CCAMLR Science, Vol. 15 (2008): 107–114

AUTOLINERS AND SEABIRD BY-CATCH: DO LINE SETTERS INCREASE THE SINK RATE OF INTEGRATED WEIGHT LONGLINES?

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Abstract

Line setters are used with integrated weight (IW) (50 g m^{-1} lead core) longlines by some autoline vessels in the Kerguelen and Crozet Islands Patagonian toothfish (*Dissostichus eleginoides*) fisheries to deter seabirds, ostensibly by expediting gear sink rates. A trial was conducted in the Ross Sea to determine the effectiveness of line setters in increasing the sink rates of IW longlines. Time-depth recorders were deployed on lines set with and without a line setter using a paired-treatment design. Sink rates of longlines set with and without a line setter were identical, including in the first few metres of the water column where seabird interactions are likely to be most intense. Longlines deployed with the line setter entered the water several metres closer to the stern of the vessel and commenced sinking sooner, thus increasing slightly (<0.5 m) the depth of longlines for given distances astern. This increase in depth is minor and unlikely to result in substantial reductions in interactions between longlines and seabirds in the Kerguelen and Crozet fisheries.

Résumé

Des lanceurs de ligne sont utilisés avec les palangres autoplombées de 50 g m^{-1} par certains palangriers automatiques dans les pêcheries de légine australe (*Dissostichus eleginoides*) des îles Kerguelen et Crozet pour décourager les oiseaux de mer en augmentant, semble-t-il, la vitesse d'immersion des lignes. Un essai a été mené en mer de Ross pour déterminer si les lanceurs de ligne permettent effectivement d'augmenter la vitesse d'immersion des palangres autoplombées. Des enregistreurs temps/profondeur ont été fixés sur les palangres qui ont été posées avec et sans lanceur de ligne, selon une conception de traitement par paires. La vitesse d'immersion était identique, que les palangres aient été posées avec ou sans lanceur de ligne, y compris dans les premiers mètres de la colonne d'eau, là où les interactions avec les oiseaux de mer risquent d'être le plus intense. Les palangres déployées à l'aide du lanceur de ligne étaient plus proches de plusieurs mètres de la poupe du navire lorsqu'elles entraient dans l'eau et ont commencé à couler plus vite, ce qui a légèrement augmenté (< 0,5 m) la profondeur des palangres à des distances données à l'arrière du navire. Il est peu probable que cette augmentation légère de la profondeur ait pour résultat une réduction importante des interactions entre les palangres et les oiseaux de mer dans les pêcheries de Kerguelen et de Crozet.

Резюме

Устройства для постановки яруса используются некоторыми автолайнерами при промысле патагонского клыкача (*Dissostichus eleginoides*) у о-вов Кергелен и Крозе для ярусов со встроенными грузилам (IW) (свинцовый сердечник 50 г/м) в целях отпугивания морских птиц, по-видимому, за счет увеличения скорости погружения яруса. В море Росса был проведен эксперимент по определению эффективности устройств для постановки яруса в плане увеличения скорости погружения IW-ярусов. Регистраторы времени-глубины применялись на ярусах, которые ставились с постановочным устройством и без него, с использованием двойного подхода. Время погружения ярусов, которые ставились с помощью постановочного устройства и без него, было одинаковым, в т.ч. в верхних нескольких метрах водного столба, где взаимодействия с морскими птицами могут быть наиболее интенсивными. Ярусы, которые ставились с помощью постановочного устройства, входили в воду на несколько метров ближе к корме судна и начинали погружаться раньше, что несколько увеличивало (<0.5 м) глубину яруса на определенном расстоянии за кормой. Это увеличение глубины невелико и вряд ли приведет к существенному сокращению взаимодействий между ярусами и морскими птицами при промысле у о-вов Кергелен и Крозе.

Resumen

Algunos barcos que emplean el sistema de calado automático en las pesquerías de austromerluza negra (*Dissostichus eleginoides*) en las Islas Kerguelén y Crozet utilizan dispositivos especiales para largar los palangres con lastre integrado (PLI) (50 g·m^{-1} alma de plomo), a fin de reducir las interacciones con las aves marinas, bajo la premisa de que el arte se hundiría más rápidamente. Se probaron estos dispositivos de largada en el mar de Ross para determinar cuán eficaces son en aumentar la velocidad de hundimiento de los palangres con lastre integrado. Se colocaron registradores de tiempo y profundidad en líneas caladas con y sin un dispositivo de largada, siguiendo un diseño experimental de pares. Las tasas de hundimiento de los palangres calados con y sin dispositivos de largada fueron idénticas, incluidos los primeros metros de la columna de agua donde hay más probabilidades de que la interacción con las aves marinas sea más intensa. Los palangres calados con el dispositivo de largada entraron en el agua varios metros más cerca de la popa del barco y comenzaron a hundirse más rápidamente, aumentando así ligeramente la profundidad de los palangres (<0.5 m) a una distancia dada detrás del barco. Este aumento en la profundidad es de poca monta y es poco probable que produzca una reducción considerable en las interacciones entre los palangres y las aves marinas en las pesquerías de Kerguelén y Crozet.

Keywords: autoline vessels, line setters, longline sink rates, seabird mortality, cooperative research, CCAMLR

Introduction

Since the mid-1990s large numbers of seabirds have been killed in the legal Patagonian toothfish (*Dissostichus eleginoides*) longline fisheries operating around Crozet and Kerguelen Islands (Subarea 58.6 and Division 58.5.1 respectively). Reported seabird by-catch rates are among the highest in the world for demersal longline fisheries (Weimerskirch et al., 2000; SC-CAMLR, 2001). Mortality peaked during the period from September 2001 to August 2003 when nearly 27 000 seabirds were killed (Delord et al., 2005). Since that time, seabird mortality has steadily decreased and in the 2005/06 season about 2 600 fatalities, primarily white-chinned petrels (*Procellaria aequinoctialis)* and grey petrels (*P. cinerea*), were recorded (SC-CAMLR, 2006). In the same season, seabird mortality in other toothfish fisheries in the Convention Area, where a full set of mitigation measures are implemented, was virtually zero (SC-CAMLR, 2006). Both autoline and Spanish system vessels have operated at Kerguelen and Crozet and the highest catch rates have been recorded by autoline vessels (Delord et al., 2005). Currently seven autoline vessels and one Spanish-system vessel operate in these fisheries (SC-CAMLR, 2006).

The reduction in seabird mortality around Crozet and Kerguelen Islands was achieved by a

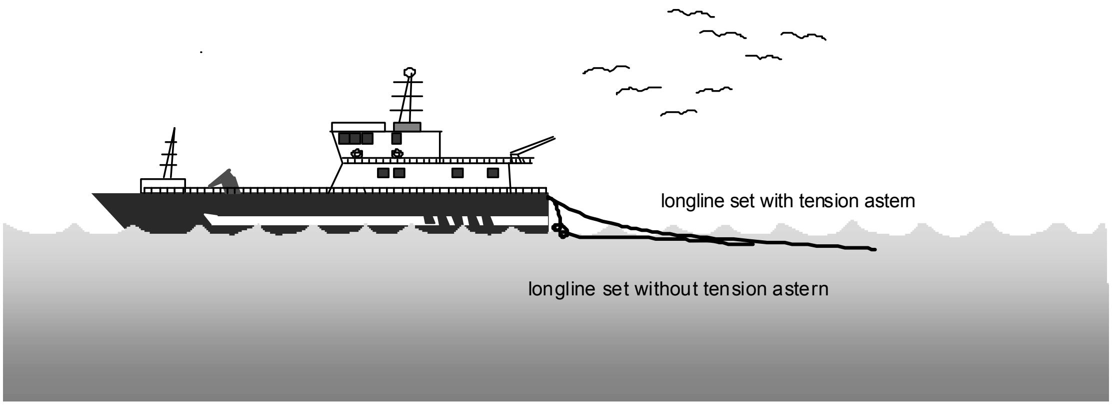

Figure 1: Stylised illustration of sink profile differences near the stern of vessels between IW longlines set with and without a line setter.

combination of seasonal and area closures, night setting, multiple bird-scaring streamer lines and use of integrated weight (IW) longlines by the autoline vessels. IW longlines contain 50 g m^{-1} lead, sink faster than unweighted (UW) lines and are highly effective in reducing seabird mortality (Robertson et al., 2006; Dietrich et al., in press). Line setters (Mustad Company, Norway) have also been fitted to some vessels based on the perception that they increase longline sink rates and therefore reduce interactions with seabirds. This perception has also been expressed by autoline fishers in some other countries and is derived from subjective assessments of gear set with and without a line setter by fishers seeking to find methods to reduce interactions with seabirds. Currently, there is no empirically derived evidence to suggest that line setters do indeed affect the sink rates of IW longlines. A line setter is a hydraulically operated device mounted aft of the automatic baiting machine which pulls the longline through opposing rubber and metal sheaves at speeds faster than vessel speed. Lines deployed with a line setter fall in the water in loose coils and with a vertical profile about 0.5 m astern (Figure 1). Longlines set without a line setter are pulled from vessels by the gear already deployed; they enter the water under tension several metres astern (depending on sea state) and at an angle to the sea surface. Tension astern is thought to delay line sinking and keep baits available to seabirds for longer. Although Løkkeborg and Robertson (2002) were unable to demonstrate faster sink rates of UW longlines set with a line setter, IW lines are heavier and may sink faster when deployed with a line setter. Here the results of a trial to determine if line setters do, or do not, affect the sink rate of IW longlines are reported and the likelihood that line setters do indeed reduce seabird mortality in the Kerguelen and Crozet fisheries is assessed.

Materials and methods

Fishing grounds, vessel and gear

The trial was conducted from 9 to 24 January 2007 in the Antarctic toothfish (*D. mawsoni*) grounds in the Ross Sea on the FV *Avro Chieftain*, a 52 m long commercial autoliner. The *Avro Chieftain* fished with 11.5 mm IW four-strand Silver swivel-line (Fiskevegn A.S., Norway). Lines were rigged with #14/0 EZ-baiter hooks on 40 cm snoods 1.4 m apart. Mackerel (*Trachurus* spp.) and squid cut into 3.5 cm lengths were used as bait. Vessel setting speed was 6–6.5 knots and the longline was deployed from 1.5 m above the water and 1.5 m to starboard of the centre line of the propeller, which was 3.5 m beneath the water's surface. During line setting, the longline landed in the up-wash side of the propeller. The vessel set lines comprising 5 to 8 magazines, each magazine being 1 800 m in length and holding 1 280 hooks.

The trial was conducted in the Ross Sea to take advantage of the relatively calm sea conditions. Line setters are not equipped with a governor, meaning that the longline deployment rate does not vary with the rise and fall of the vessel stern. Consequently, when the vessel stern rises and falls, such as in heavy seas, the longline is pulled taut, nullifying the effect of the setter. Wave height on the first set of the trial was <1.5 m but thereafter wave height was negligible.

Trial design

To eliminate the confounding effects that may arise when comparisons are made between different sets of the longline (e.g. variations in sea state and/or vessel operation), sink-rate comparisons were made using consecutive magazines in the same sets. Thus, trial magazines were set in pairs with the line setter being either engaged or disengaged for

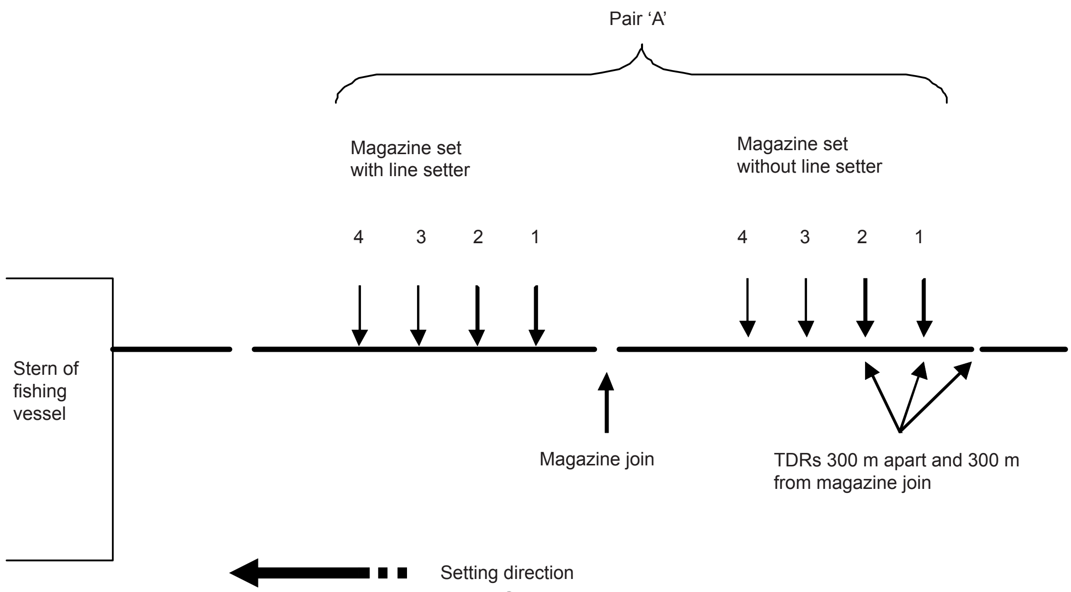

Figure 2: Example of a pair of magazines in a longline to measure the sink times of gear set with and without the line setter. The numbers indicate the positions of time-depth recorders on the magazines.

the entire magazine in a pair (Figure 2). The order of engagement of the line setter was alternated on consecutive sets of the longline to account for biases that may have existed due to setting order. The join between the two magazines in a pair marked either the beginning, or end, of the use of the line setter for each pair. Four time-depth recorders (TDRs, see below) were attached to each magazine in a pair. TDRs were placed 300 m apart, the first being 300 m from the join between consecutive magazines. This distance, which amounted to about 100 s of setting time (at 6 knots 3.1 m s^{-1}), was chosen to ensure the sink rate of one member of a pair did not affect that of the other. When the setting order required the longline be set loose (line setter engaged) then tight (line setter disengaged), the longline became tight almost the instant the setter was disengaged, and when the setting order was reversed (loose following tight) the line became slack after only a few seconds had elapsed.

Deployment of multiple TDRs enabled assessment of within-treatment differences in sink rates related to position on magazines and provided 'insurance' against TDR failure or loss on the seabed, or improper deployment during setting (e.g. jamming in the setter). All non-trial magazines were set with the line setter disengaged as in normal fishing operations. To ensure magazines set with the line setter were set slack (no tension astern) and in a consistent manner for each set, the speed of the line setter was manually adjusted so that 1–2 coils (360 degree loops) were allowed to form in the water immediately behind the vessel (to consistently achieve this degree of slack, full-time attendance of the line setter by a crew member was required).

Sink rates were measured with MK9 TDRs (Wildlife Computers, USA) programmed to record depth at 0.5 m resolution every second. The TDRs were attached to the longline on 30 cm long snoods made from 9 mm rope. The TDRs were embedded in an eye loop in the centre of the snoods, secured with cable ties and wrapped in insulation tape. Both ends of the snoods were woven into the fabric of the longline so that the snoods lay flat against the longline. This enabled the TDRs to pass through the jaws of the line setter without being crushed. TDRs were attached to the second last and third last magazines (of 5–8 magazine lines) of trial lines to avoid the pull-down effect of the anchor at the beginning of lines.

The water entry times of each TDR were recorded to the nearest second on a digital watch synchronised to the TDR internal clocks. Data were downloaded from the TDRs to computer on retrieval, the water entry time (from the digital watch) noted in the time-depth files and the median zero offset value determined from the 10 rows of data before the water entry time. This value was then used to 'correct' the depth readings of the TDRs. Sink times from the surface were evaluated to five target depths: 2, 3, 5, 10 and 20 m. Of these target depths, sink time to 2 m is considered the most critical to surface-foraging seabird species, such as albatrosses. For white-chinned petrels and grey petrels,

Table 1: Mean times taken for longlines to reach target depths when set with and without the line setter (treatment). The average standard error of the means, and the average standard error of the difference between the treatment means, were 0.8 s and 1.1 s respectively.

Treatment	Target depths (m)				
	0–2	0–3	0–5	0–10	0–20
With	7.9	12.1	20.4	38.6	76.9
Without	7.4	12.9	20.7	38.6	76.7

the deeper target depths are also important. Sink times to shallower depths were not analysed due to the 0.5 m sampling resolution of the TDRs.

Data analysis

Time-to-target depth was analysed with a linear mixed model using the SAMM package (Butler et al., 2002) of S-plus® (Insightful Company, USA). The analysis took into account the alternation in the order of the two magazines in each pair within a line, the four TDR replicates within each magazine and the repeated observations of time to each of the five target depths. Treatment, depth and the treatment x depth interaction were treated as fixed effects and pair number, magazine number and TDR number were treated as random effects. To account for possible autocorrelation among times to each of the five target depths (i.e. repeated measures), a number of variance structure sub-models were tested. These included an unstructured variance covariance matrix within each TDR, a continuous-depth exponential decay correlation structure, and a continuous-depth Gaussian decay correlation structure. For each of these last two sub-models, separate variance parameters at each depth were combined (see Butler et al., 2002 for definitions of these sub-models). The best variance model was judged using Akaike Information Criterion (AIC) (Pinheiro and Bates, 2004). Significance levels for the fixed effects were judged using sequential Wald tests (Welham and Thompson, 1997).

Results

Of a total of 24 lines set, 17 pairs (in 17 sets of the longline) were available for analysis. Pairs were rejected if operational difficulties with the line setter prevented one or both members of a pair from being set in a manner typical of the treatment being tested (see above). The variance structure sub-model judged best (AIC = 796.6) was the continuous-depth exponential decay model with a correlation parameter estimate of 0.93 (SE = 0.01) and residual variance component estimate of 16.14 (SE = 2.16, i.e. corresponding to a standard deviation in time to a given depth of approximately 4 s). None of the pair-level, magazine-level or TDR-level random effects had estimated variances that were significantly greater than zero ($P > 0.1$). There was no significant interaction between treatment and TDR position on the magazines ($P > 0.1$). Similarly, there were no significant differences in the sink times between setting methods to all target depths ($P > 0.1$). Table 1 shows the average times taken for longlines to reach target depths when set with and without the line setter.

Discussion

The average sink rate of longlines in this trial was slightly faster (0.04 m s^{-1}) than those of IW gear set from the same vessel in the Heard Island *D. eleginoides* fishery (Robertson et al., 2006). The most likely reason for this difference is the prevalence of calm seas during the Ross Sea trial. As mentioned previously, especially important is the time taken for longlines to reach 2 m depth, which is the shallowest depth to which confidence exists in the accuracy of the TDRs (Robertson et al., 2008). Gear from both setting methods took, on average, <8 s to reach this depth. This is a short time, equivalent to a sink rate of 0.25 m s^{-1} in water heavily affected by propeller turbulence. The lack of a detectable difference between setting methods for gear to reach this depth suggests that sink rates in the shallower depth ranges (e.g. 0–1 m) were similar for both setting methods. There was no sink-rate-related advantage derived from setting IW lines with the line setter.

In the only previous sink rate study using a line setter, Løkkeborg and Robertson (2002), working in the Norwegian ling (*Molva molva*) and torsk (*Brosme brosme*) fishery, were unable to demonstrate a difference in the sink rate of UW longlines deployed with and without a line setter. One reason why a line setter might have been expected to increase the sink rate of IW longlines is that IW lines (which are heavier than UW lines) deployed loosely and at a downward angle may penetrate the water column and commence sinking at a steeper angle than IW lines set without a line setter. While setter-deployed lines visually appeared to reach about 0.5 m depth at the vessel stern, the vertical and loose deployment method did not result in faster sink times. The most likely reason for this is that when setter-deployed lines came in contact with propeller turbulence, they were swept away by the turbulence and sank with much the same profile as lines deployed without the line setter.

The differences between setting methods in proximity to the vessel stern where longlines entered the water are another consideration. The stern of vessels may deter some seabird species. Line setters deploy longlines closer to the stern of vessels, the distance dependent on the vessel (e.g. height of the setting window above sea level), sea state and setting speed. During the trial, this distance varied from 3 to 4 m but may be up to 8 m with UW longlines (Løkkeborg and Robertson, 2002). Since the distance with the Kerguelen/Crozet vessels is not known, 8 m will be used as a worst-case example. At a vessel setting speed of 6 knots (3.1 m s^{-1}) this distance will be taken up in as little as 2–3 s (8 ÷ 3.1), which for a chosen distance astern is the time seabirds must wait for longlines to be equally accessible (albeit those from the line setter at a slightly greater depth). This small difference in elapsed time and associated distance behind the vessel is unlikely to result in an appreciable reduction in the interaction rates between seabirds and longlines in close proximity to the stern of vessels.

A final consideration is the effect of setting method on the aerial extent of bird-scaring streamer lines, which are mandatory for legal longline vessels in the CAMLR Convention Area. IW gear deployed from a line setter would reach 2 m depth 25 m astern (3.1 m s^{-1} x 8 s) compared to 33 m astern for lines deployed normally (25 m + the 8 m difference astern in setting position). These distances fall well within the 50–60 m aerial extent of streamer lines deployed from autoline vessels operating in the CAMLR Convention Area. The difference is unlikely to reduce interactions with seabirds that mainly take baits at or near the water surface, such as albatrosses. This assessment accords with Løkkeborg (2000) who found that UW longlines set with a line setter in the Norwegian longline fishery did not reduce mortality of Arctic fulmars (*Fulmarus glacialis*), which also forage near the surface. However, the main species killed in the Kerguelen and Crozet fisheries are white-chinned petrels, which are much better divers than albatrosses, being capable of reaching ~13 m depths (Huin, 1994). In an experiment in the New Zealand ling (*Genypterus blacodes*) fishery, the majority of dives by white-chinned petrels on IW longlines occurred 50–70 m astern, at the end of the aerial section of a single streamer line (Robertson et al., 2006). At the line sink rate and vessel setting speed mentioned above, and using 50 m aerial sections as the standard, the 2–3 s earlier commencement time to start sinking afforded by the line setter would result in lines being about 4.5 m deep compared to 4 m deep if set without the line setter, by the time longlines cleared the aerial section of streamer lines. This estimate pertains to the near-perfect sea conditions in which the trial was conducted and may not be discernible in the heavy seas that prevail where the Kerguelen and Crozet fisheries operate. Even so, a 0.5 m depth difference at 4–4.5 m depth would seem negligible for deep divers like white-chinned petrels.

Conclusion

The results indicate that line setters do not increase the sink rate of IW longlines and it is doubtful that their use will result in substantial reductions in interactions between seabirds and longlines in the Kerguelen and Crozet autoline fisheries.

Acknowledgements

We are grateful to Tangi Kitson and the crew of the *Avro Chieftain* for their wholehearted support during this trial. Barbara Wienecke and Ben Sullivan kindly commented on a draft. Comments by Kim Dietrich, an anonymous referee and Keith Reid improved a draft.

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