SCIENTIFIC COMMITTEE

EIGHTH REGULAR SESSION

7-15 August 2012

Busan, Republic of Korea

Branch line weighting options that reduce the risk of seabird bycatch

WCPFC-SC8-2012/EB-WP-10

Graham Robertson, Steven G. Candy, Ian Hay*[1]

[1] Australian Antarctic Division, 203 Channel Highway, Kingston Tasmania 7050 Australia
* (compiling author)

Branch line weighting options that reduce the risk of seabird bycatch

*Graham Robertson, Steven G. Candy, Ian Hay**
Australian Antarctic Division, 203 Channel Highway, Kingston Tasmania, Australia 7050
** (compiling author)*

Abstract:
This paper summarises key findings from several experiments to determine the most effective branch line weighting options for pelagic longline fisheries. Initial (0-2 m deep) and overall sink rates of a range of line weighting options – each comprising a different combination of weight and leader length (distance between hook and weight) – were compared and several options identified that offer faster sink rates and hence pose reduced risk of seabird bycatch. The effect on catch rates of target and non-target species of placing weights adjacent to the hook was also tested and a new design of lead weight ('sliding hook leads') was developed that offers significant economic and safety advantages over traditional leaded swivels.

Key findings include that:
- the fastest initial and overall sink rates were achieved with weights at the hook; these sank significantly faster than the same weight with any length of leader;
- 60 g weight with 1m leader also performed well, with a significantly faster sink rate than 60 g at 3.5 m from the hook;
- all weights with longer leaders had slowest initial sink rates and thus pose higher risks of seabird bycatch; and
- placing weight at the hook had no effect on catch rates of tuna like species or sharks.

Based on this research, it is recommended that consideration be given to revising the line weighting options of CMM 2007-04 to:
- require all fishers to use weighted branch lines and preferably encourage them to use a faster sinking weight option, such as 40 g or 60 g at the hook, or 60 g at 1 m;
- allow the use of 40 g at no more than 0.5 m from the hook;
- require 60 g weights to be used at no more than 1 m from the hook;
- delete the options of 60 to 98 g within 3.5 m of the hook and greater than 98 g at 4 m from the hook; and
- strongly encourage use of the new 'sliding' weights (including 'safe leads' or other proven safer methods of line weighting).

Introduction
This paper summarises findings from experiments conducted in Australia, to determine the effectiveness of various techniques to avoid seabird bycatch and mortalities from interactions with pelagic longline fishing operations. In particular, this paper examines the key findings on branch line weighting options to determine which options are likely to be most effective at reducing seabird bycatch and recommends revision of CMM 2007-04, the WCPFC conservation and management measure to mitigate the impacts of fishing for highly migratory fish stocks on seabirds.

This review focuses on branch line weighting because the faster the hook reaches a depth at which birds can no longer see or dive to the bait directly relates to a reduction in seabird bycatch. Modifying gear to increase sink rates has been proven as an effective seabird mitigation measure in demersal longline fisheries (Agnew et al., 2000; Robertson et al., 2006; Dietrich et al., 2008; Moreno et al., 2008) and the same should apply to pelagic longline fisheries. A further motivation was the dearth of studies in the published scientific literature on the relationships between gear configuration and the rate at which baited hooks sink. This relationship is critically important, as is that between sink rates and seabird mortality.

The following provides a summary of previously published research augmented with new data from trials testing the effectiveness of branch line weighting regimes in terms of sink rate, effect on catch rates of target and non-target fish species and crew safety. Although the experiments were conducted in Australia the results are relevant to tuna and swordfish fisheries in other countries as most pelagic longline fisheries in the southern hemisphere use similar gear configurations (ACAP, 2007). The two studies most referenced by this paper have been provided as the WCPFC Scientific Committee as WCPFC-SC6-EB-WP-06 and WCPFC-SC8-2012-EB-09.

Experimental determinations of factors affecting the sink rates of baited hooks to minimise seabird mortality in pelagic longline fisheries **(WCPFC-SC6-2010-EB-WP-06)**
This research examined the effect of bait species, bait life status, branch line weights and leader length (distance between the weight and the hook) through a series of experiments at sea in which the 'initial' (0-2 m), 'final' (4-6 m) and average (0-6 m) sink rates of 60 g, 100 g and 160 g weights on leaders of 2 m, 3 m and 4 m were measured using time-depth recorders (TDRs). An extract of key results from this study can be found at Annex A.

These experiments demonstrated that the sink rates of baited hooks depend on whether branch lines contain added weight, such as leaded swivels, and the proximity of the weight to the hook. Additionally, weighted branch lines typically sink in two stages (see figures at Annex B). The first stage occurs immediately on deployment and is characterized by relatively slow sink rates. The second stage occurs shortly after deployment and is characterized by a linear (i.e. constant) sink profile – and much faster sink rate – to target depth. The duration of the first stage is influenced primarily by the proximity of the leaded weight to the baited hook. Leaded weights sink faster than baited hooks until the line (i.e. the leader) connecting them becomes taut, at which time the sinking lead weight engages fully on the baited hook and pulls it down, increasing its sink rate. For any given weight, the longer the leader, the slower the initial sink rate. The sink rate of the second stage is influenced primarily by the amount of weight used.

Baited hooks on branch lines without leaded weights do not sink with the same two-stage profile. Instead they sink with a near-linear profile from the surface (e.g., Melvin et al., 2009), albeit at a slower rate than weighted gear in the second stage of its sink profile. This same linear profile would also be expected if weight is placed at the hook. In this paper the first stage is termed the 'initial' sink rate and the second, the 'final' sink rate. Both stages have implications for seabird interactions. The initial rate defines the length of time baited hooks are near the surface and thus most visible and accessible to seabirds, and the final rate has implications for dive depths and swimming speeds required if seabirds are to access baits deeper in the water column. Ideally, the sink rates for both stages should be similar (creating a linear profile from the surface) and as fast as is practicable for fishing operations.

Key findings from WCPFC-SC6-2010-EB-WP-06 are:

- for any given weight, the longer the leader, the slower the initial sink rate (and the greater the risk of seabird bycatch);
- the fastest initial and overall sink rates were achieved with weights at the hook; these sank significantly faster than the same weight with any length of leader;
- there was significant variability in the sink rates of live bait, due to a substantial proportion of live bait swimming the hook to the surface; and

- using dead bait, all three weights (60 g, 100 g and 160 g) on 3 m and 4 m leaders sank at similar rates – showing that even large increases in weight make little difference to sink rates (and the risk of seabird bycatch) when long leaders are used – with initial (0-2 m) sink rates being 2 – 3 times slower than final rates (4-6 m).

These findings are of particular relevance when considering two of the options permitted by CMM 2007-04 – namely, 98 g at 4m and 60 g at 3.5 m – with the latter being only marginally better in the initial sink rate. As later research (see below) shows, both are relatively 'slow' and less effective than options with shorter leaders, including those using lighter weights.

New branch line weighting regimes to reduce the risk of seabird mortality in the pelagic longline fisheries without affecting fish catch **(WCPFC-SC8-2012-EB-WP-09)**
This research continued earlier work and compared the sink rates of two new combinations of line weighting (120 g on 2 m leaders and 40 g at the hook) with the most common weighting option in use in Australian fisheries (60 g on 3.5 m leaders). It sought to address fishers' concerns that placing leaded weights close to the hook would adversely affect catch rates of target and non-target fish species and also to trial two new branch line weighting regimes, using custom-made 40 g and 60 g 'sliding' lead weights placed at the hook and, in the case of the 60 g weights, at 1 m from the hook. The research involved approximately eighteen months of experiments at sea on a commercial fishing vessel as well as static tests in a tank and from a moored vessel.

Key findings of this research included :

- there were no statistically detectible differences in the catch rates of target and non-target fish species between branch lines weighted with 60 g on 3.5 m leaders and those with either 120 g on 2 m leaders or 40 g at the hook;
- the fastest initial sink rates were achieved by the 40 g and 60 g weights placed at the hook, although the 120 g on a 2 m leader was only slightly slower. All three were significantly faster than 60 g on a 3.5 m leader;
- use of 120 g weights added a substantial amount of weight for crew to move during setting and hauling operations – 30 kg extra per bin of 500 branch lines compared to 60 g weights – posing safety risks and likely increased gear costs due to the greater volume of lead; and
- the sliding weights offer significant safety and economic advantages over traditional 60 g leaded swivels.

Sliding weights
The 40 g and 60 g sliding weights used in this research are quite different from traditional lead weights or leaded swivels. Both sliding weights are pencil shaped, coated with 2 mm of luminescent nylon that glows in the dark, approximately 13 mm in diameter and 60 mm in length (the 40 g weight has a hollow bottom end to fit over the crimp above the hook), have a narrow hole through their centre to allow the branch line to be threaded through them and the screw 'clamp' at the top (see photos at Annex C). The clamp is hand tightened to hold it in position on a load-free monofilament branch line, however the weights are capable of sliding in the same manner as 'safe leads' when the branch line is under load.

The weights have significant advantages over traditional weights, including improved crew safety (reduced incidence of flyback and no exposure to lead toxicity); easier deployment (the hook, bait and weight can be picked up and thrown in one hand) and retrieval (the branch line can be hauled right up to the hook with an automatic snood puller); less prone to line tangles in the bin; faster construction of branch lines (less crimping); cost less (than 60 g leaded swivels); and reduce the weight of a 500 branch line bin by 10 kg. Additionally, when used at the hook, they facilitate compliance as a glance only is required to see that weights are at the hook (rather than having to pull branch lines out of the bin to measure leader length). The only drawback with weights at the hook is increased lead loss from shark bite-offs (as the bite-off occurs above the lead). This can be greatly reduced by using a short leader (e.g. ≤0.5 m) when fishing in shark abundant waters.

Recent experiments to refine branch line weighting regimes
To better understand the differences in sink rates of the branch line weighting options tested in the above experiments and other weighting options in use, static water testing was undertaken. Although not a substitute for trials from a moving fishing vessel, the sink rates of branch line weighting options in static water provide a controlled environment unaffected by vessel movement, propeller turbulence and sea state in which to compare different line weighting regimes. The sink profiles and rates of various branch line weighting options were investigated from a stationary vessel in the sea near Hobart, Australia, using the same branch line configuration, depth sensor, branch line deployment method and analytical methods described in WCPFC-SC8-2012-EB-WP-09. Each branch configuration was tested 30 times. The branch line weighting options examined were no weight; 60 g lead weight at the hook, at 1 m, at 2 m and at 3.5 m from the hook; 45 g lead weight at 1 m from the hook; and 40 g lead weight at the hook, at 1 m, at 2 m and at 3.5 m from the hook (see static water and at-sea sink rate profile graphs at Annex D).

Key findings from these trials included:

- the fastest initial sink rates were achieved by the 40 g and 60 g weights placed at the hook; on average, these were 33 % and 30 % faster to reach 8 m (taking 11 and 11.5 seconds respectively) than 60 g on a 3.5 m leader (16.5 seconds). Put differently, when the 40 g and 60 g weights at the hook had reached 8 m, the 60 g at 3.5 m is at a depth of only around 5 m;
- 60 g at 1 m and 40 g at 1 m were also faster than 60 g at 3.5m by 25 % (just over 4 seconds) and 12 % (2 seconds), highlighting that lighter weights are proportionally more affected by increased leader length and that even a small leader makes a sizable difference to the sink rate of lighter weights;
- 40 g at the hook sinks to 8 m 20 % faster than 45 g at 1 m and 26 % faster than 40 g at 1 m; and
- baited hooks on gear with 60 g at 3.5 m from hooks reached 8 m only ~ 3 seconds (18 %) before hooks on unweighted gear.

Discussion

CMM 2007-04 permits the use of either unweighted branch lines or branch lines with 45-60 g within 1 m of the hook, 60 to 98 g within 3.5 m of the hook, or greater than 98 g within 4 m of the hook. Experience in Australia's Eastern Tuna and Billfish Fishery (ETBF) since 2007, which operates in areas with a low to moderate risk of seabird bycatch and with most setting of lines during daylight, is that using 60 g at 3.5 m results in a significantly lower rate of seabird bycatch than when using unweighted lines. However, notwithstanding that it is predominantly a low to moderate risk fishery area, 60 g at 3.5 m has not been sufficient to fully avoid bycatch of seabirds, including threatened species such as albatrosses, even with other mitigation measures in place (Robertson et al 2010). The use of line weighting options with faster sink rates is required in order to avoid or minimise the risk of seabird bycatch. Based on this, it is also reasonable to conclude that 60 g at 3.5 m is insufficient for moderate or high risk areas, especially if lines are to be set in daylight, and even if other mitigation measures, such as bird scaring lines, are in use.

The experiments conducted by Australia demonstrate the benefits of short leaders to initial and overall hook sink rates. Once leader lengths exceed 2 m, there are only trivial improvements to sink rates by moving from 60 g to 100 g. Shortening leaders from 4 m to 2 m also makes relatively minor differences. To achieve a significant improvement in average sink rates requires weight to be placed at or very close to (≤1 m) the hook. The experiments further demonstrate that a 40 g weight at the hook and a far heavier weight (120 g) within 2 m of the hook did not affect the catch rates of target and non-target fish, thereby removing an impediment to the adoption of faster-sinking line weighting regimes. If the sliding weights at the hook are to be used in areas of high shark abundance, it may be preferable to allow fishers to use a short leader, say 0.5 m, to reduce the loss of weights due to shark bite-offs. While Australian researchers are currently gathering data to assess the optimal length of leader for this purpose, it seems likely that 0.5 m will be sufficient to greatly reduce weight loss from bite-offs without making the leader length such that it starts to slow initial sink rates.

The slower initial sink rates associated with longer leader lengths (≥1 m) will result in the bait being near to the surface and visible to birds for longer periods. Greater time at the surface allows the bait to be near to, or have passed, the end of the aerial extent of a bird scaring line before reaching sufficient depth to avoid attacks by diving birds, thus significantly increasing the risk of seabird bycatch. Of the weight sizes currently in common use, 60 g weights placed at the hook are the best performing and would pose the least risk of seabird bycatch. Further, in experiments using live bait have shown that 40 g is insufficient to overcome the swimming ability of the bait fish, allowing a significant proportion of live bait to swim the hook to the surface. This results in much longer 'exposure' of baited hooks in the shallower depths with an increased risk of seabird bycatch.

While not specifically addressed in the experiments described above, Australia's ETBF experience is that traditional weights, including leaded swivels, that are crimped into place can cause crew injury from 'flybacks'. 'Flybacks' occur when a line bite-off occurs or the hook suddenly pulls free when the branch line is being hauled under higher load. While relatively rare, serious injury can occur from flybacks of weighted lines. Consideration of the most effective line weighting options must include consideration of the practicality, safety and economics of their use in fishing operations. There are now several line weighting options that offer reduced risk of injury, at similar or even reduced purchase costs to traditional weights, and their use should be strongly encouraged. The safety benefits of 'sliding' leads in flyback situations has been demonstrated by Sullivan et., al. 2012 (in press) and Australia's experience is that there are economic as well as safety benefits.

Finally, while the use of sliding leads at or near the hook is important for improved sink rates and crew safety, there are also advantages in terms of ease of inspection of line weighting regimes for compliance purposes. In typical gear bins leaded swivels crimped into branch lines on long leaders are distributed throughout several kilometres of coiled monofilament branch line, making port-based inspection of line weight mass and leader length possible for only the most accessible branch lines in the bins. This problem is avoided with the use of leads at the hook or ~0.5 m from the hook because the leads are stored hanging from the clip and hook suspension rails clear of the monofilament coils in the bins where they are highly visible. This greatly facilitates port-based inspection of weighting regimes before and after fishing trips to determine compliance with the weighting provisions prescribed by the fishery manager (or the WCPFC conservation management measure).

Revision of CMM 2007-04

Based on this research, it is recommended that consideration be given to revising the line weighting options of CMM 2007-04 to:

- require all fishers to use weighted branch lines and preferably encourage them to use a faster sinking weight option, such as 40 g or 60 g at the hook, or 60 g at 1 m;
- allow the use of 40 g at no more than 0.5 m from the hook;
- require 60 g weights to be used at no more than 1 m from the hook;
- delete the options of 60 to 98 g within 3.5 m of the hook and greater than 98 g at 4 m from the hook; and
- strongly encourage use of the new ‘sliding’ weights (including ‘safe leads’ or other proven, safer methods of line weighting).

Annexes

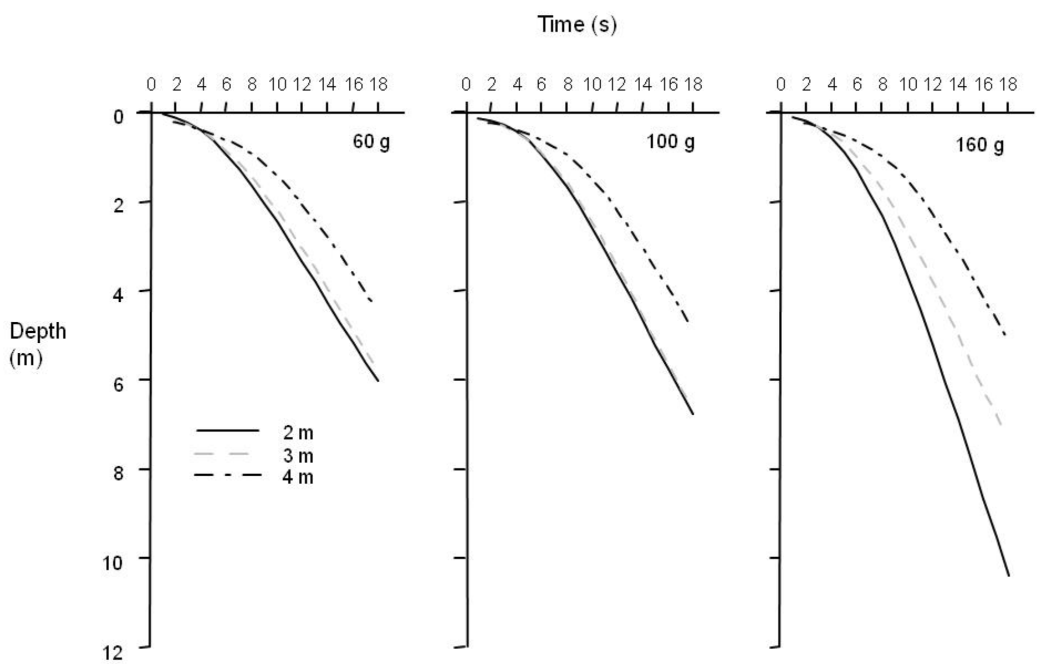
Annex A

Comparison of mean sink times and mean sink rates (from at sea testing), using dead bait only, for different weight and leader lengths in the 0–6 m depth range (≤ 20 s elapsed time)

Weight (g)	Leader length (m)	Mean sink time (s)			Mean sink rate (m s $^{-1}$)		
		0–6 m	0–2 m	4–6 m	0–6 m	0–2 m	4–6 m
60	2	17	8.6	3.9	0.35 (0.02)	0.23	0.48
60	3	19.1	9.5	4.2	0.31 (0.02)	0.21	0.48
60	4	*20	12.5	*	*	0.16	*
100	2	16.7	8.6	4.2	0.36 (0.02)	0.23	0.50
100	3	17.6	9.2	4.2	0.34 (0.02)	0.22	0.49
100	4	19.1	11.0	4.3	0.31 (0.03)	0.18	0.46**
160	2	13.4	7.4	2.7	0.45 (0.02)	0.27	0.74
160	3	15.8	8.3	3.6	0.38 (0.02)	0.24	0.59**
160	4	19.7	11.0	3.6	0.30 (0.02)	0.18	0.54**

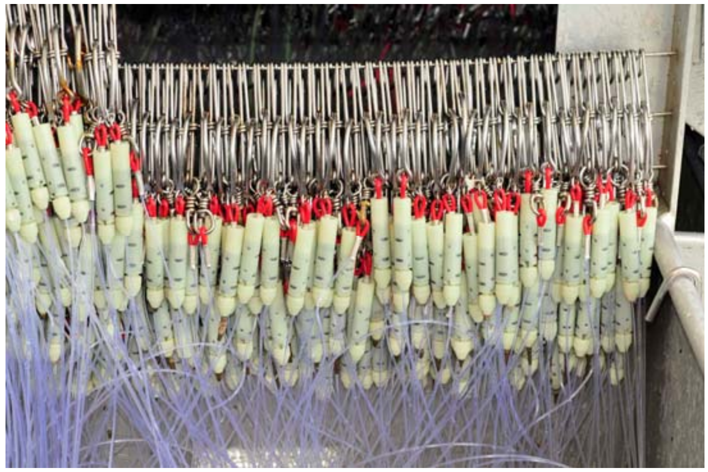
Times and values are presented as (a) cumulative values for entire profiles (0–6 m), (b) times/rates for the initial stage of sink profiles (0–2 m) and (c) times/rates for the final stages of profiles (4–6 m). Estimates in parentheses beside mean sink rates for the 0–6 m ranges are 1 s. e *After 20 s had not reached maximum depth in range. ** Probably still accelerating. (Source : WCPFC-SC6-2010-EP-WP-06)

Annex B



Mean sink profiles (from at-sea testing) of dead baits as a function of leader lengths and the weight of leaded swivels. Within each of the three swivel weights, the longer the leader the slower the initial sink rate. N = 33 for each combination of weight and leader length. (Source : WCPFC-SC6-2010-EP-WP-06)

Annex C

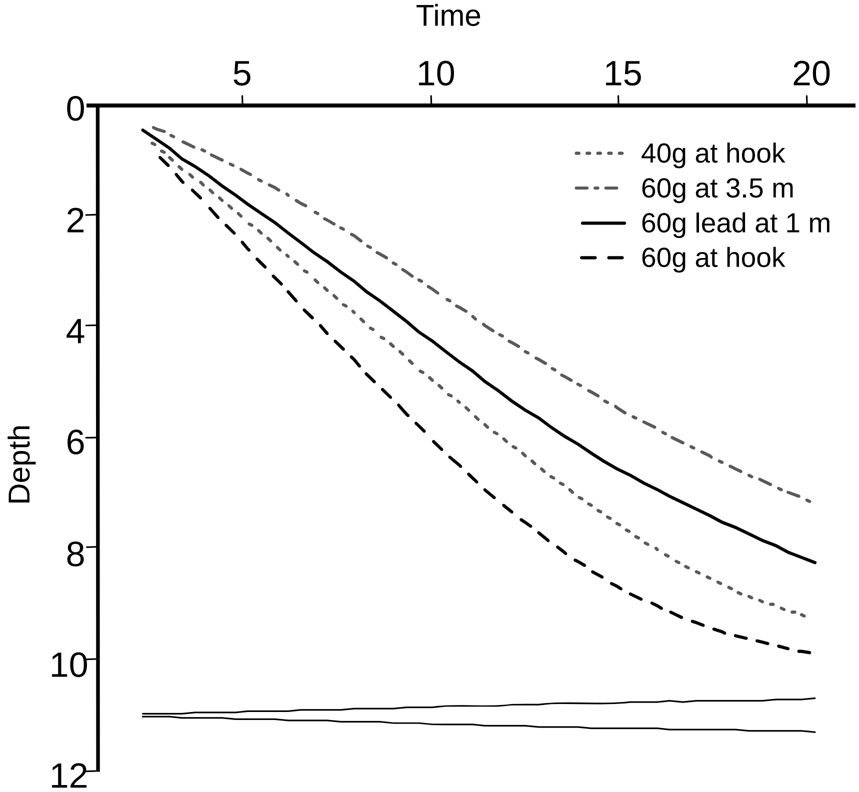
 

40 g ‘sliding’ weights at the hook; note the ease with which a bin of multiple branch lines can be inspected to check that weights are placed at the hook. (Source : WCPFC-SC8-2012-EP-WP-09)

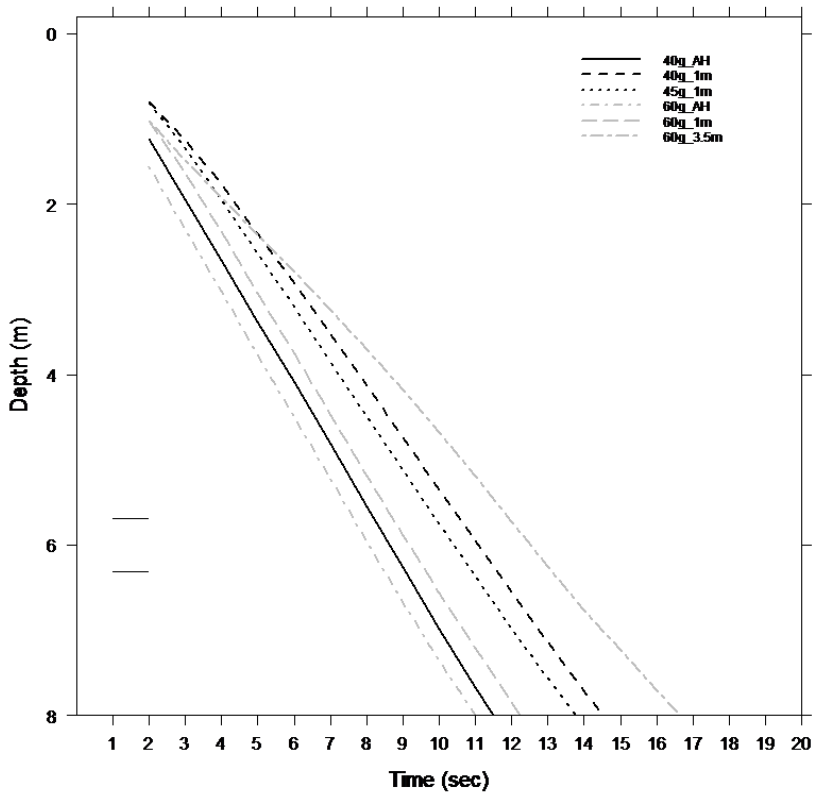
Line weight regime	Nominal depth (m)	Time to depth (sec)	Sink rate (m/s)
40 g at hook	2	4.52	0.43
60 g at hook	2	3.96	0.51
60 g at 1 m	2	5.22	0.39
60 g at 3.5 m	2	6.76	0.29
40 g at hook	5	9.7	0.50
60 g at hook	5	8.2	0.61
60 g at 1 m	5	11.1	0.44
60 g at 3.5 m	5	13.5	0.36
40 g at hook	8	15.58	0.51
60 g at hook	8	13.06	0.61
60 g at 1 m	8	18.94	0.42
60 g at 3.5 m	8	20.9	0.38

Mean sink times and sink rates (from at-sea testing) to ‘target’ depths (i.e 2 m, 5 m or 8 m) of the two weighting regimes in the 40 g hook lead fish catch trial. Also included are results for 60 g hook leads and 60 g leads 1 m from hooks (see text). N = 30 replicates/weight regime. (Source : WCPFC-SC8-2012-EP-WP-09)

Annex D



A comparison of sink rate profiles for 40 g and 60g weights, based on at-sea testing. The 95% confidence bounds of the difference at a given time are shown as horizontal bars at the bottom of the figure. If the difference between any two average profiles fora given time exceeds the difference between the upper and lower arms of the confidence bounds then the difference is statistically significant. (Source : WCPFC-SC8-2012-EP-WP-09)



A comparison of sink rate profiles for 40 g (at hook and at 1m from the hook), 45 g (at 1 m from the hook) and 60g weights (at hook, at 1 m and at 3.5m from the hook), based on static water testing, n=30. The 95% confidence bounds of the difference at a given time are shown as horizontal bars at the bottom of the figure. If the difference between any two average profiles fora given time exceeds the difference between the upper and lower arms of the confidence bounds then the difference is statistically significant. (NB Unlike the profiles above for at-sea testing, it was found that variance did not increase significantly with time and therefore the 95% confidence bounds do not depend on time)

References

ACAP. 2007. Report of the first meeting of the Seabird Bycatch Working Group of the Agreement on the Conservation of Albatrosses and Petrels. Third Meeting of Advisory Committee, Valdivia, Chile, 19–22 June 2007.

Agnew DJ, Black AD, Croxall JP, Parkes GB. 2000. Experimental evaluation of the effectiveness of weighting regimes in reducing seabird by-catch in the longline toothfish fishery around South Georgia. *CCAMLR Science* **7**: 119–131.

Baker GB, Wise BS. 2005. The impact of pelagic longline fishing on the flesh-footed shearwater *Puffinus carneipes* in Eastern Australia. *Biological Conservation* **126**: 306–316.

Dietrich KS, Melvin EF, Loveday C. 2008. Integrated weight longlines with paired streamer lines — best practice to prevent seabird bycatch in demersal longline fisheries. *Biological Conservation* **141**: 1793–1805.

Melvin EF, Heinecken C, Guy T. 2009. Optimizing tori line designs for pelagic tuna longline fisheries: South Africa. Report of work under special permit from the Republic of South

Africa Department of Environmental Affairs and Tourism, Marine and Coastal Management, Pelagic and High Seas Fishery Management Division. 29 September 2008.

Moreno CA, Castro R, Mu´jica LJ, Reyes P. 2008. Significant conservation benefits obtained from the use of a new fishing gear in the Chilean Patagonian toothfish fishery. *CCAMLR Science* **15**: 79–91.

Robertson G, McNeill M, Smith N, Wienecke B, Candy S, Olivier F. 2006. Fast sinking (integrated weight) longlines reduce mortality of white-chinned petrels (*Procellaria aequinoctialis*) and sooty shearwaters (*Puffinus griseus*) in demersal longline fisheries. *Biological Conservation* **132**: 458–471.

Sullivan, B. J., et al 2012. Safe leads for safer heads: safer line weights for pelagic longline fisheries. *Fisheries Research* (in press).

Robertson, G., et al 2010. Experimental determinations of factors affecting the sink rates of baited hooks to minimise seabird mortality in pelagic longline fisheries. WCPFC-SC6-2010-EB-WP-06.

Robertson, G., et al 2012. New branch line weighting regimes reduce risk of seabird mortality in the Australian pelagic longline fishery without affecting fish catch. WCPFC-SC8-2012-EB-WP-09.