Improved line weighting method for tuna longline fishing using livebaiting to mitigate sea bird bycatch and improve worker safety

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Executive Summary

The Australian Fisheries Management Authority (AFMA), in collaboration with the Australian Antarctic Division (AAD) of the Department of Environment, and the fishing industry, undertook a study on the impact on the survival of live baits with line weights close to the hook. Line weights are a form of seabird bycatch mitigation for pelagic longline fishing designed to sink baited hooks rapidly out of reach of seabirds. The trial was undertaken on a commercial tuna and billfish fishing vessel operating on the south coast of NSW, within the Eastern Tuna and Billfish Fishery (ETBF) during October, November and December of 2012.

It is known that commercial catch rates are greater using live baits in comparison to dead baits when fishing on the NSW South coast. It is also known that having weights closer to the hook when using dead baits reduces the risk of seabird bycatch.

Line weighting regimes trialled in Australia using dead bait in 2010 showed that a ‘sliding’ 40g weight at or near the hook is potentially safer for crew, cheaper, improves sink rates and reduces risks of seabird bycatch, while maintaining fish catch rates. However, a significant proportion of fishers use live baits for which the 40g line weighting regime is insufficient. Moving the weight to be at or near the hook dramatically increases the sink rate. However, the effects on the life status of live bait (and fish catch rates) were untested and fishers continue to prefer not to move weights nearer to the hook. This trial investigated the impact of 60g weights within 1 meter of the hook on bait life status and catch rates.

However, fishers been reluctant to move weights closer to the hook when using live baits because they believe that it will reduce survival of the live baits and reduce their catch rates. Therefore, if it can be proved that survival of baits is not reduced by having line weights closer to the hook, operators are more likely to use weights closer to the hook. This study aims to demonstrating to the ETBF industry that new line weighting setups, that are designed to improve crew safety and reduce bird catches, will not impact on catch rates of the target species.

The study used a sliding type of weight that can improve crew safety. This type of weight screws onto the fishing line and when the line is under tension and stretches (this has been when flybacks have occurred with traditional weights) the screw on weight becomes loose on the stretched line and can slide through the line.

The study found that the soak time (the time in the water) had a much larger influence on the life status of the live baits than the position of the weight on the branch line. The weights placed 0.5 metres from the hook resulted in good survival of the live baits.

Keywords

Tuna, Billfish, Fishery, seabird, bycatch, line weight, Threat Abatement Plan. Safety

Introduction

Seabird interactions in pelagic longline fisheries

Pelagic longline fisheries, for tunas and tuna-like species, are responsible for the deaths of large numbers of albatrosses and petrels throughout the southern hemisphere, and are considered a main cause of reduced population sizes at many breeding sites (Robertson and Gales, 1998). In Australia, seabird mortality in pelagic longline fisheries mainly occurs in the Eastern Tuna and Billfish Fishery. This fishery operates off eastern Australia with 30-40 fulltime, fresh (non-freezer) vessels. Effort peaked at 13 million hooks in the early 2000’s, but since 2007, fishing effort has decreased to 6-9 million hooks/year (source: Australian Fisheries Management Authority [AFMA]). The main seabird species impacted by longlining are Fleshy-footed shearwaters (*Puffinus carniepes*), Great-winged petrels (*Pterodroma macroptera*) and *Diomedia* sp and *Thalassarche* sp Albatrosses (Baker and Wise, 2005; Trebilco *et al.*, 2010). Seabird conservation is managed under a Threat Abatement Plan, which stipulates that mortality rates must not exceed 0.05 birds/1,000 hooks in any 5-degree latitudinal band in either the summer or winter season (AAD, 2006). To meet this standard, fishers are required by legislation to adopt seabird bycatch mitigation measures as part of fishing permit conditions under the *Fisheries Management Act 1992*. Requirements include combinations of: weighted branch lines, bird scaring streamer lines, offal retention during line setting and the night-setting of longlines.

Crew safety when using line weighting systems

AFMA mandates the use of line weights on longline fishing in the ETBF, these measure have been shown to significantly reduce the incidence of seabird bycatch. Though AFMA requires the use of weighted lines, it is up to the fishers themselves to decide how best to implement the requirements. AFMA is not responsible for crew safety on the vessels in the ETBF. Crew safety is the responsibility of the business owners and operators (the fishers) and their employees (the crew).

Traditional style line weights used by the fishers

There have been a number of injuries reported where fishers were using the traditional line weights (the weights that do not slide along the line when the line is under tension). The injuries have generally occurred when:

- the crew are holding a branch line with the weight attached;
- the fish is close to the vessel and the weight (at about 3.5 m from the hook) is out of the water;
- a large fish is caught (usually a shark) & the crew is pulling the fish towards themselves and the line is under tension;
- the line breaks (due to a bite off – usually a shark).

This propels the weight back towards the crew at speed (being called a ‘flyback’).

The lead weight hitting a crew member at speed has caused:

- Broken bones; and
- Puncturing and embedding of the weight in a crew member.

Sliding style weights

Because the screw on weight slides along the line when the line is under tension there is less change that the weight will ‘flyback’ at speed.

Because the weights are closer to the hook, there is a greater chance that the weight will be under the water if the line breaks. The ‘flyback’ speed of a weight under water is slower than that a weight in the air because it is dampened by the water.

However, there is no claim that flybacks cannot, or will not occur, using the screw on weights but, in theory, the chance of dangerous flybacks is reduced.

These characteristics of the new weighting system being tested make them safer for the crew.

Pelagic Longlining

Target species

Pelagic longline gear is used mainly to catch large Bigeye Tuna, Albacore Tuna and Yellowfin Tuna in tropical waters, as well as Bluefin Tuna (Atlantic, Pacific and Southern), swordfish in temperate waters. Fishers use different gear setups and fishing techniques to target different species.

Fishing Gear

Pelagic longline fishing gear is made up of a mainline, which is suspended in the water column by floatlines. Branchlines with hooks (also known as snoods) are baited and clipped to the mainline and hang from it. Weights are typically placed on these branchlines. The mainline can be many nautical miles in length with baited branchlines clipped every forty or so metres making up hundreds to thousands of hooks in each set (also known as a shot).

Fishers can alter the fishing depth range by altering the length of the floatline, changing the length of the branchline or usually by changing the number of branchlines that are set in between each floatline.

Seabird interactions most commonly occur when the baited hooks are being deployed. Seabirds dive on, and chase, the newly deployed baits while they are still near the surface of the water. Once the baited hooks are at typical fishing depths, the risk of seabirds taking the baits is very low.

Seabird bycatch mitigation measures used for pelagic longlining

There are a number of different measures that can be used to reduce the risk of seabird interactions by longline fisheries when fishing in areas with high seabird densities. These include:

Bird scaring lines (tori lines)

A bird scaring line is a long (≈100 metre) line that extends from a high point near the stern of the vessel to a drogue (usually a buoy with a weight). As the vessel moves forward the drogue creates tension in the line producing ≈90 metres of airborne line from the stern. The airborne section includes streamers of regularly spaced (every ≈3 metres) brightly coloured material. Streamers must be heavy enough to maintain a near-vertical fence in moderate to high winds. Individual streamers should extend to the water, to prevent aggressive birds from getting near the baited hooks as they are set. A bird scaring line is needed for each location where baited hooks are set.

No Offal discharged during setting

Discharging offal can attract seabirds and can create a ‘feeding frenzy’. Where offal is discharged at the same time as setting baited hooks, more birds are likely to chase the baits. By not having offal discharged during setting reduces the risk of interactions with seabirds.

Night setting

Night setting avoids periods when most seabirds are actively foraging. It is believed that the ability of albatrosses and petrels to see and detect food is reduced in darkness. Seabirds are most active during dawn and dusk and consequently the time when they are most vulnerable to longline bycatch. Setting during night hours can reduce the risk of seabird interactions. Restricting to boats to night setting can limit their targeting options.

Line weights

Seabirds have limited diving depths, typically mostly shallower than 10m. Birds will also visually target prey. The quicker that the baits sink below the seabird visual and diving depths, the less chance that the seabirds will interact with the baits. Adding weight to the baited branchline, can achieve increased sink rates. Different factors can impact on the sink rate. These include:

- The amount of weight - the heavier the weight the quicker the sink rate. However, large weights may impact on the line movement when at fishing depth and can be seen by the target fish species. This may impact on commercial catch rates.

- Distance from the hook - for dead baits the closer the bait is to the hook the greater the sink rate. However, the live bait trials showed that weights closer to the hook increases sink rate until 1m from the hook, then if the weight is closer to the hook than 1 metre the sink rate is decreased (Robertson et al. 2010). This is possibly due to the live bait actively swimming against the weight. For the type of live bait used in the ETBF, sink rates are optimised around 1m from the hook.

Fishing effort in the Eastern Tuna and Billfish Fishery

There have been between 41 to 57 fishing vessels operating in the ETBF in the last 5 years. However, in recent years, only 35 of them are fulltime pelagic longline fishers (that have greater than 50 fishing days per year). Vessels range in size between 20 – 35 metres in total length. Figure 1 provides a map of the ETBF.

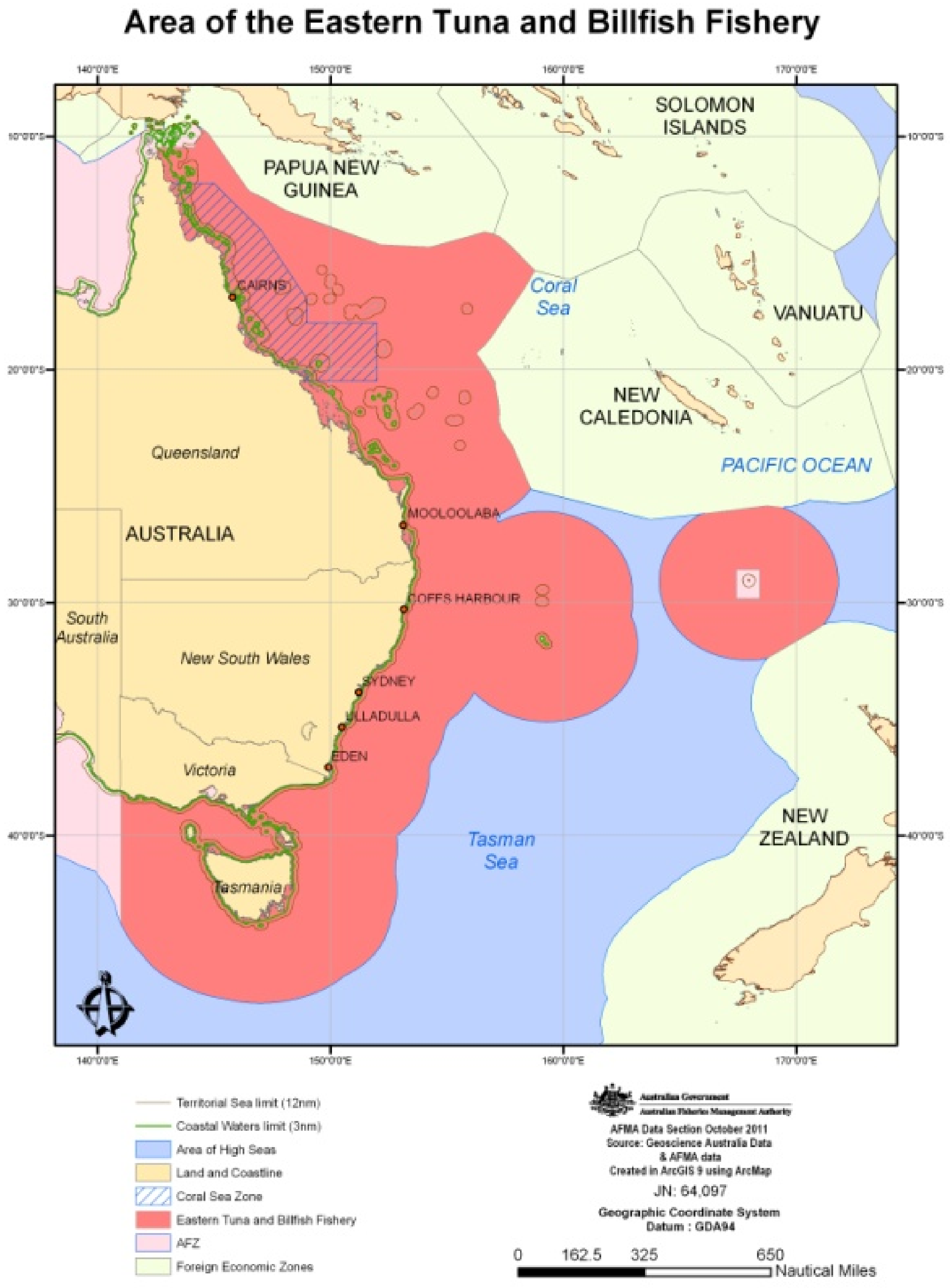

Figure 1. Map of the Eastern Tuna and Billfish Fishery.

The ETBF operators use monofilament longline, between 20nm – 50nm in length when set. Typically, the number of hooks set per shot range between 800 – 3200, with a depth range between 30 to 800 metres deep, depending on the species targeted.

There has been a decreasing trend in fishing effort (hooks, shots and boats) in the ETBF over the last 10 years.

Mitigation measures used in the ETBF have had an enormous effect on reducing seabird interactions. This, combined with the reduction in effort in the ETBF, has reduced the risk of seabird interactions to very low levels.

Table 1. Longline fishing effort in the Eastern Tuna and Billfish Fishery.

Year	Hooks	Shots	Av hooks per shot	Vessels
2007	8,443,782	6,845	1,234	57
2008	8,058,717	6,415	1,256	49
2009	8,847,469	6,639	1,333	51
2010	7,874,863	5,811	1,355	47
2011	6,761,856	5,015	1,348	40
2012	6,792,185	4,715	1,441	41

The spatial distribution of fishing effort in the ETBF is shown in figure 2. The majority of fishing effort is concentrated in waters adjacent to the NSW and Qld border. However, there is significant fishing effort in lower latitudes (south of the parallel of latitude 25 degrees South), where seabirds are seasonally present in high numbers.

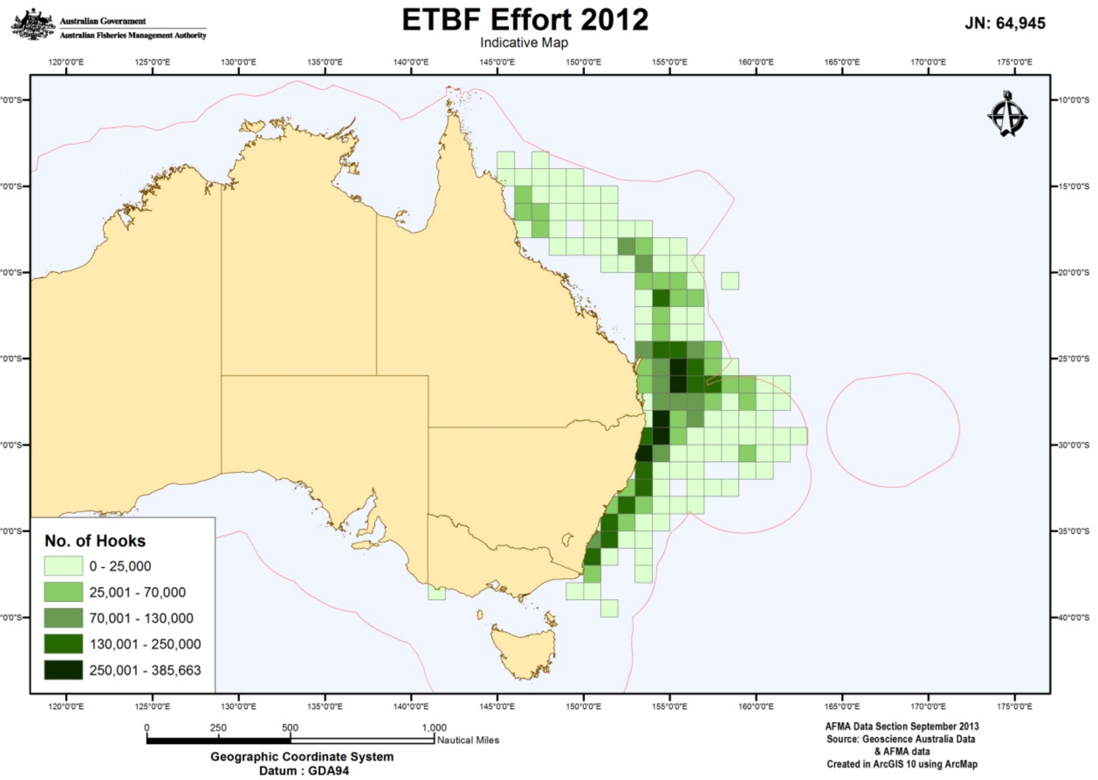

Figure 2. Map of the Eastern Tuna and Billfish Fishery fishing effort (number of hooks set) distribution.

Baits

The type of bait used when fishing can change the risk of seabird interactions and change the mitigation measure effectiveness.

The ETBF fishing vessels use both live and dead baits. Dead baits are mainly used in the northern part of the fishery (QLD), and are Squid and Pilchards (South American).

Live baiting occurs in waters adjacent to NSW. Fishers catch their own baits and maintain baits in tanks (live wells) on board the vessel with constant circulation of water to maintain water quality. Live baits used are mainly Yellowtail Scad (*Trachurus novaezelandiae*), with a smaller amount of Blue Mackerel (*Scomber australasicus*). In addition NSW fishers occasionally use dead squid, mainly arrow squid (*Nototodarus gouldi*) in combination with the live baits, depending on the conditions and target species.

Seabird interactions in the Eastern Tuna and Billfish Fishery

In Australia, seabird mortality in pelagic longline fisheries has mainly occurred in the Eastern Tuna and Billfish Fishery (ETBF). However, the rates and numbers of seabird interactions have declined dramatically to very low levels in recent years. The low level of interaction rates is believed to be a result of management measures and improved implementation by the ETBF fishing industry.

The primary seabird species the ETBF has interacted with are Fleshy-footed shearwaters (*Puffinus carniepes*), Great-winged petrels (*Pterodroma macroptera*) and *Diomedia* spp. and *Thalassarche* spp. Albatrosses (Baker and Wise, 2005; Trebilco et al., 2010). Since the introduction of seabird bycatch mitigation measures in the ETBF, interaction rates with seabirds has shown a steady decline (Figure 3).

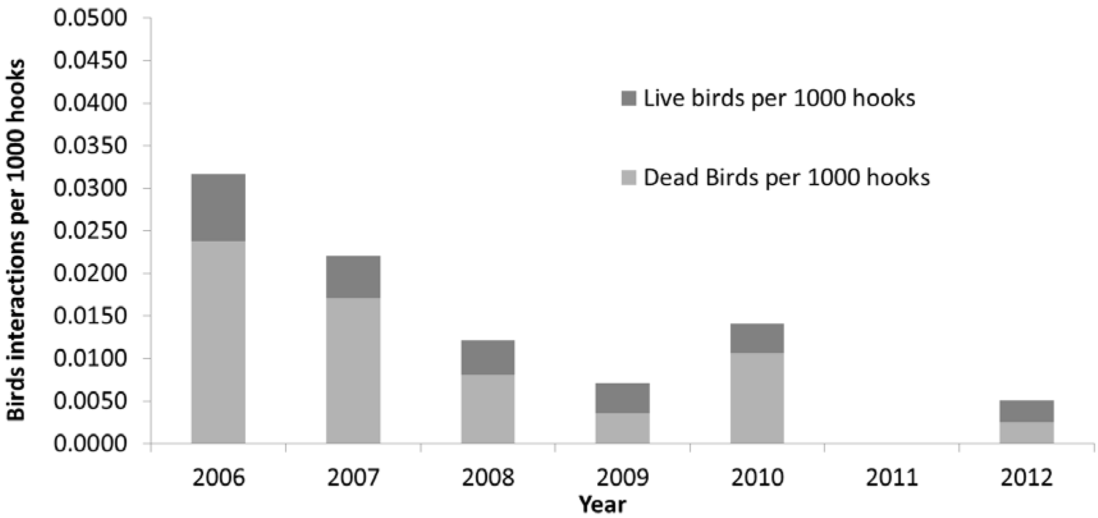

Figure 3. Seabird interaction rates in the Eastern Tuna and Billfish Fishery.

The Threat Abatement Plan for Seabirds

The incidental catch (or bycatch) of seabirds during oceanic longline fishing operations was listed as a key threatening process on 24 July 1995. Under the *Environment Protection and Biodiversity Conservation Act 1999* a Threat Abatement Plan is in place to manage the threat to seabirds from longline fisheries managed by the Commonwealth Government. The Threat Abatement Plan stipulates that mortality rates must not exceed 0.05 birds/1,000 hooks in any 5-degree latitudinal band in either the summer or winter season

Need for the study

In the winter (May–August) season of 2008 the seabird bycatch rate trigger limit in the ETBF was breached by observed vessels off the NSW coast, prompting a day-setting prohibition in that sector of the fishery. These captures indicated that the mandated line weighting in combination with a single streamer line (with dead and live bait and day-setting) could not prevent the seabird bycatch rate trigger limit from being exceeded under all conditions, and that further research was required to reduce the likelihood of the bycatch rate trigger limit being breached in the future. If line weights can be improved to increase sink rates it should reduce the risk of seabird bycatch.

A further planned outcome of the research is to improve crew safety. If safer line weights can be developed the risks to crew and the operator benefit the industry.

If the new weights used close to the hook can be shown to not impact on the life status of the live baits, fishers will be more likely to use them as catch rates can be maintained.

Crew safety

Due to the safety issues associated with using the traditional weights (discussed in the introduction), other line weighting options may assist in improving the safety of people using and working around weighted lines.

Objectives

The objective of this project is to:

1. Evaluate the effects of 60g sliding weights placed within 1 m of the hook on the life status of live baits.

Further planned outcomes:

1. Improve crew safety when using line weights; and
2. Reduce the risk of seabird mortalities from pelagic longline fishing.

This will be achieved by demonstrating to the ETBF industry that new line weighting setups, that are designed to improve crew safety and reduce bird catches, will not impact on catch rates of the target species.

Fishers know that live baits get higher catch rates than dead baits. If the life status of baits is similar between line weighting setups then catch rates should also be similar.

The new weighting setup aims to improved crew safety because the weight is a screw on design and slides along the line when the line is under tension. If the weight slides along the line it is much less likely to fly back at crew if there is a line break. Line breaks occur usually due to a shark bite off, and have resulted in several injuries to fishers in the past.

Use of the new weighting setup will help mitigate seabird bycatch as the weight is closer to the live bait and also results in faster bait sink rates. Faster bait sink rates mean that it is more difficult for sea birds to consume the bait and hook as these are out of seabird diving range more quickly.

Use of the new weighting set up will reduce fishing gear cost as only one swivel is needed per weight instead of two swivels as on a normal weight. The weight itself is expected to cost a similar amount to the weights currently used.

Use of the new weight setup will reduce labour costs, as it takes less time to make up the fishing gear (from new and for repairs) as the new weights are screw on instead of crimp on.

Methodology

The fieldwork component of the present study was undertaken on a commercial pelagic longline vessel operating in the Eastern Tuna and Billfish Fishery. The vessel used for the study was 22.3 metres in overall length with a gross tonnage of 180t. During the study, the vessel fished between latitude 31.0807°S and 33.5895°S and longitude 152.1692°E and 156.4672°E. The fishing gear used was 3mm mainline and 13 metre long 2mm branchlines with 14/0 circle hooks. The float ropes were 12 metres long and radio beacons were placed throughout the set at approximately every 160 hooks.

The gear set-up used 10 hooks per float. This gear set up resulted in a fishing depth of approximately 30 to 80 metres deep. Setting of the fishing gear was started in both daylight and night (depending on the shot) and hauled after a soak time of between 6-20 hours. Baits used included live Yellowtail Scad, live Blue Mackerel and dead squid. The majority of bait used was live Yellowtail Scad and the analyses and results are based solely on the life status of Yellowtail Scad. The live Yellowtail Scad used as bait ranged from 60g to 120g in weight.

Weather over the trips was typically south easterly winds at 20 - 30 knots being consistently interspersed with 30 - 40 knots from the north. Sea state was moderate with 1.5 - 3 metre swell and a 1 - 2 metre sea. Fishing activities generally took place along the continental shelf in the East Australian Current with a southerly direction current running at between 1.5 - 4 knots. The vessel set gear in a northerly direction and then steamed to the southern end to haul gear in a northerly direction. This was to ensure operations continued in the same general area without being pushed too far south by the strong southerly current.

The vessel had an experienced crew and undertook their normal operations, except for the use of the weighting regimes. The vessel's captain has 10 years of experience in the fishery, 4 of which were as captain. In addition to the Captain, there were 3 other crew on the vessel.

An experienced scientific observer supervised the setting and hauling of the operations and recorded data on the operations this data included: life status and species of returned bait or caught fish and on which weighting regime; location of set and haul; time of set and haul of each beacon (to calculate soak time of baits); damage/loss of branchline/snood or weights and which weighting regime.

The weighting regimes were evaluated in four trial trips totalling 12 shots. Each weighting regime was compared to another weighting regime in 4 shots. For example, the 3.5m from the hook regime was compared to the at the hook weight regime in 4 shots. The 3.5m from the hook was compared to the 0.5m from the hook regime in 4 shots and the 0.5m from the hook was compared to the at the hook weighting regime in 4 shots.

On the shots, the branchlines/snoods with different weighting regimes were set onto the mainline in an alternating fashion. For example in the 3.5m from the hook regime being compared to the at the hook weighting regime, a snood with a weigh at 3.5m from the hook was set on the mainline followed by a snood with a weight at the hook followed by a snood with a weight at 3.2m from the hook etc… alternating between the two weighting regimes for all of the hooks set on the shot.

The life status of hauled baits was compared between snoods with weights at:

- at 3.5[1]m from the hook vs at the hook;

[1] Nominal length only. Actual length varied between 2.8mt - 3.5 mt.

- at 3.5[1]m from the hook vs at 0.5m from the hook; and
- at 0.5m from the hook vs at the hook.

A total of 15,995 baited hooks were set during the study.

Trip 1 = 5,530 hooks set and observed; Yellowtail Scad 50% and dead squid 50%.
Trip 2 = 5,220 hooks set and observed; 95% Yellowtail Scad; 5% Blue Mackerel;
Trip 3 = 2,615 hooks set and observed; Yellowtail Scad 70% and Blue Mackerel 30% in shot 1; Yellowtail Scad 80% and Blue Mackerel 20% in shot 2;

Trip 4 = 2,630 hooks set and observed; 100% Yellowtail scad.

The study recorded and analysed the life status of 2,824 Yellowtail Scad baits (924 baits from the 'at the hook regime'; 941 baits from the '0.5m from the hook regime'; and 959 baits from the '3.5m from the hook regime') from the different weighting regimes.
These data were used to compare differences between line weighting methods and evaluate if the 60g sliding weight at 0.5 meter from the hook is effective for fishing with live bait (based on live bait life status on hauling).

Statistical Methods

The ranks of the life status of the recovered baits, as recorded into the following ordinal classes of (1) alive and vigorous, (2) alive and sluggish, (3) barely alive, (4) dead, were modelled using ordinal regression (McCullagh and Nelder, 1989) using predictors of line weight regime ("Weight.regime", 3-level factor of "60 g 0.5 m from hook", "60 g at the hook","60 g 3.5 m from hook"), soak time ("soak.time", continuous variable measured in hours), and haul speed ("Haul.speed", 3-level factor of "slow" (0 to 3 knots), "fast" (3 to 6 knots), and "very fast" (6 to 7 knots)). To present results clearly and easily, a soak time factor was used for prediction with levels of "<8 hr", "8-10 hr","10-12 hr", "12-14 hr", and ">14 hr". The ordinal regression model was fitted using the R-software and the `clm` function from the `ordinal` package. The default logit link function was applied and the ranks of the individual baits were used as the response variable. Ordinal regression models assume the response variable is multinomially distributed across the classes defined by the ranks and these classes are ordered, but the ranks themselves cannot be interpreted as a metric scale (e.g. a difference between rank 1 and 2 does not equate to a difference between ranks 3 and 4 as is the case if these were on a linear metric scale). The multinomial sample size for the individual (i.e. unaggregated) ranks is 1 and an unobserved or latent continuous variable is assumed to be logistically distributed across baits. The probabilities of ordinal class membership corresponding to ranks 1 to 4 are modelled using a cumulative logistic (McCullagh, 1980; Christensen, 2013 a,b,c). This ordinal regression model assumes that when observers assign baits to life status classes they are in effect, subconsciously nominating that this latent variable of "liveliness" for an individual bait falls within a given range where this range, on average over all baits and (potential) observers, is denoted as $(a_{i-1}, a_i]$ for rank classes i=2 and i=3, and $(0,a_1]$ and (a_3, ∞) for rank classes i=1 and i=4 respectively. Therefore, in addition to the regression parameters defining the slope with Soak_Time and factor level effects for Regime and Haul_speed (and any additional parameters due to interaction terms), the three threshold parameters (a_1,a_2,a_3) must be estimated.

A mixed effect version of this ordinal regression was fitted using the `clmm` function in the `ordinal` package (Tutz and Hennevogl 1996; Christensen, 2013c) with single random effect factor of shot number within trip.

The factor of interest is weight regime, however, an *a priori* assumption that soak time could also influence bait life status requires this term along with the interaction of soak time and weight regime to be included on the ordinal regression. The speed of the haul is a nuisance factor that should also be accounted for even though an *a priori* case for a significant haul speed and weighting regime interaction is more difficult to envisage. Determining a minimal, significant regression (i.e. the simplest model in which all terms are statistically significant and for which no significant terms have been omitted) used likelihood ratio tests (i.e. based on the integrated likelihood using a Laplace approximation) for the `clmm` models and t-tests for individual parameter estimates for both `clm` and `clmm` models.

Results discussion and conclusion

Table 1 gives the log-likelihood and Akikae Information Criterion (AIC) statistics for each model as well as estimates of the threshold parameters. Table 2 gives the parameter estimates for the simplest `clm` model and the corresponding `clmm` version of this model. The most complex (maximal) fixed effect model fitted was:

```
soak.time + Weight.regime + Haul.speed + Weight.regime:Haul.speed
+
     soak.time:Weight.regime + soak.time:Haul.speed +
     soak.time:Haul.speed:Weight.regime
```

Predictions were obtained using the `clm` version of the minimal significant model, with the complete call to the function given by

```
clm.01 <- clm(formula = Rank.f ~  soak.time+ Weight_regime +
     soak.time:Weight_regime, data=data)
```

(Tables 1 and 2) since a predict function is not currently available in R for `clmm`. The only consequence of this is that standard errors of predictions will be smaller for `clm` than they would be for `clmm`. However, judging on the estimated standard error of parameter estimates in Table 2, this difference will be small and the conclusions based on t-statistics for parameter estimates and the magnitude of these estimates (Table 2) do not change to any practically significant degree between the `clm` and `clmm` versions of the model.

The study showed that soak time (the time in the water) of the live baits had a large influence on the life status on hauling. For longer soak times the clm predicted a larger proportion of baits that were dead, or in a less vigorous state. After 8 hours, approximately 25% of the baits (all weighting regimes combined) were predicted to be in the ‘dead’ category while after 12 hours, this figure was approximately 40% (Figure 1). The effect of haul speed as a confounding factor can be ignored as not statistically significant when either a main effect, or a combined main effect and interaction with weight regime and, additionally, combined with the third order interaction with both soak time and weight regime were considered (Table 1).

Though statistically significant differences were observed between the different weighting regimes, these differences were not consistent over soak times. Specifically, the only statistically significant ($P<0.05$) effect of weight regime (Table 2, Figure 2) detected was that the proportion of dead baits in the ‘at the hook’ weighting regime was significantly less than the other weighting regimes at <8 hours soak time, while the converse was true and logically consistent (given that proportions must sum to 1 across life status classes) for the “live and vigorous” class. In practical terms, the difference in life status of baits with different weighting regimes is insignificant compared to the influence of soak time. That is, changing the weighting regime had less influence on life status than a change in soak time over the period of soak time tested (maximum of 20 hr).

Table 1 Sequential model fit statistics and cut-point parameter estimates for `clmm` fit

Model Terms Sequentially Dropped from Maximal Model	Log-likelihood (chi square, P^c)	AIC	Number fixed effect parameters	a_1 (SE)	a_2 (SE)	a_3 (SE)
Nil	-3286	6604	15	1.4338 (0.4167)	2.2787 (0.4181)	2.7070 (0.4187)
soak.time:Haul.speed + soak.time:Haul.speed:Weight.regime	-3287 (1.41 0.70)	6599	12	1.2995 (0.3775)	2.1438 (0.3790)	2.5721 (0.3797)
Weight_regime:Haul.speed	-3289 (4.40, 0.11)	6600	10	1.2432 (0.3296)	2.0864 (0.3311)	2.5142 (0.3319)
Haul.speed[a]	-3290 (2.73, 0.25)	6599	8	1.4400 (0.3050)	2.2823 (0.3069)	2.7095 (0.3079)
`clm`, Haul.speed[b]	-3352	6719	8	1.4765 (0.2234)	2.2807 (0.2261)	2.6958 (0.2275)

[a] Minimal significant model; `clmm` fit

[b] Minimal significant model; `clm` fit

[c] Probability level

Table 2 Fixed effect parameter estimates for minimal significant model fitted as `clm` and `clmm`

Term[a]	`clm` parameter estimate (SE, t-statistic)	`clmm` parameter estimate (SE, t-statistic)
soak.time	0.17361 (0.02144, 8.098[b])	0.17994 (0.02523,7.132[b])
Weight_regime "60 g at the hook"	-1.17247 (0.34047, -3.444[b])	-1.28630 (0.35613, -3.612[b])
Weight_regime "60 g 3.5 m from hook"	0.04033 (0.32253, 0.125[ns])	-0.44344 (0.35728, -1.241[ns])
soak.time:Weight_regime "60 g at the hook"	0.10214 (0.03298, 3.097[b])	0.11080 (0.03545, 3.126[b])
soak.time:Weight_regime "60 g 3.5 m from hook"	-0.01008 (0.02902, -0.348[ns])	0.01336 (0.03108, 0.430[ns])
Trip:shot random effect Standard Deviation		0.5203

[a] Weight regime parameters represent differences from default factor level of "60 g 0.5 m from hook"

[b] $P<0.001$

[ns] $P > 0.1$

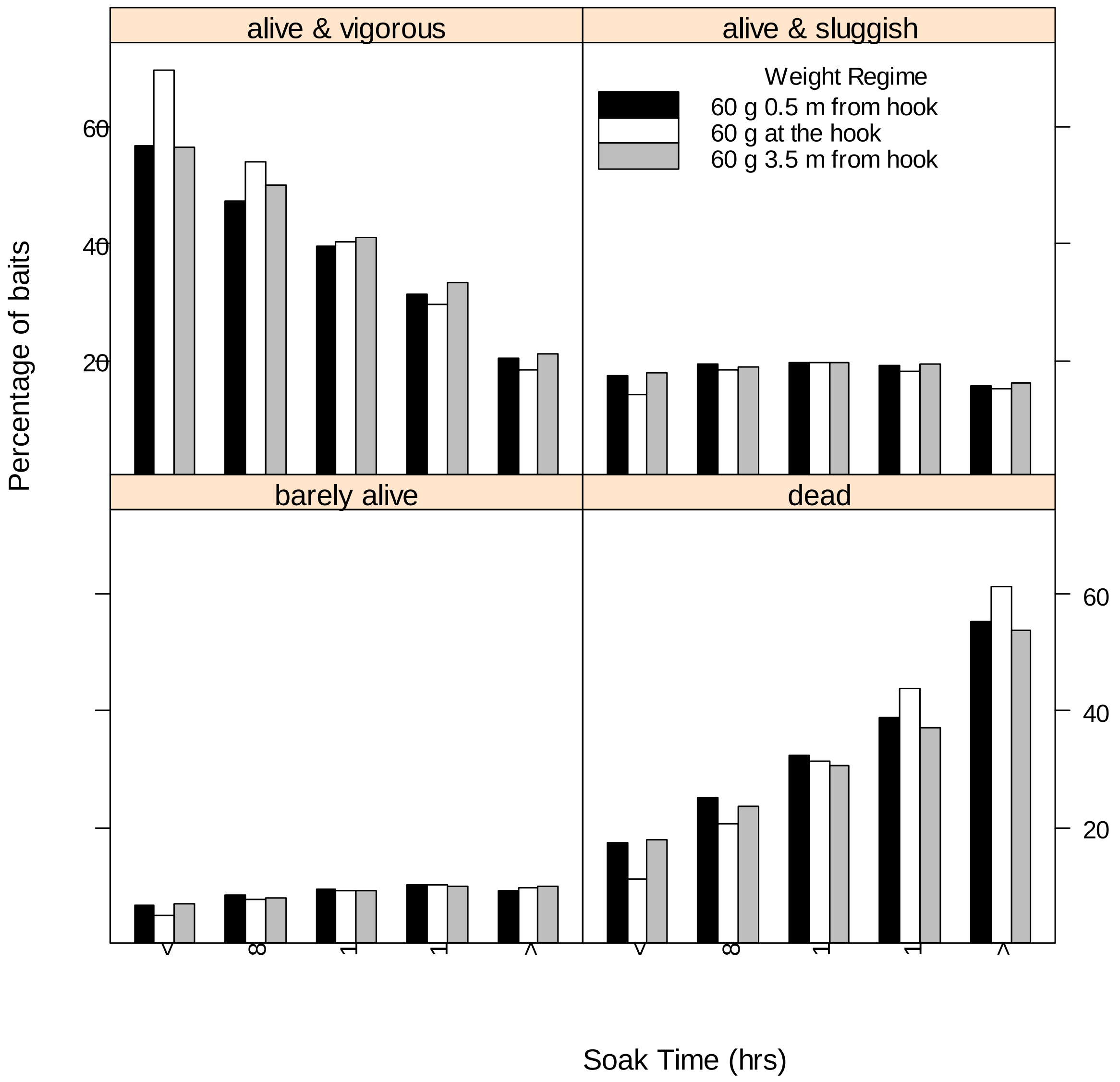

Figure 1. Predicted percentage of baits across life status classes as a function of soak time and line weighting regime obtained from the minimal significant ordinal regression model fitted using the `clm` function.

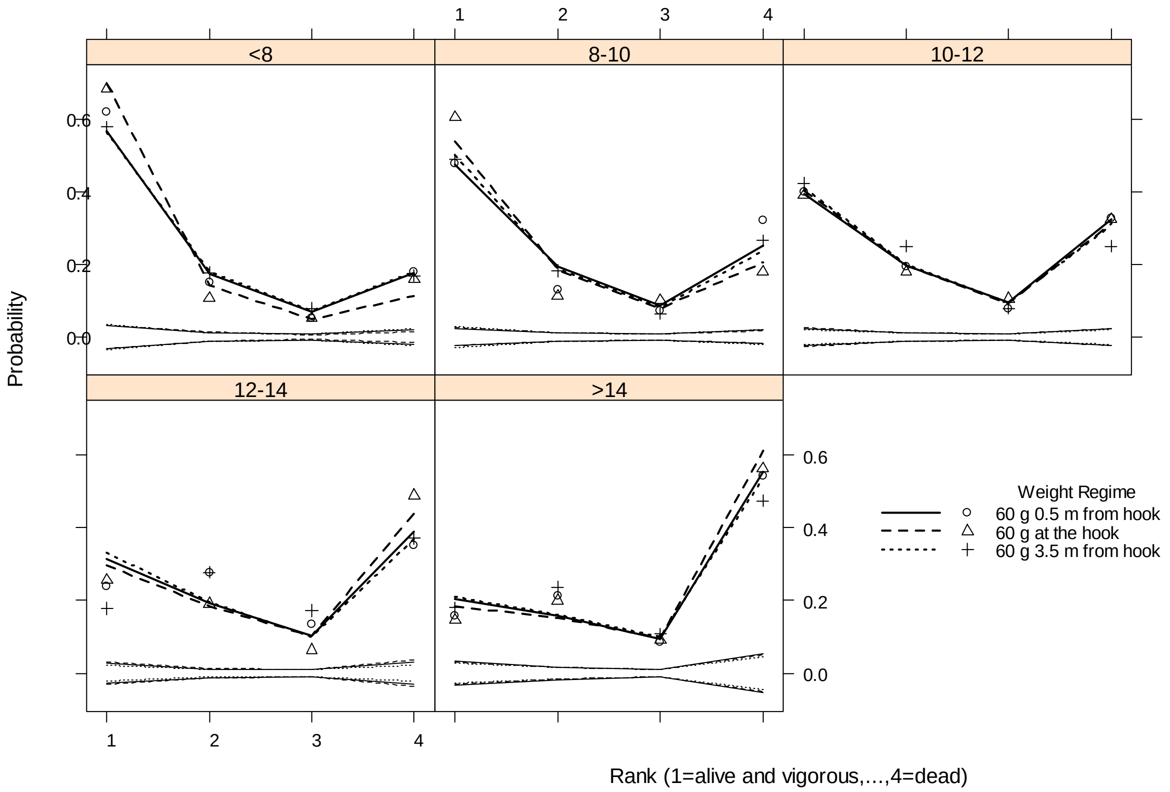

Figure 2. Observed (points) and predicted (lines) probability (i.e. percentage/100) of baits occurring within life status classes as a function of soak time and line weighting regime with predictions obtained from the minimal significant ordinal regression model fitted using the `clm` function. Approximate 95% confidence envelopes for pairwise differences between line weighting regimes are shown at the bottom of each panel. Differences that exceed the width of the envelope for a given life status class are statistically significant at the 0.05 level.

Implications

The implications of this project include:

1. Regulating that weights being placed closer to the hook with live baits will not significantly affect the life status of baits during the duration of a normal fishing operation.

2. Fisheries managers are better informed about the types of seabird mitigation that will reduce the risk of seabird interactions without impacting catch rates of the target species;

3. More options for fishers to meet their seabird bycatch mitigation requirements without impacting on catches and whilst improving crew safety.

Recommendations

AFMA and AAD will continue to promote the study and encourage uptake of improved seabird mitigation measures by the fishing industry in Australia and internationally.

Extension and Adoption

There are now two commercial fishing equipment suppliers that are producing and selling sliding weights, including one that is based in Australia.

AFMA and AAD have produced a flier about the project and its benefits to fishers. This flier will assist in encouraging uptake by industry.

AFMA observers that cover boats in the Eastern Tuna and Billfish Fishery are aware of the project and its findings (two observers participated in the study). The observers have frequent contact with fishers and will provide an extension function to operators during their normal observing duties.

Several operators in the Eastern Tuna and Billfish Fishery have since ordered and are using the sliding weights for live baiting.

Line weighting for seabird bycatch mitigation is a requirement of several Tuna Regional Fisheries Management Organisations. Those most relevant to the Australian Tuna longline fishing industry include the Western and Central Pacific Fishery Commission (WCPFC), Indian Ocean Tuna Commission (IOTC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT).

International promotion of the sliding weights close to the hooks, as a measure to improve crew safety whilst reducing the risk of seabird bycatch, was undertaken by AFMA staff at the Western and Central Pacific Fisheries Commission meeting in the Philippines on 3-7 Dec 2012. At this meeting the sliding weights used in the trial were given out to country delegates (USA, NZ etc) and the eNGO, Birdlife international.

Project coverage

The project was publicised through the AFMA update newsletter, which was then picked up by other media.

First article:

http://www.afma.gov.au/2012/11/trials-show-new-gear-in-tuna-longline-fisheries-better-for-crew-and-seabirds/

Trials show new gear in tuna longline fisheries better for crew and seabirds

Last updated 1 May 2013

Initial Lumo live bait trials have proved successful.

AFMA, in collaboration with the Australian Antarctic Division and the fishing industry, is trialling new line weighting methods for use with live bait in pelagic longline fisheries.

The new ‘lumo’ systems being trialled in the Eastern Tuna and Billfish Fishery are expected to be cheaper, safer for crew and are designed to reduce risks of seabird bycatch while maintaining tuna catch rates.

The weights are luminescent and are attached next to the hook to allow the bait to sink faster reducing the risk of seabirds taking the bait. Because of the way they attach to the line they also reduce the risk of crew member injuries from flying weights if the line snaps under pressure.

The new line weighting method is an exciting development in the tuna fishing industry and shows Australia’s commitment to maintaining sustainable world-class fisheries.

“It is encouraging to have members of the tuna fishing industry, AFMA and the Australian Antarctic Division working together to develop innovative solutions that will benefit the industry and the environment”, said Dr Nick Rayns, AFMA Executive Manager of Fisheries Management.

“Australia is a world leader in reducing seabird bycatch in tuna longline fisheries and trials like this are keeping Australia at the forefront of sustainable fisheries management”, Dr Rayns added.

While rigorous scientific analysis is yet to be undertaken, initial feedback from commercial fishers involved in the trials suggests the new method is easy to use and does not affect catch rates.

Skipper of the *Venessa S,* Alistair Lau said that the lumos were easier to handle both setting and hauling.

Deckhand Bethany King also said that she was surprised by how many fish were caught using the lumos.

This latest trial builds on past trials that used similar technology with dead bait and which have resulted in changes in AFMA's tuna and billfish fishery management arrangements.

The project is supported by funding from the Fisheries Research and Development Corporation (FRDC) on behalf of the Australian Government.

For more information please contact Nigel Abery, Senior Management Officer Tuna and International Fisheries on 02 6225 5303 or nigel.abery@afma.gov.au.

Second article in AFMA update newsletter.

http://www.afma.gov.au/2013/10/singing-the-praise-of-new-fishing-gear/

Also reprinted in Australian Maritime Digest, National, General News on 1 Nov 2013.

Singing the praise of new fishing gear

A new line weighting study in the Eastern Tuna and Billfish Fishery has shown a reduced risk to seabird capture with no influence on fish catch rate.

Previously, birds would try and eat the bait from the hooks of a long-line fishing vessels. Some would occasionally get caught and be dragged under the water. With this new weighting system, the baited hooks sink faster reducing the risk of seabirds taking the bait.

The study was completed in collaboration with the Australian Antarctic Division and the tuna fishing industry, with funding support from the Fisheries Research and Development Corporation. In addition to protecting seabirds, the new weighting system did not affect the live baits or catch rates for target species.

The new weights also have other benefits including improved crew safety, easier deployment, fewer line tangles, and they are quicker to build and are also easier for AFMA fisheries officers to inspect.

The new line weighting method is an exciting development in the tuna fishing industry and shows Australia's ongoing commitment to maintaining the highest standards. The new weights are now commercially available and tuna fishers are beginning to use them in normal commercial fishing operations.

Click here to read our previous article about the new line weighting study, or contact Nigel Abery Senior Management Officer Tuna & International Fisheries on 02 6225 5303 or nigel.abery@afma.gov.au.

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