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Performance assessment and performance improvement of two underwater line setting devices for avoidance of seabird interactions in pelagic longline fisheries.

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Summary

Two underwater setting devices, the chute and the capsule were trialled at sea. These trials were undertaken in waters off Tasmania in the presence of significant numbers of seabirds known to be vulnerable to longline fishing. Both devices adequately demonstrated their capacity to minimise seabird interactions during line setting in pelagic longline fishing. Both showed dramatically lower rates of baits taken in comparison to baited hooks set in the standard, manual, way. Most, or all, bait that were taken were the direct result of tangles on board the vessel.

The chute was developed to a stage where it is now ready for more widespread testing in the industry. When in use, over 98% of baits were successfully set, irrespective of bait type, and there were no tangles.

The capsule remains in need of further development. There continues to be problems with tangling, though this was reduced so that almost 99% of hooks are set successfully. This needs further development. Excluding those occasions when tangles occurred the capsule was capable of setting hooks at sufficient depth to avoid interactions with seabirds.

Introduction

Longline fishing is an important method, worldwide, for catching fish (Lokkeborg 1999). This fishing method is currently considered the most serious threat to the survival of albatross populations worldwide (Robertson and Gales 1998). Seabirds, particularly albatrosses and petrels, take bait from longlines as they are being set. If the birds swallow a baited hook or become entangled in the line they frequently drown.

In Australia the plight of seabirds from longline fishing has led to the development of a Threat Abatement Plan for the incidental catch (or by-catch) of seabirds during oceanic longline fishing operations (TAP) to minimise mortality (Environment Australia 1998). Other management agencies have also investigated similar processes (e.g. New Zealand government, Commission for the Conservation of Antarctic Marine Living Resources, Commission for the Conservation of Southern Bluefin Tuna, Food and Agriculture Organisation).

In New Zealand in 1995, the government and fishing industry agreed that underwater setting of baited hooks may have considerable potential for reducing seabird bycatch and so proposals were sought for the development of underwater setting devices. Two prototype devices were produced, a chute and a capsule (O'Toole & Molloy in press).

At a similar stage of development for both devices, the New Zealand fishing industry opted to have further development and testing of only one, the chute, continue. However, as considerable potential was recognised for successful development of the capsule device, a collaborative project involving the Department of Conservation (DOC) and MS Engineering in New Zealand and in Australia, the Tasmanian Parks and Wildlife Service with funding from the Fisheries Research and Development Corporation (FRDC), the Australian Fisheries Management Authority (AFMA) and Environment Australia (EA) evolved. So, with development completed in New Zealand on the capsule device and extensive testing at sea remaining, an agreement was reached whereby both devices were to undergo final testing and refinement in Australia.

Thylacine Tuna Fisheries generously provided the F/v Thylacine as a platform to test the devices between September 1999 and February 2000. This proved inadequate to surmount various obstacles identified in the initial testing. A delegation from the Australian Seafood Industry Council (ASIC) met with the Minister for Environment and Heritage in February 2000 and sought the Minister's support to conduct a six-month trial of underwater setting chutes and defer the commencement of the general seabird observer program as prescribed under the TAP. The Minister supported this initiative and asked that the TAP Team convene to examine the technical aspects of the proposal. The Team met in March 2000 and recommended that further testing and refining of the chute was needed prior to a broader trial commencing. AFMA (through the ARF) and EA continued to provide funding which permitted dedicated use of the vessel to evaluate specific aspects of the devices during normal fishing operations as well as to finalise features of chute design and installation for optimum performance. Contingent upon final development and successful testing of the chute, was to be a ten-vessel pilot program of chute use for a six-month period for seabird interaction assessment. It was anticipated that, on completion of testing the capsule could also be a viable underwater setting option for industry to consider using.

2. Material and Methods

2.1 The test vessel

The Thylacine is a 20m steel construction vessel operated by a captain and three crew. Specific aspects of this vessel relevant to device testing were that its normal line setting speed is about 5 knots, with a hook setting interval of 7 seconds, its aft line setting position (where the devices were mounted) is 1.2m above sea level, its wheelhouse is well aft.

Aside from attempting to have the devices perform satisfactorily within normal operation constraints of vessel speed and setting cycle times, the objective was to exceed these where possible. Hull height is a factor here that will also influence setting depth with the underwater setting devices. Wheelhouse position influences device deployment and retrieval options; all variations of vessel design needed to be considered.

2.2.1 The chute

Two chutes were used. One, based upon a prototype used successfully in New Zealand, built and supplied by the DOC, was not found to perform satisfactorily. This "slotted pipe" chute was constructed of stainless steel with a length of 7m. A second chute incorporating all features of the prototype that had been identified as essential to optimum performance was constructed. This chute subsequently underwent numerous modifications, some beneficial to optimum performance, some detrimental. It ultimately became 8m in length, having been initially trialled at 7m then 9m. Considering vessel hull height at which the chute was mounted on its multi-directional pivot bracket, at the setting speed of around 5 knots, chute angle into the water of 60^0 could be maintained. This put the lower end of the chute from which baits are ejected 4.3m underwater. This varied between 4.2m and 4.6m, depending upon sea conditions. Various methods of chute deployment and retrieval systems were trialled. A range of weights was tried in the chute's backbone. A more comprehensive description is given by Barnes & Walshe (1997).

2.2.2 The capsule

Unlike with the chute, baits set by capsule can be delivered to a pre-selected depth but this can be varied. This is achieved with a programmable winch drum from which the line attached to the capsule is fed. Cycle time is dependent upon the depth to which the capsule descends which, to match a hook setting interval of around 7 sec, permits setting to between 8m and 11m (the amount of line from drum to capsule). A more comprehensive description of the device is given by Brothers & Molloy (in press).

Strategies to reduce and preferably eliminate the problem encountered, of hook and line entanglement with the capsule were pursued.

2.3 Device Testing

Both devices were subjected to a variety of tests, however priority was placed on the chute because of the planned broader trial of the device. Testing was aimed specifically at measuring the capacity of the devices to achieve certain predictable expectations operators had of them. Achieving these requirements was also what provoked design modifications throughout the trials.

2.3.1 Bait retention on hooks during setting.

Two procedures were used to ascertain the rate of bait loss from hooks. The first involved deployment of the baited hook on its branch line (the 20m length of line that attaches each hook to the longline) with the underwater setting device and immediately recovering this once the hook had departed out of the device as the vessel proceeded ahead at its usual setting speed. Because this procedure may overestimate the rate with which baits are lost, (vessel setting speed is sufficient to pull baits free if the line onto which it is connected is not let go from the vessel) the following procedure was also used to assess bait loss rate: immediately upon having set a sample of baited hooks (main line included) these were hauled aboard again. Relatively small numbers of hooks (about 100) were set and hauled in this way to minimise the "soak" time and so reduce the likelihood of losing baits to fish. Also, when the lines and hooks were recovered this was done manually (not using hydraulic snood haulers) at slow vessel speed to prevent baits tearing from hooks.

Because different types of bait are widely used in longline fishing operations a variety of such baits were subjected to these tests: jack mackerel, slimy mackerel, redbait, squid and live bait* (jack mackerel).

* *Note the use of live bait in this instance does not pre-suppose the authors condoning of such practice.*

2.3.2 Setting Depth Deployment

The depth at which baited hooks could be deployed was known simply from chute length or capsule line length. These depths were verified using Wildlife Computers Mark 7 Time Depth Recorders (TDR). TDRs were attached to baited hooks. They record the depth every second to an accuracy of half a metre. To aid equilibration, they were placed into a bucket of seawater at least half an hour before setting. Their internal time clock was synchronised to the nearest second with a watch to best record the time of their deployment.

Of equal importance to setting depth was the sink rate performance of baited hooks after their deployment. This sinking performance post-deployment was further assessed against potential influences like propeller turbulence by changing the mounting position of devices (and so the position astern at which baits were deployed) across the vessel's stern. An expected outcome of this was also determining the optimum mounting position on a vessel.

Line Tangling

In all line setting and hauling operations continuous observations were made to record the frequency of and cause of line tangles.

Seabird Interactions

To determine the effectiveness of the devices in relation to seabird interactions, continuous observations were maintained throughout all line setting episodes. Records were kept noting:

- seabird species composition;
- their abundance and behaviour;
- each attempt by a bird to take a baited hook referenced to the distance astern of the vessel;
- whether the attempt was successful or not; and
- in which way was this achieved e.g. surface seize, surface dive, aerial plunge dive etc.

For each such event a correlation with an operational event (particularly relating to deficiencies of equipment or how it was being used) was sought. Maximising opportunities to identify deficiencies was achieved by conducting a proportion of line setting in daylight, when birds are likely to be more troublesome. Furthermore, bird abundance and foraging enthusiasm was heightened by discarding offal during line setting. A bird scaring line was not used during device testing (bird scaring line use is compulsory in the AFZ south of latitude 30° S. This exemption was authorised by means of a scientific permit issued by AFMA.

Every attempt was made to minimise bird mortality by halting line setting so that any hooked birds could be immediately recovered and hopefully released.

3. Results

3.1. Underwater setting chute

3.1.1 Retention of baits.

3.1.1.1 Bait retention (dead bait)

In the trial that involved bait setting only on a branchline that was immediately retrieved, two (1.10 %) of 181 baits were lost (Table 1). Both baits lost were redbait. Some of the jack mackerel used was too large for the chute (250g fish, a size not usually selected for baiting hooks). When 92 baited hooks, attached to the mainline, were set and immediately retrieved, four (4.3%) were lost (the first hook set was in the water for 66 minutes). Overall, in bait retention trials, over 98% of 273 bait remained on the hook at the time of recovery.

3.1.1.2 Bait retention (live bait)

Fifty-two live (two of which were sluggish when set) and four dead bait (these died between being caught and being set) were set during the live bait trial. Fifty (89%) were still on the hook when they were hauled (up to 70 minutes later) (Table 2). Of the 52 live ones, 46 were still alive when hauled (88%). Six baits were missing from the hook, and three were dead when hauled. We could not determine which of the missing and dead baits hauled were the dead baits set.

3.1.2 Setting performance

12,260 hooks have been observed set on 23 shots with the chute (Table 3). A number of modifications were made to the chute throughout the trials. These included changing the length, altering the shape to improve venturi performance and narrowing of the slot (for the branchline). Improvements were also made to the way baits were loaded into the chute. Twenty-five and 35 kg weights were tried in the back bone of the chute. Increased weights increased the setting depth, and kept the chute more stable in rougher sea conditions. These did not result in increased tangling.

3.1.2.1 Bird behaviour

The modifications made to the chute during the trials changed the effect of it on bird behaviour quite significantly. Thus on the first two cruises, while 3,246 hooks were set, eight birds were caught during line setting. On the final cruise, while 3,642 hooks were observed, no birds were caught on hooks. In addition, and more importantly, only one bait was observed to be taken and this was thought to have already come off the hook.

Table 4 summarises species counts made through each set and is evidence that not only were vulnerable species (refer Gales et al 1998 for species composition of bycatch) present, sufficient individuals were foraging in the region to have culminated in high rates of interactions had conventional setting methods been used.

A total of eight birds were caught during the development trials but none were in the last 61% of hooks set once design and operational deficiencies were rectified. Of the birds caught two were known to have died, with the fate of the remainder uncertain, as the extent of injury from being caught could not be ascertained accurately before release. Species composition along with the reason, if known, for capture is presented in Table 5.

3.1.2.2 Tangling

Several modifications were made to the setting chute during the period of this study to overcome problems with tangles (and associated bird problems). On cruise 2, it was noted that about 27% of baited hooks were coming out of the chute prematurely, and this was why a number of birds were caught and baits taken. Further problems that were observed on this cruise were that some bait became jammed in the slot at approximately water level. This was due to the branchline pulling the bait out into the slot at water level. Both of these problems were overcome by a combination of improvements to slot design, retaining brushes and operator use. A further problem was that any untimely delay clipping the branchline onto the mainline resulted in the baited hook being pulled to the surface. On cruise 3, this was observed to be occurring with approximately 12% of branchlines. This was overcome by coordinating bait release into the chute and branchline clipping to the mainline.

3.1.2.3 Setting depth

When used in the stern port quarter, the chute set baited hooks on average to 5.7m (n=27; s.d. = 1.6). When used in the centre, it set to 4.9m (n=4; s.d. = 1.1); when used with live bait, it set to 7.7m (n=3; s.d. = 0.3). No significant differences in mean setting depth were found between the positions, or the use of live bait ($F_{2,31} = 2.94$; $p=0.07$), though live bait were almost statistically set deeper than dead bait.

Capsule

3,550 hooks were observed set during five shots using the capsule during 1999, while during the current study a further 6,150 were observed set on ten shots (Table 6). So, a total of 9,700 hooks have been observed set using the capsule on 15 shots.

Performance

Bird behaviour

On all cruises where the capsule was used for line setting, birds were observed to have few interactions with the baited hooks, and these all resulted from tangling (see section 3.2.1.2). During two cruises in June no birds were observed caught, and nine baits were observed taken. At least five of these were a result of the branchline tangling with the capsule, two were the results of tangles in the snood box and one was the result of the fisher holding the line too long before attaching it to the mainline.

Table 7 summarises species observed and counts made every 15 minutes during setting using the capsule.

Tangling

Tangling was an as yet unsolved problem with this device. Most tangling resulted from the branchline forming a loose loop between the hook and the clip, with this loop drifting across the course of the capsule on its return to the vessel. The majority of tangles were the result of the branchline catching on the capsule as it returned, but a small number were a result of the hook catching on the ball (this 16kg lead weight is suspended 6m below the capsule and acts as a capsule control mechanism). The number of tangles may be reduced (but not eliminated) by the improved coordination between the release of the bait and clipping to the mainline. No operational benefit was obtained when the capsule was mounted at the stern centre; tangling rate is less if mainline deployment is kept as far as possible from the bait deployment position.

For the last two shots of the second cruise, the performance of a plastic coated lead ball was assessed. The plastic coating had the advantage of being smoother than the lead-only ball causing it to track in the wake more successfully (the ball and capsule showed less tendency to move into the centre of the vessel's wake). There also seemed to be less tangles when this ball was used (1.3 tangles/100 hooks).

Tangling rates increased when the setting speed increased to 6.5 knots (6.7 tangles/100 hooks) compared to 4.5 knots (4.3 tangles/100 hooks).

Setting depth

When used with an 11.5m rope to the capsule it set hooks, on average at 6.7m (n=15; s.d.=1.6). This was not significantly different from the depth at which hooks were set using the chute ($F_{1,45} = 3.00$; $p = 0.09$). When a shorter (8.0m) rope was used, the setting depth was 5.5m (n=2; s.d.=2.1). When the capsule was deployed at the centre of the stern with 11.5m of rope, the setting depth was on average 6.3m (n=3; s.d.=1.8).

Further measurements were taken with the device in different positions along the stern of the vessel, and with different capsule rope lengths (Table 8). When the capsule was moved along the stern of the vessel, there was no difference in average depth set ($F_{2,22}$ = 0.13; p = 0.88). There was no difference with the two tested rope lengths ($F_{1,22}$ = 1.80; p = 0.19).

Manual bait setting

A small number of baited hooks were deployed by conventional means, manually on the sea surface astern, instead of by capsule or chute. These baited hooks sank much more slowly than did the hooks released by capsule and chute (Figure 1). Thirty seconds after release, manually set hooks had still not got to the same depth as the capsule or chute set hooks (these manually released baits were only set when there was no danger of bird interactions).

Discussion.

Both underwater setting devices noticeably lowered bird activity in the area immediately behind the vessel by comparison to hooks set manually. When baits are set manually during the day there are frequently large numbers of birds immediately behind the vessel, with almost continuous diving attempts to get sinking baits. When the underwater setting devices were being used, there was little close attendance in the vessel's wake astern, and no diving attempts for baits. Comparatively smaller numbers of seabirds would attend the vessel by patrolling in the vicinity, including back and forth in the wake. Birds generally remained further astern roaming more widely.

On the final cruise during which the chute was used, one of 3,642 baits set was taken. Whilst it was suspected that this bait had already come off the hook when taken by the bird, this is a bait loss rate of 0.3 /1000 hooks. During two cruises using the capsule, nine of 6,150 hooks set were taken, a rate of 1.5 /1000 hooks. Of these, at least five were the direct result of a tangle between the capsule and a branchline, and one was the result of too long a delay clipping the branchline onto the mainline.

During 1988, while observing manual bait setting on Japanese longline vessels, Brothers (1991) found that baits were taken at the rate of at least 8.0 baits/1000 hooks. Therefore the rates that baits were taken by birds when the chute was in use was more than an order of magnitude lower, while that for the capsule was also much lower. In addition, most of the baits that were observed to be taken (six out of ten) by birds were the direct result of branchlines and baits being pulled back to the surface (and it is quite likely that the others were as well), and hence were the direct result of the equipment or its operators malfunctioning rather than the design of the machines. These results would indicate that these underwater setting devices could be expected to greatly reduce the catch rate of seabirds. The reduction will be assisted by operator familiarity.

The TAP (Environment Australia 1998) requires that effective seabird mitigation measures be mandatory for operators setting pelagic longlines south of latitude 30 South. AFMA is currently clearing a package of draft regulations through Agriculture, Fisheries and Forestry which, when enacted, will require these operators to set at night. Operators can seek exemption from night setting if they can demonstrate a device and/or method which ensures that seabirds are not at risk during line setting. The current study has shown that both devices are effective in lowering bird activity during line setting (and hence lowering the potential for seabird bycatch). Figure 2 graphically demonstrates the reason these devices are likely to be effective. When an unweighted or weighted branchline is thrown from the vessel's stern, it slowly sinks from the surface. A birdline on a typical domestic fishing boat offers protection to the baits for 14-23 seconds behind the vessel (Brothers and Reid in prep.). With an unweighted branchline, the baited hook would be expected to be 2.4-4.4m below the surface when beyond the protection of the bird line. At least some of these depths are within the reach of many species of seabirds commonly encountered behind longline vessels. Using weighted branchlines (e.g. 80g placed at the hook), the baited hook would be 4.2-6.9m below the surface. While this is probably going to be generally out of reach of diving seabirds, it is reliant on the birdline functioning adequately, and hence there is an increased likelihood of problems. In comparison, both underwater setting devices were setting hooks at 5.7-6.7m. At these depths, even with unweighted branchlines, the hooks are already below the depths at which most seabirds are apparently vulnerable.

From these analyses, it is clear that both underwater setting devices set baited hooks at a depth that makes them unavailable to seabirds, and hence should allow pelagic longline fishing to occur without any seabird problems. However, are they practical for commercial fishing operations?

The chute sets without tangles, and loses little bait in setting. Therefore for fishing operations it appears from these trials to be functioning at a level that should already be acceptable. The fishermen in this trial were very happy with the device, and considered it made fishing easier. It functioned well at the range of speeds that were tried. The Difficulties were initially encountered with the mechanics of was deploying and retrieving the chute. This has now been overcome and can now be done manually by three crew or by two with mechanical assistance. The difficulties encountered with this device when it was initially set up suggest some care needs to be used before peak performance will be obtained.

The capsule still requires some work to make it entirely suitable for fishing operations. There is one main area of difficulty remaining; that of tangling. During the two cruises a number of hooks were caught on the lead ball behind the capsule. Tangling was also found to increase as the speed of setting increased. When a plastic coated ball was used, no hooks caught on it, and there were reduced tangles generally. However, hooks continued to be caught on the capsule. More work to reduce catching points may significantly reduce tangling. Most tangling occurred when the wind or sea was coming toward the vessel from the starboard side. This tended to push a loop of the branchline over the returning capsule, and often the capsule would catch this. Swapping sides at which the capsule is operated may help overcome this cause of tangling. Assuming these problems can be overcome, the setting capsule has certain advantages over the chute in that it is more compact and versatile, giving greater flexibility with setting depths and times as well as minimal daily set-up for use procedures, and it is completely out of the way as soon as the last hook is set. Previous observations of bait retention in the capsule had found no bait loss from 200 hooks set (Brothers & Molloy, in press).

Conclusions

Two underwater setting devices, the capsule and the chute, were trialed and adequately demonstrated their capacity to minimise line setting seabird interactions for pelagic longline fishing. When in use there were few baits taken by seabirds. Most of those that were taken were the direct result of tangles on board the vessel, especially tangles in the snood bin.

The setting chute has been developed to a stage where it is ready for more widespread testing of its industry-wide suitability as a mitigation device. When in use there were no tangles as a result of its use, and over 98% of baits remained on hooks when set irrespective of bait types.

The capsule device remains in need of further development. Problems with tangling have not been overcome, though they have been reduced. There is a requirement for further work to get it into an acceptable state. Nevertheless, when it was being used it showed good success for setting hooks underwater at sufficient depth to avoid seabirds.

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	Weight placed in chute					
	25kg			35kg		
Bait type	Number of baits set	Number of bait lost	Percentage lost	Number of baits set	Number of bait lost	Percentage lost
Jack mackerel	49	0	0%			
Redbait	11	0	0%	53	2	4%
Squid	11	0	0%	57	0	0%

Table 1: Dead bait retention when using the chute
Numbers of baits of each type set during trials of retention of dead bait, plus numbers and percentage of baits that fell off the line during setting. Two different size weights used to change the angle of the chutes entry in the water.

Life status	Number of baits assigned to each life status category on hauling	Percentage by life status category
Alive & vigorous	38	68%
Alive & sluggish	7	13%
Lost on haul, status unknown	1	2%
Part eaten and dead	3	5%
Part eaten and alive	1	2%
Missing from hook	6	11%
Total	56	

Table 2: Live bait retention by the chute
Number and condition of live baits at time of hauling during trials of retention of live bait. At the time of setting, four bait were dead, and two were alive but sluggish.

Cruise	Date	Hooks set	Birds caught	Baits taken by birds (observed)	Tangles
1	16-Mar	500	0		20
	17-Mar	500	0		6
	17-Mar	121	1	4	6
2	26-Mar	275	0		1
	26-Mar	550	0	1	5
	27-Mar	600	5	~100	
	28-Mar	700	1		
3	07-Apr	500	0		
	09-Apr	300	0		
	10-Apr	700	1		
	11-Apr	500	0		
4	27-Apr	600	0		
	28-Apr	600	0		
5	08-May	350	0	0	0
	09-May	56	0	0	0
	10-May	770	0	0	0
	11-May	1000	0	0	0
6	03-Jun	800	0	1	1
	04-Jun	400	0	0	
	04-Jun	92	0	0	
	05-Jun	800	0	0	0
	07-Jun	800	0	0	0
	08-Jun	750	0	0	0

Table 3. Detail of cruises and dates of each shot when the chute was used: including detail of the number of hooks set, how many birds were caught during the set, number of baits taken from the hooks, and the number of tangles that were recorded.

Date	Species	Counts during line setting during chute trials (15 minute interval 500mX500m astern)						
16-Mar	Shy albatross	2	1	3	2	1		
	Black-browed albatross		1	1				
	Buller's albatross	1	1	2				
	Yellow-nosed albatross				1			
	Giant-petrel sp.		1	1				
	Short-tailed shearwater	3			1	4		
	Silver Gull		1	1				
17-Mar	Shy albatross	1	3	1	1	1		
	Black-browed albatross				4			
	Buller's albatross	1	10	7		1		
	White-chinned petrel	1	3		1	1		
	Short-tailed shearwater					1		
17-Mar	Shy albatross	32						
	Black-browed albatross	1						
	Buller's albatross	12						
	Short-tailed shearwater	7						
26-Mar	Shy albatross	3						
	White-chinned petrel	1						
27-Mar	Wandering albatross		1	5				
	Shy albatross	8	34	75				
	Buller's albatross		5	20				
28-Mar	Wandering albatross			1				
	Shy albatross		5	11	12			
	Black-browed albatross			2	1			
	Buller's albatross	1	3	8	4			
	White-chinned petrel	1		1	4			
	Short-tailed shearwater			1	8			
09-Apr	Wandering albatross					1		
	Shy albatross	19	5	2	3			
	Black-browed albatross					1		
	Buller's albatross				1			
	White-chinned petrel					1		
	Silver Gull	2						
10-Apr	Shy albatross	10	15	6	10	4	1	1
08-May	Wandering albatross	1						

	Shy albatross	4	5						
	Great-winged Petrel	1							
10-May	Royal albatross	1							
	Shy albatross	3							
	Black-browed albatross	1							
	Buller's albatross	1							
	Giant-petrel sp.	1							
11-May	Royal albatross				1				
	Shy albatross	1	15	4	5	6			
	Buller's albatross	1		3	2	1			
	Yellow-nosed albatross					1			
	Cape petrel			1	2				
	Great-winged Petrel					1			
	Fairy Prion					3			
03-Jun	Wandering albatross			1	2			1	1
	Shy albatross	4	3	12	19	1	4	7	4
	Black-browed albatross			1	1		1	1	
	Buller's albatross			1	2	1			
	Giant-petrel sp.	2		2	2	1			
	Cape petrel	1	1	2	2	1	4	2	2
	Crested Tern	2							
04-Jun	Shy albatross	8	7	5	1				
	Black-browed albatross	1							
	Buller's albatross	1							
	Giant-petrel sp.		1	2					
	Cape petrel	2	3	5	2				
	Great-winged Petrel	1							
	Australasian gannet			1					
05-Jun	Shy albatross	4	7	12	12	8	2	4	
	Black-browed albatross					1		1	
	Buller's albatross	1	1	2	1	3	1		
	Cape petrel				1	2		3	
	Sooty shearwater							1	

Table 4. Species and number of seabirds observed every 15 minutes in a 500mX500m area astern of the vessel during line setting using the chute.

Date	Species	Cause of capture	Fate	
			Died	Released alive
17-Mar	Shy albatross	Clip on delay		y
27-Mar	Shy albatross	Chute slot too wide	y	
27-Mar	Shy albatross	Chute slot too wide		y
27-Mar	Shy albatross	Chute slot too wide		y
27-Mar	Shy albatross	Chute slot too wide		y
27-Mar	Shy albatross	Chute slot too wide		y
28-Mar	Shy albatross	Chute slot too wide		y
10-Apr	Shy albatross	Not known	y	

Table 5. Seabirds caught during underwater setting device development and cause of their capture, and their fate after capture.

Cruise	Date	Hooks	Birds caught	Baits taken by birds	Tangles
1	14-Jun	800	0	1	28
	15-Jun	400	0	1	15
	16-Jun	400	0	2	13
	16-Jun	200	0	0	14
	18-Jun	650	0	0	50
	19-Jun	800	0	0	47
	20-Jun	800	0	0	48
2	28-Jun	800	0	0	53
	29-Jun	900	0	5	9
	30-Jun	400	0	0	8

Table 6. Detail of cruises and dates of each shot when the capsule was used: including detail of the number of hooks set, how many birds were caught during the set, number of baits taken from the hooks, and the number of tangles that were recorded.

Date	Species	Counts during line setting with the capsule (15 min interval 500 mX500m)					
14-Jun	Shy albatross	2	2	3	6	5	
	Black-browed albatross	1	2	2			
	Buller's albatross				1	3	
	Yellow-nosed albatross		1			1	
	Giant-petrel sp.		1	2		1	
	Cape petrel		1	1	1	1	
	Fairy prion		1				
	Grey petrel				1		
15-Jun	Royal albatross	2					
	Shy albatross	1	9				
	Black-browed albatross	1	1				
	Cape petrel	4	8				
	Great-winged petrel	2	1				
	White-headed petrel	1					
	Grey petrel	2					
16-Jun	Royal albatross				2		
	Shy albatross	4	3	19	50		
	Black-browed albatross				1		
	Buller's albatross			5	5		
	Yellow-nosed albatross			2	2		
	Giant-petrel sp.				1		
	Cape petrel		1	1			
	Fairy prion				5		
	Grey petrel				1		
	Sooty shearwater	1					
16-Jun	Shy albatross	10					
	Buller's albatross	1					
	Cape petrel	4					
	Crested tern	4					
18-Jun	Wandering albatross				1		
	Royal albatross				1		
	Shy albatross	9	11	16	7		
	Black-browed albatross	2	2	2	3		
	Yellow-nosed albatross		1	1			
	Giant-petrel sp.				1		
	Cape petrel	2	3	3	5		
	Great-winged petrel	1			1		
	Fairy prion				1		
19-Jun	Royal albatross			1	1	1	
	Shy albatross	8	12	5		3	1
	Black-browed albatross		1				1
	Buller's albatross	1	3		1		
	Yellow-nosed albatross			2			
	Giant-petrel sp.			1	1		
	Cape petrel		2			2	3
	Sooty shearwater				1		
	Australasian gannet				2		
20-Jun	Shy albatross	1	3	1			
	Black-browed albatross	1	1				
	Buller's albatross	4	1				
	Yellow-nosed albatross			1			
	Giant-petrel sp.			1			

	Cape petrel		1				
	Fairy prion		1				
28-Jun	Wandering albatross						1
	Royal albatross			1	2	1	2
	Shy albatross	1	4	15	2	3	2
	Black-browed albatross			1	2	1	1
	Yellow-nosed albatross				1	1	
	Giant-petrel sp.			2	3		1
	Cape petrel	1	2	2	7	4	7
	Great-winged petrel				1		
	Antarctic prion						1
	Grey petrel					1	1
29-Jun	Royal albatross	2	4	4	1	3	3
	Shy albatross	4	15	23	17	10	20
	Black-browed albatross			1		1	1
	Buller's albatross		1	2	2	2	1
	Yellow-nosed albatross					1	1
	Giant-petrel sp.			1	2	1	2
	Cape petrel			1	4	10	6
	Grey petrel	3					
	Fairy prion		1				

Table 7. Species and number of seabirds observed every 15 minutes in a 500mX500m area astern of the vessel during line setting using the capsule.

Capsule position	Rope length	N	Setting depth	Standard.deviation.
port	long	2	6.0	0.0
	short	4	3.0	1.4
centre	long	5	3.4	1.1
	short	6	5.2	2.0
starboard	long	5	5.0	3.3
	short	6	3.0	1.4

Table 8. Setting depths of baited hooks when using the capsule in different positions along the stern, and with different rope lengths (short=8.5m; long=11.6m). N is the number of sets for each position and rope length.

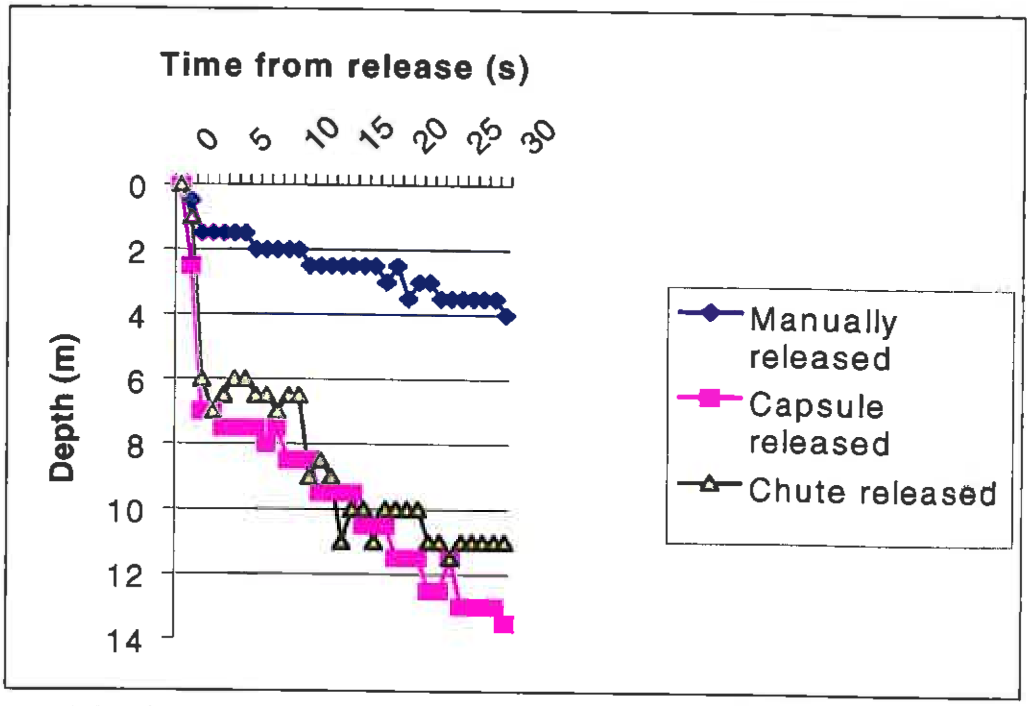

Figure 1. Typical sink depth performance of baited hooks using three setting methods over first 30 seconds from release (each line represents the depth every second for a TDR on a baited hook set in the manner given).

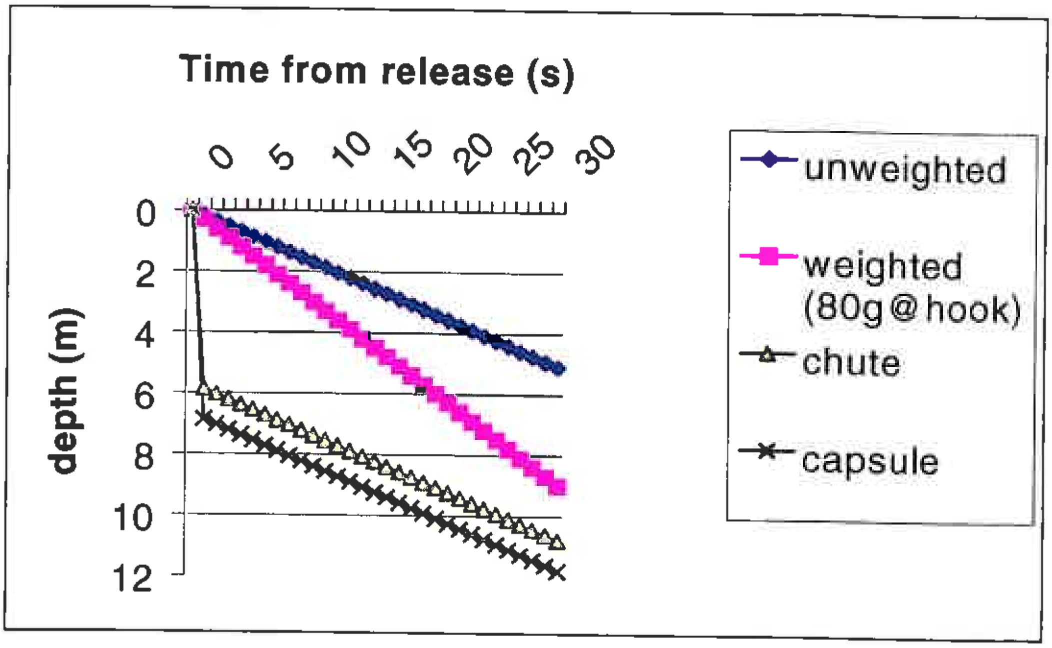

Figure 2. Comparison of the average sink performance of a range of baited hooks over first 30 seconds from release.

Unweighted hook is a average sink rate for a nylon monofilament line, using performance of 0.17 m/s (from Brothers and Reid, in prep). Weighted hook is that for a nylon monofilament line with an 80g weight at the hook (0.30 m/s). Chute and capsule use the average release depth found with the device placed in the port stern quarter, and then using the average sink rate for an unweighted nylon monofilament branchline.

Appendix. Dates and activities conducted using the 'Thylacine' during the testing of the chute and capsule (river trial means testing equipment in the Derwent River, sea trials are tests over open ocean).

Activity	**Device**	**Date**
River trial	Chute	03-February 2000
River trial	Chute	03-March 2000
Sea trial	Chute	16-March 2000
Sea trial	Chute	17-March 2000
Steaming	Chute	25-March 2000
Sea trial	Chute	26-March 2000
Sea trial	Chute	27-March 2000
Sea trial	Chute	28-March 2000
Steaming	Chute	06-April 2000
Sea trial	Chute	07-April 2000
Repair	Chute	08-April 2000
Sea trial	Chute	09-April 2000
Sea trial	Chute	10-April 2000
Sea trial	Chute	11-April 2000
River trial	Chute	19-April 2000
Steaming	Chute	26-April 2000
Sea trial	Chute	27-April 2000
Sea trial	Chute	28-April 2000
Sea trial	Chute	08-May 2000
Sea trial	Chute	09-May 2000
Sea trial	Chute	10-May 2000
Sea trial	Chute	11-May 2000
River trial	Chute	02-June 2000
Sea trial	Chute	03-June 2000
Sea trial	Chute	04-June 2000
Sea trial	Chute	05-June 2000
Steaming	Chute	06-June 2000
Sea trial	Chute	07-June 2000
Sea trial	Chute	08-June 2000
Steaming	Capsule	13-June 2000
Sea trial	Capsule	14-June 2000
Sea trial	Capsule	15-June 2000
Sea trial	Capsule	16-June 2000
Sea trial	Capsule	18-June 2000
Sea trial	Capsule	19-June 2000
Sea trial	Capsule	20-June 2000
Steaming	Capsule	27-June 2000
Sea trial	Capsule	28-June 2000
Sea trial	Capsule	29-June 2000
Sea trial	Capsule	30-June 2000
Total days		**40**