Branchline Weighting on Two Japanese Joint Venture Vessels Participating in the 2009 South African Tuna Fishery: A Preliminary Report

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Introduction

Research was carried out aboard two tuna longline vessels, the F/V Fukuseki No. 5 and the F/V Wakashio No. 83, participating in the Japanese tuna joint venture fishery in the South Africa EEZ from August 4 to September 7, 2009. The principal objective was to compare the performance of two tori line designs: "light" tori lines with short streamers and the Alaska-Japanese line which mixes streamers that extend to the water with short streamers (see Melvin et al. 2009). A secondary objective was to introduce weighted branchlines into the fishery as a seabird bycatch mitigation measure using the safest line weighting system available. Our intention was to monitor the sink rate of weighted and unweighted branchlines to inform the distance astern that birds have access to baited hooks and require protection with a tori line. We also aimed to gauge the reaction of the fishing master and the crew to using weighted branchlines.

Line weighting entered into our research plans for two reasons. It was clear from our 2008 work in the South African tuna fishery (Melvin et al. 2009) that baited hooks on unweighted branchlines sank out of the reach of seabirds well astern of the vessel – over 150 m – and that this distance could nearly double if a branchline was set into the wake. The likelihood that tori lines can protect baited hooks within the reach of seabirds beyond 150 m astern is near zero. In addition, the two vessels hosting this research quickly exceeded their seabird bycatch caps for the South Africa fishery in 2009. This event strongly suggested that current mitigation measures - two tori lines and night setting - were insufficient to prevent seabird mortalities. We introduced "safe-leads" to our research plan because they are the safest option available for enhancing the sink rate of baited hooks in order to shrink the distance astern requiring protection from tori lines. It is important to note that we did not set out to evaluate the loss rate or the durability of individual safe leads, nor did we aim to evaluate safe lead technologies relative to other weighting options.

Weighting branchlines in pelagic longline fisheries is problematic because it can be a safety hazard to crew. Lead on a branchline can come back at the vessel (flyback) like a bullet when a fish is lost during line hauling, either by the fish biting off the hook (typically sharks) or from a hook becoming dislodged. This phenomenon has been responsible for serious injuries – especially eye injuries - and at least one death (Marine Safety Solutions 2008). FishTek, a United Kingdom Company, introduced and is refining "safe-leads" as a safe branchline weighting technology for pelagic longline applications. This technology allows a monofilament line to pass freely through the weight when tension on the line is suddenly released, as when a fish suddenly comes free from a hook as it is being landed.

Safe-leads are made up of a rubber gasket sandwiched between two leads held in place by two "O" rings forming a squat, spindle-shaped weight. The monofilament portion of the branchline is threaded through a hole in the center of the gasket. Squeezing the release button widens the aperture of the hole allowing the branchline to be threaded through the safe lead. Releasing the button settles it onto the branchline where the safe-lead maintains its position via 5 kg of pressure. The sudden accelerating force of the recoiling branchline in a flyback overcomes the friction of the gasket allowing the line to slip through the center of the lead, which serves to dampen the leads velocity, thus reducing or eliminating danger (http://www.fishtekmarine.com/safeleads.php).

The diameter of the monofilament branchline and the distance of the lead from the hook are important specifications for applying safe-leads to branchlines so that they function properly. The diameter of monofilament line should range from 1.6 to 2.2 mm to allow for proper grip and release. Based on the maximum amount of stretch expected before a hook bite-off or a hook becoming dislodged, FishTek recommends that the safe lead be placed 2 m from the hook to allow adequate distance for the lead to slide along the monofilament line and dampen the velocity of the lead thereby minimizing danger to crew. The minimum recommended distance between the hook and the lead is 1 m. At this distance, the safe-lead will function properly, but there is a high likelihood it would be lost in the case of a bite off. If the safe-lead is placed at a distance of less than 1 m and the hook becomes dislodged it will still function to dampen the recoil speed to the vessel and remains safer than a traditional weighted swivel.

Port side experiments have demonstrated that the safe-lead technology works reliably (Gilman 2008; Marine Safety Solutions 2008; and Sullivan et al. 2009) and at least one at-sea trial is underway comparing safe-leads to weighted swivels, the most commonly used branchline weight used in pelagic tuna fisheries.

This preliminary report of the branchline weighting component of our results is being provided in advance of a final report of all our finding in order to inform development of branchline weighting for testing in 2010 and to inform Marine and Coastal Management's planned review of permit requirements for the 2010 South Africa tuna fishery.

Methods

Each vessel was provided 1000, 60g safe-leads. Half included green luminescent components ("O" rings and gasket) and half were non-luminescent (black). Safe-lead weighted branchlines were deployed within two of 10 to 12 radio beacon segments each day. The Fukuseki deployed 220 branchlines per segment and the Wakashio deployed 240, yielding 440 and 480 weighted branchlines per set, respectively. The monofilament portion of each branchline was 1.8 mm and 1.9 mm diameter, well within the 1.6 to 2.2 mm safe-lead specification. Although FishTek recommend that safe-leads be placed at 2 m above the hook, the fishing masters insisted on placing the leads 50 cm from the hook to minimize tangles during line setting (see discussion). Initially crimps were positioned just above the lead to maintain the prescribed distance of 50 cm; however, as fishing proceeded and hooks were replaced, crimps were not. A position of approximately 60 to 70 cm from the hook proved most compatible with the circumference of the branchline coils and became the typical configuration. As branchlines were coiled for storage, crew members repositioned and maintained or replaced safe-leads as needed.

Longline sets were made in such a way as to include at least one hour of daylight setting to allow us to evaluate tori line performance using seabird behavior. A typical set therefore straddled night, dawn and early day with two to three radio beacon segments set in the dawn to day period. Because researchers were tasked with monitoring both the set and the haul, as well as doing periodic sink rate measurements, their time was rationed. They observed the retrieval of five to six of the 11 to 12 segments each haul with the priority of observing all hooks retrieved during the dawn-daylight behavioral observations. To ensure that we consistently monitored at least one segment of weighted branchlines during the haul, one weighted branchline segment was positioned adjacent to the daytime segments – the last two segments set - and observed daily. Haul observations focused on catch – both fish and birds. For this preliminary report, we compared fish catch rates (tuna and swordfish only) between weighted and unweighted branchlines on adjacent segments set at night using vessel logbook data (14,260 hooks for each branchline type).

For weighted branchline segments, researchers qualitatively documented general performance; they did not quantify broken safe-leads or catch by the two safe-lead types – luminescent vs. non-luminescent. Although weighted branchline segments were consistently deployed in the prescribed sequence over time, branchlines with luminescent and non-luminescent safe-leads became mixed making it impossible to record catch rate by lead type. Also on occasion, the researchers noted that not all branchlines in a weighted branchline segment actually had safe-leads, but this was rare. This phenomenon, coupled with the reality that three branchlines are being hauled at any one time, made it impossible to be 100% certain that each branchline in a weighted branchline segment had a lead. Safe-lead loss was estimated by counting the number of safe-leads remaining on board after the fishing trip.

Star–Oddi time depth recorders (TDRs), model DST Centi-ex, and *SeaStar* software, were used to measure the sink rate of baited hooks with and without 60 g safe-leads (Melvin et al. 2008). TDRs were fixed to the branchline with Tesa tape 70 cm above the eye of the hook – approximately one turn of a branchline coil. The water entry time was recorded for each TDR to the nearest second using a digital wristwatch. Seconds to 10 m depth were extracted from each data record and corrected to compensate for the weight of the TDR using the results of static sink rate tests of branchlines with and without TDRs (Data from Graham Robertson, AAD).

Results
Each vessel fished for 31 days and together they deployed a total of 157,785 branchlines of which 28,520 were weighted branchlines.

Weighted branchlines sank at 0.53 m/s to a depth of 10 m, 2.9 times faster than unweighted branchlines (0.18 m/s). At a setting speed of 9.5 knots over ground, baited hooks on weighted branchlines sank beyond the reach of seabirds within 100 m of the stern (94.8 m), while hooks on unweighted branchlines sank to 10 m beyond 300 m from the vessel (302 m).

Table 1. **Summary Weighted vs. Unweighted Branchline Information.** 60 g safe-leads were deployed on the Fukuseki Maru # 5 and Wakashio Maru # 83, 6 Aug and 7 Sept 2009. Fish catch rates (tuna only) between weighted and unweighted branchlines on adjacent segments set at night were compared using vessel logbook data. Shorter than recommended (0.7 cm vs. 2 m) distance between the hook and the safe-lead probably caused leads to be lost at a high rate.

Category	Number	m/sec	/1,000 hooks
Unweighted branchlines (UBs) deployed	129,265		
Weighted branchlines (WBs) deployed	28,520		
WBs per set	920		
UB seconds to 10 m	50.0	0.20	
WB seconds to 10 m	18.9	0.53	
UWs bird mortalities/rates	126		0.975
WBs bird mortalities/rates	2		0.070
UB fish landed			17.2
WB fish landed			15.2
Beginning safe leads	2,000		
Remaining safe leads	886		39.0

On two occasions, both on 28 August, baited hooks with TDRs attached to unweighted branchlines were captured and brought to the surface by birds. The first bait was sinking at 0.16 m/s and was initially captured at 9.1 m depth, approximately 254 m astern of the vessel. The second bait was sinking at 0.14 m/s and was captured at 5.2 m depth, approximately 156 m astern. The birds were not hooked during either event and the branchlines sank again after the attack.

One hundred twenty eight birds were killed overall: 126 on unweighted branchlines (0.975/1,000 hooks) and two birds (a white-chinned petrel during daylight and a cape gannet near dawn) on weighted branchlines (0.070 birds/1,000 hooks). Both birds were taken on one vessel in calm weather conditions while using both tori line designs.

On average, fish (tunas and swordfish only) were caught at similar rates on unweighted (15.2 fish/1,000 hooks) and weighted (17.2/1,000 hooks) branchlines set at night.

In a total of 62 fishing days, 1,114 safe-leads of the original 2,000 were lost or broken (39 leads/1,000 hooks).

Two crew members were injured when the hooks on weighted branchlines pulled out and flew-back as a fish was being hauled. One of the two injuries was clearly due to the presence of a lead on the branchline. Both injuries had the potential to be serious; however, both crew members recovered and returned to their duties. No injuries were observed during the hauling of unweighted branchlines.

Discussion

Sink Rates

We confirmed that unweighted branchlines sink beyond the access of seabirds well astern of the vessel and beyond the protection of tori lines– in this study over 300 m astern – and weighting branchlines reduced this distance by nearly three times. This result strongly suggests that weighted branchlines are essential to consistent seabird conservation in this fishery. The 94.8 m sinking distance of weighted branchlines to our benchmark depth of 10 m matched the aerial extents that were achieved by both tori line designs we tested. This evidence strongly suggests that tori lines coupled with line weighting and night setting would be highly successful in preventing seabird mortalities in this fishery. Evidence that seabirds reached baits to a depth of at least 9.2 m confirms our belief that an effective seabird mitigation strategy must protect baits to at least our benchmark of 10 meters. This is especially true when the consequences of secondary interactions – where a diving bird captures and brings baited hooks to the surface potentially making them available to threatened albatrosses – are considered.

Seabird Mortality

Very few birds were killed on weighted branchlines; however, it is important to note that most weighted branchlines were deployed at night in the dark when very few bird mortalities occurred on the more numerous and slower sinking unweighted branchlines. This result confirms the effectiveness of setting gear when ambient light levels are very low – nighttime with little moonlight. Some weighted branchlines were deployed during daylight hours and future analysis of these data will look very closely at the light level (day or full moon) in relation to attack rates and bird mortality. The two weighted branchline mortalities occurred when light levels were high: the moon was nearly full and they were deployed just after dawn.

Given that unweighted branchlines were randomly present in a weighted branchline segment, we cannot rule out that birds caught in a weighted segment were caught on a branchline without a safe-lead. Researchers did not record this information, but because contamination was extremely rare we are assuming that the birds were caught on a weighted branchline. Even so, seabird bycatch rates were 14 times lower on weighted branchlines than on unweighted branchlines and it is likely that statistical testing will show a dramatically significant difference. Results so far suggest that fish catch rate are similar between weighted and unweighted branchlines. We will explore this relationship further using all available data and considering all conditions.

Practical Issues
The Fishing Masters on both vessels feared that using weighted branchlines would decrease fish catch and lead to more tangles during line setting. Consequently, most of their comments on branchline weighting are not specific to safe-leads, but rather address using a single lead to weight a branchline. The Fukuseki fishing master communicated that he felt the weighted branchlines were not fishing properly. He believes that when the fishing is good anything will work to catch fish, including weighted branchlines, but when the fishing is poor the catch depends on proper bait presentation. Setting weighted branchlines with a bait casting machine results in a "hinge" effect as the weight leads the bait when landing on the water and while sinking. Fishing masters indicated that they felt this jackknifing effect would increase the number of tangles and prevent the bait from sinking in a manner that is attractive to fish. We note that this concern could be unique to long coiled branchlines deployed with a bait casting machine and not other modes of pelagic longlining. Fishing masters also felt that baited hooks once at depth would not flutter properly in the current, however, we note that the closer the weight is placed to the hook the more likely it is that bait presentation will be affected. Given the speed at which branchlines are retrieved and the chaos that can ensue when landing a fish, we could not quantify tangles for weighted branchlines relative to unweighted branchlines to address the tangles question. When quizzed many of the crew of the Fukuseki confided that weighted branchlines were cumbersome to coil and to cast. Our preliminary finding that fish catch was similar between the two branchline types suggests that weighted branchlines do not reduce fish catch or increase tangling.

Safe-leads
In this study, safe-leads were lost in two ways: by bite offs or they would break apart when "O" rings failed. Unfortunately, researchers could not quantify or even estimate the proportion of bite offs to broken safe-leads due to the poor proximity of the catch monitoring station to the gear repair station and our priority of accurately quantifying catch. Had we anticipated breakage, we could have had crew retain broken leads as they encountered them. The speed of hauling in this fishery could put more stress on safe-lead components than slower hauling speeds typical of coastal fisheries. We note that branchlines in the coiled branchline style of longline fishing are retrieved using a hydraulic spooler while the vessel is moving at three to six knots yielding a branchline speed through the water of around 20 knots or more. The last 10 m or so is coiled by hand but resulting in a lower but still high through-water speed. FishTek is actively working to reduce safe-lead breakage by replacing elastic "O" rings with stainless steel snap rings.

It is important to point out that during the final 4 days of fishing, hundreds of blue sharks were caught and released. It is likely that many of the leads were lost during this period. We note that when a safe-lead is lost it successfully prevents an injury, and therefore, has met its intended purpose. It is highly likely that the shorter than recommended (0.7 cm vs. 2 m) distance between the hook and the safe-lead caused leads to be lost at a high rate. When settling on a hook-to-weight distance in this study, we sought to balance the concerns of the fishing masters with exploring the safest available line weighting technology to minimize bird mortalities. A lead closer to the hook is likely to sink the baited hook faster and satisfy the fishing masters' concerns regarding potential increased tangling during the set, but probably lead to a higher safe-lead loss rate and was less safe.

No injuries were observed when hauling back branchlines on one vessel, but two injuries occurred during the haulback of weighted branchlines on the other. In both cases, the hook was dislodged from the fish as opposed to it being bitten off. Hook pull-outs are more dangerous because the lead and hook remain on the line and flyback at the vessel. In the first case, a hook pulled out as a swordfish was being landed. The flying hook and weight hit a crewmember who was sinking a harpoon. The hook hit his cheekbone and created a wound that took 5 days to heal and left a nasty scar. To what extent the safe-lead was responsible for the wound could not be determined. In the second case, a safe-lead flew across the deck as one crewmember pulled in a blue shark. The lead hit a second crewmember in the forehead with enough force that he buckled slightly, but didn't fall. In this case the lead clearly caused the injury. It broke the skin and left a 1 cm wound. Had we used weighted swivels, as opposed to safe-leads, in this trial we fear that the rate and severity of branchline weighting related injuries could have been much higher.

The Future

The fishing masters and vessels owners we worked with now agree that line weighting should be pursued further to achieve seabird conservation in the South Africa fishery and other fisheries. However, we note that they desire a weighting regime that uses the least amount of added weight, maintains fish catch and is safe. Currently, South African permit conditions require vessels that have caught 25 birds to either weight their gear or stop fishing for a three-day period bracketing the full moon. An effective line weighting regime in combination with well designed tori lines would allow them to avoid the cap and/or provide an alternative to not fishing around the full moon if they do. The challenge now is to find a line weighting system that addresses the jackknifing and branchline tangling issue and is safe during line hauling.

The fishing master of the Fukuseki No 5 – Kazuhiro Yamazaki – has proposed a new branchline weighting configuration, which he believes is safe and will eliminate the "hinge" or "jackknifing" effect while maintaining fish catch. It involves using two weights separated by 70 to 100 cm of wire trace. This double-weight configuration would be attached to the hook with a 2 m length of monofilament line. We understand that he believes that that the second weight will dampen the velocity of the first in a flyback and perhaps that weight spread over 1 m of line would be safer than a single weight.

Given the preliminary results of this study, we know that branchlines with a 60g weight branchline positioned 70 cm from the hook sank beyond the reach of seabirds within tori line aerial extents that were achieved. Therefore, we propose that future research into a new weighting configurations should aim to achieve a sink rate of 0.53 m/second or exceed it. We plan to work with Japan Tuna, Tuna South Africa and other collaborators over the next several months to help develop an effective and safe line weighting configuration to include in our 2010 research program. This will include preliminary testing of the double weight-configuration that has been proposed. Port side studies quantifying the velocity and impact of flybacks and static sink rate measurements will be important first steps before large scale testing at-sea. Given that safe-leads remain the safest way to deploy weighted branchlines for tuna fishing tests, safe-leads will serve as the basis of comparison to determine the relative safety of the double weight system. A hybrid of the two concepts could be a possible outcome. In any case, the change from unweighted to weighted branchlines will require fishing masters to accept change and summon their collective experience to develop a safe branchline weighting system.

Conclusions

Weighted branchlines are essential to consistent seabird conservation in the South Africa joint venture tuna fishery. Based on preliminary analyses, branchlines weighted with 60 g safe-leads:

- Sank to a depth of 10 m within 100 m or the vessel and within the aerial extent of both tori line designs tested, and
- Caught birds at a rate 14 times less than unweighted branchlines,
- Caught fish at a rate similar to unweighted branchlines.

Future efforts should focus on developing a branchline weighting configuration that:

- Satisfies fishing masters' concerns regarding potential increased tangling during the set,
- Sinks to 10 m within 100 m of the stern at 9.5 knots setting speed, and
- Minimizes danger to crew during line hauling.

Alternative weighting configurations, such as the double weight configuration proposed by the Fishing Master of the Fukuseki No. 5, should first be tested dockside before being tested at sea. These tests should determine the velocity and impact of flybacks relative to safe-leads, which remain the safest branchline weighting system available. Tests should also determine sink rates and these sink rates should match or exceed the sink rate of 60 g safe leads (0.53 m/sec). The successful branchline weighting configuration should then be incorporated into the final round of tori line comparisons in the South Africa joint venture tuna fishery in 2010.

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