NEW DEEP SETTING TECHNIQUE TESTED IN MOOLOOLABA, AUSTRALIA

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A new technique for setting tuna and swordfish longlines that was designed to avoid shallow water bycatch species and improve catch rates for bigeye tuna has been tested. SPC's Fisheries Development Officer, Steve Beverly, with the help of the Australian Fisheries Management Authority (AFMA), SeaNet (www.oceanwatch.org.au), and two longline fishing companies operating out of Mooloolaba in Queensland, Australia, were behind the experiment.

The objectives of the project – which took place during March, April, and May 2004 – were to perfect the new deep setting technique so that it could be duplicated by any longline boat, and to test it alongside normal setting practices to see if catch rates changed. To be feasible, the new technique had to either improve or not change catch rates for the main target species, bigeye tuna and broadbill swordfish.

The vessels used for the fishing trials were Southern Moves' vessel, F/V *Blue Moves* (Fig. 1), and Cafferel Tuna's vessel, F/V *Diamax* (Fig. 2). The project could not have been completed without the generous support of the fishing fleet. F/V *Blue Moves* and F/V *Diamax* are part of the Mooloolaba fleet that fishes in Australia's Eastern Tuna and Billfish Fishery, which is managed by AFMA. AFMA provided funding for the project under their Eastern Tuna and Billfish Management Advising Committee – Initiated Research Fund. SeaNet provided logistical support and liaison with local operators. Two trips were made, one on each boat. All bugs were worked out of the setting technique on F/V *Blue Moves* so that data could be collected on the trip on F/V *Diamax*. Temperature and depth recorders, or TDRs, were used on all project baskets and on some normal baskets for comparison.

Background

Pelagic longlining targets tuna and billfish species but also catches other species that may or may not be marketable. Target species include bigeye tuna (*Thunnus obesus*), yellowfin tuna (*T. albacares*), albacore tuna

Figure 1 (top): F/V *Blue Moves*
Figure 2 (bottom): F/V *Diamax*

(*T. alulunga*), broadbill swordfish (*Xiphias gladius*), and striped marlin (*Tetrapterus audax*). There are two groups of non-target species caught by longliners: byproduct and bycatch. Byproduct species include those that are not targeted but are retained because they have commercial value. These include species such as mahi mahi, or dolphin fish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), opah, or moonfish (*Lampris guttatus*), and some billfish and shark species among many others.

Bycatch species are those non-target species that are discarded because they either have no commercial value or because they are endangered and are protected by international law. Discarded bycatch species that have no commercial value include species such as lancetfish (*Alepisaurus* spp), snake mackerel (*Gempylus serpens*), pelagic rays (*Dasyatis violacea*), some sharks, and undersized tunas and billfish, among many others. Discarded bycatch species that are endangered and are protected by international law include sea turtles, sea birds, marine mammals, some shark species and, in some areas, billfish.

There are seven species of sea turtles worldwide: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), flatback (*Natator depressus*), leatherback (*Dermochelys coriacea*) and the Kemp's ridley (*Lepidochelys kempii*), which only occurs in the Gulf of Mexico and the northwest Atlantic.

SPC's Oceanic Fisheries Programme reviewed turtle bycatch in the western and central Pacific Ocean tuna fisheries for the South Pacific Regional Environmental Programme's (SPREP) Regional Marine Turtle Conservation Programme. The review stated that incidental catches of sea turtles in the longline fishery occur when turtles encounter baited hooks or when they get entangled in mainlines or floatlines. When mortality occurs it is typically due to drowning. If turtles are hauled just after getting hooked or entangled they usually survive. Observer reports show that tropical areas have more turtle encounters and that depth of set appears to be the most important factor. Analysis of data suggests that bait and time of set do not have as much of an effect as depth of set. Estimates from observer data show that turtle encounters on shallow sets are 10 times higher than on deep sets, and that when there are turtle encounters on deep sets they are almost always on the shallowest hooks in the set. "This suggests that there is probably a critical depth range of hooks where most marine turtle encounters would be expected to occur in the western tropical Pacific longline fishery" (SPC 2001).

A Hawaii study of turtle dive-depth distribution revealed that loggerheads spend most of their time in depths shallower than 100 m, and that even though olive ridleys dove deeper than loggerheads, only about 10 per cent of their time was spent deeper than 100 m (Polovina et al. 2003). The report concluded that incidental catches of turtles should be substantially reduced with the elimination of shallow longline sets. If the new deep setting technique could land all hooks below 100 m and still fish effectively, then it could be a solution to the turtle bycatch issue as the surface down to 100 metres seems to be the critical depth range of most sea turtles. (See *Fisheries Newsletter # 93* for a discussion of the turtle bycatch issue in the Hawaiian longline fishery).

Pelagic longlines can be set to fish at a variety of depths from near surface waters to depths down to 400 and 500 m, depending on target species. Even deep-set lines, however, have a high percentage of their hooks – the ones nearest the floats – fishing in shallow water. Since the 1970s, longline fishing has evolved, and much more has been learned about the vertical distribution of main target species, relationships of catches to thermocline depth and other environmental factors, and actual depths and shapes of longline sets. The introduction of monofilament longline systems using mechanised line setters, or shooters, has allowed fishermen to increase and to control the depth of set by throwing line out at a rate faster than the speed of the vessel. But, without the use of TDRs, it is difficult to know for sure the actual depth achieved because of environmental factors. One thing has not changed, however. The basic shape of the longline has always been a catenary type curve – the shape taken by a chain or cable suspended between two points and acted upon by gravity. Even with deep sets a substantial portion of the branchlines in the catenary curve remain at shallow depths.

Generally, longline gear fishing deeper in the water column is more effective in targeting bigeye tuna, probably due to the preference of bigeye tuna for 10-15°C water (Hampton et al. 1998). Prior to 1974, though, virtually all longliners operating in the Pacific set their hooks in shallow depths. Deep setting was introduced around the latter part of 1974 and was quickly adopted by most vessels targeting bigeye tuna in equatorial Pacific waters. Gear with more than 10 branchlines per basket was considered to be deep gear. A basket with 6 branchlines was assumed to fish at 170 m, while a basket with 13 branchlines was assumed to fish at 300 m (Fig. 3). Bigeye catch rates were better on deep sets and catch

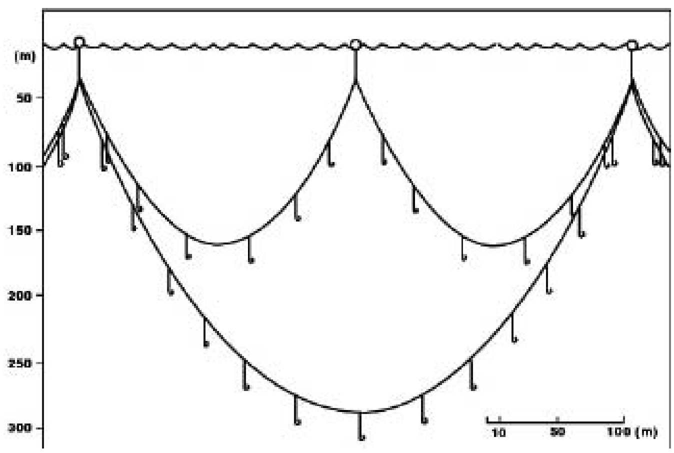

Figure 3: Catenary curves of regular longlines with 6 branchlines and with 13 branchlines per basket (Suzuki and Warashina 1977).

rates for all other species decreased with deep sets.

Since the advent of deep setting, however, some fleets have reverted back to shallow setting. Shallow sets are made during a two-week period – one week before and one week after a full moon. The sets are generally made at night and target bigeye tuna. Longliners targeting broadbill swordfish use roughly the same strategy – shallow night sets using squid bait and lightsticks and fishing around a full moon. The longline fleet operating in the Eastern Tuna and Billfish Fishery in Australia has, for the most part, adopted this technique.

New deep setting technique

A need was seen to develop a method that would take advantage of the habits of turtles and bigeye tuna by avoiding one while targeting the other. The problem was how to set and haul a pelagic longline that fished only in water below 100 m. At the same time, the method had to be easily adaptable by longline fishermen. The initial concept for the project was first presented at SCTB16 in Mooloolaba in 2003 (see *Fisheries Newsletter # 106*).

For the new deep setting technique, normal floatlines were used in pairs separated by a blank section of mainline with no baited branchlines for a distance of 50 m. The section of mainline that holds the baited branchlines was suspended directly under these floats and was weighted down at each end by a 3 kg lead weight attached to the mainline by a standard snap (Fig. 4). The distance between the floats and the lead weights was the target depth for the shallowest hooks in the basket – 100 metres. Therefore, portions of the mainline acted as supplemental floatlines. These portions of the mainline being used as supplemental floatlines were hauled the same as the rest of the mainline. All parameters, such as target depth of shallowest hooks, were simple to change and the only new gear needed was lead weights with lines and snaps, additional floats and floatlines, and additional mainline. All other fishing gear remained the same as the boats normally used.

The experimental longline was set as follows: The line setting timer was set so that every beep corresponded to 50 m of line. Then, a float with normal floatline was attached to the mainline and thrown overboard as the boat was underway. The mainline was ejected by the line setter at a rate slightly faster than the speed of the boat. After 50 m of line was paid out, a second float was deployed. Then 100 m of mainline was paid out in the same manner. This section of mainline acted as a supplemental floatline. The length

Figure 4: Three kilogram lead weight with swivel snap

of this section was metered using the line-setting timer. One beep of the line setting timer equalled 50 m, so there was one beep between the two paired floats and two beeps between the second float and the first lead weight. After the first weight was deployed, baited branchlines were attached to the mainline in the normal fashion. After 12 to 20 branchlines (one basket) were deployed, a second lead weight was attached to the mainline. The second lead weight was attached at the beep normally used to signify a float (i.e. the end of that basket). A float was attached after two more beeps and a second float on the next beep and the whole process was then repeated.

The sagging rate – the ratio between the distance the boat travelled for one basket and the length of line paid out for one basket – needed to be pre-determined. The sagging rate calculation for the weighted deep sets was similar to sagging rate calculations for a normal longline set except that the expected shape of the line from float to float was rectangular rather than a simple curve. Sagging rate was based on: target depth of the shallowest hook, distance between hooks, distance between the paired floats, and basket size. Sagging rate was easy to calculate but was different for each target depth of shallowest hook and for different basket sizes. Total distance travelled by the boat for each basket was equal to total length of line paid out minus twice the depth. Total line paid out for each basket was equal to the length of line in the basket (the portion with branchlines attached) plus twice the depth, plus the distance between the two floats at the end of the basket. The ratio of these two numbers, length of line paid out and distance travelled by the boat, gave the sagging rate. For example, if the target depth of the shallowest hook was 100 m and there were 20 hooks in a basket with 50 m intervals between hooks, then the boat travelled 1050 m + 50 m = 1100 m. The length of line paid out was 1100 m + 2 x depth, or 1300 m. Therefore, the sagging rate equalled 1100 m/1300 m, or 0.85 (Fig. 5).

Once the sagging rate had been calculated, it could be used to adjust boat speed and line setter speed. In the above example, if line setter speed was 10 kt then boat speed was set at 8.5 kt – in order to eject ample line to get the line to settle as planned. Theoretically, if all parameters were followed, there shouldn't have been much sag in the fishing part of the line. It should have taken on a roughly rectangular shape with the fishing portion of the line lying parallel to the surface (as in the schematic diagram in Fig. 5). During trials, however, it was found that some sag still occurred between the lead weights. Therefore, the line actually fished at a variety of depths, but all below the target depth of the shallowest hook. The sag was probably caused by the weight of individual branchlines.

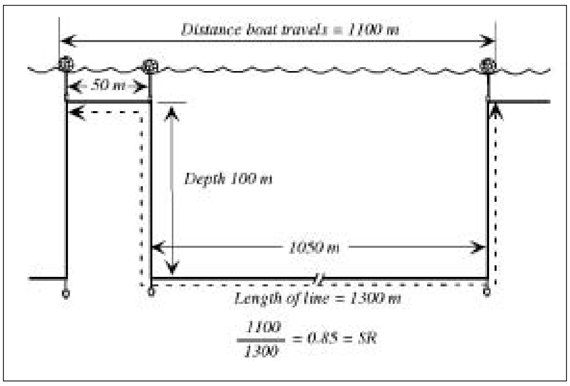

Figure 5: Calculating sagging rate for one basket using the deep setting technique

Standard longline snaps weigh 45 grams, and hooks weigh 15 grams each. These two components alone would add 1.2 kg to a 20-hook basket. If necessary, more sag could have been put into the fishing portion of the line by decreasing boat speed or by increasing the number of hooks in a basket, as with normal setting, and conversely, sag could have been reduced by increasing boat speed.

Fishing trials

Trip narrative: F/V Blue Moves

On 29 March, F/V *Blue Moves* got underway from Mooloolaba at 1715 hours, heading south. Between 30 March and 6 April, seven sets were made in coastal waters along the continental shelf around 29° S and 154° E. Each set consisted of 1000 hooks baited with *Illex* spp. squid with a light stick on every other branchline. Sets were made generally just on or after sunset and hauls were made the following day starting in the morning.

Fishing was generally terrible. A total of 7000 hooks yielded only 51 saleable fish (not counting numerous *Escolar* spp. that were retained but are of low value). The catch consisted of 14 yellowfin tuna, 2 bigeye tuna, 27 mahi mahi, 3 swordfish, and 5 albacore weighing approximately 1.5 metric tonnes.

Unfortunately, poor catches like this had been typical for the Mooloolaba fleet for the previous six months (see *Fisheries Newsletter # 108*).

On a more positive note, the new deep setting technique worked fine. Project baskets were set on three of the seven sets, two using the line setter and one without using the line setter. The boat's normal technique was to not use the line setter, but instead do a typical swordfish type set (shallow night set around the full moon using squid and lightsticks). Baskets had 12 hooks each. During the project sets, basket size was kept at 12 hooks but the setting sequence was changed for the deep set baskets. TDRs (Fig. 6) were attached at both ends and at the middle of each basket to monitor set depth, and were set to record every 10 minutes. TDRs were also put on some normal baskets for comparison.

Project results were generally good. Actual depths corresponded to target depths for the shallowest hooks of about 100 m on the sets using the line setter. The gear was somewhat cumbersome to set at first but hauling went without difficulty. In fact, the line came up very easily as it was made taut by the weights.

Results from the set using lead weights but no line setter showed that lead weights have almost no effect on sinking the mainline if there is no sag put into the line. The line initially sank to 45 m but came back up to normal depth of 25 m with the stretch and spring back of the line. Therefore, the deep setting technique did not work without using a line setter.

The trip on F/V *Blue Moves* was considered to be a shakedown cruise to work out any bugs in the deep setting technique. Some modifications were made to the gear after the first set. The lines on the lead weights were shortened to 0.5 m and the lines on the TDRs were shortened as well.

This made the setting sequence much easier on the third set. It was determined that 50 m between floats was sufficient to avoid tangles with the portions of mainline acting as floatline. Also, the technique of using the line setting timer to regulate depth was initiated.

Figure 6: Star-Oddi TDR (www.Star-Oddi.com)

Trip narrative: F/V Diamax

On 21 April, F/V *Diamax* got underway from Mooloolaba, heading northwest. After three days of travel, two sets were made around 18° S and 155° E without much luck. A decision was made to head south after the poor fishing in the north. A temperature break was identified using the on-board real-time altimetric charts from MaxSea (www.maxsea.com). The remaining five sets were carried out around 23° S and 156° E fishing between the 24°C and 25°C surface isotherms. Fishing improved a great deal so no further movements were made other than slight adjustments. On each set, 400 hooks in 20 hook baskets were set using lead weights while 600 hooks were set using normal gear configurations in 10 or 20 hook baskets. TDRs were put on both types of baskets. It was decided to keep the target depth of the shallowest hook at 100 m, knowing that the sag would place the middle of the baskets deeper. Sagging rate for the set was 0.85. Figure 7 is a schematic

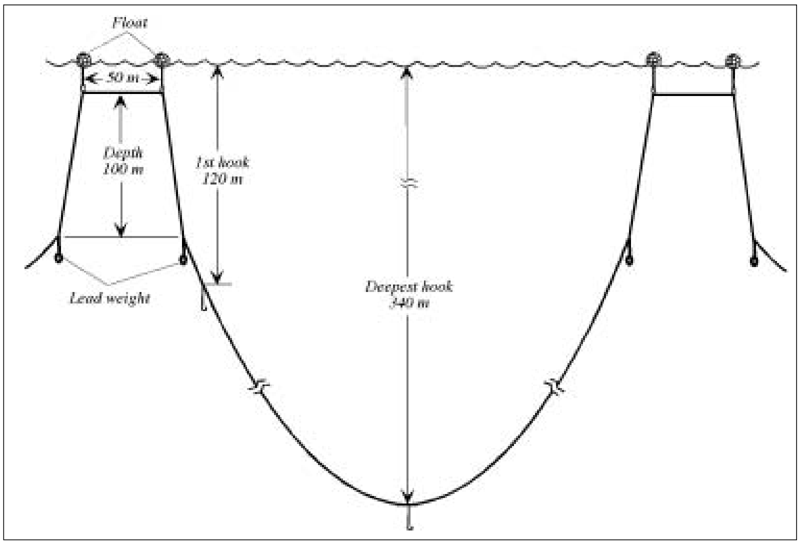

Figure 7: Diagram showing configuration of weighted gear with 20 hooks per basket and target depth for shallowest hook of 100 m using a sagging rate of 0.85.

of the theoretical shape of that basket.

A large swordfish (Fig. 8) was caught on the same set. Fortunately, there was a TDR attached adjacent to the branchline that was taken by the swordfish. The depth was 130 m and bite time was 17h15 for a daytime swordfish bite. The spike in the line was caused by the swordfish swimming away from the line, causing it to rise. The swordfish presumably died at midnight when the depth line went flat.

Several bigeye tuna (Fig. 9) were caught on the weighted gear. TDR data often showed spikes indicating depth and time of bite.

Fishing effort and catch on F/V **Diamax**

In the sets using project gear configurations, 6000 hooks were set, 2420 with lead weights and 3580 without lead weights. A total of 69 fish of the five main target species were caught (bigeye, yellowfin, albacore, swordfish, and striped marlin). The project gear caught 31 target species fish, weighing 1184 kg on 2420 hooks, giving nominal CPUEs of 1.3 fish per 100 hooks and 49 kg/100 hooks. The normal gear caught 38 target species fish, weighing 1452 kg on 3520 hooks, giving nominal CPUEs of 1.08 fish per 100 hooks and 41 kg/100 hooks. These CPUEs were based on average fish weights. Bigeye tuna, averaged 37.6 kg gilled and gutted (G&G). By observation, fish caught on the deeper weighted gear were generally bigger than fish caught on the shallower gear. This included a 90 kg (G&G) bigeye tuna and a 188 kg headed and gutted (H&G) broadbill swordfish. Project gear outfished the normal gear by about 17 per cent.

Figure 8 (top): Crew of F/V *Diamax* with 200 kg swordfish caught on a deep day set using the new deep setting technique.

Figure 9 (bottom): One hundred kg bigeye tuna caught with the new deep setting technique.

Further manipulation of the catch figures shows CPUEs for normal gear for bigeye tuna of 0.56 fish /100 hooks and 21 kg/100 hooks, while CPUEs for project gear for bigeye tuna were 0.95 fish /100 hooks and 36 kg/100 hooks. Therefore, project gear outfished normal gear for the main target species by 42 per cent. For swordfish, the normal gear had CPUEs of 0.3 fish/100 hooks and 17 kg/100 hooks. For the project gear swordfish CPUEs were 0.25 fish/100 hooks and 14 kg/100 hooks – about the same as with the normal gear. All of the swordfish caught on the project gear were caught at depths greater than 100 m and many were caught during daylight hours.

Discussion and conclusions

Most of the original design parameters of the deep setting technique were retained but others were changed, most during the trip on F/V *Blue Moves*, but some on F/V *Diamax*. It was found that 3 kg lead weights were sufficient to sink the fishing portion of the line down to the target depth of the shallowest hook. Lines for attaching the lead weights to the mainline only need to be about 0.5 metres long, and one standard longline snap was enough to keep the lead weights in place. Originally, the lines were 4 m long and had two snaps to keep them from sliding on the mainline. These proved to be too cumbersome, especially during setting. Floatline lengths of 10 m were sufficient and, in any case, had little effect on target depth of shallowest hooks, other than adding to the overall depth achieved by a small amount. Fifty metres was enough for the distance between the two floats at each end of a basket to keep the longer portions of mainline being used as supplemental floatline from tangling. These lines became entangled only once and that was when a large swordfish was hooked on the first hook in a basket and pulled the lines together. Two sizes of hard plastic longline floats were used during the trials – 300 mm floats with 14.5 kg buoyancy, and 360 mm floats with 20 kg buoyancy. The 300 mm floats proved to be sufficient to support the 3 kg lead weights and the longline. The setting timer proved to be very useful in regulating the distance between floats and lead weights (i.e. the target depth of the shallowest hook). The original expectation of the entire basket of branchlines fishing at or near the same depth was unrealistic and, in fact, was not realised. The fishing portion of the line suspended between the two lead weights hung in a sagging shape, similar to the sag normally encountered in longline fishing. This worked out to be advantageous as a range of depths could be fished, all below the target depth of the shallowest hook. In other words, nothing changed in the way the line fished except that everything was displaced 100 m downwards.

All original project objectives were met. The technique was perfected and proved to work almost flawlessly. Experienced longline fishermen should have little or no trouble adapting to the technique. Target depths were achieved so that all hooks fished below the mixed layer where bycatch encounters normally occur. The technique was simple enough so that it could be duplicated on almost any longline vessel using a monofilament system with a reel and line setter. Finally, target species CPUEs on F/V *Diamax*, compared with the normal portion of the sets, were enhanced or unchanged, depending on species and, although one short trip was not statistically significant, it may be considered to be indicative.

There were some drawbacks to the technique, however. More gear was needed to conduct the deep setting technique – additional floats and floatlines, lead weights with line and snaps, and more mainline. For a boat setting 1000 hooks in 20 hook baskets this would cost around AUD 4000. It could be cheaper if less expensive weights were used. More time was needed to set and haul the weighted gear. For example, if the target depth for the shallowest hooks was 100 m then 50 seconds more setting time was needed for each basket (providing that 10 seconds equalled 50 m of line being ejected from the line setter). A similar increase in time was needed for hauling. For a line totalling 1000 hooks with 20 hooks per basket, this would add 105 minutes to time spent on deck. Lastly, fewer yellowfin tuna and byproduct species were caught on the deep-set gear. Byproduct species add significantly to a longline vessel's revenue, but species such as mahi mahi, tend to bite during the haul so catch rates for these fish wouldn't be affected.

Results from the F/V *Diamax* were encouraging but were only indicative of the new deep setting technique's possibilities. No turtles were caught, but this was expected. Turtle encounters in the longline fishery are infrequent. What was shown, however, was that all hooks in a longline can be set in the zone outside of where turtle encounters normally occur. By inference, no turtles would have been caught unless they struck baits as the line was being set or hauled, or if they became entangled in floatlines. The same can be said for other shallow water bycatch species. The slight increase in nominal target species CPUEs using the deep setting technique as compared with normal setting during the trip on F/V *Diamax* was also only indicative of what might happen in the longer term. More work needs to be done to prove the efficacy of this new technique and to show that it can significantly mitigate encounters with turtles and other bycatch species while, at the same time, significantly increase the nominal CPUE of deep water target species, especially bigeye tuna. Work also needs to be done to ascertain if the deep setting technique will prove to be feasible for deep day swordfish sets. The 200 kg swordfish caught at 130 m at 1700 hours on F/V Diamax was astounding but was also only indicative.

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