the bill). Although this is an intriguing possibility, Endre Søviknes' hypothesis is weakened by the relatively high proportion of birds caught on stubs set through the tube when the streamer line was *not* in use (14 out of 32; Table 5).

An explanation for the higher by-catch on stubs set through the tube than with those set only using the streamer line may of course be that the streamer line actually works *better* than the tube in keeping the birds away from the hooks. Both Endre Søviknes and the skipper were strongly convinced that the tube worked well. Both said that the effect was comparable with the streamer line, but probably not better. However, they say that an important advantage of using the tube is that it is easier to handle than the streamer line. Until recently this was not the case, but after modifications by Mustad, the tube is said to have worked excellently. Also, with this improvement they claim not to have to use horn-blowing and shooting to scare the birds away any more (although the experience of this study somewhat contradicts this: see **Appendix 9**).

As the fishermen progressively store catch in the freezer rooms to the fore of the vessel and as, in contrast, fuel-oil and frozen bait stored in the rear end of the vessel are steadily withdrawn for use, the stern of the vessel rises during the course of a fishing trip. This causes a change in the angle between the tube and the water. As a consequence, it is possible that later in the fishing trip the line floats higher in the water, especially in heavy seas when the vessel is pitching, than it does earlier on, and thus promotes a higher by-catch rate by bringing the bait closer to the surface (Løkkeborg 1996, 1998, S. Løkkeborg, pers. comm.). This may explain some of the results of this study, but it is impossible to distinguish any such effect from the possibility that higher by-catch in the later stages of the trip were simply caused by higher seabird densities (see Figure 3) compared with earlier in the trip when seabird numbers were comparatively low.

Similar probelms were encountered in the study by Ryan and Watkins (in prep) around the Prince Edward islands (see 18.2.2, below); the vessel's pitching in heavy seas occasionally caused the line to surface.

It seemed to the observer in the present study that the tube functioned as it should during the whole cruise. Its penetration, even in rough sea, did not appear to him to fluctuate markedly. He was therefore of the view that the line was kept at a quite stable depth for most of the stubs, reducing the possibility that more birds were killed because of the line floating higher. However, the observer concedes the following two possible effects of rough seas: (i) that the line-tube angle changed during rough conditions when the whole vessel pitched a lot more; (ii) the line was nearer the surface when the vessel was on the crest of a large wave than when it was in the trough.

18.2 Comparison with other studies on underwater setting and streamer lines

Internationally, there is increasing research on mitigating measures in longline fisheries. Four case studies are chosen here for their special relevance to the present study.

Three studies of the influence on seabird by-catch using underwater setting have been conducted, in Norwegian, South African and New Zealand waters respectively. A fourth study sheds light on best-practice use of streamer lines.

18.2.1 Studies by Svein Løkkeborg (Institute of Marine Research, Bergen) in 1996-1998

Løkkeborg's study (Løkkeborg 1996, 1998) was of bait loss and seabird (effectively fulmar) by-catch from experimental longlines set by by the *M/S Stålbjørn* targeting ling and tusk and using an early prototype of the tube. The study was conducted from 9-22 May 1996 off the coast of mid-Norway (64º03'-65º50'N) at a depth of 172-455m. Twelve 'fleets' of lines carrying a total of 56,700 baited hooks, and set in 'traditional' fashion, i.e. without using any mitigating measures, caught 99 fulmars (1.75 per 1000 hooks). By-catch rate for the same fishing effort was reduced more than threefold with underwater setting (28 fulmars, 0.49 per 1000 hooks), but much lower still using only a streamer line (2 fulmars, 0.04 per 1000 hooks).

Svein Løkkeborg also studied mitigation of bait loss and seabird bycatch on the M/S *Søviknes*, fitted with an improved tube design, in August 1998, two months after our study (Løkkeborg 1999). It had not been possible for us to combine forces in the field with Løkkeborg because the owners had made it clear they were unwilling to accommodate more than one observer on any one trip. Moreover, we had a particular interest in relating by-catch to seabird density and behaviour, and only our NOF observers had the necessary expertise to measure these aspects. Another significant difference is that, compared with the our project (which was very much dependent on the voluntary compliance of the skipper with our observer's wishes), Løkkeborg secured a much greater degree of control and flexibility over experimental design and procedure by fully chartering the vessel for his trials, with the catch a financial bonus for the crew.

Løkkeborg's experiments aboard M/S *Søviknes*, starting on day 1 of a new fishing trip, compared four setting treatments; the fulmar by-catch in each case is shown in brackets as, respectively, numbers of birds, and birds per 1000 hooks:

1 no mitigation measures [74, 1.06]
2 bird-scaring line with short streamers suspended [2, 0.03]
3 bird-scaring line with long streamers suspended [0, 0]
4 setting funnel (= tube) [6, 0.09]

[(2) is a rudimentary form of scaring device, similar to the line with no streamers at all traditionally used by Norwegian longliners; the more elaborate streamer line (3) incorporates some of Løkkeborg's own design features.]

For each of the treatments (1-4), 11 settings totalling 70 000 hooks were made, using squid or mackerel as bait (fishermen prefer squid which, being firmer, is less easily dislodged from hooks: S Løkkeborg, pers. comm.). Video recordings were made of all the settings. Apart from seabird by-catch (all fulmars), potential increases in catches of target fish (mainly haddock, tusk and ling) were quantified. The results showed significant differences between setting methods in seabird by-catch, bait loss and catch rates of fish. The lowest by-catch (0 birds) was with the bird-scarer fitted with long streamers, followed by 2 birds (0.03 per 1000 hooks) when shorter streamers were used. Six birds (0.09 per 1000 hooks) were caught using the setting funnel but 74 birds (1.06 birds per 100 hooks) when no device of any sort was used.

The experiment also demonstrated a reduction in bait loss and higher catches of target species in settings that employed mitigating measures. Bait loss was lowest with bird-scaring lines (ca 15%), intermediate with underwater setting (ca 15-25% depending on bait type) and highest with no mitigating measures (ca 20-30%). Catch rates of target fish reflected this, being highest with bird-scaring lines, intermediate with underwater setting and lowest with no mitigating measures.

Whereas the NOF study suggested that most of the birds may have been foul-hooked while taking bait fragments not attached to hooks, Løkkeborg's study did not look for this distinction and assumed that all the fulmar by-catch arose from trying to steal bait off hooks. If this were so, significant bait loss might have been expected to translate into commensurate seabird by-catch. However, Løkkeborg (pers. comm.) pointed out that bait loss far exceeded bird by-catch because fulmars are good at stealing bait off hooks without getting caught. As proof of this, in the experiments to quantify bait loss with different treatments (in which the line was set then quickly hauled in again), only one bird was actually caught (S Løkkeborg, pers. comm.).

Løkkeborg summarised his 1998 results as follows:

- both the bird-scaring line and underwater setting (1) greatly reduced seabird bycatch, (2) reduced bait loss, (3) increased catch rates of target fish

- the bird-scaring line was superior to the setting funnel

- the two bird-scaring lines (short and long streamers, respectively) performed similarly, indicating that the scaring line without streamers[3] traditionally used by Norwegian fishermen is effective.

These results are extremely important in two respects:

1 For the finding, in such a fine-grained way, that a succession of increasingly effective mitigating measures translates into lower rates of bait loss and correspondingly higher catch rates of target fish. This result is apparently robust to the possibility that, e.g., the treatments using mitigating measures coincided with - for independent reasons - better fishing opportunities. This result is the most significant in terms of persuading fishermen to apply the best practicable mitigating measures.

2 For showing that there appears to be no special advantage, at least in the context of this particular study and its potential seabird (fulmar) by-catch, in using underwater setting and indeed it was inferior to bird-scaring lines in these experiments. Moreover, Løkkeborg believes that, far from even having to use a sophisticated bird-scaring line with long streamers, the rudimentary line already used may be adequate. However, arguably a more-consistently low by-catch could be achieved using a bird-scaring line with longer streamers; studies in the Southern Ocean indicate that streamer line design is very important, with best protection achieved by having long streamers extending right down to the water's surface: N. Smith, pers. comm.).

It is important to note that Løkkeborg's trials in 1998 (unlike in 1996) started at the very beginning of the fishing trip. This ensured that the tube was being tested at its maximum potential efficiency, so that any shortfall on performance could not be blamed on the timing of the experiments. As Løkkeborg has pointed out (see 18.1.5, above), the effectiveness of the setting tube may decline as the fishing trip proceeds, due to a gradual rise in the stern of the vessel as the relative weight allocation of cargo shifts forward from the bait freezer to the catch freezer. In any case, even if the manufacturers were to criticise Løkkeborg's experimental design in 1996 (and NOF's in 1998) on these grounds, the

[3] This sort of rudimentary device is quite widespread in longline fisheries, and not just in Norway. According to Antonio Sanchez and Eduardo Belda (pers. comm.), Spanish longliners fishing off the Columbretes Is near Castellon (Spain) routinely use such a line, which they describe as a buoy - or other floating object - towed ca. 30-50m behind the vessel. They say this works well as first but the birds then habituate and get caught in numbers, mainly Cory's shearwaters *Calonectris diomedea* but also sometimes yellow-legged herring gulls *Larus michahellis* and Audouin's gulls *L. audouinii*.

fact remains that a mitigating measure has to be effective throughout a fishing trip if it is to serve its purpose well.

18.2.2 Study by the Percy Fitzpatrick Institute (University of Cape Town, South Africa)

The following information derived from Ryan and Watkins (in prep.). The vessel (M/S *Stålbjørn*) on which Svein Løkkeborg conducted his trials in 1996 was renamed M/S *Eldfisk* and the effectiveness of its setting tube (which deployed the line 1-2m below the surface) tested in waters off the sub-Antarctic Prince Edward Island EEZ, south of South Africa, from August 1998 to May 2000 where the vessel was targeting Patagonian toothfish *Dissostichus eleginoides*.

The impetus to establish the effectiveness of the tube is that the licensing arrangements (following a CCAMLR Conservation Measure) allow longliners to fish only at night in order to reduce albatross by-catch; the vessel owners hoped that if the tube proved successful they would be allowed to fish during the day, at least in winter, and thus boost catch rates. Prior to these trials, the vessel had already been twice to the Prince Edward Islands but had only used the tube once or twice because the owners were concerned about the ca 5% bait loss caused by friction in the tube.

The field experiments were designed to assess seabird and fish catch rates by day and by night, using settings in and out of the tube, by alternating three types of settings (S1-3):

S1) Normal fishing: lines set at night, not underwater setting (= control)
S2) Underwater setting at night (= night experimental)
S3) Underwater setting by day (=day experimental)

The aim was to use fish and bird catch rates to test the following hypotheses:

H1) Underwater setting reduces bird bycatch at night (compare S1 and S2)
H2) Underwater setting limits daytime by-catch to levels similar to those at night (cf. S1-3)
H3) Underwater setting increases fish catch rate (cf. S1 and S2)

The tube was used (in conjunction with a bird-scaring line, appropriate line-weighting and setting speed) in 52% of 1714 sets (total effort 5.12 million hooks). Overall seabird bycatch rate was low (0.022 birds per 1000 hooks) and was dominated by white-chinned petrels *Procellaria aequinoctialis* (88% of 114 birds killed). By-catch rate was three times lower when the tube was used both by day and at night. Daytime catch rates with the tube were less than those incurred during night sets without the tube.

This is the first extensive demonstration that underwater setting significantly reduces incidental mortality of seabirds. It indicates that underwater setting could arguably justify daytime setting in this fishery and thus increase fishing efficiency. Allowing vessels to fish throughout the day, especially in summer when nights are short, would provide a strong economic incentive for fishers to adopt the tube.

However, whether the Mustad tube reduces seabird by-catch in the toothfish fishery to acceptable levels is debatable. Small numbers of albatrosses were caught during daytime sets with the tube, and the tube's use for daytime sets would need to be closely monitored because the introduction of daytime fishing would substantially increase overall fishing effort.

Ryan and Watkins also comment usefully on the length ot the tube. As in Løkkeborg's and the present study, they found that the pitching of the tube occasionally lifted the line to the surface in heavy seas. They agree there is a need to increase the depth at which the line is set (cf Brothers *et al*

1999) but it is probably unrealistic to set the line below the foraging depth of all southern-hemisphere species (white-chinned petrels dive to at least 10m). Consequently, stern-mounted tubes are unlikely ever to achieve zero seabird by-catch.

18.2.3 New Zealand underwater setting chute

Two underwater setting devices for pelagic longline vessels have been developed in New Zealand, to the stage where they are now fully operational. The first is an underwater setting 'chute' (= tube), the second an underwater setting capsule device which facilitates the transport of a baited hook within a retrievable capsule to a predetermined depth where it is released (Brothers *et al* 1999).

Only the chute is described here. The following description is adapted from Brothers *et al* (1999). Although similar in principle to the Mustad underwater setting tube, the chute system (Barnes and Walshe 1997) is markedly different in design. It is intended for potential use in both pelagic and demersal fisheries. The chute penetrates deeper (3m) than the Mustad tube and, unlike that tube, relies upon being withdrawn from the water when it is not in use because it is flexibly mounted. This is a feature of relevance to stress considerations associated with hanging comparatively fragile gear off big ships in rough weather. To achieve and maintain its setting depth, the chute system relies upon a winch/paravane mechanism. A combination of water injection and venturi force accelerates the passage of baited hooks down the chute. Conceivably it would be possible to ensure rapid, simple chute withdrawal, a facility essential to cope with unexpected events such as main line jamming that necessitates rapid vessel manoeuvring.

As in the present study, the NZ Dept of Conservation recognises that the effectiveness of the chute is likely to be influenced by a number of factors including setting time, vessel size, setting speed, seabird species present around the vessel and fishing gear. In NZ waters, a number of the petrel species are all good divers (cf white-chinned petrel, 18.2.2, above). However, the chute is looking quite promising for some fisheries and it is hoped that the night setting obligatory in NZ waters in combination with the chute may be highly effective (J Molloy, pers. comm.)

18.2.4 Alaskan research on paired streamer lines

The following information was provided by Ed Melvin (Washington Sea Grant Program). Extensive testing in Alaska has found that paired streamers are effective at the 92-100% level in two demersal longline fisheries in which the highest by-catch is of northern fulmar. Essentially, paired streamers were found to completely preclude birds from 60-90 metres of the wake zone. Some comparisons were made with single streamers in 2000 but because seabird interactions were weak irrespective of mitigating measures, it proved impossible to establish statistically significant differences between paired and single streamers.

However, from indirect measures such as attack rates and bird abundance, the Program has compelling evidence that paired streamers allow many fewer birds access to bait-snatching. This is because paired streamer lines account for differences in seas and wind, and can be deployed the same way each time, regardless of weather. If the vessel sets in a cross wind, a single streamer line gets blown off the path of the longline, whereas with paired streamer lines the up-wind line can blow near to the longline and has a chance of providing some protection. On the negative side, deploying paired streamers generates more line in total behind the vessel, increasing the risk and incidence of snagging – but only if the lines are deployed improperly. A skilled crew experiences no problem, and has no complaints providing there are hydraulic facilities for retrieving the gear.

19 Assessment of effectiveness of mitigating measures

19.1 The pros and cons of tube vs. streamer line

A considerable number of mitigation measures designed to reduce the by-catch of seabirds by longline fisheries has been developed, described and recommended (e.g. Brothers 1991, CCAMLR 1994, Alexander *et al* 1997, Robertson and Gales 1998, Brothers *et al* 1999, FAO 1999). These measures include setting lines at night; trailing bird-scaring lines and streamers behind vessels during line-setting ('tori poles' and 'tori lines'); using machines to cast baits clear of the vessel's wake during line-setting; weighting lines more heavily so that they sink more quickly; thawing bait; using bait that sinks more readily; designing hooks to minimise snaring birds; closing fishing areas or seasons; and not dumping offal near the fishing lines during setting and hauling. Various attempts have been made to measure the relative efficiencies of these measures but such comparisons are fraught with difficulties, not least because few approaches have been conducted under controlled conditions, the combinations of mitigating measures vary from fishery to fishery, and any answers forthcoming are not easily transferable from one set of conditions to another.

The present study sought essentially to establish the effectiveness of the Mustad underwater setting tube. As our fieldwork opportunities were limited to pilot studies, the main aim in 1998 was to compare the performance of the tube with the conventional mitigating measure (streamer line) used by the vessel (and large Norwegian autoliners generally), rather than testing the tube in comparison with no mitigation measures at all. In any case, the skipper was understandably reluctant to expend much fishing effort without deploying any mitigating measures at all. As it turned out, he even used measures (shooting, horn-blowing) additional to the streamer line.

So we cannot gauge the absolute effectiveness of the tube over the control situation of 'no mitigating measures'. However, the indications, from the skipper and crew's verbatim evidence, and from this and the related study by S. Løkkeborg are that while the tube significantly reduces seabird by-catch (and thus bait loss), it performs no better that a streamer line in this respect and may be inferior to it, at least in the conditions that prevailed in these north-east Atlantic studies (unlike in the southern-hemisphere study around the Prince Edward Islands where the tube significantly reduced by-catch). Certainly, there is no compelling evidence for the tube emerging with any clear mitigating advantage over the streamer line in the north-east Atlantic studies so far.

Of greatest concern is whether the tube, in its present form, is capable of setting the line deep enough to avoid catching birds in all weather conditions and in all stages of the fishing trip (given that the tendency is for the stern to ride higher as the trip proceeds). While acknowledging the potential of underwater setting, Brothers *et al* (1999) says of the Mustad tube: "*In its present form it delivers baits only 1.5 m below the surface in calm seas, insufficient considering the potential sink rate of this gear, the reduction in setting depth in rough seas and seabird diving abilities, especially in the Southern Ocean where pursuit divers, such as the White-chinned Petrel, are commonly caught on longlines.*" In this respect it is also worth noting that northern fulmars have been observed diving up to at least 4m beneath the surface in pursuit of offal (Fisher 1952).

So what are the arguments in favour of the Mustad tube? While one of the vessel owners (Endre Søviknes) judged the tube and streamer line to be about equally effective as mitigating measures, he said that they much preferred the 'convenience' of using the tube, particularly with the most recent modifications made by Mustad. Also, because of the tube's relative efficiency, since using the tube they had largely given up using other minor mitigating measures (horn-blowing and shooting).

In terms of uptake of the tube by the Norwegian fishing industry (only 1 vessel in 61 known to be fitted with the tube at the time of writing), it is clear that the convenience of the tube has not been a sufficiently compelling selling point to outweigh the substantial cost of the tube, especially when it has to be added to an already operational vessel rather than being budgeted for in building the vessel from the outset. Confidence in the tube can only be further undermined by the results (which the present study does not contradict) of Løkkeborg's studies giving a boost to the streamer line. The cost-effectiveness of the streamer line evidently seems more attractive and commends its use to owners and skippers of longline vessels, even if the streamer line is less convenient and less tidy to deploy. Moreover, robust as the tube is, it takes a serious buffeting on its stern-mountings, and fishermen are bound to have concerns about the 'shelf life' of the tube and the wisdom of a major long-term investment if it turns out that it requires a lot of maintenance against wear and tear.

It seems that these will remain practical obstacles to the popularity of the tube in the north-east Atlantic, even if Mustad continues to develop and finesse its design. Moreover, there may well be engineering constraints on making the tube much more efficient than it is now. For example, there must be a trade-off between, on the one hand, increasing the length of the tube to achieve deeper penetration, and on the other, the changing strength/weight ratio of the tube and the drag it imposes on itself and the vessel's passage through the water. However, it may be that, without overcoming these intrinsic limitations imposed by the structure of the tube itself, some of the drawbacks can be overcome by using the tube in conjunction with other mechanisms and techniques, some of which are described below.

19.2 Advice to the longlining industry in the North-East Atlantic

19.2.1 Setting tube

The by-catch rates found in this 2-year study indicate that: (i) the use of the tube did not eliminate seabird by-catch, (ii) (at least in 1998), the streamer line may have been more effective than the tube in mitigating by-catch, although daily by-catch rate was too variable to prove this.

Løkkeborg's (1999) study indicated that the Mustad underwater setting tube and streamer line each (as stand-alone measures) greatly reduce seabird by-catch but that the streamer line was the more effective of the two mitigating measures. The evidence from the present study does not support the view that the Mustad underwater setting tube performs better than the streamer line.

Nevertheless, underwater setting either from vessels designed with a built-in 'moon-pool' for through-the-hull setting, or using a stern-mounted tube of some sort, is potentially an effective way of separating seabirds from baited hooks and improvements may come with further development. In the meantime, through-the-hull setting is unlikely to become commonplace in the near future, and the Mustad tube is delivering less than expected, so the immediate priority is to take a pragmatic view and to design a system and protocol for reducing incidental mortality which is applicable to the existing fleet.

19.2.2 Streamer line

Even if this study cannot endorse that the Mustad tube currently represents best practice for the Norwegian and other north-east Atlantic fleets, the key issue is to ensure that the vessels are not going for the lowest common denominator by either shunning mitigating measures entirely or just using a streamer line (and possibly a sub-standard one) simply because everyone else does.

The first recommendation, therefore, is that,

- **In the short term, these fleets should be obliged to use a streamer line at all times during line setting.**

Notwithstanding the indications form Løkkeborg's work that it matters little in terms of by-catch whether it has long or short streamers, practice elsewhere in the world shows that streamer configuration is important, so:

- **the streamer line should be of standard, approved design such as that recommended by CCAMLR for demersal longlining (Alexander *et al* 1997).**

The most important part of the streamer line is the aerial section; the longer this is, the less time the seabirds have to reach the sinking longline to retrieve baits (Smith 1999). However, a streamer line by itself is not enough to prevent incidental by-catch of seabirds in some fisheries.

Work in Alaskan longline fisheries (18.2.4, above) points compellingly to the significantly superior mitigating effect for fulmars of paired streamer lines compared with a single streamer line. The Norwegian longline fishery should therefore ideally commit to use of paired streamer lines, especially when the ambient fulmar density is high. Even greater reductions in bait loss can be expected to accrue from using paired streamer lines.

- **Best practice suggests use of paired streamer lines, and Norwegian research should establish the effectiveness and feasibility of their use.**

19.2.3 Line-weighting regimes

CCAMLR has given a great deal of thought to reviewing mitigation measures and its conclusions have implications well beyond the Southern Ocean. There is broad agreement in CCAMLR, including representatives of the fishing agencies, that although underwater setting might be a solution (and certainly a desirable target) in the long term, the low sink rate of lines at setting is one of the most serious contributory factors to facilitating access of seabirds to hooks. Slow-sinking longlines tend to hook and drown more seabirds than longlines that sink fast (Robertson *et al*. 2000). CCAMLR therefore maintains that, in the medium term, line-weighting offers the simplest and best prospect of progress, superior to some types of bird-scaring line. It is CCAMLR's view that a widespread focus on line-weighting might avoid a proliferation of devices.

CCAMLR has specified target line sink rates for fishing in the southern hemisphere and is putting a lot of energy into devising appropriate line-weighting regimes for the various types of longline fishery operating there. Field trials off South Georgia with regimes of 0.2-0.3 m-per-second sink rates gave bird catch rates in daytime in summer that were as low as rates at night-time in winter (Agnew *et al* 2000, J. P. Croxall, pers. comm.). Agnew *et al* (2000) conclude: *"The fact that such low catch rates are achievable even when fishing during the day at a time of year when black-browed albatross and white chinned petrels are most vulnerable, suggests that it may be possible to reduce seabird by-catch to acceptably low levels from longline fishing at any time around South Georgia."*

The importance of coupling line-weighting with a streamer ('tori') line is also the conclusion of a study of New Zealand vessels fishing for toothfish with Mustad autoline equipment in the Ross Sea (Smith 1999). The solution investigated to mitigating by-catch was to set a longline in such a way as to sink it beyond the diving depth of seabirds quickly and within the aerial section of a streamer line. A streamer line can protect a longline directly behind a vessel for up to 100 m. With no line weighting, the longline only sank to a depth of 2-5m at 100m behind the vessel, and several seabird species were able to dive to this depth and become hooked. When effective line weighting was used (ca 5 kg every 40-60m), the longline sank to >10m at 100m behind the vessel, and very few scavenging seabirds can retrieve baits from this depth. The study employed manual addition of weights, which is impracticable in terms of time and labour as a routine practice. Smith (1999) is certain that more efficient methods of accelerating line sink rates need to be developed, possibly through integrated line weighting. In other words, the weighting should be built into the line itself, possibly in the form of a weighted snood attachment.

The recommendation from this is, therefore, that:

- **Urgent attention should be given to the design, testing, and implementation of integrated line-weighting so achieve sink rates that will enhance the effect of a streamer line**

S. Løkkeborg is sceptical about the practicability of line-weighting, thinking that it would make gear too heavy to set and haul, and that accordingly magazines (for storing line, snoods and hooks in the automated system) would have to be prohibitively robust and heavy. However, in the face of compelling evidence that line-weighting is so effective in reducing by-catch, the technical problems of overcoming any reservations about line-weighting may seem slight to manufacturers as compared to trying to perfect an underwater setting tube.

19.2.4 Line shooter

Another factor that may affect longline sink rates is the tension of the line as it is deployed. Line tension occurs from the drag of the line already deployed plus the weight of the anchor. A potentially promising development by Mustad, which could possibly be used in conjunction with line-weighting, is a 'line shooter' which puts slack into the line at the outset as it is deployed. The line shooter also allows the line to go through the baiting machine at constant speed, thus increasing baiting efficiency. Shorter lines might also be expected to sink faster than longer lines (due to the proportionally greater influence of the anchor).

S. Løkkeborg and colleagues studied the effect of line tension and line ('fleet') length on longline sink rates in August 1999 on the same vessel as used in the present study. The line shooter expelled the line at ca 0.5 knots faster than the vessel's speed, causing it to fall in loose coils behind the vessel. The results reported in Robertson *et al* (2000) were equivocal and most of the trials did not show a significant relationship effect of line tension or line length on sink rate.

However, they did draw attention to one possible advantage: loose lines enter the water ca 0.5m astern compared to ca 10m astern for tensioned lines. Assuming lines start sinking as soon as they hit the surface, loosely-set lines might be expected to have sunk to ca 50cm by the time tensioned lines even enter the water. So the authors suggested that the onset of sinking might be of advantage to the seabirds, even if the intrinsic rate of sink does not differ.

- **While the line shooter may improve baiting efficiency, further data are needed in a variety of sea conditions to establish any mitigating effect on seabird by-catch.**

19.2.5 Other mitigating measures

It is clear from the present study that the discharge of offal is a serious contributory factor to the by-catch of seabirds. It is not clear where the offal in the wake emanates from (baiting machine, fishermen throwing bait fragments it into the sea, or bait falling off hooks during line-setting). But reducing or eliminating this discharge would significantly reduce seabird by-catch.

- **The causation of generating offal in the wake of the vessel during line-setting needs to be more closely examined and ways found of eliminating it at source.**

Finally, the practice - as discovered during this study to be allegedly widespread in the Norwegian offshore longline fishery - of shooting (with shotgun or other firearm) at seabirds as a 'mitigating measure' cannot be condoned. Mitigating measures should serve to enhance the survival of non-target species, not to increase their mortality. In any case it is likely that shooting does little or nothing to deter birds from baited lines but presumably makes the skipper or crew feel better that they are doing 'something' to get rid of their frustration at seeing bait snatched from hooks.

- **Firearms should have no place among the mitigating measures used by the Norwegian or any other fleet.**

19.2.6 Mitigating measures: conclusion

It has always been recognised that there will be no single panacea for mitigating seabird by-catch and bait loss, and that a suite of technical measures, combined with best fishing practice, will be required in longline fisheries. The scenario recommended here, at least for existing vessels which have to work within design constraints, is a combination of single or paired streamer (tori) lines, line weighting, and a shooting device to slacken the line at setting (this appears to at least enhance baiting efficiency and may possible reduce seabird by-catch).

These measures have the merit of being already available or well advanced in development (streamer line, line shooter) or having a proven track record experimentally. It would be a suitable challenge for Mustad to co-develop a line shooter that could accommodate an integrally weighted line. Any or all of these mitigating measures would be enhanced by preventing bait or other offal from entering the wake of the vessel during setting operations. In concert, it is likely that these mitigating measures would reduce seabird by-catch in the north-east Atlantic to acceptable levels, and would also do away with any need (if indeed such a need can be justified at all) to shoot towards or at seabirds which is unacceptable and cannot be classed as a bona fide 'mitigating measure'.

It is also our view that a proven set of effective mitigation measures cannot be left as a take-or-leave option for voluntary uptake by longline vessels. Rather:

- **A proven suite of measures should be a statutory requirement of national and European fishing regulations, just like other technical conservation measures such as mesh sizes etc.**

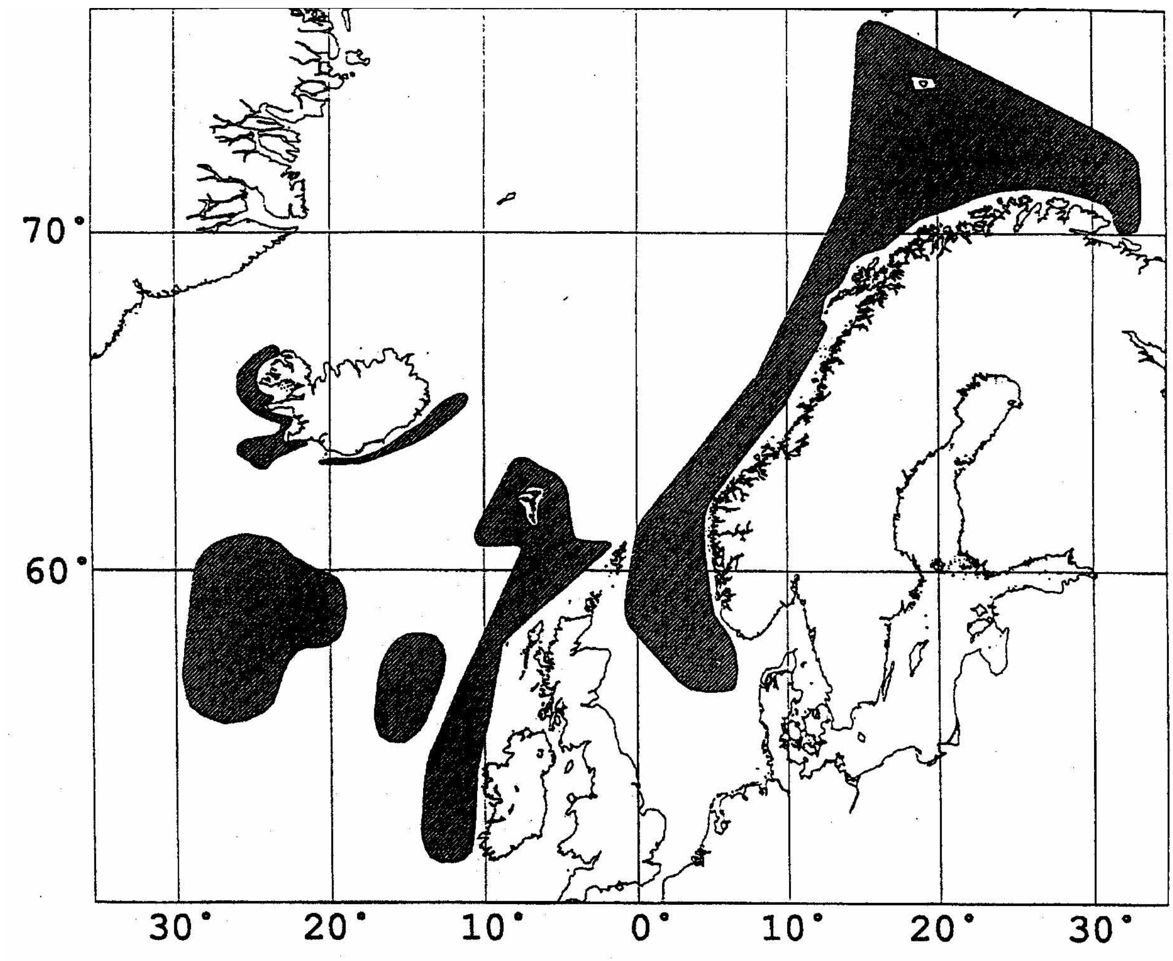
Finally, serious thought also needs to be given to longline vessels as yet not built and Norway, as a key innovator and exporter of longline design, should be at the cutting edge of this. Building on the 'moonpool' precedent, the aim should be to internalise underwater setting in the hull of the vessel, in order not just to do away with the rather crude bolt-on tube but also to re-align underwater setting away from the propellor and its wash which - as described above (18.1.5, 18.2.1) can undermine the effectiveness of underwater setting (G. Robertson, pers. comm.).

- **Norway should take a lead in developing longline vessels and gear with a view to integrating mitigating measures, and especially underwater setting, into the hull design and construction.**

20 By-catch of seabirds by longline fisheries in the NE Atlantic

This section (much of which was synthesised in Brothers *et al* 1999) reviews the literature on incidental mortality of seabirds from longlining in the region, attempts to assess the scale of that mortality from demersal longlining on the key species affected (fulmar) and the implications for the conservation status of that species. The extent of longline fishing in the north-east Atlantic is shown in **Figure 6.**

Figure 6. The main fishing grounds used by longline vessels in the north-east Atlantic (reprinted from Brothers *et al* 1999 by kind permission of the FAO, Rome)



The few studies of the direct impact of fishing gear on seabird mortality in the north-east Atlantic have largely been confined to net mortality, with hardly anything known on impacts of longline fisheries. With negligible designated research carried out by independent observers, the available data are poor and hardly compatible with evaluating the scale of overall mortality and thus the level of risk – other than in broadly qualitative terms - that longlining poses to any North Atlantic seabird species.

20.1 United Kingdom

The only known data for UK waters concern a four-hour watch in April 1992 by an independent observer (D. Thomas) aboard a longliner fishing for (mainly) dogfish and rays with 12 x 1 mile racks of 1200 hooks off the south coast of Wales. The observer recorded the following seabirds caught during line-setting: 1 fulmar, 1 gannet, 1 lesser black-backed gull, 5 great black-backed gulls, 2 unidentified gulls (RSPB, unpublished).

The Spanish longline fishery for hake (and - when the market is buoyant - some deepwater sharks) in the western approaches to the UK apparently catches few birds, according to Perez *et al* (1995) who reported only two fulmars and one Manx shearwater taken by the fishery during 1994 in ICES regions VII and VIII. Whereas these figures almost certainly under-represent the true scale of seabird by-catch in that region, they must also to some extent reflect the paucity of fulmars in waters west and south of the UK where the Spanish fishery concentrates, when compared to further north (Stone *et al* 1995, M L Tasker *in litt.*).

20.2 Iceland

In 1996, the Icelandic longlining fleet consisted of 805 registered vessels, of which 475 were open and 330 were decked vessels; the latter landed 84% of the total longline catches. Total effort exerted by the Icelandic fleet in 1996 was 230 million hooks (Løkkeborg in Brothers *et al* 1999). In that year, the Icelandic and Norwegian longline fleets landed, respectively, 69,000 tonnes (US$ 68 million) and 144,000 tonnes (US$ 152 million), mainly Atlantic cod, haddock and tusk (**Table 6**).

Table 6. Annual longline landings (tonnes) of groundfish in Norway and Iceland in 1996 (from Cooper *et al* 1999).

Country	Atlantic Cod	Haddock	Tusk	Ling	Wolf fish	Greenland Halibut	Total
Iceland	38967	7524	4933	1393	11083	2447	69018
Norway	63897	29670	17564	14497	5829	6151	144146

Information on the seabird by-catch in Icelandic longline fisheries is sparse in the extreme, based as it is on the recovery of a small number of ringed birds. In Iceland, ringing recoveries indicate that longlining by-catch is the second largest source of ringing recoveries after by-catch in fishing nets, affecting fulmars (5 recoveries) and great skuas (15 recoveries) (Petersen 1998, A. Petersen pers. comm. to J. Cooper).

While the ringing recoveries for great skua may point to a possible impact on the Icelandic population (roughly stable at estimated 5,400 pairs, i.e. ca 40% of the European population: Tucker and Heath 1994), it is notable that the recoveries outnumber those for fulmar by a ratio of 3:1, whereas in population terms, Icelandic breeding fulmars outnumber great skuas by around 300:1. Superficially this may suggest that great skuas could be more vulnerable to capture on longlines than fulmars but this is not borne out by direct observations on susceptibility in the present study. The more likely explanation is one or a combination of the following: (1) compared with fulmars, a higher proportion of great skuas is ringed; (2) the foraging dispersion of great skuas from breeding colonies is probably less than fulmars so the concentration of birds at risk to longliners may be higher; (3) fishermen are more likely to retrieve and hand in rings from great skuas because they only exceptionally take them as by-catch and thus consider them worthy of special attention.

Although ringing recoveries are the only tangible evidence, it is generally considered that large numbers of fulmars are taken by the Icelandic longline fleet (Bakken and Falk 1997, Petersen 1998 and *in litt.*). Petersen (1998) notes that "Because of their sheer numbers, northern fulmars get hooked on longlines in large numbers, probably with no influence on the population." A. Petersen (pers. comm. to J. Cooper) surmised that the Icelandic longlining fleet annually kills "thousands or low tens of thousands of fulmars" but that this does not pose any apparent conservation threat to the Icelandic fulmar population estimated at 1-2 million pairs.

20.3 Faeroes

The following information was supplied to E. Dunn by Jákup Reinert, Head of Fisheries Department, Faeroes. The Faeroes has longlining fleet of over 700 vessels in three size categories. The fleet structure, dispersion, and deployed fishing capacity are shown in Table 7:

Table 7. Composition of Faeroese longlining fleet and hooks deployed in fishing season Sep 1997-Aug 1998.

Size of vessel (GRT*)	Fishing zone	No of licensed vessels	Number of hooks
>110	shelf, deepwater, distant waters	19	107,731,000
15-110	shelf	55	42,250,000
<15	inshore on shelf	644	3,125,000
Totals		**718**	**153,106,000**

*GRT = Gross Registered Tonnage

The largest vessels (autoliners) fish offshore as far as the Barents Sea; the medium-sized vessels conduct 1-2-day fishing trips; the small wooden inshore vessels may use use longlines or handlines. Collectively, these longliners deploy ca 150 million hooks annually to target cod, haddock, less often ling and tusk. As in Norway, redfish (*Sebastes*) is a new and developing target species (Berger Olsen, pers. comm.).

According to Berger Olsen, the main seabird species taken as by-catch is the fulmar, the incidental mortality varying quite markedly between seasons and areas. There is indirect evidence that great skuas may also be taken occasionally: there are a few ringing recoveries of this species from 'vessels at sea' but without further details it is only speculative that some of these derived from longlines. The risk from longlining to the Faeroese great skua population, estimated at ca 275 breeding pairs (Hagemeijer and Blair 1997) is thus unknown but likely to be small for the reasons outlined above for Iceland. In the past, guillemots were recorded as by-catch in the Faeroese longline fishery for salmon, but this fishery (as in Norway) is now closed.

20.4 Norway

20.4.1 Salmon longline fishery

During 75 fishing days in March-June 1969, a single longlining vessel targeting Atlantic salmon (a fishery since closed) off northern Norway caught 294 birds, including: fulmar (52), north Atlantic gannet (3), kittiwake (43), common guillemot (107), puffin (83) (Brun 1979). If these figures are representative of this fishery, then extrapolating this level of mortality to the entire fleet of ca 120 vessels indicated a toll of around 60,000 birds each summer, comprising 10,000 fulmars, 600 gannets, 9000 kittiwakes, 21,000 common guillemots and 18,000 puffins (Brun 1979). Although Myrberget (1980) rightly questioned the validity of extrapolating from one vessel to the whole fleet, arguing that the data should not be given too much weight, the figures do indicate that this fishery caught an unusually wide spectrum of seabird species and in large numbers. The reason for this is not known though possibly the lines were set near the surface with attractive bait where they were easily accessible to birds. However, as indicated, the fishery is no longer in existence so these figures are now only of historical interest.

20.4.2 Demersal longline fishery

Norway has 61 large autoliners operating offshore in the NE Atlantic (Brothers *et al* 1999) but, as in Iceland and the Faeroes, there are many more smaller longliners fishing closer to the Norwegian coast. The lines of these inshore vessels are baited onshore by hand and coiled into tubs or baskets. Depending on size and number of crew, each of these vessels carries from a few up to 100 tubs of 300-400 hooks each, and stays at sea for 1-2 days. The catch is landed fresh and processed onshore. By contrast, the offshore autoliners set 30,000-35,000 hooks per day, a trip may last 6-7 weeks, and the catch is headed, gutted and frozen onboard (S. Løkkeborg in Brothers *et al* 1999).

In total, the Norwegian longlining fleet in 1996, excluding vessels which landed less than 10 tonnes, amounted to 813 vessels, of which 79 were longer than 25m and landed 60% of the total catch. The 61 autoliners set an estimated 476 million hooks in 1996 (Løkkeborg in Brothers *et al* 1999). However, longlining effort is much greater, in terms of vessel numbers, if we include vessels which operate mainly other gears (such as gill-nets) but which use longlines on occasions: the Norwegian Directorate for Fisheries confirmed to C. Steel that in 1996, the number of Norwegian vessels that used a longline and caught fish at least once by this method was 9206.

Norwegian demersal longline fisheries (see Table 4 for target species) take mainly fulmars (Løkkeborg 1990, 1996, 1998, Løkkeborg and Bjordal 1992). In the present (1998) study, in addition to 31 fulmars, 1 great black-backed gull was caught. Whereas fulmars are readily hooked, herring gull and kittiwake are skilled at stealing bait without getting caught (Løkkeborg 1990), and in general the by-catch of gulls appears to be negligible. The observations in the present study also suggest that skuas (irrespective of species) are even less attracted to baited hooks than are gulls.

Apart from our own study, Løkkeborg's are the only truly experimental studies to date into the interaction between longlining and seabirds in the north-east Atlantic. A summary of fulmar by-catch rates from the two studies conducted by Løkkeborg in, respectively, 1996 and 1998 are shown in **Table 8**, along with the results from this study (Parts 1 and 2).

Table 8. Summary of by-catch rates of fulmars from studies of demersal longlining in Norway.

Area	Month, year	Mitigating Measures	No. hooks	No. fulmars	Fulmars/1000 hooks	Source
Mid-Norway	May-96	None	56,700	99	1.75	Løkkeborg 1998
		Tube	56,700	28	0.49	
		Streamer line	56,700	2	0.04	
N. Norway	Oct-97	Streamer line	279,000	9-10	0.03-0.04	This study (Part 1)
		Tube	481,500	6	0.01	
Mid-Norway	Jun-98	Tube ± Streamer line	139,000	25	0.18	This study (Part 2)
		Streamer line	62,200	0	0	
Mid-Norway	Aug-98	None	70,000	74	1.06	Løkkeborg 1999
		Tube	70,000	6	0.09	
		Short streamers	70,000	2	0.03	
		Long streamers	70,000	0	0	

21 Synthesis: How many fulmars do the Nordic fleets take annually?

To attempt to translate the by-catch figures (**Table 8**) into annual by-catch estimates, we need to know the total fishing effort (hooks set) and seasonal distribution of hook-setting. We can estimate this for the Norwegian offshore autolining fleet but its total annual hook deployment needs to be broken down by season to take account of the dramatically different seabird by-catch rates between summer and winter. In 1997, C. Steel gathered statistics from the Norwegian Directorate for Fisheries on tonnage of fish (all species) caught by Norwegian longliners in different areas for each month of 1996. The fishing area classification in the source data is very detailed (ca 50 areas listed) and no attempt has been made here to translate these into the ICES system of statistical areas. Rather they have been grouped into broad regional sea categories, including North Sea, Norwegian Sea, Barents Sea etc. (**Table 9**). In the case of the 'North Sea', the fishing grounds are on the northern perimeter, notably the Faeroe-Shetland Channel.

Table 9. Winter, summer and total (annual) fish catches from Norwegian longlining vessels in 1996 expressed in metric tonnes and also as percentages of the winter, summer and annual totals.

Sea Region	Winter catch	Summer catch	Annual catch	% Winter	% Summer	% Annual
Barents Sea	68,006	253,984	321,990	5.43	49.60	18.25
Around Iceland	429	8,511	8940	0.03	1.66	0.51
NE Atlantic	1,469	1,952	3,421	0.12	0.38	0.19
Norwegian Sea	736,156	77,196	813,352	58.77	15.08	46.09
North Sea	129,361	154,922	284,283	10.33	30.25	16.11
Skagerrak	6,659	4,050	10,709	0.53	0.79	0.61
West of UK	305,694	9,093	314,787	24.41	1.78	17.84
NW Atlantic	4,791	2,366	7,157	0.38	0.46	0.41
Unknown	20	0	20	0.00	0.00	0.00
Grand Total	**1,252,585**	**512,074**	**1,764,659**	**100.00**	**100.00**	**100.00**

From the evidence (Part 1) that the incidence of seabird mortality from longlining is relatively minor in the winter months, the fish catch data were also subdivided by season, namely 'winter' (Oct-Apr) and 'summer' (May-Sep). Table 8 shows that winter catches (71% of annual total) greatly exceeded those of summer (29%). The majority of winter landings derived from the Norwegian Sea (59%), followed in importance by waters West of the UK (24%), and the North Sea (10%), and Barents Sea (5%). In summer, the distributional pattern changed markedly, with the Barents Sea yielding 50% of catches, followed by the North Sea (30%) and Norwegian Sea (15%).

Applying the seasonal distribution (71% winter, 29% summer) of catches to the total number (476 million) hooks set by the 61-strong autolining fleet in 1996, and assuming no seasonal bias in the number of hooks set per vessel, or catch per unit effort (CPUE), we find that ca 338 million hooks were set in winter and 138 million in summer. To estimate the seabird by-catch that these respective seasonal longlining efforts would incur, the following by-catch rates were used:

- Winter fulmar by-catch rate (streamer line only) = 0.02 birds per 1000 hooks (based on all 760,500 hooks for N. Norway in Table 8).

- Summer fulmar by-catch rate 0.023 birds per 1000 hooks (based on average of 3 summer measures with streamer/short streamer lines, i.e. 0.04, 0, 0.03, given in Table 8). At least large Norwegian longliners traditionally use a bird-scaring line with no streamers which S. Løkkeborg believes (see 18.2.1, above) to be as effective in reducing bird by-catch as a line with streamers (irrespective of length).

Table 10 synthesises these data on hook numbers (annual total for 61 autoliners) and fulmar by-catch rates, and makes the additional assumption that by-catch rates do not vary between the fishing regions listed in Table 9:

Table 10. Estimated fulmar-by-catch rate (birds per 1000 hooks) by the Norwegian autolining fleet in 1996.

Season	Total hooks (millions)	By-catch rate	Birds caught
Winter	338	0.02	6760
Summer	138	0.023	3174
Total	**476**		**9934**

This suggests that the incidental mortality of fulmars from the offshore autolining fleet may be ca 10,000 birds per year. This estimate, however, is rather sensitive to the estimate of by-catch rate. As Table 8 shows, summer by-catch rate with no mitigating measures was 1.06 in Løkkeborg's 1998 study and even higher (1.75) in his 1996 study. If a significant proportion of Norwegian longliners used no mitigating measures at all in 1996, the summer by-catch rate could have been 0.5-1.0 birds per 1000 hooks. If this range of values is applied to Table 10, the total summer by-catch of fulmars increases markedly to 69,000-138,000 and the annual total to 75,760-144,760 birds.

So there is some uncertainty, possibly by an order of magnitude, in the estimates of Norwegian by-catch attributable to the autolining fleet. Extrapolating beyond these vessels to the rest of the Norwegian fleet, and the other Nordic fleets, is more speculative still, especially without knowing the overall use of mitigating measures. In the case of Norway, it needs to be taken into account that, apart from the 61 autoliners, another 18 longliners - though not equipped for autolining - are substantial vessels (each exceeding 25m in length), over 800 vessels each landed >10 tonnes of fish, and the total number of vessels engaged in any longlining at all was over 9000. Even though many of the smaller vessels will be operating closer inshore where fulmar densities are lower (but gull densities higher), it would not seem unrealistic to suppose that the total Norwegian fleet takes an annual by-catch of 20,000 fulmars, and the total may easily run to 50,000-100,000.

To this, we need to include the by-catch taken by the Icelandic and Faeroese fleets. As we have seen, the Icelandic fleet has been speculated to take a by-catch of fulmars running into ‘thousands or low tens of thousands’ (see 20.2, above). This seems reasonable, given that the Icelandic fleet deployed 230 million hooks in 1996, and if the by-catch rates they inflicted were of a magnitude experienced in Norwegian waters. By the same token, the 150 million hooks deployed in 1997-1998 by the Faeroese fleet, especially the 19 large autoliners, can be expected to account annually for a further few thousand fulmar deaths.

Taking the activities of the three fleets together, it seems reasonable to suppose that, conservatively, they take an overall annual by-catch of 50,000-100,000 fulmars and quite possibly twice as many. In addition to this, a potentially significant number of fulmars and large gulls are killed by shooting to deter other birds.

What does this mean in terms of overall population status of fulmars in the region? The fulmar by-catch indicated by this analysis is clearly small when compared with the massive north-east Atlantic breeding population of fulmars, estimated at ca 2-4 million pairs (**Table 11**: based on Snow and Perrins 1998). This figure excludes Greenland: 200,000-750,000 pairs (Lloyd *et al* 1991), which is somewhat peripheral to the region being considered here. (Most of the Greenland colonies are on the west coast although winter dispersion certainly includes at least the more northern areas of the north-east Atlantic, e.g. there are ringing recoveries of Greenland fulmars in Icelandic waters: P G H Evans, pers. comm.). All of these status figures refer to birds of breeding age, which in the case of the fulmar is advanced with birds not reaching sexual maturity until they are about nine years old (Lloyd *et al* 1991). The total fulmar population will therefore be much larger when the immature cohorts and non-breeding adults, whose collective status is hard to assess, are added.

Table 11. Estimated breeding status (pairs) of fulmars in the North-east Atlantic.

Region	Minimum	Maximum
Svalbard/Jan Mayen	100,000	1,000,000
Iceland	1,000,000	2,000,000
Faeroes	500,000	500,000
Britain/Ireland	570,000	570,000
France	1,000	1,000
Norway	6,000	7,000
Russia*	13,000	13,000
Total	**2,190,000**	**4,091,000**

* In this context, Russia = Franz Josef's Land and Novaya Zemlya

22 The case for acting to reduce seabird by-catch

In the course of this study, the case for taking action to address the impact of longlining on fulmars has been challenged on number of occasions, notably by fishermen. These are dealt with below in the form of answers to these disclaimers that the fishing industry has no case to answer . These arguments are particularly relevant to Iceland and Faeroes which appear to be taking no formal action to reduce seabird by-catch in their longline fisheries, less so to Norway which has accepted the arguments to the extent that it is now developing a FAO National Plan of Action (NPOA).

22.1 Claim 1: Longlining is of net benefit to fulmars

Norwegian fishermen have suggested to us that longlining is of net benefit to fulmars in that the survival enhancement through discharging of offal and non-commercial fish outweighs the mortality inflicted by longlines. (NB: Norway operates a discard ban on commercially important fish species, and an unknown amount of commercially important fish are allegedly discarded as well). This may well be true but it is not a credible argument for not attempting to minimise seabird by-catch, especially as bait-snatching can impose a significant burden in terms of bait loss to fishermen, perhaps especially those with smaller inshore vessels which lack the economy of scale helping larger vessels to write off a certain level of bait loss.

Moreover, while it is conceded that the fulmar *par excellence,* as well as some other seabird species, have clearly profited from fishery waste this century (Camphuysen *et al* 1995, Camphuysen and Garthe 1997, though see latter for doubt cast on the strength of the affinity between fulmar status and fishery waste), this should not necessarily be regarded as a positive or desirable outcome for seabird community structure nor for the marine environment in general. Rather, it is a striking example of the extent to which fishery activities can shift the balance in the wider marine ecosystem.

Nor are high discard rates indicative of sustainable fishing practices. According to recent research in the North Sea, 90% of whitefish discards are under-sized and non-commercial fish (*Hansard* 1 July 1999, p. 420); this in turn is symptomatic of the degraded age structure of stocks in the region due to chronic overfishing of mature generations of larger individual fish. As Svelle *et al* (1997) put it: "*The need to discard heavily in the North Sea reflects the pattern of sustained overexploitation which has generated an age structure dominated by juvenile fish. Most discards thus reflect what amounts to deliberate targeting of juvenile fish around the minimum landing size.*"

So it is not a credible argument to simply trade off one human impact on a seabird species against another. While one may enhance numbers and the other reduce numbers, both are unwanted by-products of fishing activities. In short, we have to look at the impact of longlining on fulmars on its own merits.

22.2 Claim 2: Since longlining poses no conservation risk to seabirds, no action is needed

The evidence from this and related studies indicates that current levels of longlining effort do not threaten the status of fulmars or any other of the affected seabird species. The low level of assessed risk would appear not to advocate taking firm measures to address this impact. However, this overlooks three issues:

1 Increasingly, there is a presumption that fishing activities should, wherever possible, pursue best practice to avoid unnecessary mortality to non-target species, irrespective of whether this mortality threatens the overall status of the impacted species. The FAO Code of Conduct for Responsible Fisheries (FAO 1995) states:

General principles

<u>Art 6.6</u> *"Selective and environmentally safe fishing gear and practices should be further developed and applied, to the extent practicable, in order to maintain biodiversity and to conserve the population structure and aquatic ecosystems and protect fish quality. Where proper selective and environmentally safe fishing gear and practices exist, they should be recognised and accorded a priority in establishing conservation and management measures for fisheries. States and users of aquatic ecosystems should minimise waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species. "*

Management measures

<u>Art 7.6.9</u> *States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species [.....] States and sub-regional or regional fisheries should promote, to the extent practicable, the development and use of selective, environmentally safe and cost-effective gear and techniques.*

Fishing gear selectivity

<u>Art 8.5.1</u> *States should require that fishing gear, methods and practices, to the extent practicable, are sufficiently selective so as to minimise waste, discards, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species and that the intent of related regulations is not circumvented by technical devices. In this regard, fishers should cooperate in the development of selective fishing gear and methods. States should ensure that information on new developments and requirements is made available to all fishers.*

These Articles make it clear that by-catch of organisms other than target fish should be minimised, using the most selective gear available. The phrase 'to the extent practicable' invokes achieving a balance between applying the most selective gear for environmental purposes, and achieving an economically viable fishery, but in the case of longlining we would argue that this is not a conflict situation which should impede the "priority" the FAO attaches to taking appropriate measures.

On this issue, of specific relevance to the North Sea and the compliance of Norway (which was a lead party with the European Commission), the Statement of Conclusions from the Intermediate Ministerial Meeting (Ministry of Environment Norway 1997) on the Integration of Fisheries and Environmental Issues, reflects the FAO Code of Conduct:

- <u>Art 9</u> *"The Ministers AGREE that fishing practices should be adjusted to minimize the deterioration of sensitive habitats and unacceptable incidental mortality generated by such practices. The Ministers therefore INVITE the competent authorities to consider within the appropriate fora and without delay:*

- <u>Art 9.1</u> *application of measures, particularly in relation to selective fishing gear, to minimise catches of, and/or damage to, all organisms which may be caught or damaged by fishing gears and in which the fishermen operating such gears have no commercial interest."*

With impetus from such fora and commitments, in February 1999 the FAO Committee on Fisheries (COFI) adopted an 'International Plan of Action (IPOA) for Reducing Incidental Catch of Seabirds in Longline Fisheries' (FAO 1999)[4]. The IPOA describes concrete and specific steps for reducing the by-catch at national, regional and global levels, and to that end calls for the IPOA to be translated into National Plans of Action (NPOAs). States are to conduct assessments of seabird by-catch in their waters and, if the assessment justifies action, develop and adopt a NPOA which they should have started to implement no later than the COFI session in 2001. Suggested elements of a NPOA include: prescription of mitigating measures; plans for research and development of improved measures or practices and evaluation of their effectiveness (review the NPOA at least every four years); plans for outreach programmes to raise awareness of the IPOA, the NPOA and the need to reduce seabird by-catch; data collection programmes to determine the incidental by-catch of seabirds in longline fisheries and the effectiveness of mitigation measures, using onboard observers as necessary.

[4] As an invited member of FAO's Technical Working Group on Reduction of Incidental Catch of Seabirds in Longline Fisheries, John Cooper (Birdlife International) was one of the authors of the background paper (Brothers et al 1999) which assessed the scale of longlining impacts globally and reviewed mitigation measures.

Significantly, an earlier draft of the IPOA contained the pivotal clause “Action is not conditioned on the conservation status of seabird populations” but regrettably this specification was deleted in subsequent drafting. At the FAO session in July 1998, some nations were insistent that only rare or endangered species should be covered by the IPOA but this was not specified in the final document. The implication of the IPOA/NPOA, while not as explicit as it was before the deletion of the conditional clause, is therefore that measures should be taken to avoid the by-catch of all seabirds.

While the IPOA is (like the FAO Code of Conduct) voluntary, the objectives state that “All concerned States are encouraged to implement it.” The assessment should enable States to determine “if a problem exists with respect to incidental catch of seabirds” and thus the need for a NPOA. The present study would indicate that seabird by-catch in Nordic longline fisheries is on a sufficiently large scale (albeit not status-threatening), and the mitigating technology affordable, accessible, and beneficial to the fishers (in respect of reducing bait loss) to justify the drawing up of a NPOA by the constituent countries (Norway, Iceland, Faeroes).

2 Although the northern subspecies (*fuscus*) of the lesser black-backed gull *Larus fuscus* was not recorded as by-catch during this study, there is a real possibility that this gull suffers mortality from longlining, at least in the more inshore waters. Any such mortality could pose a threat to the gull's precarious population status. This is one of only seven birds listed in the national Norwegian red data book as "endangered" (top priority). It breeds along the coast of north-east and northern Norway, and the population has declined dramatically in recent decades to only 500-1000 pairs. If only about 50 adult birds (less than one per autoliner) are killed annually (by shooting or entanglement) during longlining, this clearly poses a significant threat to the population. However, the incidence and frequency of such by-catch would be hard to discover and assess without extensive monitoring by on-board observers.

3 While longlining by-catch may not currently pose any significant threat to the population status of fulmars, it is worth putting this interaction in the context of potentially changing conditions for this and other seabirds in the north-east Atlantic.

One possibility is a future downturn in the availability of discards and offal, a resource which has apparently generated the fulmar increase in the region this century (fulmars scavenge mainly offal: Camphuysen *et al* 1995). With almost half of the North Sea catch routinely jettisoned dead, discarding is widely regarded as a waste of resources and one of the worst by-products of the imbalance between fishing effort and available marine living resources. Implicit in the imperative to reduce overfishing is the pressure to reduce bycatch of ‘unwanted’ fish, thereby addressing the underlying pressure for discarding. Implicit in reduced fishing mortality is also a presumption that the discharge of offal (as distinct from whole fish) will decline.

Although not automatically applicable to the Norwegian, Faeroese and Icelandic fleets, measures addressed by new EU regulations which could potentially reduce discards for wide-ranging fulmar populations are (i) improvements in technical conservation measures (notably better gear selectivity, especially by increasing mesh size and introducing escape panels in nets), (ii) a reduction in fishing effort. Of these two approaches, the proposed reduction in fishing effort is likely to be by far the more effective. EU fleet capacity reduction targets agreed in April 1997 of 20-30% between 1997 and 2001, if implemented effectively, should cause a significant downturn in fishing mortality, and thus in the amount of fish waste (discards and offal) jettisoned by fishing vessels. That said, offal is always likely to be discharged by fishing vessels in significant amounts as there will always be fewer constraints on offloading offal than whole fish.

In the long term, global warming might also significantly affect the distribution and abundance of fulmars, and indeed the fish stocks which indirectly support them through discards and offal. While the future pattern of discarding, far less of global warming, is speculative, factors such as these do suggest that any known impacts on fulmars, such as from longlining, should be kept under review.

23 Conclusions and Recommendations

The main findings from Part 1 (1997) and Part 2 (1998) of this study are as follows:

Longlining impact of the Norwegian demersal autolining fleet in the Norwegian Sea

1 Seabird by-catch appears to be low in autumn-winter, higher in spring-summer.

2 Virtually all (> 99%) of the seabird by-catch in this and related studies was of fulmars. They were caught mainly during line-setting, with occasional captures during line-hauling.

3 The findings for other species in this study were as follows:
- Large gulls (*Larus*) are exceptionally caught.
- Kittiwakes showed no interest in the baited hooks (though S. Løkkeborg says they can be adept at stealing bait without getting caught).
- Skuas (all four species) were attracted to the vicinity of longlines, but mainly to cleptoparasitise gulls rather than to snatch bait from hooks. While no skuas were taken as by-catch in this study, great skuas feature in the by-catch of the Icelandic longlining fleet.
- Gannets plunge-dived near the line during setting but were never caught.

4 Counts of fulmars flying behind the vessel were significantly and positively correlated with numbers of fulmars bait-snatching on the surface. Higher fulmar densities therefore probably promote higher bait-snatching intensity.

5 Fulmar by-catch rate tended to be positively correlated with counts of fulmars flying behind the vessel, but the relationship was not statistically significant.

6 Most (71%, n=21) of the fulmars caught (Part 2 of the study) were foul-hooked (i.e. snared on parts of the body other than the bill), adding to observational evidence that most birds were caught while scavenging loose offal in the vessel's wake, rather than when trying to snatch bait directly from hooks.

7 Two conclusions follow from (6), namely that (i) fulmar by-catch rate does not equate simply to rate of bait loss (this relationship is further weakened by the fact that fulmars are good at snatching bait from hooks without getting caught: S. Løkkeborg, pers. comm.), and (ii) discharge of offal during line-setting evidently attracts fulmars and thus facilitates birds getting hooked.

8 The two vessels under study used a variety of mitigating measures, namely underwater setting (on one), streamer line, sounding the ship's horn, and shooting.

9 Shooting (with shotgun) was usually in the air but sometimes directly at birds when bird density was especially high, causing some fatalities. One skipper believed that such shooting, as a deterrent practice, is widespread in the Norwegian offshore fleet.

10 Although not quantified, the observer (in 1998) found that the streamer line definitely affected the birds' behaviour by keeping them away from the area immediately behind the vessel where the setting line was entering the water, instead forcing them to scavenge further behind the vessel than when the streamer line was not deployed.

11 The skipper's experience was that the Mustad underwater setting tube was an effective mitigating measure, comparable in effect with - but probably not better than - the streamer line in mitigating by-catch.

12 Fulmar by-catch rates (birds per 1000 hooks) in relation to applying the various technical mitigating measures (streamer line only, tube only, streamer line plus tube) were as follows:

October 1997	: 0.03-0.04 (streamer line)
	: 0.01 (tube)
June 1998	: 0.18 (streamer + tube)
	: 0 (streamer line)

These by-catch rates indicate that: (i) the use of the tube did not eliminate seabird by-catch, (ii) (at least in 1998), the streamer line may have been more effective than the tube in mitigating by-catch, although daily by-catch rate was too variable to prove this.

13 Løkkeborg's (1999) study indicated that the Mustad underwater setting tube and streamer line each (as stand-alone measures) greatly reduce seabird by-catch but that the streamer line was the more effective of the two mitigating measures.

14 The evidence from the present study does not support the view that the Mustad underwater setting tube performs better than the streamer line. This is consistent with the possibility that, as Løkkeborg found, the streamer line may actually be the more effective of the two measures, at least under certain conditions in this fishery.

15 On this basis, the current underwater setting tube does not represent the most practicable way forward for the longline industry in the north-east Atlantic, and while it may be improved with development, pragmatism suggests other and better solutions to reducing seabird by-catch in the short term for existing longline vessels in this fishery.

16 A review of mitigating measures elsewhere suggests that a combination of an approved streamer line (preferably paired) and line-weighting offer the best prospect of reducing seabird by-catch to acceptable levels in existing vessels in the fishery. This is not to say that underwater setting tubes do not confer benefits in other fisheries (cf Study of Mustad tube in South African waters).

17 With a view to the seabird-friendly longliner of the future, however, Norway should take a lead in developing longline vessels and gear with a view to integrating mitigating measures, and especially underwater setting, into the hull design and construction so as to prevent the propellor wash bringing the line to the surface.

18 The seasonal distribution of fish catches by the Norwegian offshore longlining fleet (61 vessels) shows that 71% of the catch is taken in Oct-May compared with only 29% in summer.

19 Estimates of by-catch by the Nordic fleets are hampered by lack of data, notably on (i) observations of seabird by-catch in longlining operations; (ii) fishing effort and risk to fulmars by the substantial Norwegian fleet sector which operates closer inshore than the large autolining fleet (iii) fishing effort of, respectively, the Icelandic and Faeroese fleets; (iv) mitigation measures deployed by all fleets other than offshore Norwegian longliners.

20 Based on the seasonal by-catch rates from this and other studies, and data on fishing effort (total hooks set in 1996), the Norwegian offshore autolining fleet may take as by-catch ca 10,000 fulmars annually, assuming it widely applies streamer lines as a mitigating measure. If mitigating measures are scarcely used, the estimate of by-catch could increase by ten times or more over this figure.

21 The total Norwegian longlining fleet (including the inshore fleet of smaller vessels) is estimated to conservatively take ca 20,000 fulmars annually but the actual total may easily be 50,000-100,000.

22 The combined activities of the Norwegian, Icelandic and Faeroese longlining fleets are conservatively estimated to take a by-catch of 50,000-100,000 fulmars annually, but the true figure could be significantly higher (depending, e.g., on the deployment of mitigating measures).

23 While fulmars are caught in significant numbers by longlining, the estimated annual mortality is not thought to be status-threatening given that the North-East Atlantic breeding population of fulmars is ca 2-4 million pairs, and the overall population much higher when non-breeding adults and immatures are included.

24 Notwithstanding the fact that longlining does not apparently pose any significant risk to the status of fulmars in the region, the Nordic countries which deploy significant longlining fleet capacity have international obligations, notably under the FAO Code of Conduct for Responsible Fisheries (1995), to minimise incidental by-catch of seabirds from their operations.

25 Recognising these obligations, the scale of the by-catch (significant, albeit not status-threatening), and the potential to reduce economically damaging bait loss by taking effective action, the assessment from this study is that Norway, and also Iceland and the Faeroes, have a problem with incidental by-catch of seabirds. Iceland and the Faeroes should address this, as Norway is currently doing, by developing and implementing a National Plan of Action (NPOA) under the International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries, a FAO global strategy adopted by FAO-COFI in Rome in February 1999.

26 This study recommends that a NPOA in the case of Norway and other longlining fleets in the north-east Atlantic should include the following elements:

- Collect and package data on fishing effort (hooks deployed annually) in a way that enables seabird by-catch rates (birds per 1000 hooks) to be calculated for the overall effort of the whole fleet.
- Assess the deployment of mitigating measures by the fleet.
- Encourage the deployment of streamer lines (preferably paired) of approved, effective design.
- Assess the effectiveness of these and other mitigation measures under the spectrum of operating conditions.
- Advocate best practice to fishermen and raise awareness.
- Encourage the manufacturers of longline equipment (Mustad etc) to develop appropriate mitigating measures, especially effective streamer lines, integrally weighted lines, and line-

shooting/slackening devices, and initiate research to experimentally test the effectiveness of these, individually and in combination, at sea.

- Devise a suite of measures of proven effectiveness as part of the statutory national fishing regulations, just as mesh size etc are part of statutory technical measures, and enforce them accordingly.

- With a view to the seabird-friendly longliner of the future, take a lead in developing longline vessels and gear with a view to integrating mitigating measures, and especially underwater setting, into the hull design and construction so as to avoid any effects of the propellor in bringing the line to the surface.

- Research and implement ways of minimising the discharge of offal into the wake of vessels, which attracts and aggravates the by-catch of seabirds.

- Legislate (at least in Norway) against the practice of shooting at birds as a 'mitigating measure' and enforce accordingly.

- Implement an observer scheme to better assess the scale of seabird by-catch by all sectors (inshore and offshore) of the longlining fleet, and compliance with mitigating measures.

References

Agnew, D J, Black, A, Croxall, J P and Parkes, G (2000) *Experimental evaluation of the effectiveness of longline weighting regimes for longlines in toothfish fishery around South Georgia*. CCAMLR Science 7, 119-132.

Alexander, K, Robertson, G and Gales, R (1997) *The incidental mortality of albatrosses in longline fisheries. Report on the Workshop from the First International Conference on Biology and Conservation of Albatrosses, Hobart, Australia, September 1995*. Australian Antarctic Division, Kingston.

Anon (1997) *W Isles boat tries deep water netting*. Fishing News 43 (29 Aug 1997).

Bakken, V and Falk, K (eds) (1998) *Incidental Take of Seabirds in Commercial Fisheries in the Arctic Countries.* CAFF Tech. Rep. No 1, Circumpolar Seabird Working Group (CSWG). Akureyri. Iceland.

Barnes, P and Walshe, K A R (1997) *Underwater setting methods to minimise the accidental and incidental capture of seabirds by surface longliners. Report on a prototype device developed by Akroyd Walshe Ltd.* Science for Conservation 66, 1-21.

BirdLife International (2000) *Threatened Birds of the World*. Lynx Edicions and BirdLife International. Barcelona and Cambridge, UK.

Bjordal, Å and Løkkeborg, S (1996) *Longlining*. Fishing News Books. Oxford.

Brothers, N (1991) . Albatross Mortality and Associated Bait Loss in the Japanese Longline Fishery in the Southern Ocean. *Biological Conservation, 55, 255-268*

Brothers, N P, Cooper, J and Løkkeborg, S (1999) *The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation.* FAO Fisheries Circular No. 937. FAO, Rome.

Brun, E (1979) *Present status and trends in population of seabirds in Norway*. Pp. 289-301 *in* Bartonek, JC and Nettleship, DN (eds) Conservation of marine birds in northern North America. US Fish and Wildlife Service, Washington, D.C.

Camphuysen, C J, Calvo, B, Durinck, J, Ensor, K, Follestad, A, Furness, R W, Garthe, S, Leaper, G, Skov, H, Tasker, M L and Winter, C J N 1995. *Consumption of discards by seabirds in the North Sea*. Final Rep. EC DG-XIV research contract BIOECO/93/10. NIOZ Rapp. 1995-5. Netherlands Institute for Sea Research, Texel.

Camphuysen, C J and Garthe, S (1997) *An evaluation of the distribution and scavenging habits of northern fulmars (Fulmarus glacialis) in the North Sea*. ICES Journal of Marine Science 54, 654-683.

FAO (1995) *Code of Conduct for Responsible Fisheries*. Food and Agriculture Organization of the United Nations. Rome.

CCAMLR (1994) Report of the ad hoc Working Group on incidental mortality arising from longline fishing. SC-CAMLR XIII Annex 8.

FAO (1999) *International Plan of Action for Reducing Incidental Catch of Seabirds in Longline Fisheries*. Food and Agriculture Organization of the United Nations. Rome.

Fisher, J (1952) *The Fulmar*. The New Naturalist Series. Collins. London.

Hagemeijer, W J M and Blair, M J (eds) *The EBCC Atlas of European Breeding Birds*. T & A D Poyser. London.

Lloyd, C, Tasker, M L and Partridge, K (1991) *The Status of Seabirds in Britain and Ireland*. T & A D Poyser. London.

Løkkeborg, S (1990) *Sjøfugl i fiskeredskap - et problem både for fugl og folk*. Vår Fuglefauna 13, 200-204.

Løkkeborg, S (1996) *Sea-bird bycatch and bait loss in longlining using different setting methods*. SC-CAMLR/WG-EMM: CAMLR Science Committee Working Group on Environmental monitoring and management, August 1996.

Løkkeborg, S (1998) *Seabird by-catch and bait loss in long-lining using different setting methods*. ICES J. Mar Sci. 54, 145-149.

Løkkeborg, S (1999) *Reducing bycatches of seabirds in longlining by means of various mitigation measures.* Poster paper presented to ICES/SCOR Symposium on Ecosystem Effects of Fishing. Montpellier, France, 15-19 March 1999.

Ministry of Environment Norway (1997) *Statement of Conclusions: Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues*, 13-14 March 1997, Bergen, Norway. Oslo.

Myrberget, S (1980) *Registrering av sjøfugl drept under laksefiske 1978* (Registrations of seabirds killed in connection with the salmon fishery in 1978). Vår Fuglefauna 3, 45-48.

Perez, N, Pereda, P, Uriarte, A, Trujillo, V, Olso, I and Lens, S (1995) *Discards of the Spanish Fleet in ICES Divisions VII and VIII*. Ref No. PEM/93/005.

Petersen, A (1998) *Incidental take of seabirds in Iceland.* In Bakken, V & Falk, K (eds) Incidental Take of Seabirds in Commercial Fisheries in Arctic Countries. CAFF Tech Rep. No 1, Circumpolar Seabird Working Group (CSWG). Akureyri. Iceland.

Robertson, G and Gales, R (eds) (1998) *The Albatross: Biology and Conservation*. Surrey Beatty and Sons. Chipping Norton, NSW.

Robertson, G, Løkkeborg, S and Wienicke, B (2000) Effect of longline tension and fleet length on longline sink rates. P. 53 in Abstracts from Second International Conference on the Biology and Conservation of Albatrosses and other Petrels, 8-12 May 2000. Honolulu, Hawaii.

Ryan, P G and Watkins, B P (in prep) *Reducing incidental mortality of seabirds with an underwater longline setting funnel*.

Smith, N W M (1999) *Longline sink rates on bottom autoline vessels*. Poster paper presented to ICES/SCOR Symposium on Ecosystem Effects of Fishing. Montpellier, France, 15-19 March 1999.

Snow, D W and Perrins, C M (1998) *The Birds of the Western Palearctic.* Concise Edition. Vol 1, Non-Passerines. OUP. Oxford.

Stone, C J, Webb, A, Barton, C, Ratcliffe, N, Reed, T C, Tasker, M L , Camphuysen, C J and Pienkowski, M W (1995) *An atlas of seabird distribution in north-west European waters.* JNCC. Peterborough, UK.

Svelle, M, Aarefjord H, Tore Heir H and Øverland, S (eds) (1997) *Assessment Report on Fisheries and Fisheries-related Species and Habitat Issues*. Ministry of Environment-Norway. Oslo.

Tucker, G M and Heath, M F (1994) *Birds in Europe: their conservation status*. BirdLife Conservation Series No. 3. BirdLife International. Cambridge, UK.

Webb, A and Durinck, J (1992) *Counting birds from ship*. Pp. 24-37 *in* Komdeur, J, Bertelsen, J and Cracknell, G (eds) (1992) *Manual for Aeroplane and Ship Surveys of Waterfowl*. IWRB Spec. Publ. No. 19. Slimbridge, UK.

Appendix 1

The document contains a number of operational details already described in the main part of this report but these are included here again for completeness, and to give an authentic idea of the background information and guidance instructions issued to longline observers for practical field use.

1A Field methodology 1997

Methods for assessment of catch on longlining vessels

These instructions for observers on the pilot study were developed by Euan Dunn and his colleagues in the Conservation Science Department of the RSPB, in cooperation with Christian Steel (NOF) and Mark Tasker (JNCC). The document is rather detailed, and the observers carrying out the fieldwork were encouraged to extract the most important information and make a concrete and more trimmed 'action list' themselves for the cruise, in order to get a clear view of the various pieces of the work that needed to be done, and in what sequence.

I At the start of the cruise

A From the ship's plans, find out the height of the stern and the bridge wing above the waterline. Use this data to calculate the height of your eye above waterline and thus the width of the calliper jaws that will delimit the outer bounds of the 300 m transects used for seabird counts (see Webb & Durinck 1992, which we will provide for you; this is the standard guide used by the JNCC's Seabirds-At-Sea-Team, hereafter called JNCC's Methods Manual).

B Find out the setting regime (number of 'stubs' of lines normally set and hauled each day, at what intervals and in what lay-out) the skipper is likely to operate so that you can plan your own time budget. In general, a longline may vary in length from a few hundred metres in small scale coastal fishing to more than 50 km in large scale oceanic longline fisheries, but the regime will be rather constant on autoline vessels in question in this project.

In autolining, the working unit is the so-called 'stub' which is a specified length of line with a certain number of 'snoods' (branchlines) with hooks spaced at regular intervals, as well as floats and anchors (see table below). According to Løkkeborg it generally takes about 30 min to set a stub and 2-3 hours to haul it, depending on depth, currents and number of hooks. Normally, several stubs are set straight after one another, before they start hauling them (see below).

Autoline system

Component	Features	Norwegian equivalent
Hook with snood	-	Krok med fortom
Line	130 hooks	Line
Magazine	10 lines, i.e. 1300 hooks	Magasin
Stub/Fleet	4-5 magazines, i.e. 5200-6500 hooks, linked together	Stubb

Every 24 hours, an autoliner sets 30.000-40.000 hooks, typically by deploying 6 "large" stubs or 8 "small" stubs. The stubs are not linked together, and may be set in different lay-outs.

C The regime the longliner operates will vary between areas, seasons and skippers. The vessel works continuously throughout the 24 hrs, 7 days a week, alternating between setting and hauling. On the Sep-Oct fishing trips we are observing, Løkkeborg believes the destination will be the Egga and Røst banks and the main fish targeted probably ling ('lange'), tusk ('brosme') and (further north) haddock ('hyse'/'kolje'). According to the skippers of our vessels, both vessels usually set 6-8 stubs in one go, this taking approx. 4 hrs. Hauling (which starts immediately after setting) takes about 2-3 hrs per stub (depending on depth, currents and number of hooks), thus hauling the entire set of stubs takes about 16-20 hrs.

Often, depending on topography etc., they will set the stubs in a parallel lay-out. Løkkeborg describes the setting (for ling and tusk) of stubs along 2 parallel lines, each line with 3-4 stubs set just following each other. Once the first line of 3-4 stubs is set, and from where this line ends, the vessel turns 90 degrees, sails about 1 nautical mile and sets the other line of 3-4 stubs backwards parallel with the first line. Then the vessel completes the rectangle by returning to where setting the first line started, and begins to haul.

At times they may also set more or less all the stubs in 6-8 parallel lines, typically down the continental slope, with each stub starting at the top of the slope.

D Once it has hauled its stubs, the vessel re-sets them further along the fishing grounds, so that the vessel may move along setting and hauling 'like a tractor ploughing a field'. Although this is a standard pattern, make sure you know what actual pattern your own skipper will use, as this may vary. Ask him this well in advance of the start of fishing activity so that you can plan your own time budget accordingly (see below for details).

E Spend some time at the very start of the cruise to familiarise yourself with the setting regime of the vessel, and how many stubs the vessel usually deploy. Investigate the various components of the longlines and the machinery, and make notes of different options available (hook numbers pr. stub, hook types, number of barbs on the hooks, hook sizes, hooks spacing, various snood lengths etc.) for later use in the **Line Setting Recording Form**. Obtain samples of all hook types used if possible - Løkkeborg says that normally just one or two hooks are used. Find out if the variability of how the gear is used vary a lot, or is likely to be rather constant throughout the cruise. Also find out if the bait will be the same throughout the cruise, and if it will be frozen, thawed, or semi-thawed, as this affects its buoyancy (typically, bait is semi-thawed mackerel or squid). All of this information is later to be entered in the **Line Setting Recording Form** for each stub that is set.

F From the skipper, find out typical percentages of baited hooks, because not all hooks are baited as they pass through the automated baiting machine (this is unlikely to vary between stubs, but it may vary with the type of bait used). The proportion of hooks baited in automated longlining varies between 85% and 95%. For underwater setting, also find out from the skipper, for the particular bait being used, the percentage of that bait typically lost (by friction) when passing through the tube. It will not be practical to determine this by direct observation of the tube but the skipper will know the average rate of bait loss for the equipment and bait he is using. These two measures should be roughly constant for the cruise, and also these shall be entered in the **Line Setting Recording Form** for each stub that is set.

G Investigate possibility of storing dead birds in the vessel's freezer for further analysis (see Methods, below, for storage details). It is difficult to predict how many birds will be caught, and therefore, how many to retain for later analysis. This will depend partly also on how much storage capacity the skipper can offer you, and the arrangements for transferring stored birds to a museum on the mainland (e.g. 500 fulmars may be too many to handle).

In Løkkeborg's study, 3 stubs (each with ca. 4725 hooks) were set and hauled each day for 12 days under different setting conditions. The stubs set without any mitigating measures (tube or streamer line) caught 99 birds, those set through the tube caught 28 birds, and those set with a streamer line (but without the tube) caught 2 birds. Most of the birds were fulmars. On 5 out of the 12 days, with no devices, no birds were caught, on other days up to 22 were caught.

On this basis, it seems that bycatch rate is very patchy and erratic from day to day but the Vessel Without Tube (VWOT) could possibly catch hundreds of seabirds in total. For detailed guidance on how to select birds for collection, see below. If (see hauling methodology below), you did not watch the haul yourself, ask the crew if they will agree to remove and pile up the birds for you so that you can deal with them shortly afterwards. Be helpful in accepting the place they suggest the birds be piled, and assure them you will remove them very soon after hauling.

H Investigate possibility, in vessel equipped with underwater setting tube (VWT), of skipper agreeing to set some stubs without using the tube, in order to serve as a control experiment. The skipper of the VWT tells us he has virtually given up using the other mitigating measures (streamer line). He might possibly be willing to set a stub or two without the tube, just to show how effective the tube is (but remember that it is not unusual for longlining to take no bycatch on some days, so *not* using the tube does not guarantee that birds will be caught).

In vessel without underwater setting (VWOT), if another mitigating measure is used (e.g. streamer line; this vessel also sometimes uses a gun to scare birds off), you might be able to persuade the skipper (as control experiment) to set some stubs without whatever measure they are using. But remember that this is low priority because it is unlikely to yield useful results unless lots of control experiments are done. The observer should use judgement also on how flexible the skipper is likely to be about such suggested changes of fishing practice.

Unless you are told to the contrary before you join the vessel, we CANNOT offer to compensate skippers for any loss of catch they suffer by temporarily NOT using mitigating measures in this way.

II Methods of survey during transit to and from fishing grounds, and during transit between fishing grounds

A The purpose of this exercise is to get background data on seabird density, according to JNCC's Methods Manual so that, in the event of getting data on fishing effort subsequently, we can begin to produce a predictive model of seabird bycatch in different regions of the sea.

B Seabirds should therefore be counted between port of departure and arrival on the fishing grounds, during any significant transits between fishing grounds, and on return journey from fishing grounds to port. Take also any other opportunities you get to record background densities when the vessel is not actively fishing or discarding unwanted fish/offal. Providing there is enough daylight to do it, the hour before the first stub is set is a useful time to establish a background density which can subsequently be related to 'snapshot' counts during setting (see below) and to seabird bycatch.

For establishing background densities, observers should use the methodology in which they were trained on the Bergen ferry trip. Andy Webb tells me he supplied you with a few basic data sheets for recording background densities. You will need, in advance, to make enough photocopies of these to last you through your fishing trip. The best all-round observation point is the 'bridge roof' but do not use this unless the radar is at least 2 metres above head-height (radar rays are a danger to testicles!), and - of course - the skipper may not be happy for you to be up there anyway. If you do decide to use the bridge roof, use a safety line if the vessel is rolling badly. The next best (and most likely) place to observe is the 'bridge wing' (i.e. the gangways which run along the port and starboard sides of the bridge. It does not matter which side you use: just use the side that gives you the best chance (e.g. most sheltered from wind and rain) of detecting the birds on any particular day. Thus the side you use can vary from day to day. Again, a safety line may be necessary according to conditions. As both the bridge roof and bridge wings are generally quite exposed, transect counts may only be possible if the weather is not too bad. Observers should use their own judgement about this, and about the choice of vantage points. Observers will not be expected to observe continuously, of course, but should collect representative data. The bare minimum is 10 minutes but, as the SAST trainer has told you, longer spells of observation are recommended and will certainly yield data that are more robust statistically. Remember to make a note of how recently any type of discarding has occurred.

III General sequence of observing setting and hauling

A The observer's time budget will be determined by the lay-out of the stubs and the outcome of a random selection of which stubs to watch. The following general principles apply:

- a The observer should work, in total, for a max. of 10 hrs daily. This applies to observing the setting and hauling of <u>max. 4 stubs (depending on depth, currents and number of hooks)</u>, and <u>which block of stub to watch should be randomised</u>. It is also important to <u>watch *all* of the 30 minutes it takes to set a stub</u> (see below for details).
- b The observer should always watch the haul of the <u>same</u> stubs that they earlier watched being set. This matching is necessary because the snapshot counts (see below) of birds during setting have to be related to the bycatch that was taken under those particular conditions of seabird density.
- c We realise that the need to (i) randomise stubs and (ii) match hauled stubs to set stubs means that the observer's sleep cycle will be complicated (see appendix), but this is an inevitable result of making statistically meaningful observations.
- d The most important parameters to get out of this study are (i) number of seabirds taken daily as bycatch, (ii) the number of baited hooks set daily which produced that bycatch, so that (iii) we can establish a bycatch rate per 1000 hooks set, and extrapolate this to the fishing trip as a whole (which means keeping track of the number of stubs set in total over the fishing trip).
- e The observer should feel free to take a day off, say once a week, to rest, sort data and equipment, and, perhaps to join in on other crew activities. This time off is not compulsory, and the observer should make his own judgement about rest and meal-times etc. within the bounds of getting the job done and fitting in with what the vessel and crew are doing.

B Following on from these general principles, the observer next needs to know how to allocate his sampling time, according to the particular setting regime the vessel uses, which is dictated by the lay-out, timing of the setting and the length/hauling time of the stubs.

Setting typically starts early in the morning, when normally all the stubs will be set following each other, with hauling taking most of the rest of the day and night. The subsequent hauling of all of the stubs will take 16-20 hrs, i.e. most of the rest of the day and night. The observer should randomise (see appendix) which block of 4 stubs to watch of the (typically) 8 stubs that are set. The observers will take a rest as the vessel sails between stubs, or as the vessel sets the block of 4 stubs which is not to be watched. This same procedure (randomly choosing the block of stubs to watch being set, etc.) applies if the vessel sets, say, 6 stubs in 2 blocks of 3. However many stubs the vessel sets in a day, the observers must always ensure he watches the same stubs being hauled as he earlier watched being set. It is also worth noting whether the vessel sets 6 or 8 stubs, it will take equally much time to set and haul them, simply because more hooks are deployed if they reduce the number of stubs. Watching the setting and hauling of half of the stubs will anyway correspond to approx. 10 hours of observing time, because some time every day is most likely spent at other things than fishing.

In the case of, for example, watching the haul of 4 out of 8 stubs, it would be unreasonable to expect you to watch the haul for 8 hrs because, as you will see later, you are asked to record the detailed sequence of fish and birds as they get hauled over the side. So divide the 8 hrs into 16 half-hr periods. Randomly select 8 of these 16 periods (see appendix). In each of the selected 8 half-hr periods, observe for 20 minutes and rest for 10 min (the rest periods, which can be taken at any stage of your own choosing during each half-hour period, are a safeguard against the possibility that the randomisation will produce a string of several successive half-hour periods which could be very tiring to watch). This effectively means that, in total you will record details from about 2 hrs 40 min (i.e. 8 x 20 min) of 8 hours hauling, although you will obviously have to be on deck for much longer than this.

C The observer should make diagrams of the spatial arrangement of line-setting, showing how the stubs are placed in relation to each other, where anchors and floats (buoys) are positioned, and any other relevant features. It may be that this will be constant during the fishing trip, but if the pattern of setting lines varies, it would be valuable to know this and to be able to visualise it. Also keep thinking of what would make useful photographs to help in this understanding, so remember to take photos of what may seem like routine activities. Things that may seem obvious when you are on the vessel may be less easy for others to visualise back on land.

IV Methods of survey during line setting (see Line Setting Recording Form, Bird Count Recording Form)

A Position yourself at the stern of the vessel. Be advised by the crew, but probably the best place is the 'half-deck' above and forward of the stern.

B On the **Line Setting Recording Form,** record all the characteristics of the setting of the particular stub, as the form requests (see also the first part of this document). Allocate a <u>Setting Reference Number (SRN)</u> that is unique to a particular setting of the stub so that the setting data, bird count data and bycatch data can all be cross-referenced.

C Apart from underwater setting, record on the **Line Setting Recording Form** if the vessel is using any other <u>Technical Measures</u> to reduce seabird bycatch, notably streamer line (= 'tori' pole. Norwegian: "tjalkeskremme") which longliners commonly use as a bird scarer, or if the crew are using a gun to scare birds away. Details of any such technical measures should be recorded on a separate sheet. In the case of a streamer line, record the line length, number and length of streamers and their spacing along the line. Take some photographs of the streamer line in use (it will be hauled in when the vessel is not fishing), and any other mitigating measures used.

D Record on the **Line Setting Recording Form** if any Discards or offal are being discharged from the vessel during setting (or if you know whether there was any such discharging shortly before setting began), as this may affect the number of birds attracted to bait, and may present an alternative food for seabirds during setting. If possible, record what species of fish are being discarded, and in what numbers (this may happen at times other than set ting, and it would be useful to have such information).

E Just before line setting begins, make a note on the **Line Setting Recording Form** of the time, wind speed/direction, light level (cloud cover and, - if it is before dawn - also the lunar phase (quarter moon, half moon, etc.) as strong moonlight has been found to increase bait-snatching intensity). Note also if the fishermen use a searchlight or any other deck lighting during night setting (we are told they don't want to use a searchlight because it facilitates bait -snatching). You will not find much room on the Line Setting Recording Form for entering 'Light level' details or whether or not a searchlight (etc.) is used, so just make notes as best you can on the Form you are using for a particular stub-setting. Avoid putting such details in your notebook as this would complicate subsequent cross-referencing. Also record the vessel's position (i.e 'North' and 'East'), course and speed from the GPS system. Use JNCC Methods Manual to record the Sea State and Swell just after the GPS readings are taken. Also record Depth (at which line is being set) from the sonar on the ship's bridge. At end of setting, or if any significant change in the weather, vessel's course or other background conditions occur, record vessel's position and other conditions again.

F For the observer on the ship fitted with the underwater setting tube (VWT), watch the tube for 1 minute to see if the lower end is fully submerged or if it ever rises clear of the sea surface. Under Tube clear? on the **Line Setting Recording Form,** record it as Yes (for 'clear' of the surface) or No (for 'not clear' of the surface). Also, the penetration of the tube below the surface may vary with how much fish is stored at the front of the vessel (this tends to increase as the cruise proceeds, causing the stern - and thus the tube - to rise higher in the water); so estimate and record the average Tube depth to which the bottom of the tube penetrates below the surface during a particular session of setting.

G Bird Count Recording Form. Before you start recording bird counts, enter the Setting Reference Number (SRN) which, as stated earlier (see instructions for line-setting), is unique to the setting of that stub on that particular date. Then, every 10 minutes from the start of the setting session you are observing (the time when each 10-min period starts must be recorded under TIME on the form), make a 'snapshot' count of the total numbers of each bird species in the air and on the water behind the ship within 300 m of the ship in a 180 degree scan. The densities of birds and the mobility of birds in the air may make exact counts of some species difficult. If so, try to count birds in blocks of 10, 50 or 100. Make a note of the 'Accuracy' of every count (e.g. 'to the nearest 10', 'to the nearest 50', etc.) for each species. Also make a note of how recently any type of discarding has occurred.

A few times (say 3) each day take a photograph of dense bird flocks as you are doing the snapshot counts. This should be from your fixed observation at the rear of the vessel. Use a fixed focal length (to make photographs comparable) and note the time, the number of the frame on the film, and the number of the film, for subsequent cross-referencing to the right snapshot count. These photographs could be used when the fieldwork is over to calibrate your counts, and see how your performance to this respect develops as the cruise goes by.

Although there is no set form for this, as time permits make notes of the general behaviour of different seabird species towards the baited hooks as they are set. E.g. kittiwakes are said to be good at stealing bait without being caught, while fulmars are more vulnerable to capture. It is also worth recording which, if any, seabird species near the vessel show no interest in the bait at all. Try to estimate the distance behind the vessel at which snatching takes place (this distance may vary with, e.g., whether underwater setting and/or a streamer line is used). It is virtually impossible to quantify attempts at bait-snatching because it happens a long way behind the vessel, often in the thick of a large following flock. However, though not high priority, please try to record (somewhere on the Bird Count Recording Form) at least once when you are observing a block of stubs being set, the intensity of bait-snatching activity for each species on a scale of 0-5 (i.e. 0 = zero, 1 = very little, 2 = some, 3 = moderate, 4 = quite a lot, 5 = intense). Though crude, this will at least give another measure, in addition to the actual seabird bycatch, of the effectiveness of mitigating measures.

H Record the time at which the setting of the stub stops.

V Methods of assessing catch during line hauling (see Catch Sequence Recording Form and Catch Sums Recording Form)

A Use the **Catch Sequence Recording Form**. Make a note of the Setting Reference Number (SRN) of the stub that is being hauled, and the time at which you start ('Start time') and stop ('Stop time') observing the haul or part of the haul so that we have a record of which of the half-hour periods you observed.

B Record ('Light on vessel') if a searchlight or other deck lighting is used during hauling, as this may assist seabirds in being attracted to hauling activities.

C Record ('Bait snatching') any seabirds you see attempting to snatch bait or hooked fish during hauling (occasionally this happens) and record any birds that get caught.

D Some hooks will be hauled in which have no birds or fish on them but which still do have bait attached. Make a note (in 'Unused bait') of what the fishermen do with this bait. Do they throw it overboard while they are hauling (which seems to be the case from other studies, and this can be the reason for attracting seabirds which get caught during hauling) or do they keep it to be discarded later? If they throw it overboard, make a note of where they throw it (e.g. near the line or at the opposite side of the ship).

E Stand near the point at which the longline is hauled onto the ship (usually starboard foredeck), taking care not to get in the fishermen's way, but so that you can observe all the catch before it is removed from the hooks. There may be some biological significance (e.g. dominance hierarchy) in the sequence in which certain seabird species are caught as the line is set, e.g. dominant species may tend to have first access to baited hooks and get caught first. So count the numbers of all species caught (including also fish, for ease of data handling, if this is acceptable for the skipper - see below) and enter them in the **Catch Sequence Recording Form** as follows: Assuming the line is hauled in slowly enough to record the sequence of captures, record the order of catch, using 'F' for Fulmar, 'K' for Kittiwake, 'G' for Gannet, 'L' for Ling, 'T' for Tusk, and so on. Most of the fish catch should be dominated by only a few species, so this should not be as hard as it sounds.

Observers should agree between themselves in advance what code-letters they will use for the different species of birds and fish, making sure of course that each letter is only used once. If agreement between observers is not possible, at least make sure you (as an individual observer) have a consistent coding system for your own data collection.

F Later, add up the totals for each species under 'Tally' on the **Catch Sums Recording Form**.

G It is highly desirable, if at all possible, for observers to find out how many seabirds were taken during a whole day's fishing operation, even though the observer will only be watching part of the haul. This being so, try to get the fishermen to cooperate in collecting seabirds from the parts of the haul you are not observing. The fishermen should be asked if they would just pile up the birds for later inspection by you, followed by collection and storage in freezer (see below). By comparing the number of seabird corpses you count yourself, compared with what the fishermen pile up, you might get some idea of how reliable the fishermen are at doing this (although admittedly this will be difficult if, as we suspect, the seabird bycatch is going to be highly clumped in space and time). It is, however, of crucial importance that you record at least the number of stubs/hooks that have been set, yielding the pile of birds the fishermen have collected for you. For this purpose, use the **Line Setting Recording Form** as if you had observed the setting yourself, but make sure you enter **'crew'** in the observer field. Also, assign a SRN as usual and otherwise record as many characteristics as possible of these settings you have not watched yourself. Add up the totals for each bird species in the **Catch Sums Recording Form** (skip the **Catch Sequence Recording Form** in these cases), and the fishermen should not, of course, be expected to contribute to any of the data collection on *fish* when you are not there.

H It may be that skippers will not be happy for observers to record fish catch in the detail expected in the **Catch Recording Forms**. The observer should find out what level of detail the skipper will tolerate. If the skipper is unhappy for every fish to be recorded, just get a general idea of the catch composition (from the number of boxes of each species which each session of line-setting produces). The main idea behind recording the fish is to get an idea of the bycatch of rare deepwater sharks etc. about which there is conservation concern.

I If freezer storage facilities are available on the ship, collect the hooked dead birds and place each separately in a plastic bag. Fix a label to the bag and write the SRN (Setting Reference Number) on it. Seal the bag and place it in the freezer. All seabirds retrieved to begin with should if possible be kept, at least until you know how many are being caught. Later, if a lot are caught, you could begin to take a random sample (see below). But it is difficult to be prescriptive about such things till we know what storage facilities are possible. It could easily be a couple of hundred fulmars, for example.

J Arrangements are being made with Christian Steel to have the frozen seabird samples stored in the Zoological Museum (Bergen) for subsequent analysis. This will require arrangements to be made for removal and local storage of the seabirds after the vessel docks in port.

IMPORTANT: *During the trip, please note any problems with the methodology, any improvements, etc. which could help refine our approach in future. If you run into major problems at any early stage, contact Christian Steel immediately. It would be especially valuable for Per Inge to keep us informed on how things are going as there may be lessons for Terje whose trip starts a little later.*

Also, we may not have thought of all possibilities, so note anything that you think we have overlooked which actually contributes to understanding what is affecting the rate of seabird by-catch.

Randomising

Randomising has been mentioned several places in the instructions, because this yields more statistically robust data and helps us avoiding bias or unwanted links. Here is a simple way of randomising on board the longlining vessels.

If the storage capacity is limited you are to randomly select a limited number of birds to store in the freezer, from a total number of caught birds. Give each of the birds a unique number from 1 to n. Your calculator probably has a random function, giving you a random number between 0 and 1 when pressing a specific key. Assign random numbers from this calculator function to each of the birds from 1 to n, one after the other. (If your calculator does not have this function, you could throw a dice.) If you are to pick 4 birds to store, you simply select the 4 birds with the highest number values. If the 4th and the 5th bird should get the same number (most likely to happen if you use a dice), you will have to throw the dice again for these two birds specifically to make a random selection.

The same method should be applied when selecting half-hours for watching during hauling: assign a random number to each of the typical 16 half-hr periods of the total of 8 hrs hauling time (see above), and select the 8 half-hrs with the highest values. It also applies when selecting the block of stubs to watch from a total number of stubs: assign a random number to the first half (stub 1-4 or 1-3) and another to the last half (stub 5-8 or 4-6), and select the block with the highest value. Note that the random selection must be done on a *new* basis (with the calculator or the dice) *every day*, not using the selection from previous days.

This procedure will lead to you having a complicated cycle of activity and rest/sleep. For example, if in the morning your random selection results in you watching the 1st block of 4 stubs being set, the cycle will be:

set 1st block	= 2 hrs watch
set 2nd block	= 2 hrs rest
haul 1st block	= 8 hrs watch
haul 2nd block	= 8 hrs rest

If, however, the random selection results in you watching the 2nd block of 4 stubs, then:

1st block set	= 2 hrs rest
2nd block set	= 2 hrs watch
haul 1st block	= 8 hrs rest
haul 2nd block	= 8 hrs watch

The 'worst' (in terms of minimising rest) random sequence of days would obviously be when you watch the 2nd block 1st (i.e. in the first 24 hr-day), followed by the 1st block the next day. This means that there will only be a 4-hr gap between watching the haul of the 2nd block (day 1) and starting the watch of the 1st block (day 2). But the good news is that, providing the vessel always starts setting around the same time each morning, you should then have a 12-hr break (i.e. 8 hrs rest during hauling of 2nd block followed by another 4 hours to make up the 24-hr day) until the start of the next 24-hr cycle of activity You can easily work out your activity cycle for other combinations that your randomisation produces, and it would be a good idea to do this just to get an idea of what the challenge is!

English-Norwegian glossary

bait	agn
bait snatching	(fuglenes) stjeling av agn
barbed hook	krok med mothake(r)
bow	baug (foran på båten)
buoyancy	flyteegenskaper
calliper jaws	"vinkelbein"
dice	terning
discards	utkast (av fisk som av en eller annen grunn ikke skal brukes - utkast av fisk er generelt forbudt i Norge)
focal length	brennvidde (mm på et zoom-objektiv)
JNCC	Joint Nature Conservation Committee (engelsk forskningsinstitusjon)
lunar phase	månefase
offal	avfall (her: innmat etc. fra sløying av fisk)
searchlight	lyskaster
snood	fortom
stern	akterende (bak på båten)
stub	stubb (her: lineenhet)
swell	dønning (bølger)
thaw	tine (fra frossen tilstand)

Appendix 1B

Line Setting Recording Form

Ship | Observer | Date | SRN

Number of Hooks | Type of Hooks | Size of Hooks

Spacing of Hooks | Snood length

Bait type | % Hooks baited | % Bait loss in tube

Technical Measures | Discards or offal

Course | Speed | Light on vessel

Time	North	East	Depth	Sea State	Swell	Wind Speed	Wind Direction	Light Level	Tube depth	Tube clear?

Appendix 1C

Bird Count Recording Form

SRN [ ] Page Number [ ] Of [ ]

Time	Species	Count	Accuracy

Appendix 1D

Catch Sequence Recording Form, 1997

SRN		**Page Number**		**... of totally**	**... pages**
Start time		**Stop time**		**Light on vessel**	
Bait snatching		**Unused bait**			

Record the following codes in the boxes in the order they appear on the line: F - Fulmar, G - Gannet, K - Kittiwake, GS - Great Skua, HG - Herring Gull, GB - Great Black-backed Gull, LB - Lesser Black-backed Gull, GG - Glaucous Gull, IG - Iceland Gull, T - Tusk, L - Ling, C - Cod etc. Transfer the sums to Catch Sums Recording Form. Mark start and stop times for each observing session (see Methodology).

Appendix 1E

Catch Sums Recording Form, 1997

SRN	Species	TALLY

Appendix 2

Crews and Crewing arrangements, 1997

Name of vessel:	*M/S Søviknes* (VWT)	
Skipper:	*Svein Ove Myrbø*	
Crew composition:	1 machinist:	*Endre Søviknes*
	1 cook:	*Tore Westlund*
	2 fish cleaners	*Odd Einar Drågen*
		Lennart Klemetsen
	7 setting/hauling crew	
		Stig Sylvestersen
		Richard Pilskog
		Eivind Grytten
		Frank Uggedal
		Kyrre Løvik
		Ole Johnny Male
		Anders Øygaard

Shift system: 3-4 fishermen on one shift, one shift 12 hours (?)

Setting: 1 man responsible for guiding the line into the tube and feeding the autoliner with bait.

1-2 men watching the autoliner and feeding the autoliner with magazines.

Hauling: 1 man at the foredeck, controlling the hauling and gaffing fish that falls of the hooks. Equipped with a gaff, and a 4 m long bar with hooks for gaffing fish from the sea that is lost during hauling. Incoming fish is thrown into a metal-box.

2 men cleaning the fish from the metal box when it is full.

1-2 men replacing the line into magazines.

Name of vessel:	*M/S Værland* (VWOT)
Skipper:	*Jan Einar Søviknes*
Crew:	*Roy Aslaksen*
	Per Magne Dahle
	Paul Sofus Eysturdal
	Jim André Kurseth
	Mikkjal Nilsen
	Nils-Egil Sandblåst
	Torbjørn Solevåg
	Bjarte Andre Søviknes
	Ivar-Martin Søviknes
	+ One other (details not known)

Appendix 3

Detailed itinerary and course of fishing trip of VWT, 1997 (Time in GMT)

Name of vessel: M/S Søviknes (VWT)
Skipper: Svein Ove Myrbø

Date	Time	Latitude (N)	Longitude (E)	
29.09	1250			Leaving Ålesund
30.09 (steaming)	0710	63°42′	9°15′	
30.09	1130	64°19′	9°59′	
30.09	1630	64°53′	11°19′	
01.10 (steaming)	0700	67°00′	13°44′	
01.10	1200	67°44′	14°14′	
01.10	1600	68°22′	14°16′	
02.10 (fishing)	1555	68°40′	13°48′	
02.10.	1700	68°48′	13°59′	
02.10	1743	68°53′	14°03′	
03.10	1802	68°45′	13°46′	
03.10	1837	68°41′	13°40′	
04.10	0312	68°56′	15°40′	
04.10	0407	68°53′	14°00′	
04.10	0658	68°49′	13°49′	
05.10 (steaming)	1440	68°34′	14°52′	
05.10	1612	68°34′	14°13′	
06.10 (fishing)	0515	68°47′	13°39′	
06.10	0700	68°53′	13°43′	
07.10	0552	68°49′	14°04′	
07.10	0728	68°16′	14°05′	
08.10	0500	68°58′	14°45′	
08.10	0627	69°00′	14°39′	
09.10	2348	69°35′	16°41′	
10.10	0137	69°36′	16°42′	
10.10	2125	69°33′	17°00′	
10.10	2252	69°40′	16°43′	
11.10	2314	69°43′	16°43′	
11.10	0037	69°36′	17°05′	
12.10	1900	69°44′	16°48′	
12.10	2053	69°33′	17°17′	
13.10	1757	69°41′	16°19′	
13.10	2032	69°32′	16°38′	

Date	**Time**	**Latitude (N)**	**Longitude (E)**	
14.10	2054	69°37′	16°09′	
15.10	2227	69°41′	16°39′	
16.10	0002	69°32′	17°03′	
16.10	1928	69°42′	16°43′	
16.10	2109	69°33′	17°09′	
17.10	1414	69°40′	16°57′	
17.10	1511	69°35′	17°42′	

Appendix 4

Species list for observers

NB - this is a much more elaborate list than encountered on the longlining trips, but is presented here in its entirety for sake of completeness.

English	Latin	Norwegian
Birds		
Arctic skua	*Stercorarius parasiticus*	Tyvjo
Arctic tern	*Sterna paradisaea*	Rødnebbterne
Black guillemot	*Cepphus grylle*	Teist
Common gull	*Larus canus*	Fiskemåke
Common scoter	*Melanitta nigra*	Svartand
Eider	*Somateria mollissima*	Ærfugl
Fulmar	*Fulmarus glacialis*	Havhest
Gannet	*Morus bassanus*	Havsule
Glaucous gull	*Larus hyperboreus*	Polarmåke
Great black-backed gull	*Larus marinus*	Svartbak
Great shearwater	*Puffinus gravis*	Storlire
Great skua	*Stercorarius skua*	Storjo
Guillemot	*Uria aalge*	Lomvi
Herring gull	*Larus argentatus*	Gråmåke
Iceland Gull	*Larus glaucoides*	Grønlandsmåke
Kittiwake	*Rissa tridactyla*	Krykkje
Lesser black-backed gull	*Larus fuscus*	Sildemåke
Long-tailed skua	*Stercorarius longicaudus*	Fjelljo
Manx shearwater	*Puffinus puffinus*	Havlire
Pomarine skua	*Stercorarius pomarinus*	Polarjo
Puffin	*Fratercula arctica*	Lunde
Razorbill	*Alca torda*	Alke
Sooty shearwater	*Puffinus griseus*	Grålire
Marine mammals		
Bearded seal	*Erignathus barbatus*	Storkobbe (= blåsel)
Bottlenose dolphin	*Tursiops truncatus*	Tumler
Common dolphin	*Delphinus delphis*	Delfin
Common seal	*Phoca vitulina*	Steinkobbe (= fjordsel)
Fin whale	*Balaenoptera physalus*	Finnhval
Grey seal	*Halichoerus grypus*	Havert (= gråsel)
Harbour porpoise	*Phocoena phocoena*	Nise
Harp seal	*Phoca groenlandica*	Grønlandssel
Hooded seal	*Cystophora cristata*	Klappmyss
Humpback whale	*Megaptera novaeangliae*	Knølhval
Minke whale	*Balaenoptera acutorostrata*	Vågehval
Pilot whale	*Globicephala melaena*	Grindhval
Ringed seal	*Phoca hispida*	Ringsel (= snadd)
Risso's dolphin	*Grampus griseus*	Rissodelfin
Sperm whale	*Physeter macrocephalus*	Spermhval

English	**Latin**	**Norwegian**
White-beaked dolphin	*Lagenorhynchus albirostris*	Kvitnos
White-sided dolphin	*Lagenorhynchus acutus*	Kvitskjeving
Fish		
Anglerfish (Monkfish)	*Lophius piscatorius*	Breiflabb
Argentine	*Argentina silus*	Vassild
Black scabbard	*Aphanopus carbo*	Dolkfisk
Bib	*Trisopterus luscus*	Skjeggtorsk
Blue ling	*Molva dypterygia*	Blålange
Blue-mouth	*Helicolenus dactylopterus*	Blåkjeft (?Heliocolenus)
Blue whiting	*Micromesistius poutassou*	Kolmule
Boarfish	*Capros aper*	Villsvinfisk
Catfish	*Anarihichas lupus*	Gråsteinbit
Cuckoo ray	*Raja naevus*	Gjøkskate
Cod	*Gadus morhua*	Torsk
Common dab	*Limanda limanda*	Sandflyndre
Common skate	*Raja batis*	Storskate
Common sole	*Solea solea*	Tunge
'Deepwater' sharks	*Squalus spp.*	I Norge kun piggå
Dogfish	*Scyliorhinus canicula*	Småflekket rødhai
Dragonet	*Callionymus lyra*	Vanlig fløyfisk
Four-bearded rockling	*Rhinonemus cimbrius*	Firetrådet tangbrosme
Grey gurnard	*Eutrigla gurnardus*	Knurr
Greater forkbeard	*Phycis blennoides*	Skjellbrosme
Greater weever	*Trachinus draco*	Fjesing
Haddock	*Melanogrammus aeglefinus*	Hyse (kolje)
Hake	*Merluccius merluccius*	Lysing
Halibut	*Hippoglossus hippoglossus*	Kveite
Herring	*Clupea harengus*	Sild
Horse mackerel	*Trachurus trachurus*	Taggmakrell
John Dory	*Zeus faber*	St. Petersfisk
Lemon sole	*Microstomus kitt*	Lomre
Lesser weever	*Trachinus vipera*	Dvergfjesing
Ling	*Molva molva*	Lange
Long rough dab	*Hippoglossoides platessoides*	Gapeflyndre
Mackerel	*Scomber scombrus*	Makrell
Morid	*Mora moro*	Mora
Mullet	*Mullus surmuletus*	Mulle
Norway pout	*Trisopterus esmarkii*	Øyepål
Orange roughy	*Hoplostethus atlanticus*	*Mangler norsk navn*
Plaice	*Pleuronectes platessa*	Rødspette
Poor cod	*Trisopterus minutus*	Sypike
Rabbit fish	*Chimaera monstrosa*	Havmus
Red gurnard	*Aspitrigla cuculus*	Tverrstripet knurr
Roughhead grenadier	*Macrourus berglax*	Isgalt
Roundnose grenadier	*Coryphaenoides rupestris*	Skolest
Saithe	*Pollachius virens*	Sei
Salmon	*Salmo salar*	Laks
Sandeel	*Ammodytes spp.*	Sil (kun småsil/havsil)

English	Latin	Norwegian
Seabass	*Dicentrarehus labrax*	Havåbor
Sea trout	*Salmo trutta*	Ørret (aure) Her: Sjøørret
Solenette	*Buglossidium luteum*	Glasstunge
Spurdog	*Squalus acanthias*	Pigghå
Starry ray	*Raya radiata*	Kloskate
Thornback ray	*Raja clavata*	Piggskate
Tusk	*Brosme brosme*	Brosme
Whiting	*Merlangius merlangus*	Hvitting
Various		
Blue mussel	*Mytilus edulis*	Blåskjell
Brittle star	*Class Ophiuroidea*	Slangestjerne
Cuttlefish	*Order Teuthoidea*	10-armet blekksprut
Octopus	*Order Octopoda*	8-armet blekksprut
Sea urchin	*Class Echinoidea*	Kråkebolle
Starfish	*Class Asteroidea*	Sjøstjerne
Squid	*Todarodes sagittatus*	Akkar

Appendix 5

Relevant information about all the stubs used during the trip on the Vessel With the Tube (VWT), 1997.

SRN (Setting Reference Number) of each stub denoted by a combination of data and a letter, thus (e.g.) 0210 A.

Setting time (not exact) in brackets.

Weather (see JNCC Manual for scale of measurement): Sea state-Sea swell-Wind speed-Wind direction.

SRN	Setting time	Weather	Light conditions	Depth	Hooks	Fish catch
0210 A-C	1555 start	1-3-1-S	Clouds: 40 % cover	101 m	15000	
	(1700)			81 m		
	1743 stop			90 m		
0310 A	1802-1837	1-2-1-SE	Dark, clouds: 40 %	95 m	5000	
0410 D	0312 start	2-2-2-E	Dark, clouds: 20%	110 m	19500 (D-F)	
	0350 stop			76 m		
0410 E	0407 start			90 m		
	0543 stop			79 m		
0410 F	0558 start			85 m		
	0630 stop			?		
0610 C	(0445) start			?		
	0515 stop	2-2-2-E		77 m	23400	
0610 D-F	0700 stop			101 m		
0710 D	0452 start	2-3-3-E	Clouds: 10 %	81 m	15600	
	0615 stop			99 m		
0710 E	0615 start			99 m		
	0650 stop			-		
0710 F	0650 start			-		
	0728 stop			77 m		
0810 E	0500 start	3-2-3-E	Dawn, clouds: 0 %	70 m	14300	
	0521 stop		Gradually daylight	68 m		
0810 F	0521 start			68 m		
	0549 stop			74 m		
0810 G	0557 start			77 m		
	0627 stop			70 m		
1010 E	2348 start	3-2-3-E	Dark	65 m	18200	
	0013 stop			50 m		
1010 F	0013 start			50 m		
	0037 stop			171 m		
1010 G	0046 start			130 m		
	0108 stop			56 m		
1010 H	0108 start			56 m		
	0137 stop			68 m		

SRN	Setting time	Weather	Light conditions	Depth	Hooks	Fish catch
1010 K	2125 start	2-2-2-SE Rain	Dark	53 m*	39000	
	2206 stop			70 m*		
1010 L	2206 start			70 m		
	2243 stop			90 m		
1010 M	2252 start			97 m		
	? stop			55 m		
1010 N	2309 stop			45 m		
1110 D	2236 start	2-2-?-E	Dark, half-moon,	56 m	19500	
	2314 stop		clouds: 0 %	86 m		
1110 E	2323 start		No moon, clouds: 0 %	88 m		
	0000 stop			56 m		
1110 F	0000 start			56 m		
	0037 stop			41 m		
1210 A	1900 start	2-2-2-E	Dark, half-moon,	83 m	19500	
	1936 stop		clouds: 0 %	58 m		
1210 B	1936 start			58 m		
	2013 stop			43 m		
1210 C	2013 start			43 m		
	2053 stop			45 m		
1310 A	1757 start	1-2-1-E	Dark, clouds: 0 %	103 m*	18200	
	1833 stop		full moon	67 m*		
1310 B	1833 start			67 m		
	1914 stop			76 m		
1310 C	1923 start			77 m*		
	1953 stop			133 m*		
1310 D	2001 start			137 m		
	2032 stop			88 m		
1410 E	(2025) start	1-2-1-E	Dark, full-moon,	61 m	15600	
	2054 stop		0 % clouds	63 m		
1410 F*	2054 start			63 m		
	2127 stop			79 m		
1410 G	2139 start			81 m		
	2210 stop			72 m		
1510 E	2227 start	2-2-2-S	Dark, full-moon,	117 m	15600	
	2259 stop		5 % clouds	61 m		
1510 F	2259 start			61 m*		
	2330 stop			45 m*		
1510 G	2330 start			45 m		
	0002 stop			157 m		
1610 D	1928 start	5-2-5-S	Dark, full-moon	83 m	16900	
	1958 stop			58 m		

SRN	Setting time	Weather	Light conditions	Depth	Hooks	Fish catch
1610 E	1958 start			58 m		
	2029 stop			50 m		
1610 F	2029 start			50 m		
	2109 stop			112 m		
1710 A	(1340) start	3-2-3-SE	Daylight, 70-80 % clouds	-	14300	
	1355			58 m		
	1409 stop			54 m		
1710 B	1414 start		100 % clouds	58 m		
	1447 stop			43 m		
1710 C	1447 start			43 m		
	1511 stop			32 m		

* Tube not in use

Appendix 6

Relevant information about all the stubs used during the trip on the Vessel Without the Tube (VWOT), 1997.
Observation time is given in minutes, and catch rate is the number of hooks with catch divided on the observation time (number of catch per minute).

SRN	Setting Time	Weather	Depth	Co-ordinates	Observation Time	Catch rate
2010A	21:03	Rain	116-90	70° 54' N, 26° 09' E — 70° 54' N, 25° 59' E	133	2.4
2010C	22:17	Rain	x — 103	70° 56' N, 26° 10' E — 70° 56' N, 26° 00' E	60	3.2
2210A	00:22	Clear sky	156 — 142	71° 15' N, 27° 10' E — 71° 12' N, 27° 18' E	96	4.9
2210B	00:53	Some snow	x — 68	71° 12' N, 27° 18' E — 71° 09' N, 27° 18' E	61	3.9
2210C	01:26	Variable	68 — 45	71° 08' N, 27° 17' E — 71° 05' N, 27° 17' E	22	1.0
2210E	22:26	Cloudy	x — 152	71° 01' N, 70° 58' E — 70° 58' N, 26° 23' E	120	0.4
2210F	22:56	Cloudy	x — 122	70° 78' N, 26° 23' E — 70° 55' N, 26° 19' E	60	3.4
2410A	00:01	Cloudy	143 — 130	71° 27' N, 26° 39' E — 71° 24' N, 26° 40' E	90	1.8
2410B	00:30	Cloudy	128 — 147	71° 24' N, 26° 39' E — 71° 20' N, 26° 40' E	60	1.8
2410C	01:01	Cloudy	150 — 154	71° 20' N, 26° 39' E — 71° 17' N, 26° 39' E	30	1.2
2410D	21:27	Cloudy	146 — 106	71° 10' N, 26° 30' E — 71° 07' N, 26° 29' E	30	4.2
2410E	21:54	Cloudy	104 — 134	71° 07' N, 26° 29' E — 71° 04' N, 26° 30' E	90	4.2
2410F	22:22	Cloudy	128 — 158	71° 04' N, 26° 30' E — 71° 00' N, 26° 29' E	60	3.5
2610A	18:38	Clear sky	183 — 104	71° 15' N, 28° 04' E — 71° 12' N, 28° 05' E	90	6.1
2610B	19:10	Clear sky	113 — 25.5	71° 12' N, 28° 05' E — 71° 09' N, 28° 04' E	91	3.9
2710E	23:03	Snowy	143 — 85	71° 13' N, 28° 14' E — 71° 09' N, 28° 13' E	30	8.0
2710F	23:40	Snowy	55 — 140	71° 08' N, 28° 16' E — 71° 11' N, 28° 17' E	60	5.6
2710G	00:15	Cloudy	153 — 58	71° 11' N, 28° 20' E — 71° 07' N, 28° 19' E	90	7.1
2810A	20:01	Unknown	52 — 140	71° 06' N, 28° 22' E — 71° 09' N, 28° 23' E	30	3.9
2810B	20:40	Unknown	138 — 57	71° 08' N, 28° 25' E — 71° 05' N, 28° 25' E	102	8.4
2810C	21:16	Unknown	51 — 112	71° 04' N, 28° 28' E — 71° 07' N, 28° 29' E	75	8.0

SRN	Setting Time	Weather	Depth	Co-ordinates	Observation Time	Catch rate
2910A	21:30	Rainy	153 — 109	71° 05' N, 28° 47' E — 71° 02' N, 28° 47' E	90	5.7
2910B	22:23	Rainy	44 — 156	71° 02' N, 28° 44' E — 71° 05' N, 28° 45' E	10	5.5
2910C	23:03	Rainy	132 — 50	71° 06' N, 28° 42' E — 71° 02' N, 28° 42' E	80	7.1

Appendix 7

Overall composition of fish catch/bird by-catch per stub set by the Vessel Without The Tube (VWOT), 1997.

Data obtained from each of the stubs. The species are given the following codes: BC=blue catfish, C=cod, D=dab, F= fulmar, H=haddock, Ha=halibut, KC=king crab, L=ling, LC=lesser catfish, T=tusk, Ra=ray (not identified to species), Re=redfish, S=saithe, X=unknown.

SRN	BC	C	D	F	H	Ha	KC	L	LC	T	Ra	Re	S	X	Total
2010A															
Count		102			135					29	15		3	34	318
%		32.1			42.5					9.1	4.4		0.9	10.7	
2010C															
Count		75	1		103				1		2	2		8	192
%		39.1	0.5		53.6				0.5		1.0	1.0		4.2	
2210A															
Count		83			213	1			1	134	8		21	10	471
%		0.2			45.2	0.2			0.2	28.5	1.7		4.5	2.1	
2210B															
Count		37			62					94	22		22	237	
%		17.1			28.6					43.3	10.1		10.1		
2210C															
Count					6				3	12					21
%					28.6				14.3	57.1					
2210E															
Count		140	2		150				1	12	14	3		6	328
%		42.7	0.6		45.7				0.3	3.7	4.3	0.9		1.8	

SRN	BC	C	D	F	H	Ha	KC	L	LC	T	Ra	Re	S	X	Total
2210F															
Count		99	3		92					3	1	2		1	201
%		49.3	1.5		45.8					1.5	0.5	1.0		0.5	
2410A															
Count	3	77			60				1	4	13	1		3	162
%	1.9	47.5			37.0				0.6	2.5	8.0	0.6		1.9	
2410B															
Count	1	43			28					5		1		5	83
%	1.2	51.8			33.7					6.0		1.2		6.0	
2410C															
Count		6			16				1	13	7	1			44
%		13.6			36.4				2.3	29.5	15.9	2.3			
2410D															
Count		26			53					39	1	4		4	127
%		20.5			41.7					30.7	0.8	3.1		3.1	
2410E															
Count		73			228		1		1	60	5	2		6	376
%		19.4			60.4		0.3		15.9	1.3	0.5		1.6		
2410F															
Count		65			63			2	3	28	17	27		7	212
%		30.7			29.7			0.9	1.4	13.2	8.0	12.7		3.3	
2610A															
Count		122			315					84	16			16	553
%		22.1			56.9					15.2	2.9			2.9	

SRN	BC	C	D	F	H	Ha	KC	L	LC	T	Ra	Re	S	X	Total
2610B															
Count		97			162				4	64	18		1	11	357
%		20.7			45.4				1.1	17.9	5.0		0.3	3.1	
2710E															
Count		74		1	129			1		21	8	1		6	241
%		30.7		0.4	53.5			0.4		8.7	3.3	0.4		2.5	
2710F															
Count		92			190				1	30	13			10	336
%		27.4			56.5				0.3	8.9	3.9			3.0	
2710G															
Count		196	2		354				1	37	23	1		24	638
%		30.7	0.3		55.5				0.2	5.8	3.6	0.2		3.8	
2810A															
Count		60			34					7	10	1		6	118
%		50.8			28.8					5.9	8.5	0.8		5.1	
2810B															
Count		135			614				1	28	49		1	24	852
%		15.8			72.1				0.1	3.3	5.8		0.1	2.8	
2810C															
Count		115			409					33	21		1	24	603
%		19.1			67.8					5.5	3.5		0.2	4.0	
2910A															
Count		88			203					190	13	1		15	510
%		17.3			39.8					37.3	2.5	0.2		2.9	

SRN	BC	C	D	F	H	Ha	KC	L	LC	T	Ra	Re	S	X	Total
2910B															
Count		11			29					9	2		3	1	55
%		20.0			52.7					16.4	3.6		5.5	1.8	
2910C															
Count		100	1		386	2				47	14		1	15	566
%		17.7	0.2		68.2	0.4				8.3	2.5		0.2	2.7	
Total															
Count	4	1916	9	1	4034	4	1	3	78	928	289	45	37	252	7601
%	0.05	25.27	0.12	0.01	53.21	0.05	0.01	0.05	1.02	12.24	3.81	0.59	0.49	3.32	100

Appendix 8

Appendix 8A: Methods for assessment of catch on longlining vessels, 1998
These instructions have been developed by Euan Dunn and his colleagues in the Conservation Science Department of he RSPB, in cooperation with Christian Steel (NOF) and Mark Tasker (JNCC) for the NOF observer in the 1998 project, Terje Lislevand (hereafter TL). Mention is also made of PIV =Per Inge Vernæsbranden, 1997 NOF observer on the M/S *Søviknes.* The document is rather detailed, and the observer(s) carrying out the fieldwork is encouraged to extract the most important information and make a concrete and more trimmed 'action list' themselves for the cruise, in order to get a clear view of the various pieces of the work that needs to be done, and in what sequence.

Some of the technical details about M/S *Søviknes* are already available in PIV's 1997 report, and TL should familiarise himself with this in advance, especially to spot details which PIV did not pick up. Also, TL will find that he is already familiar with many of the questions from last year. But they are all repeated here for the sake of completeness.

Basic information

Vessel	M/S *Søviknes* (Vessel With Tube = VWT)
New specifications for 1998	tube now equipped with spring-loaded sheet (probably along the slit) to prevent line from slipping out accidentally.
Skipper for trip	Svein Ove Myrbø (same as during PIV's trip last year)

I At the start of the cruise

A From the ship's plans, find out the height of the stern and the bridge wing above the waterline. Use this data to calculate the height of your eye above waterline and thus the width of the calliper jaws that will delimit the outer bounds of the 300 m transects used for seabird counts (see Webb & Durinck 1992, which we will provide for you; this is the standard guide used by the JNCC's Seabirds-At-Sea-Team, hereafter called <u>JNCC's Methods Manual</u>).

B Find out the setting regime (number of 'stubs' of lines normally set and hauled each day, at what intervals and in what lay-out) the skipper is likely to operate so that you can plan your own time budget.

In autolining, the working unit is the so-called 'stub' which is a specified length of line with a certain number of 'snoods' (branchlines) with hooks spaced at regular intervals, as well as floats and anchors (see table below). According to Løkkeborg it generally takes about 30 min to set a stub and 2-3 hours to haul it, depending on depth, currents and number of hooks. Normally, several stubs are set straight after one another, before they start hauling them (see below).

Autoline system

Element	Consists of	Norwegian equivalent
Hook with snood	-	Krok med fortom
Line	130 hooks	Line
Magazine	10 lines, i.e. 1300 hooks	Magasin
Stub/Fleet	4-5 magazines, i.e. 5200-6500 hooks, linked together.	Stubb

Every 24 hours, an autoliner sets 30.000-40.000 hooks, typically by deploying 6 "large" stubs or 8 "small" stubs. The stubs are not linked together, and may be set in different lay-outs.

C The regime the longliner operates will vary between areas, seasons and skippers. The vessel works continuously throughout the 24 hrs, 7 days a week, alternating between setting and hauling. The destination of TL's trip will almost certainly be the Egga and Røst banks and the main fish targeted probably ling ('lange'), tusk ('brosme') and (further north) haddock ('hyse'/'kolje'). The M/S *Søviknes* usually sets 6-8 stubs in one go, this taking approx. 4 hrs. Hauling (which starts immediately after setting) takes about 2-3 hrs per stub (depending on depth, currents and number of hooks), thus hauling the entire set of stubs takes about 16-20 hrs.

Often, depending on topography etc., they will set the stubs in a parallel lay-out. Løkkeborg describes the setting (for ling and tusk) of stubs along 2 parallel lines, each line with 3-4 stubs set just following each other. Once the first line of 3-4 stubs is set, and from where this line ends, the vessel turns 90 degrees, sails about 1 nautical mile and sets the other line of 3-4 stubs backwards parallel with the first line. Then the vessel completes the rectangle by returning to where setting the first line started, and begins to haul.

At times they may also set more or less all the stubs in 6-8 parallel lines, typically down the continental slope, with each stub starting at the top of the slope.

D Once it has hauled its stubs, the vessel re-sets them further along the fishing grounds, so that the vessel may move along setting and hauling 'like a tractor ploughing a field'. Although this is a standard pattern, make sure you know what actual pattern your own skipper will use, as this may vary. Ask him this well in advance of the start of fishing activity so that you can plan your own time budget accordingly (see below for details).

E Spend some time at the very start of the cruise to familiarise yourself with the setting regime of the vessel, and how many stubs the vessel usually deploy. Investigate the various components of the longlines and the machinery, and make notes of different options available (hook numbers pr. stub, hook types, number of barbs on the hooks, hook sizes, hooks spacing, various snood lengths etc.) for later use in the **Line Setting Recording Form**. Obtain samples of all hook types used if possible - Løkkeborg says that normally just one or two hooks are used. Find out if how the gear is used varies a lot, or is likely to be rather constant throughout the cruise. Also find out if the bait will be the same throughout the cruise, and if it will be frozen, thawed, or semi-thawed, as this affects its buoyancy (typically, bait is semi-thawed mackerel or squid). All of this information is later to be entered in the **Line Setting Recording Form** for each stub that is set.

F From the skipper, find out typical <u>percentages of baited hooks</u>, because not all hooks are baited as they pass through the automated baiting machine (this is unlikely to vary between stubs, but it may vary with the type of bait used). The proportion of hooks baited in automated longlining varies between 85% and 95%. For underwater setting, also find out from the skipper, for the particular bait being used, the <u>percentage of that bait typically lost (by friction) when passing through the tube</u>. It will not be practical to determine this by direct observation of the tube but the skipper will know the average rate of bait loss for the equipment and bait he is using. [NB: When PIV asked the skipper about this, he said Mustad had investigated bait loss caused by the tube and they concluded that there was negligible bait loss from this cause]. These two measures should be roughly constant for the cruise, and also these shall be entered in the **Line Setting Recording Form** for each stub that is set.

G Investigate possibility of storing dead birds in the vessel's freezer for further analysis (see Methods, below, for storage details). It is difficult to predict how many birds will be caught, and therefore, how many to retain for later analysis. This will depend partly also on how much storage capacity the skipper can offer you, and the arrangements for transferring stored birds to a museum on the mainland (e.g. 500 fulmars may be too many to handle).

In Løkkeborg's study, 3 stubs (each with ca. 4725 hooks) were set and hauled each day for 12 days under different setting conditions. The stubs set without any mitigating measures (tube or streamer line) caught 99 birds, those set through the tube caught 28 birds, and those set with a streamer line (but without the tube) caught 2 birds. Most of the birds were fulmars. On 5 out of the 12 days, with no devices, no birds were caught, on other days up to 22 were caught.

On this basis, it seems that bycatch rate is very patchy and erratic from day to day but settings outside the tube could possibly catch significant numbers of seabirds. For detailed guidance on how to select birds for collection, see below. If (see hauling methodology below), you did not watch the haul yourself, ask the crew if they will agree to remove and pile up the birds for you so that you can deal with them shortly afterwards. It is important to try and get firm, reliable assurances from the crew on this. Be helpful in accepting the place they suggest the birds be piled, and assure them you will remove them very soon after hauling.

- As soon as conveniently possible when you arrive on board, discuss with the skipper the arrangements, agreed in principle in earlier discussions between with Christian Steel and Noralf Gjerseth, about the control experiments to assess bycatch when lines are deliberately set outside the tube. Given that the vessel may set 6 stubs per day, Noralf agreed that "they could set 1 stub per day outside the tube, but probably not more." In order to achieve our objectives in a single14-day fishing trip, it is essential that the skipper agrees to this bare minimum of 1 stub per day outside the tube. If you can persuade him to set <u>more</u> than one stub per day outside the tube, then you should do this, emphasising that it is the only way of proving that the tube works. <u>Remember</u>:
- It is by no means clear that Noralf and Svein Ove will have spoken on this issue - this could work in your favour or it could be a disadvantage because we have no written guarantee from Noralf that the M/S *Søviknes* will definitely set at least 1 stub per day outside the tube.
- We cannot offer to compensate skippers for any loss of catch they suffer by not using the tube this way.
- It is not unusual for longlining to take no bycatch on some days, so *not* using the tube does not guarantee that birds will be caught.

The skipper of the M/S *Søviknes* - Svein Ove Myrbrø -during PIV's trip used other mitigating measures: streamer line, also regular use of horn-blowing, and shotgun (into the air). He used the streamer line when there were too many birds behind the vessel. He used the streamer line almost every time the tube was not in use, and also sometimes when the tube was in use. It is important for TL to appreciate that the only thing we really want to experimentally 'control for' on this trip is the use or non-use of the tube. This means that, in order to avoid potential influences on bycatch rates from other variables, we should try and keep conditions (including other mitigating measures) as constant as possible when we are comparing these two 'control treatments'. One thing in particular we should avoid, therefore, is the skipper setting the streamer line (or any other combination of mitigating measures) ONLY when a stub is set outside the tube. In other words, if the skipper accepts that we are conducting an experiment to show how NOT using the tube affects bycatch, he must not interfere with the objectivity of that experiment by introducing mitigating measures in efforts to compensate for not using the tube. If the skipper does insist on varying mitigating measures in this way, the particular measures used during the setting of EACH stub should be carefully recorded.

II Methods of survey during transit to and from fishing grounds, and during transit between fishing grounds

A The purpose of this exercise is to get background data on seabird density, according to JNCC Methods Manual so that, in the event of getting data on fishing effort subsequently, we can begin to produce a predictive model of seabird bycatch in different regions of the sea.

B Seabirds should therefore be counted between port of departure and arrival on the fishing grounds, during any significant transits between fishing grounds, and on return journey from fishing grounds to port. Take also any other opportunities you get to record background densities when the vessel is not actively fishing or discarding unwanted fish/offal. Providing there is enough daylight to do it, the hour before the first stub is set is a useful time to establish a background density which can subsequently be related to 'snapshot' counts during setting (see below) and to seabird bycatch.

For establishing background densities, TL should use the methodology in which he was trained on the Bergen ferry trip and which he perfected on his longliner trip last year. You will not be expected to observe continuously, of course, but should collect representative data. The bare minimum is 10 minutes but, as the SAST trainer has told you, longer spells of observation are recommended and will certainly yield data that are more robust statistically. Remember to make a note of how recently any type of discarding has occurred.

C General sequence of observing setting and hauling
The following sequence is based on the likelihood that the vessel will set 6 stubs, as this is the number we have been told to expect for this trip. The following general principles apply:

a The most important parameters to get out of this study are (i) number of seabirds taken daily as bycatch in, respectively, settings through the tube and outside the tube, (ii) the number of baited hooks set daily which produced that bycatch, so that (iii) we can establish a bycatch rate per 1000 hooks set, and extrapolate this to the fishing trip as a whole (which means keeping track of the number of stubs set in total over the fishing trip).

b The observer should work, in total, for a max. of 10 hrs daily. This includes observing the setting of all the stubs.

c The observer should always watch the haul of the first stub set that day. This will give him time to arrange the boxes necessary for stacking up the seabirds that will (hopefully) be taken by the line that is set outside the tube, and any others caught in lines set through the tube (see below for details). The observer may also watch subsequent stubs, providing he doesn't need sleep.

D The observer should begin by choosing at random which of the stubs should be set daily outside the tube. He should make sure the skipper is aware of this arrangement and explain the reason for it (basically randomisation prevents the possibiltiy of any systematic influences on the rate of bycatch).

Setting typically starts early in the morning, when normally all the stubs will be set following each other, with hauling taking most of the rest of the day and night. The subsequent hauling of all of the stubs will take 16-20 hrs, i.e. most of the rest of the day and night.

In the case of 6 stubs, it would be unreasonable to expect you to watch the haul for all of these as they get hauled over the side. In last year's fieldwork, we made complicated arrangements to enable you to watch a random selecetion of these, whilst also geting some rest and sleep. This time, we are making it easier in the following respects:

- We will not be asking you to note the detailed sequence of birds and fish on the hooks as this is very labour-intensive and not likely to be worth the effort.

- We are hoping that you can set up a series of boxes, numbered 1-6 (in the case of 6 stubs) in which the crew can simply store seabirds caught when you are not there. Naturally, you will impress on them the importance of doing this accurately and consistently, and especially making sure they appreciate the importance of collecting all the birds (especially when bycatch is heavy) and not throwing any away. After watching the hauling of the first stub, the observer could get some sleep until he feels able to watch later stubs, and during his sleeping time the the crew attends to the seabirds caught. [NB: if the observer thinks for any reason that the crew is not attending properly to this, then it is particularly important that he tries to personally observe the hauling of the stub which was set outside the tube, as this will be the one with, hopefully, the most information to yield in terms of bird by-catch.]

III Methods of survey during line setting (see Line Setting Recording Form, Bird Count Recording Form)

A Position yourself at the stern of the vessel. Be advised by the crew, but probably the best place is the 'half-deck' above and forward of the stern.

B On the **Line Setting Recording Form,** record all the characteristics of the setting of the particular stub, as the form requests (see also the first part of this document). Allocate a <u>Setting Reference Number (SRN)</u> that is unique to a particular setting of the stub so that the setting data, bird count data and bycatch data can all be cross-referenced.

C Apart from underwater setting, record on the **Line Setting Recording Form** if the vessel is using any other <u>Technical Measures</u> to reduce seabird bycatch, notably streamer line (= 'tori' pole. Norwegian: "tjalkeskremme") which longliners commonly use as a bird scarer, or if the crew are using a gun or horn to scare birds away. Details of any such technical measures should be recorded on a separate sheet. In the case of a streamer line, record the line length, number and length of streamers and their spacing along the line. Take some photographs of the streamer line in use (it will be hauled in when the vessel is not fishing), and any other mitigating measures used.

D Record on the **Line Setting Recording Form** if any <u>Discards or offal</u> are being discharged from the vessel during setting (or if you know whether there was any such discharging shortly before setting began), as this may affect the number of birds attracted to bait, and may present an alternative food for seabirds during setting. If possible, record what species of fish are being discarded, and in what numbers (this may happen at times other than setting, and it would be useful to have such information).

E Just before line setting begins, make a note on the **Line Setting Recording Form** of the time, wind speed/direction [Note: last year's form didn't have anywhere to put weather details], light level (cloud cover and, - if it is before dawn - also the lunar phase (quarter moon, half moon, etc.) as strong moonlight has been found to increase bait-snatching intensity). Note also if the fishermen use a searchlight or any other deck lighting during night setting (we are told they don't want to use a searchlight because it facilitates bait-snatching). You will not find much room on the Line Setting Recording Form for entering 'Light level' details or whether or not a searchlight (etc.) is used, so just make notes as best you can on the Form you are using for a particular stub-setting. Avoid putting such details in your notebook as this would complicate subsequent cross-referencing. Also record the vessel's position (i.e 'North' and 'East'), course and speed from the GPS system. Use JNCC Methods Manual to record the Sea State and Swell just after the GPS readings are taken. Also record Depth (at which line is being set) from the sonar on the ship's bridge. At end of setting, or if any significant change in the weather, vessel's course or other background conditions occur, record vessel's position and other conditions again.

F Watch the tube for 1 minute to see if the lower end is fully submerged or if it ever rises clear of the sea surface. Under Tube clear? on the **Line Setting Recording Form,** record it as Yes (for 'clear' of the surface) or No (for 'not clear' of the surface). Also, the penetration of the tube below the surface may vary with how much fish is stored at the front of the vessel (this tends to increase as the cruise proceeds, causing the stern - and thus the tube - to rise higher in the water); so estimate and record the average Tube depth to which the bottom of the tube penetrates below the surface during a particular session of setting.

G Bird Count Recording Form. Before you start recording bird counts, enter the Setting Reference Number (SRN) which, as stated earlier (see instructions for line-setting), is unique to the setting of that stub on that particular date. Then, every 10 minutes from the start of the setting session you are observing (the time when each 10-min period starts must be recorded under TIME on the form), make a 'snapshot' count of the total numbers of each bird species in the air and on the water behind the ship within 300 m of the ship in a 180 degree scan. The densities of birds and the mobility of birds in the air may make exact counts of some species difficult. If so, try to count birds in blocks of 10, 50 or 100. Make a note of the 'Accuracy' of every count (e.g. 'to the nearest 10', 'to the nearest 50', etc.) for each species. Also make a note of how recently any type of discarding has occurred.

A few times (say 3) each day take a photograph of dense bird flocks as you are doing the snapshot counts. This should be from your fixed observation at the rear of the vessel. Use a fixed focal length (to make photographs comparable) and note the time, the number of the frame on the film, and the number of the film, for subsequent cross-referencing to the right snapshot count. These photographs could be used when the fieldwork is over to calibrate your counts, and see how your performance to this respect develops as the cruise goes by.

Although there is no set form for this, as time permits make notes of the general behaviour of different seabird species towards the baited hooks as they are set. E.g. kittiwakes are said to be good at stealing bait without being caught, while fulmars are more vulnerable to capture. It is also worth recording which, if any, seabird species near the vessel show no interest in the bait at all. Try to estimate the distance behind the vessel at which snatching takes place (this distance may vary with, e.g., whether underwater setting and/or a streamer line is used). Although it is difficult to quantify attempts at bait-snatching because it happens a long way behind the vessel, often in the thick of a large following flock, PIV has suggested the following may be possible (and superior to the very crude and subjective index suggested for last year's fieldwork): at a spot estimated at ca. 100m behind the vessel (or the nearest spot where the birds are snatching), count the number of birds which are bait-snatching over a 5-minute period during the setting of a stub. By keeping the binoculars on th spot and counting all the birds snatching in this period, a more accurate idea of the intensity of bait-snatching emerges.

H Record the time at which the setting of the last stub stops.

IV Methods of assessing catch during line hauling (see Catch Recording Form)

A The **Catch Recording Form** will only be filled in in-detail for hauls that you actually watch yourself. You will still need to enter data on total birds caught (and, if you can, total amount of each type of fish caught) for hauls of stubs watched by the crew (i.e. when they store birds in your absence) but obviously you will not have the same amount of detail for these hauls monitored by the crew. For all hauls, however, make a note of the Setting Reference Number (SRN) of the stub that is being hauled. For hauls you observe yourself, record:

B the time at which you start ('Start time') and stop ('Stop time') observing the haul or part of the haul.

C Record ('Light on vessel') if a searchlight or other deck lighting is used during hauling, as this may assist seabirds in being attracted to hauling activities.

D Record ('Bait snatching') any seabirds you see attempting to snatch bait or hooked fish during hauling (occasionally this happens) and record any birds that get caught.

E Some hooks will be hauled in which have no birds or fish on them but which still do have bait attached. Make a note (in 'Unused bait') of what the fishermen do with this bait. Do they throw it overboard while they are hauling (which seems to be the case from other studies, and this can be the reason for attracting seabirds which get caught during hauling) or do they keep it to be discarded later? If they throw it overboard, make a note of where they throw it (e.g. near the line or at the opposite side of the ship).

F Enter amount of target catch (fish) and non-target catch (i.e. seabird bycatch) in the **Catch Recording Form** as boxes of each species of fish, and numbers of each species of seabird. If you get the chance, note any unusual fish (such as deepwater sharks).

G If freezer storage facilities are available on the ship, collect the hooked dead birds and place each separately in a plastic bag. Fix a label to the bag and write the SRN (Setting Reference Number) on it. Seal the bag and place it in the freezer. All seabirds retrieved to begin with should if possible be kept, at least until you know how many are being caught. Later, if a lot are caught, you could begin to take a random sample (see appendix). But it is difficult to be prescriptive about such things till we know what storage facilities are possible. It could easily be a couple of hundred fulmars, for example.

H Arrangements are being made with Christian Steel to have the frozen seabird samples stored in a Norwegian museum (or equivalent) for subsequent analysis. This will require arrangements to be made for removal and local storage of the seabirds after the vessel docks in port.

IMPORTANT: *During the trip, please note any problems with the methodology, any improvements, etc. which could help refine our approach in future. If you run into major problems at any early stage, contact Christian Steel immediately. Also, we may not have thought of all possibilities, so note anything that you think we have overlooked which actually contributes to understanding what is affecting the rate of seabird by-catch.*

V Randomising

Randomising has been mentioned in the instructions, because this yields more statistically robust data and helps us avoiding bias or unwanted links. Here is a simple way of randomising on board the longlining vessels.

If the storage capacity is limited you are to randomly select a limited number of birds to store in the freezer, from a total number of caught birds. Give each of the birds a unique number from 1 to n. Your calculator probably has a random function, giving you a random number between 0 and 1 when pressing a specific key. Assign random numbers from this calculator function to each of the birds from 1 to n, one after the other. (If your calculator does not have this function, you could throw a dice.) If you are to pick 4 birds to store, you simply select the 4 birds with the highest number values. If the 4th and the 5th bird should get the same number (most likely to happen if you use a dice), you will have to throw the dice again for these two birds specifically to make a random selection.

The same method should be applied when selecting which stub should be set outside the tube. Note that the random selection must be done on a *new* basis (with the calculator or the dice) *every day*, not using the selection from previous days.

VI Statistical Treatment

Since working with average bycatch rates generates high variance, it is preferable to apply paired comparisons to bycatches set, respectively, with and without the tube. It is recommended to use either a Paired t-test or a Wilcoxon Matched Pairs test. The t-test looks at the magnitude of the difference in bycatch between the two sorts of stub settings, whereas the Wilcoxon looks at whether the difference in bycatch between one setting is bigger or smaller or the same as the paired comparison. The two stubs to be compared should be as close as possible in time and space to each other. In other words, the bycatch for a stub set outside the tube should be compared with the bycatch in the stub immediately before or after it.

The Wilcoxon test is more robust but less powerful than the t-test. The t-test, being parametric, requires a normal distribution in the data whereas the non-parametric Wilcoxon test does not. Both tests are very simple, so you could easily discover (by using the appropriate statistical table, which you should get from any standard text and take with you) whether the results are approaching/reaching a statistically significant difference. However, you should not stop sampling as soon as you arrive at a significant difference, and indeed in a 14-day fishing trip you will probably need all the data you can get. This is why it would be helpful to get the vessel to set more than one stub outside the tube per day, if possible even on a few days, to generate more ‘pairs’ for comparison. Remember, however, that the stubs selected for setting outside the tube should be chosen at random from the total sequence of stubs to be set during any one day.

Appendix 8B

Catch Recording Form, 1998

Date	SRN	Start Time	Stop Time	Vessel light	Bait Snatching	Unused bait	Fulmar tally	Other Birds tally	Fish Catch Tally

Appendix 9

Short description of the observed stubs (1998) according to geographical position, length (number of hooks), environmental factors and mitigating measures. Stubs set outside the tube are shown in bold.

SRN	Start	End	No. hooks	Sea state	Swell	Wind speed	Mit. measure
0906a	66°03'N, 006°3'0E	66°03'N, 006°23'E	3700	4	2	4	Tube
0906b	66°03'N, 006°23'E	66°03'N, 006°16'E	3700	4	2	4	Tube
0906c	66°02'N, 006°15'E	66°02'N, 006°26'E	5000	4	2	4	Tube
0906d	66°01'N, 006°26'E	65°57'N, 006°24'E	5000	4	2	4	Horn
0906e	65°57'N, 006°24'E	-	5000	4	2	4	Tube
0906g	65°57'N, 006°29'E	66°01'N, 006°28'E	6200	4	2	4	Tube
1006a	65°59'N, 006°25'E	65°59'N, 006°12'E	6200	4	2	4	Tube
1006b	66°00'N, 006°13'E	66°00'N, 006°25'E	6200	4	3	4	Tube
1006c	66°00'N, 006°25'E	66°00'N, 006°13'E	6200	4	2	4	Tube, horn
1006d	66°01'N, 006°14'E	66°01'N, 006°26'E	6200	5	3	5	Tube, horn, shoot
1006e	66°02'N, 006°26'E	65°58'N, 006°29'E	-	4	2	4	Tube, horn, shoot
1106a	**66°06'N, 006°32'E**	**66°06'N, 006°22'E**	**5000**	**4**	**2**	**4**	**Streamer, horn**
1106b	66°06'N, 006°22'E	66°06'N, 006°13'E	5000	4	2	4	Tube, streamer
1106d	66°06'N, 006°05'E	66°06'N, 006°12'E	3700	4	3	4	Tube, streamer
1106e	66°06'N, 006°13'E	66°06'N, 006°22'E	5000	4	2	4	Tube, streamer
1106f	66°06'N, 006°23'E	66°06'N, 006°32'E	5000	4	2	4	Tube, streamer
1106g	**66°07'N, 006°33'E**	**66°07'N, 006°23'E**	**5000**	**4**	**2**	**4**	**Streamer**
1106h	66°07'N, 006°22'E	66°07'N, 006°12'E	3700	4	2	4	Tube, streamer
1206a	66°09'N, 006°35'E	66°09'N, 006°26'E	5000	2	1	2	Tube, streamer
1206b	**66°09'N,**	**66°09'N,**	**5000**	**2**	**1**	**2**	**Streamer,**

SRN	Start	End	No. hooks	Sea state	Swell	Wind speed	Mit. measure
	006°25'E	**006°16'E**					**horn**
1206c	**66°09'N, 006°15'E**	**66°09'N, 006°07'E**	**3700**	**2**	**1**	**2**	**Streamer**
1306a	**66°09'N, 006°20'E**	**66°09'N, 006°27'E**	**3700**	**2**	**1**	**2**	**Streamer, horn**
1306b	66°09'N, 006°27'E	66°09'N, 006°37'E	5000	2	1	2	Tube, streamer
1306c	**66°10'N, 006°38'E**	**66°10'N, 006°28'E**	**5000**	**2**	**1**	**2**	**Streamer, horn**
1306d	66°10'N, 006°27'E	66°10'N, 006°20'E	3700	2	1	2	Tube, streamer
1406a	66°11'N, 006°13'E	66°11'N, 006°19'E	2500	2	-	2	Tube, streamer
1406b	66°11'N, 006°19'E	66°11'N, 006°27'E	3700	2	1	2	Tube, streamer
1406c	**66°11'N, 006°27'E**	**66°11'N, 006°37'E**	**5000**	**2**	**1**	**2**	**Streamer**
1406d	66°12'N, 006°43'E	66°12'N, 006°30'E	6200	2	1	2	Tube, streamer
1406e	**66°12'N, 006°30'E**	**66°12'N, 006°21'E**	**5000**	**2**	**1**	**2**	**Streamer**
1506a	**66°13'N, 006°27'E**	**66°13'N, 006°40'E**	**6200**	**2**	**1**	**2**	**Streamer, horn**
1506b	66°14'N, 006°42'E	66°14'N, 006°30'E	6200	2	1	2	Tube, streamer, horn
1506c	66°14'N, 006°32'E	66°14'N, 006°44'E	6200	2	1	2	Tube, streamer, horn
1506d	66°15'N, 006°44'E	66°15'N, 006°32'E	6200	2	1	2	Tube, streamer, horn
1506e	**66°16'N, 006°34'E**	**66°16'N, 006°46'E**	**6200**	**2**	**1**	**2**	**Streamer, horn**
1606a	66°17'N, 006°37'E	66°18'N, 006°50'E	6200	2	1	2	Tube, horn
1606b	**66°18'N, 006°52'E**	**66°18'N, 006°40'E**	**6200**	**2**	**1**	**2**	**Streamer, Horn**
1606c	66°19'N, 006°41'E	66°19'N, 006°54'E	6200	2	1	2	Tube, streamer, horn
1606d	**66°20'N, 006°56'E**	**66°20'N, 006°44'E**	**6200**	**3**	**2**	**3**	**Streamer, horn**
1606e	66°20'N, 006°45'E	66°21'N, 006°57'E	6200	3	2	3	Tube, streamer, horn