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SHORT NOTE: A REVIEW OF THE EFFECTIVENESS OF STREAMER LINES AS A SEABIRD BYCATCH MITIGATION TECHNIQUE IN LONGLINE FISHERIES AND CCAMLR STREAMER LINE REQUIREMENTS

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A REVIEW OF THE EFFECTIVENESS OF STREAMER LINES AS A SEABIRD BY-CATCH MITIGATION TECHNIQUE IN LONGLINE FISHERIES AND CCAMLR STREAMER LINE REQUIREMENTS

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Abstract

Based to a large degree on the precedent set by CCAMLR in 1991, the streamer line has become the primary, and most commonly prescribed, seabird mitigation device in world longline fisheries. This paper reviews CCAMLR streamer line requirements (Conservation Measure 25-02 (2002), formerly Conservation Measure 29/XIX) in light of a review of existing literature and available data on the effectiveness of single and paired (or multiple) streamer lines.

Research to determine the optimal streamer line design and configuration is lacking and is identified as a high priority. Future streamer line research should compare the attack or dive rate of multiple southern hemisphere seabird species or foraging guilds as a function of distance astern in response to single and multiple streamer lines deployed according to specific performance and material standards. Improvements to streamer line requirements set out in Conservation Measure 25-02 are discussed and proposed relative to recent Alaskan requirements. Proposed changes include: requiring that the streamer line be deployed over the hookline within 100 m of the stern; increasing the height of the streamer line attachment point to the vessel and/or specifying the aerial extent of the streamer line; requiring that individual branched streamers extend to the water in the absence of wind and swell and be attached throughout the aerial extent of a streamer line; including ultraviolet-protected plastic tubing as a permitted streamer material; relaxing the number and placement of swivels in favour of a performance standard; requiring that streamer line attachment points to the vessels and the towed object be deployed windward of the hookline; and recommending that fishers deploy a minimum of two streamer lines on a voluntary basis according to performance and material standards. Based on the recommendations of this review and the discussions of the ad hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF), the CCAMLR streamer line requirements were changed by the Commission in 2003.

Résumé

En raison principalement du précédent établi par la CCAMLR en 1991, la ligne de banderoles est devenue le principal dispositif d'atténuation de la capture accidentelle d'oiseaux de mer dans les pêcheries à la palangre dans le monde et le dispositif le plus communément prescrit. Ce document examine les conditions fixées par la CCAMLR pour les lignes de banderoles (mesure de conservation 25-02 (2002), ancienne mesure de conservation 29/XIX) en vue d'une analyse de la littérature existante et des données disponibles sur l'efficacité des lignes de banderoles simples et doubles (ou multiples).

La recherche visant à déterminer la conception et la configuration optimales des lignes de banderoles n'est pas au point et est reconnue comme une priorité absolue. Les prochaines recherches sur les lignes de banderoles devraient comparer le taux d'attaque ou de plongée de diverses espèces d'oiseaux de mer de l'hémisphère sud ou de groupes d'espèces aux mêmes habitudes alimentaires en fonction de la distance à l'arrière selon que sont déployées des lignes de banderoles simples ou multiples conformes à des normes spécifiques de performance et sur les matériaux. Une amélioration des conditions établies dans la mesure de conservation 25-02 est examinée et proposée en fonction de conditions récemment adoptées en Alaska. Parmi les changements proposés : exiger que la ligne de banderoles couvre la ligne d'hameçons sur 100 m à l'arrière; accroître la hauteur du point d'attache de la ligne de banderoles au navire et/ou spécifier l'étendue aérienne de la ligne de banderoles; exiger que les banderoles séparées s'étendent jusqu'à la surface de l'eau en l'absence de vent et de houle et qu'elles soient attachées sur toute l'étendue aérienne de la ligne de banderoles; autoriser l'utilisation de tubes en plastique anti-ultraviolet; assouplir le nombre d'émerillons imposés et leur placement en faveur d'un niveau de performance; exiger que le point d'attache des lignes de banderoles au navire et l'objet remorqué soient situés au vent de la ligne d'hameçons; et recommander que les pêcheurs déploient à titre volontaire au moins deux lignes de banderoles conformément aux normes de performance et sur les matériaux. Sur les recommandations de cette étude et des discussions du groupe de travail *ad hoc* sur la mortalité accidentelle induite par la pêche à la palangre (WG-IMAF), la Commission a modifié les conditions relatives aux lignes de banderoles en 2003.

Резюме

В значительной степени благодаря прецеденту, созданному АНТКОМом в 1991 г., поводцы для отпугивания птиц стали основным и наиболее часто рекомендуемым устройством для снижения прилова морских птиц при ярусном промысле во всем мире. В статье рассматриваются требования АНТКОМа в отношении поводцов для отпугивания птиц (Мера по сохранению 25-02 (2002), ранее – Мера по сохранению 29/XIX) на основе обзора существующей литературы и имеющихся данных об эффективности одиночных и сдвоенных (или нескольких) поводцов для отпугивания птиц.

Исследования по определению оптимальной конструкции и конфигурации отсутствуют и считаются высокоприоритетными. Будущие исследования поводцов по отпугиванию птиц должны проанализировать интенсивность нападения или ныряния различных видов морских птиц южного полушария или добывающих пищу гильдий как функцию расстояния за кормой в зависимости от применения одиночных и множественных поводцов для отпугивания птиц, используемых в соответствии с предусмотренными нормами и стандартами на материалы. Обсуждается и предлагается улучшение установленных в Мере по сохранению 25-02 требований в отношении поводцов для отпугивания птиц с учетом последних требований на Аляске. Предлагаемые изменения включают: требование о том, чтобы поводец для отпугивания птиц был задействован над хребтиной в пределах 100 м за кормой; увеличение высоты точки крепления этого поводца к судну и/или точное определение зоны охвата этого поводца; требование о том, чтобы отдельные ответвления доставали до поверхности воды в отсутствие ветра и волнения и крепились по всей надводной части поводца для отпугивания птиц; включение защищенных от ультрафиолетового излучения пластиковых трубок как разрешенного материала для изготовления поводцов для отпугивания птиц; ослабление требования о числе и расположении вертлюгов в пользу уровня эффективности; требование о том, чтобы точка крепления поводца для отпугивания птиц к судну и буксируемый объект находились с наветренной стороны от хребтины; и рекомендацию, чтобы промысловики на добровольной основе применяли как минимум два таких поводца в соответствии с установленными нормами и стандартами на материалы. Исходя из рекомендаций этого анализа и обсуждения в специальной Рабочей группе по побочной смертности, вызываемой промыслом (WG-IMAF), в 2003 г. Комиссия изменила требования АНТКОМа в отношении поводцов для отпугивания птиц.

Resumen

Se puede decir que el precedente establecido por la CCRVMA en 1991 es, en gran medida, responsable de que las líneas espantapájaros se hayan convertido en el elemento disuasorio más recomendado para mitigar la captura de aves marinas en las pesquerías de palangre a nivel mundial. Este trabajo examina los requisitos de la CCRVMA con respecto a las líneas espantapájaros (Medida de Conservación 25-02 (2002), anteriormente Medida de Conservación 29/XIX) a la luz de la revisión de la información publicada actualmente y de los datos disponibles sobre las líneas simples y dobles (o múltiples).

En la actualidad faltan estudios sobre el diseño y configuración óptimos de la línea espantapájaros, y se estima que éstos debieran tener alta prioridad. En el futuro, los estudios deberán comparar la tasa de buceo, o ataques, de varias especies de aves marinas o gremios tróficos del hemisferio sur, en función de la distancia de la popa cuando se utilizan líneas espantapájaros simples o múltiples de acuerdo a un estándar de rendimiento y materiales utilizados. Las mejoras propuestas a los requisitos de líneas espantapájaros dispuestos en la Medida de Conservación 25-02 se comparan con los requisitos exigidos recientemente en las pesquerías de Alaska. Los cambios propuestos requieren que: la línea espantapájaros sea desplegada sobre la línea de pesca hasta 100 m de la popa; se aumente la altura de sujeción de dicha línea al barco y/o se determine la extensión cubierta por la línea espantapájaros; los chicotes sean de un largo tal que toquen el agua en ausencia de viento y marejada y estén acoplados en toda la extensión cubierta por la línea espantapájaros; el material de construcción incluya una tubería plástica resistente a los rayos ultravioleta; no se exija un número específico de destorcedores situados a una distancia determinada si se puede mejorar el rendimiento; los puntos de sujeción al barco y el objeto remolcado sean desplegados a barlovento de la línea de pesca; y por último, se recomienda que los pescadores desplieguen voluntariamente dos líneas espantapájaros como mínimo, de acuerdo con estándares de rendimiento y de material de construcción. En 2003 la Comisión modificó los requisitos pertinentes a la línea espantapájaros adoptada por la CCRVMA, sobre la base de las recomendaciones de este examen y del debate del Grupo de Trabajo sobre la mortalidad incidental causada por la pesca (WG-IMAF).

Keywords: streamer line, tori line, bird scaring line, performance standards, seabird by-catch mitigation, conservation measure, CCAMLR

Introduction

Recognising that mounting evidence that the incidental capture of seabirds in demersal longline fisheries in the CCAMLR Convention Area was linked to declines in seabird populations, CCAMLR adopted Conservation Measure 29/X[1] in 1991. A key element of this conservation measure was the requirement that all longline vessels fishing in the Convention Area tow a single streamer line of a specified design while deploying fishing gear.

A streamer line, also called a bird scaring or 'tori' line, is a line that is attached to a high point near or at the stern and towed behind the vessel. Streamers are attached to the aerial portion of the line, which is maintained by the drag of the line through the water. When deployed properly, the streamer line moves erratically and hazes birds from the area above the sinking hookline, thus hindering seabird attacks on baits, and consequently reducing seabird mortality. CCAMLR streamer line specifications, detailed in the appendix to Conservation Measure 29/X, were based on early observations of streamer lines used in the Japanese pelagic longline fishery for bluefin tuna off Tasmania (Brothers, 1991), and remained virtually unchanged since 1991 (CCAMLR, 2002; see apendix to this paper).

Recent work in demersal longline fisheries strongly suggests that streamer lines deployed in pairs or threes are more effective at reducing seabird attacks and mortality than a single streamer line (Melvin et al., 2001; Sullivan and Reid, 2002). Similarly, some single streamer line systems, such

[1] Conservation Measure 29/X, the original conservation measure adopted at the Tenth Meeting, was changed to Conservation Measure 25-02 in 2002 (see CCAMLR, 2002) and is now referenced as Conservation Measure 25-02 (2002).

as the boom-and-bridle system[2] used by New Zealand vessels, are considered to be more effective than the streamer line specified by CCAMLR (SC-CAMLR, 2002; Fenaughty, 2001; Smith, 2001). Based on these observations, the CCAMLR ad hoc Working Group on Incidental Mortality Arising from Fishing (WG-IMAF) noted in 2002 that CCAMLR streamer line requirements could be improved, and recommended that paired streamer lines or the boom-and-bridle single streamer line be used on a voluntary basis in the Convention Area (SC-CAMLR, 2002).

This paper responds to WG-IMAF's request that the streamer line requirement be updated and improved based on available science. To this end, literature and available data on the effectiveness of streamer lines in reducing seabird mortality in longline fisheries were reviewed. Changes to the original CCAMLR streamer line requirement are recommended, based on the review and experiences in the Alaskan demersal longline fisheries.

Literature review

Seabird conservation in longline fisheries is achieved through a suite of mitigation measures or optimal vessel-management practices. The streamer line has become the primary and most commonly prescribed seabird mortality mitigation measure in longline fisheries throughout the world, based to a large degree on the precedent set by CCAMLR in 1991. Despite worldwide application of streamer lines, research to determine the optimal streamer line design and configuration is lacking and should be of the highest priority in order to achieve seabird conservation in world longline fisheries (Melvin and Robertson, 2001). Streamer line designs in current use stem from the best efforts and anecdotal observations of fishers, fishery observers and researchers. The effectiveness of streamer lines as a seabird deterrent is influenced by a host of biological and physical factors, as well as the design of the streamer line, how it is deployed relative to the hookline, and the rate at which gear sinks out of the range of scavenging seabirds. The assemblage of seabirds present around the vessel, the diving ability and competitive interactions of individual species within that assemblage, fishing location, time of year and weather conditions are also likely to affect the performance of streamer lines and other seabird mitigation technologies.

Single streamer line

Attempts to demonstrate significant reductions in the by-catch of seabirds using a single streamer line compared to no streamer lines have had mixed results. Work in Southern Hemisphere pelagic longline fisheries (Murray et al., 1993; Duckworth, 1995; Klaer and Polacheck, 1995; Brothers et al., 1999b) and demersal longline fisheries (Ashford et al., 1994, 1995; Ashford and Croxall, 1998; Benavides and Arana, 1998) was inconclusive, with the exception of Moreno et al. (1996). Based on a subset of data collected under comparable conditions, Moreno et al. recorded significantly fewer birds caught when a single streamer line was used; however, they note that one vessel using a streamer line had high levels of by-catch when fishing near islands. The reason why these studies were unable to show consistent and clear benefits from using streamer lines vary, but a factor common to all was a lack of consistency in streamer line design and performance. Differing seabird species, the limited scale of experiments, and a wide array of confounding factors also contributed to ambiguous results.

In contrast, several controlled studies in the Northern Hemisphere have demonstrated dramatic reductions in seabird by-catch and, in some cases, seabird attacks on baits using streamer lines. Løkkeborg (2003) demonstrated that single streamers based on the CCAMLR design significantly reduced the incidental catch of northern fulmars (*Fulmarus glacialis*) by 98% to 100% compared with a control of no deterrent across four experimental cruises over several years. Further, he demonstrated that significantly fewer baits were lost to fulmars, and in one experiment, that fish catch significantly increased (32%) using a streamer line. Boggs (2001) reported a 70% reduction in North Pacific albatross contacts with baits using streamer lines in a simulated pelagic fishery.

There is strong evidence that mitigation success or failure is specific to the species assemblage or perhaps the guild (surface-seizing versus diving foragers) of seabirds attending longline operations and cannot be generalised for all seabirds. Melvin et al. (2001) demonstrated that single streamer lines based primarily on the CCAMLR design, but deployed according to a performance standard (>40 m aerial coverage), significantly reduced the by-catch rates of predominantly surface-seizing foragers (northern fulmars and Laysan (*Phoebastria immutabilis*) and black-footed (*P. nigripes*) albatrosses) by 96% compared to a

[2] A system that allows the vessel attachment point of a single streamer line to be positioned to the windward side of the hookline in order to optimise effectiveness.

Table 1: Numbers of hooks observed during hauling, and observed seabird (mostly black-browed albatross) mortality recorded with different numbers of streamer lines on hooks set in daytime on cruise 3 (Sullivan and Reid, 2002).

Number of Streamer Lines	Hooks Observed	Birds Killed	By-catch Rate
1	8 307	6	0.722
2	60 847	11	0.181
3	85 042	2	0.024

control of no deterrent in the Alaskan demersal sablefish (*Anoplopoma fimbria*) fishery (hand-bait systems). Although seabird by-catch rates were reduced by 71% with a single streamer line in the Alaskan Pacific cod (*Gadus macrocephalus*) fishery (auto-bait systems), the result was not significant, primarily due to the presence of short-tailed shearwaters (*Puffinus tenuirostris*), a diving seabird, and the experimental design (single streamer line performance was not a central question and only anecdotal data were sought). However, single streamer lines completely eliminated the by-catch of surface foraging birds in the cod fishery; short-tailed shearwaters, which were virtually absent in the sablefish fishery, were the only seabird caught when single or paired streamer lines were used.

Several researchers have noted that single streamer lines can be less effective in crosswinds (Løkkeborg, 1998; Melvin et al., 2001; Brothers et al., 1999a; Agnew et al., 2000). Under these wind conditions, streamer lines can be blown downwind of the hookline leaving it exposed to seabird attacks. Melvin et al. (2001) observed that streamer lines flown from the leeward side of the vessel were least effective, but also that single streamer lines deployed in light winds can also be ineffective. Løkkeborg (2001) suggested that the wind effect could be remedied by using paired streamer lines. Ashford et al. (1994) also suggested that paired streamer lines are likely to be more effective than a single streamer line.

Paired streamer lines

In Alaska, paired streamer lines (deployed according to a >40 m aerial extent performance standard) significantly reduced seabird by-catch by 88% to 100% compared to a control of no deterrent over two years in the sablefish and Pacific cod fisheries (Melvin et al., 2001). Comparing single streamer lines to paired streamer lines in the final year of that study, seabird catch rates were lower using paired streamers, but differences were small (4% to 23%) and not significant.

Importantly however, seabird behaviour as measured by attacks on baits confirmed the benefits of paired streamer lines compared to single streamer lines (Melvin et al., 2001). Paired streamer lines resulted in significantly fewer seabird attacks and virtually no albatross attacks. The few attacks that did occur were farther from the stern where seabird attacks are less likely to be successful due to the increasing depth of the hookline. In contrast, single streamer lines failed to eliminate albatross attacks and did not displace attacks away from the stern. Based on this behavioural evidence, the authors recommended that paired streamer lines be used in preference to single streamer lines in Alaska and all demersal fisheries. Alaskan demersal longline vessels are now required to use paired or single streamer lines depending on vessel size and gear type (NMFS, 2004).

Multiple streamer lines were tested in at least two Southern Hemisphere fisheries: the toothfish fishery in the Falkland/Malvinas Islands and the Australian eastern tuna and billfish pelagic fishery. Sullivan and Reid (2002) collected data on seabird catch rates when single, double and triple streamer lines were used in the Falkland/Malvinas Islands demersal toothfish fishery in November 2002 (Table 1). Streamer lines had an aerial extent of 30 to 70 m depending on sea state; individual streamers were 0.75 to 1.5 m long and did not extend to the surface of the water.

Data collection on single streamer lines was limited and opportunistic in that it took place on two occasions when one of two streamer lines broke midway through gear deployment. Seabird catch rates (primarily black-browed albatrosses (*Thalassarche melanophrys*)) were 75% lower using two and 97% lower using three steamer lines compared to a single streamer line. Logistic regression modelling of these data showed that mortality decreased significantly with an increase in the number of streamer lines and a range of environmental and operational variables (Reid and Sullivan, 2004). Although not definitive, these data strongly suggest that multiple streamer lines are more effective than single streamer lines at deterring black-browed albatrosses – one of the most aggressive and commonly caught albatrosses in Convention Area longline fisheries. Data from the streamer line trials in Australia were unavailable.

Performance standards

Possible improvements to CCAMLR streamer line requirements are identified in this section, based on a review of current published material and new data on CCAMLR streamer line performance standards. A performance standard is an explicit instruction describing how a mitigation measure must be deployed in order to be effective. Conservation Measure 25-02 (2002) stipulated the following: 'The streamer line is to be suspended at the stern from a point approximately 4.5 m above the water and such that the line is directly above the point where the baits hit the water. The streamer line … is to have a device at the end to create tension so that the mainline streams directly behind the ship even in crosswinds' (see appendix).

Specifying the height of the attachment point to the vessel aims to create a span over which the streamer line is in the air. Alaskan streamer line performance standards take a more direct approach. They specify the minimum aerial distance and allow fishers to decide how best to achieve it (including height of the attachment point). Specifying the aerial extent of the line is important for two reasons: it maximises the efficiency of the line as a seabird deterrent and prevents hang-ups on the hookline (Melvin et al., 2001).

The Alaskan minimum aerial distance was based on three factors: the size of the vessel, the distance behind the vessel to which most attacks (~90%) by surface-seizing foragers (excluding shearwaters) occur without a streamer line, and the distance at which hooklines sink beyond the diving range of surface-seizing seabirds (2 m) (Melvin et al., 2001; Melvin, 2003). In Alaskan fisheries, this distance is 60 m for vessels 30.5 m and over, and 40 m for vessels less than 30.5 m (NMFS, 2004). The performance standard for all vessels using snap-on gear (gangions attached and removed each deployment) was reduced to 20 m based on the slower setting speeds typical of this gear type, and for operational reasons.

Although estimates of the sink rate of hooklines in Convention Area demersal fisheries are docmented and the dive capabilities of most Southern Hemisphere seabirds are known (Robertson, 2001), data on the attack profile of Southern Hemisphere seabirds on sinking longlines without a streamer line are few, making it difficult to use the Alaskan methodology for determining the optimal aerial extent for a CCAMLR requirement. In the only published study of seabird behaviour with and without streamer lines in a Southern Hemisphere pelagic longline fishery, Brothers (1991), in 12 days of fishing, estimated that albatrosses (7 species) made 70% fewer attacks on longline baits when a streamer line was used (catch rates not reported). Most attacks (62%) without a streamer line occurred within 50 m of the stern; 88.5% occurred within 100 m. When a streamer line was used few attacks occurred within 50 m (2.3%, or 1% of the rate without a streamer line). Attack rates beyond 50 m were similar. The aerial extent of the streamer line and the sink rate of the gear were not reported; however, the line was attached to the vessel at a point 4 m above the water. These data are difficult to extrapolate to a possible performance standard for demersal fisheries because of the long snoods (gangion) used, typical of pelagic gear (20–35 m), and the vessel speed of 10 knots (demersal gear is rarely set in excess of 8 knots).

White-chinned petrel (*Procellaria aequinoctialis*) dive rates (the best approximation of attack rate for diving birds) in response to single (with unweighted and integrated weight hooklines) and double streamer lines (with integrated weight hookline and an acoustic cannon) provide the best available information on possible streamer line performance standards for application to Southern Hemisphere longline fisheries (Robertson and Wienecke, unpublished data). White-chinned petrels are the most commonly caught species in Convention Area longline fisheries, due largely to their aggressive diving behaviour, which is difficult to deter (Robertson, pers. comm.). Using protocols from Melvin et al. (2001), dive rate data were collected on the FV *Janas* as a function of distance astern to 100 m behind the vessel in the New Zealand ling longline fishery near Solander Island in November 2002 (Robertson and McNeill, 2003). Streamer lines were attached to the vessel at 4 m above the water using the boom-and-bridle system, achieving an aerial extent of up to 60 m.

For all three treatments, dive rates peaked at 70 m, which is 10 m beyond the aerial extent of the streamer line(s). The distribution of dives was similar for the unweighted (UW) and integrated weight (lines with 50 $g.m^{-1}$ lead integrated into two strands of the ground line – IW-50) single streamer line treatments, with 92% and 94% of dives occurring within 80 m of the stern respectively. That most dives occurred within the aerial extent (60 m) of

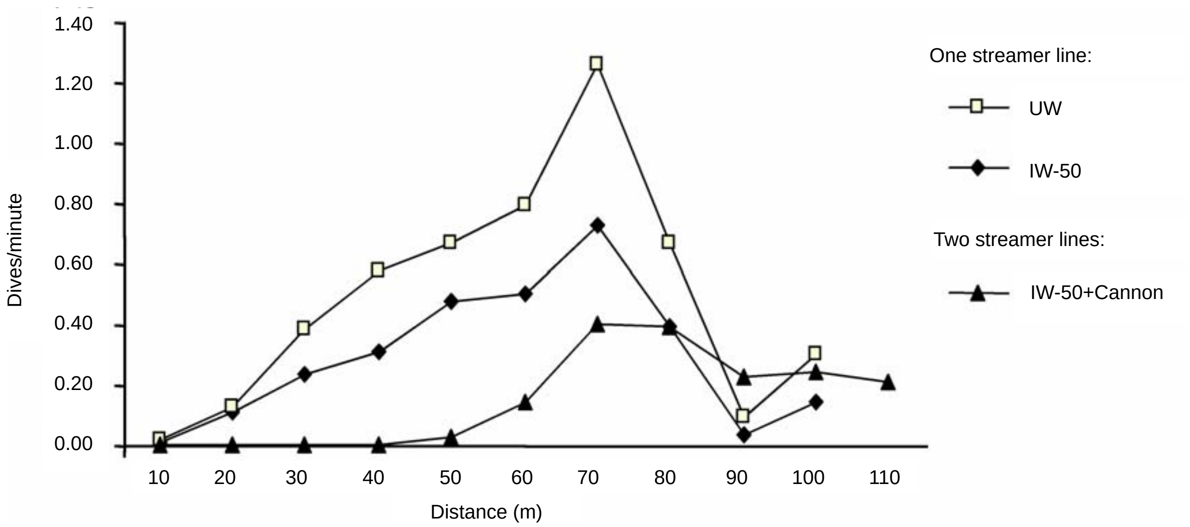

Figure 1: Dives per minute of white-chinned petrels on baited hooks using three mitigation strategies: 50 g.m^{-1} integrated weight longline with a single streamer line (IW-50), unweighted or standard longline with a single streamer line (UW) and 50 g.m^{-1} integrated weight longline with two streamer lines and an acoustic cannon firing randomly (IW-50+Cannon; Robertson and McNeill, 2003).

both single streamer line treatments (53% to 56%) suggests that the boom-and-bridle single streamer line does not readily deter white-chinned petrels and/or that streamer line performance could be improved. Without a control in which no deterrent is used, reasons for limited performance cannot be determined. The observation that the single streamer line was displaced from its position over the sinking gear in winds exceeding 25 knots might partially explain the vulnerability of the hookline to white-chinned petrel attacks within 60 m.

These single streamer line data strongly suggest that a streamer line with an aerial extent greater than 60 m would be more effective than the Conservation Measure 25-02 (2002) standard of a 4.5 m attachment point at reducing white-chinned petrel dives. The Alaskan experience suggests that aerial distances of 40 to 60 m are difficult to achieve at attachment heights of less than 6.1 m. Given these observations, the 4.5 m height requirement in Conservation Measure 25-02 (2002) should be increased or be replaced with an aerial extent requirement of at least 80 m. More data of this type on a variety of seabird species and/or foraging guilds, as well as data on the aerial extent of streamer lines used in the fishery, are needed to identify the optimal aerial extent of streamer lines for longline fisheries of the Southern Ocean.

In the New Zealand trials, the paired streamer lines with an acoustic cannon virtually eliminated dives within 50 m of the stern (Figure 1). Despite the confounding effects of the cannon, potential benefits of paired over single streamer lines for white-chinned petrels cannot be discounted. Additional work comparing the dive and attack rates of Southern Hemisphere seabirds in the presence of single and paired streamer lines should be a research priority.

Streamer line position relative to sinking baits, especially in strong crosswinds, is also a critical component of streamer line performance. Conservation Measure 25-02 (2002) states that streamer lines must be deployed 'such that the line is directly above the point where the baits hit the water' (see appendix). Given that most demersal hooklines enter the water within 8 m or less of the stern, Conservation Measure 25-02 (2002) could be ineffective in conditions where strong winds and seas prevail. If the streamer line is positioned over a point close to the stern where baits enter the water, this could leave most of the hookline unprotected in a strong crosswind. A standard that calls for deploying the streamer line over the sinking baits within 100 m of the stern with a requirement to deploy the streamer line from the windward side of the vessel is highly likely to improve performance. Also, this change would provide a clear picture of what a fisher is being asked to achieve.

The tension created by the towed object at the end of a streamer line is critical to both maintaining aerial extent and positioning the streamer line relative to the hookline. Conservation Measure 25-02 (2002) addresses this: 'The streamer line … is to have a device at the end to create tension so that the mainline streams directly behind the ship even in crosswinds' (see appendix). To be effective, both ends of the streamer line (the towed object at the seaward end of the streamer line and the attachment point to the vessel) should be on the windward side of the hookline in order to arc the streamer line over sinking hooks. Alternatively, requiring a minimum of two streamer lines – one from either side of the vessel – would maximise hookline protection in crosswinds and eliminate the need for placement requirements for a single streamer line.

Material standards

Conservation Measure 25-02 (2002) specifies the diameter and length of the mainline, the materials, spacing, and length and configuration (branched) of the streamers, and the placement of swivels and streamers within the line. Several authors have reported difficulties and complications with this design, particularly in regard to the streamers becoming fouled on the hookline (Ashford et al., 1995; Benavides and Arana, 1998). The following discussion is based on anecdotal information and is presented to inform future research and discussion.

Mainline

The weight of the mainline, the height of the attachment point and the amount of drag at the end of the streamer line, together with vessel speed and sea state, determine the aerial extent of the mainline. If the aerial extent of the streamer line is specified by CCAMLR as recommended here, the line diameter and number and placement of swivels could be determined by individual vessel captains. This change would also simplify construction and therefore compliance. The Alaskan streamer line, which proved highly effective and is made available to the fleet at no cost, is made of an 8 mm (5/16 inch) line devoid of swivels (except at either end) to minimise weight (and therefore increase aerial coverage) and reduce cost.

A mainline length of 150 m is considerably longer than the Alaskan line (90 m) and could create operational problems for some vessels in strong winds, especially if two or more streamer lines are used. However, this length might be justified for diving seabirds such as shearwaters and white-chinned petrels, assuming the in-water extent of a streamer line deters seabird dives on the hookline. This does not appear to be the case from the Robertson and McNeill (2003) white-chinned petrel dive data or the Brothers (1991) albatross data. In some cases the 150 m length without a towed object might enhance the tension on the line affecting the aerial extent, but a shorter line coupled with an appropriate towed object could accomplish the same result. A 100 m mainline with an appropriate towed object is likely to perform as well as a 150 m line without a towed object and could lead to fewer operational constraints.

Streamers

The number of streamers required per line (five) in Conservation Measure 25-02 (2002) is too few. If the aerial extent of the streamer line were 80 m, at 5 m spacing this would have streamers out to 25 m leaving 55 m without streamers. Requiring streamers at specific intervals along the entire aerial extent of the mainline would result in a more effective streamer line and is strongly recommended.

Regarding the length of individual branched streamers, Conservation Measure 25-02 (2002) specifies the following: 'The length of the streamer should range between approximately 3.5 m nearest the ship to approximately 1.25 m for the fifth streamer. When the streamer line is deployed the 'branch' streamers should reach the sea surface and periodically dip into it as the ship heaves' (see appendix). If the height of the required streamer line attachment point to the vessels is increased or the aerial extent of the streamer line is specified, these recommended streamer lengths would not extend to the sea surface. It is recommended, therefore, that the wording of Conservation Measure 25-02 (2002) be amended to include a requirement that streamers extend to the water in calm seas without wind.

Information is not available to evaluate the remaining specifications of the initial CCAMLR streamer line design (streamer spacing, configuration, materials and mainline length). In some situations (crosswinds and intense interaction with white-chinned petrels and black-browed albatrosses) streamers spaced at less than 5 m might be more effective. The ideal streamer material should be of a density that is not rendered ineffective in strong winds (maintains a vertical to semi-vertical position), is of a texture that is not easily hooked should it contact the hookline, and will release from a hook if it does become hooked. Ultraviolet (UV) protected plastic tubing was found effective in Alaska and met these criteria. Cord (required by Conservation Measure 25-02 (2002)) was less preferred because, due to its coarse texture, it was more likely to foul on hooks and not release with increasing pressure. 'Branched' (undefined in Conservation Measure 25-02 (2002) but assumed from the diagram to be two lengths joined at the attachment point to the mainline) streamer lines probably create more of a visual barrier and behave more erratically than unbranched streamers.

Conclusions

The following conclusions were drawn from this review:

- Research to determine the optimal streamer line design and configuration is lacking and should be of the highest priority in order to achieve seabird conservation in world longline fisheries.

- Mitigation success or failure is species-specific or perhaps specific to foraging guild and cannot be generalised to all seabirds.

- Streamer line research should compare the attack or dive rate of multiple Southern Hemisphere seabird species or foraging guilds as a function of distance astern in response to single and multiple streamer lines deployed according to specific performance and material standards.

- The streamer line requirements of Conservation Measure 25-02 (2002) should be modified to reflect findings of current research. Changes should include: requiring that the streamer line be deployed over the hookline within 100 m of the stern; increasing the height of the streamer line attachment point and/or specifying the aerial extent of the streamer line; requiring that individual branched streamers extend to the water in the absence of wind and swell and be attached throughout the aerial extent of a streamer line; including UV-protected plastic tubing as a permitted streamer line material; relaxing the requirements regarding the number and placement of swivels in favour of a performance standard to prevent twisting and fouling of individual streamers; requiring that streamer line attachment points to the vessels and the towed object be deployed to windward of the hookline so that streamers protect the hookline in crosswinds; and recommending that fishers deploy a minimum of two streamer lines on a voluntary basis according to performance and material standards, one on either side of the hookline.

- Fisheries observers should be required to collect data on the aerial extent of streamer lines in CCAMLR longline fisheries; a requirement for a minimum aerial extent of streamer lines should be incorporated into the CCAMLR conservation measure based on these data.

Epilogue

At its 2003 meeting, the Commission instituted new streamer line requirements (CCAMLR, 2003) to reflect recommendations presented in this review and the discussions of WG-IMAF (SC-CAMLR, 2003; see appendix).

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Liste des tableaux

Liste des figures

Список таблиц

Список рисунков

Lista de las tablas

Lista de las figuras

APPENDIX

COMPARISON OF CCAMLR STREAMER LINE REQUIREMENTS BEFORE (CONSERVATION MEASURE 25-02 (2002)) AND AFTER (CONSERVATION MEASURE 25-02 (2003)) STREAMER LINE REQUIREMENTS WERE CHANGED BY THE COMMISSION IN 2003

CONSERVATION MEASURE 25-02 (2002)

Minimisation of the Incidental Mortality of Seabirds in the Course
of Longline Fishing or Longline Fishing Research in the Convention Area

6. A streamer line designed to discourage birds from settling on baits during deployment of longlines shall be towed. Specification of the streamer line and its method of deployment is given in the appendix to this measure. Details of the construction relating to the number and placement of swivels may be varied so long as the effective sea surface covered by the streamers is no less than that covered by the currently specified design. Details of the device dragged in the water in order to create tension in the line may also be varied.

Appendix to Conservation Measure 25-02 (2002)

1. The streamer line is to be suspended at the stern from a point approximately 4.5 m above the water and such that the line is directly above the point where the baits hit the water.

2. The streamer line is to be approximately 3 mm diameter, have a minimum length of 150 m and have a device at the end to create tension so that the main line streams directly behind the ship even in cross winds.

3. At 5 m intervals commencing from the point of attachment to the ship five branch streamers each comprising two strands of approximately 3 mm diameter cord should be attached. The length of the streamer should range between approximately 3.5 m nearest the ship to approximately 1.25 m for the fifth streamer. When the streamer line is deployed the branch streamers should reach the sea surface and periodically dip into it as the ship heaves. Swivels should be placed in the streamer line at the towing point, before and after the point of attachment of each branch streamer and immediately before any weight placed on the end of the streamer line. Each branch streamer should also have a swivel at its attachment to the streamer line.

CONSERVATION MEASURE 25-02 (2003)

Minimisation of the Incidental Mortality of Seabirds in the Course
of Longline Fishing or Longline Fishing Research in the Convention Area

7. A streamer line shall be deployed during longline setting to deter birds from approaching the hookline. Specifications of the streamer line and its method of deployment are given in the appendix to this measure.

Appendix to Conservation Measure 25-02 (2003)

1. The aerial extent of the streamer line, which is the part of the line supporting the streamers, is the effective seabird deterrent component of a streamer line. Vessels are encouraged to optimise the aerial extent and ensure that it protects the hookline as far astern of the vessel as possible, even in crosswinds.

2. The streamer line shall be attached to the vessel such that it is suspended from a point a minimum of 7 m above the water at the stern on the windward side of the point where the hookline enters the water.

3. The streamer line shall be a minimum of 150 m in length and include an object towed at the seaward end to create tension to maximise aerial coverage. The object towed should be maintained directly behind the attachment point to the vessel such that in crosswinds the aerial extent of the streamer line is over the hookline.

4. Branched streamers, each comprising two strands of a minimum of 3 mm diameter brightly coloured plastic tubing[6] or cord, shall be attached no more than 5 m apart commencing 5 m from the point of attachment of the streamer line to the vessel and thereafter along the aerial extent of the line. Streamer length shall range between minimums of 6.5 m from the stern to 1 m for the seaward end. When a streamer line is fully deployed, the branched streamers should reach the sea surface in the absence of wind and swell. Swivels or a similar device should be placed in the streamer line in such a way as to prevent streamers being twisted around the streamer line. Each branched streamer may also have a swivel or other device at its attachment point to the streamer line to prevent fouling of individual streamers.

5. Vessels are encouraged to deploy a second streamer line such that streamer lines are towed from the point of attachment each side of the hookline. The leeward streamer line should be of similar specifications (in order to avoid entanglement the leeward streamer line may need to be shorter) and deployed from the leeward side of the hookline.

[6] Plastic tubing should be of a type that is manufactured to be protected from ultraviolet radiation.

Streamer Line