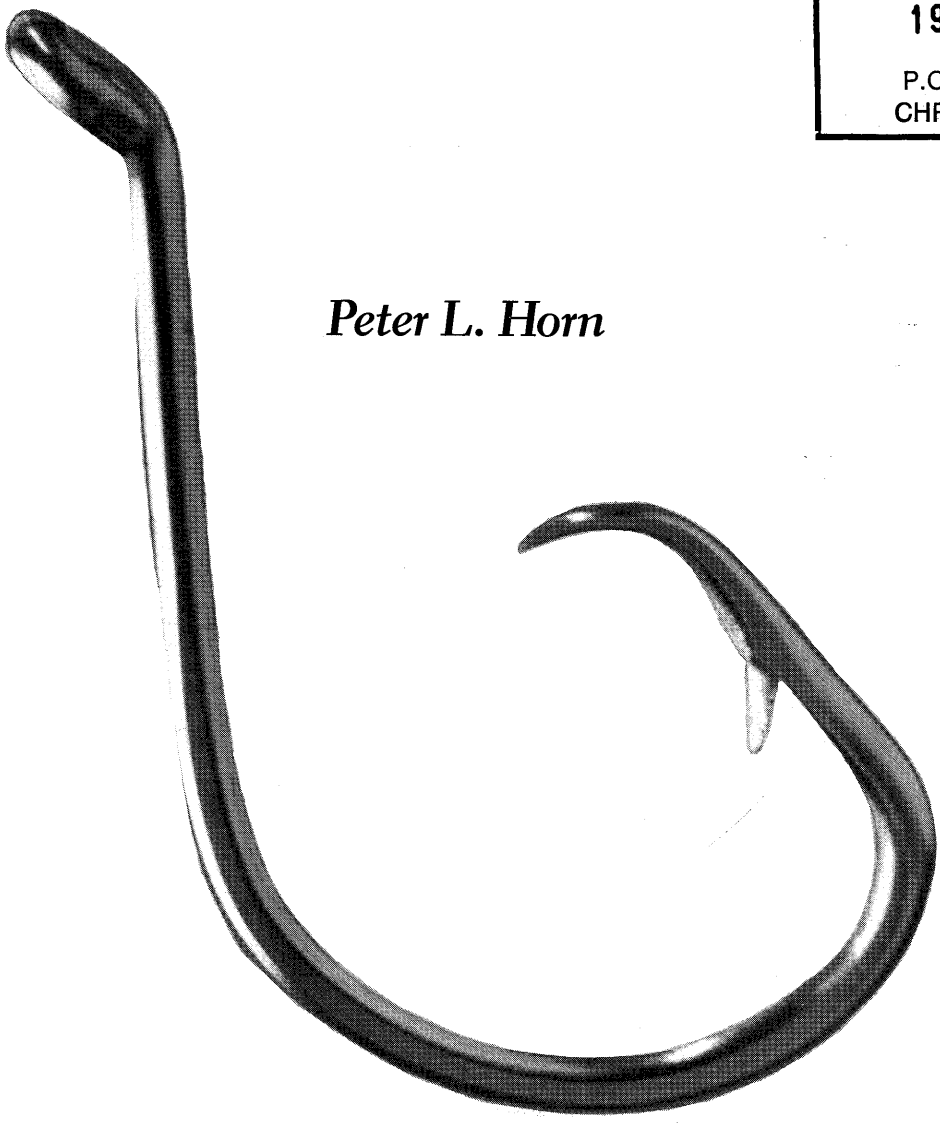
An evaluation of the technique of tagging alfonsino and bluenose with detachable hook tags



Peter L. Horn

New Zealand Fisheries Technical Report No. 16
ISSN 0113-2180
1989

MAF Fish

An evaluation of the technique of tagging alfonsino and bluenose with detachable hook tags

Peter L. Horn

New Zealand Fisheries
Technical Report No. 16
1989

Published by MAFFish
Wellington
1989

ISBN 0-477-08087-1

MAF Fish

MAFFish is the fisheries business group of the New Zealand Ministry of Agriculture and Fisheries. It was established on 1 April 1987 and combines the functions of the old Fisheries Research Division and Fisheries Management Division and the fisheries functions of the old Economics Division.

The *New Zealand Fisheries Technical Report* series in part continues the *Fisheries Research Division Occasional Publication* series. Conference proceedings and bibliographies will now be published in the *New Zealand Fisheries Occasional Publication* series.

Inquiries to:
The Editor,
Fisheries Research Centre,
P.O. Box 297,
Wellington,
New Zealand.

Edited by C. M. Coffey and G. G. Baird
Set in 10 on 11 Times

Contents

Abstract

Horn, P. L. 1989: An evaluation of the technique of tagging alfonsino and bluenose with detachable hook tags. *N.Z. Fisheries Technical Report No. 16.* 15 p.

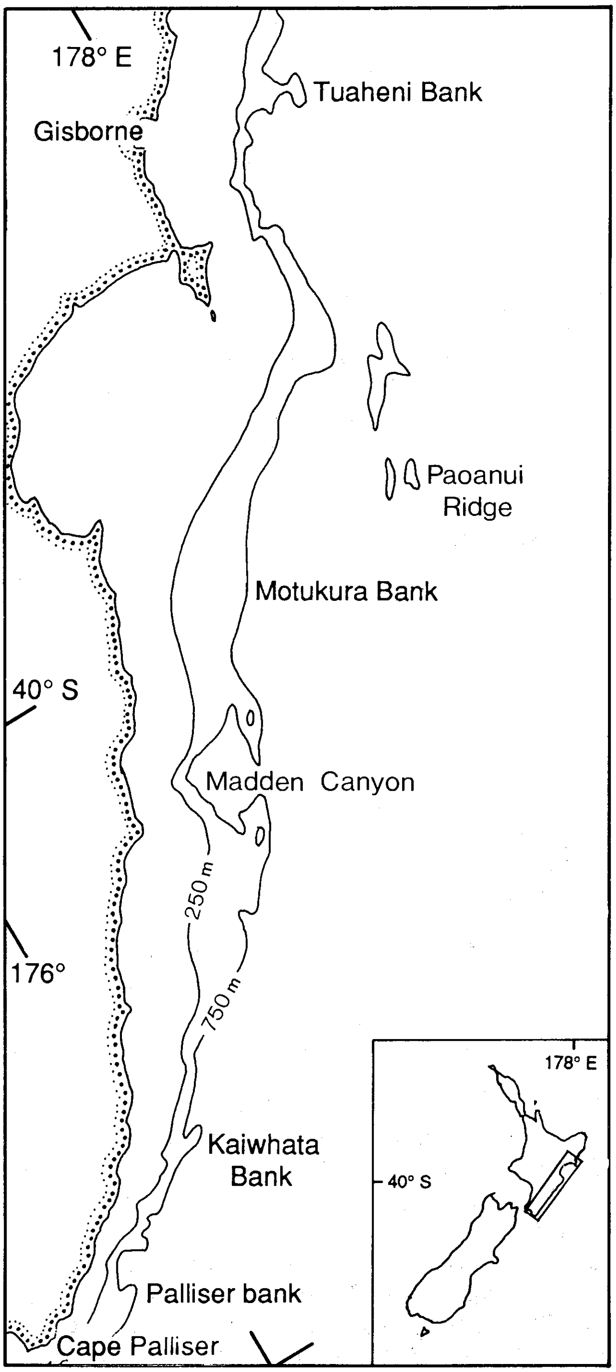
A description is given of a two-phase programme in which alfonsino (*Beryx splendens*) and bluenose (*Hyperoglyphe antarctica*) were tagged with streamers attached to fish hooks. A pilot study determined the most suitable gear configuration and tag design for use in the second phase. Fish were then tagged on six commercial alfonsino-bluenose fishing grounds between Gisborne and Cape Palliser. The tagged hooks were fished on trot lines in the usual way, but were attached to snoods with traces of 5.5 kg breaking strain nylon that broke when the fish took the hook and struggled to escape. About 2000 bluenose, but few alfonsino, were tagged. Tag returns up to 31 May 1989 show that bluenose are fairly sedentary in the short term. Possible applications and drawbacks of the technique are discussed.

Introduction

The midwater trawl fishery for alfonsino (*Beryx splendens*) and bluenose (*Hyperoglyphe antarctica*) developed in 1983 and has become one of the major fisheries in the Central (East) Fisheries Management Area. These species are now taken regularly from various banks and seamounts off the coast between Gisborne and Cape Palliser (Figure 1). Bluenose have been taken on lines for many years (Graham 1953). However, alfonsino have been consistently line-caught only since the mid 1980s when tarred fishing gear was replaced with monofilament nylon. The national catch of line-caught alfonsino has never exceeded 5 t annually.

Biological investigations have shown that alfonsino and bluenose probably migrate between grounds (Horn and Massey, in press). Length and age frequency distributions of both species varied between grounds, and there appeared to be seasonal changes in length frequency distributions on individual grounds. Age or size specific migration is probably the reason for the differing length frequency distributions. An investigation of the extent and direction of migration by alfonsino and bluenose would help determine any stock boundaries and possibly enable estimates of mortality to be made from age frequency distributions.

Alfonsino and bluenose are both moderately deepwater fish, generally found in 200–1000 and 100–600 m respectively. Tagging these fish at the surface means they experience sudden, and possibly fatal, changes in water temperature, light intensity, and, in particular, pressure. Landed bluenose often have overinflated swim bladders, everted stomachs, subcutaneous emphysema, and other internal injuries associated with a change in pressure. Alfonsino have open swim bladders, and they have been successfully surface-tagged in Japan from waters of 100–200 m (Ikenouye and Masuzawa 1967, 1968). However, in waters over 300 m off New Zealand, most alfonsino suffer a fatal shock in the short time taken to land, measure, tag, and return them to the water. Ikenouye and Masuzawa (1967) noted the importance of quickly measuring and tagging the fish. Thus, it is necessary to develop a method that enables alfonsino and bluenose to be tagged without removing them from their habitat.



Hook tagging

The use of tags on detachable hooks has been tested in at least two previous studies. Phillips (1968) attempted to tag Californian rockfish with plastic discs fastened with wire to detachable hooks. The only tag recovered was from a kelp bass at liberty for about 2 y. Grimes *et al.* (1983) used detachable hook tags in a study of tilefish off the east coast of the United States. Baited hooks with 30 cm tags of red vinyl tubing were attached to lines with light breaking strain snoods. It was assumed that a fish would take the bait and struggle to escape, hence breaking the snood and swimming away with the hook set in its mouth and the tag streaming alongside its body. Two hook types (circle and J-shaped) and three strengths of snoods (0.9, 1.8, and 2.7 kg breaking strain) were tested. Of the 384 tags lost, 7 were later recovered, all of which were on circle hooks.

Grimes *et al.* (1983) felt that breakable trace strength was crucial to this tagging method. Each trace must be strong enough to ensure that the hook is set firmly in the fish's mouth, but weak enough for the fish to break it. None of the tags set on 0.9 kg traces were returned, which suggests that these traces did not offer sufficient resistance to set the hook. The ideal trace strength would need to vary depending on the species being targeted.

During 1987, detachable hook tagging of alfonsino and bluenose was conducted in two phases. Initially, a pilot survey was carried out to refine the technique for this fishery by determining the best hook type, tag design, and breakable trace strength. Alfonsino and bluenose were then tagged on six fishing grounds between Gisborne and Cape Palliser. The aims of the second phase were to evaluate the effectiveness of this technique as a means of tagging alfonsino and bluenose, to assess the extent and direction of their migration, and to evaluate the possible applications of this technique to other fisheries.

Figure 1: The six grounds on the east coast North Island where the detachable tags were lost.

Pilot survey

Methods

The first phase of the programme was carried out in February-March 1987 from a chartered Napier-based line-fishing vessel, *Kotare*. Trot lines of 4–12 droppers were used, depending on the gear being tested and the ground being fished (Figure 2). The droppers were of braided nylon, about 30 m, and marked off at 0.9 m intervals. Thirty snoods (30–40 cm of either 20 or 33 kg nylon) were clipped to each dropper, one to each mark. Lines were usually set for about 3 h in the early morning and the early evening. Frozen squid was used as bait.

Hook selection. Large J-shaped hooks are usually used in the bluenose commercial fishery. However, in this study much smaller hooks were used to ensure the tagged fish could still feed. Four hook types were tested (Figure 3), and all were stainless steel, except the circle hook which was plated. All hook types were fished simultaneously, on droppers set in groups of 4 (one of each hook type per dropper), and with 4, 8, or 12 droppers placed randomly on each trot. Fishing was conducted on the Tuaheni Bank and the Paoanui Ridge. The fishing efficiencies (the proportion of fish caught to baited hooks set) of the four hook types were compared, and the number of foul-hooked fish was recorded. Data were gathered for 15 groups of 4 droppers.

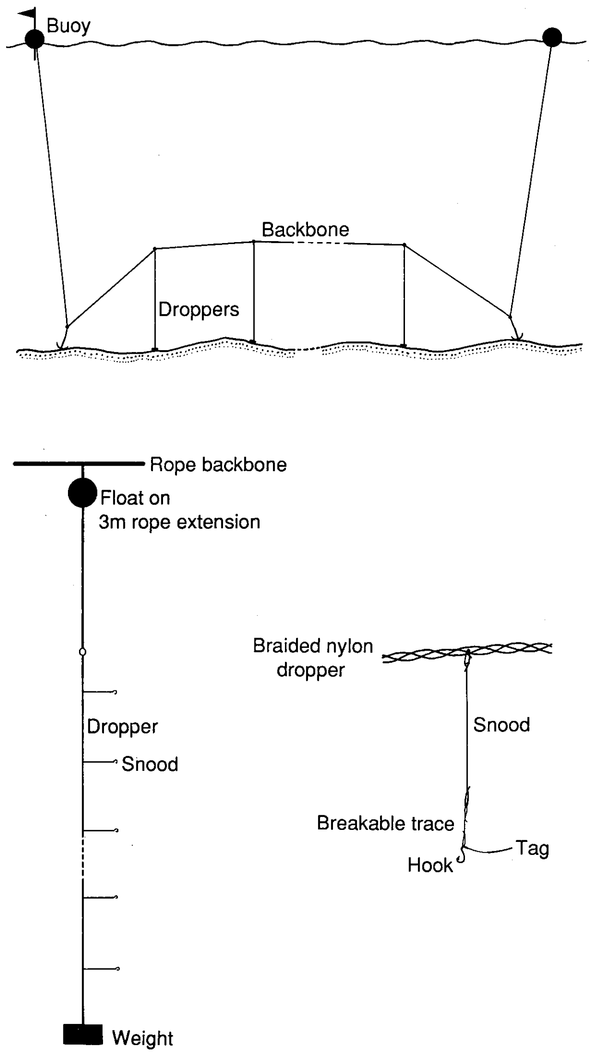


Figure 2: Fishing gear configuration used during the pilot survey and the detachable tagging survey.

Tag selection. The ideal tag for this programme needed to be highly visible against alfonsino and bluenose, yet have a minimal effect on the fishing efficiency of the gear. Yellow and green tags were compared because both contrasted well with fish colour. In addition, the effect on fishing success of having the tags 10 or 20 cm from the hooks was investigated; it was thought that tags too close to the bait could repel fish. The tags being tested were unlabelled streamers (85 mm long, 6 mm wide) of nylon-reinforced PVC, crimped to hooks (Mustad Beak 6/0) with a length of multistrand stainless steel wire (Figure 3). Four tag types were tested; green or yellow with a long or short wire. All tags were fished simultaneously, one tag type per dropper, with an experimental control (i.e., a dropper of Beak hooks without tags). The order of the droppers was random. Fishing was conducted on the Tuaheni Bank and the Motukura Bank. The fishing efficiencies of the hooks with each tag type were compared with the efficiency of the control line.

Trace selection. To examine different trace strengths, tagged circle hooks (Mustad Circle Tuna No. 9) were attached to snoods with 2, 3, or 4 kg nylon traces (one strength per dropper) and fished with a control dropper of similar hooks on full strength gear. The four-dropper trots were fished 16 times on the Tuaheni Bank, the Madden Canyon, and the Motukura Bank. All fish retained on the weak strength traces were noted, and the control droppers provided an indication of which fish were breaking the weak traces.

Additional tests were conducted to compare the effectiveness of 3.0, 4.0, and 5.5 kg traces to set hooks. A hook attached to a trace was placed loosely in the mouth of a fresh dead bluenose and jolted back with sufficient strength to break the trace and simulate a fish rapidly striking a bait. Twenty trials were conducted for each strength of nylon.

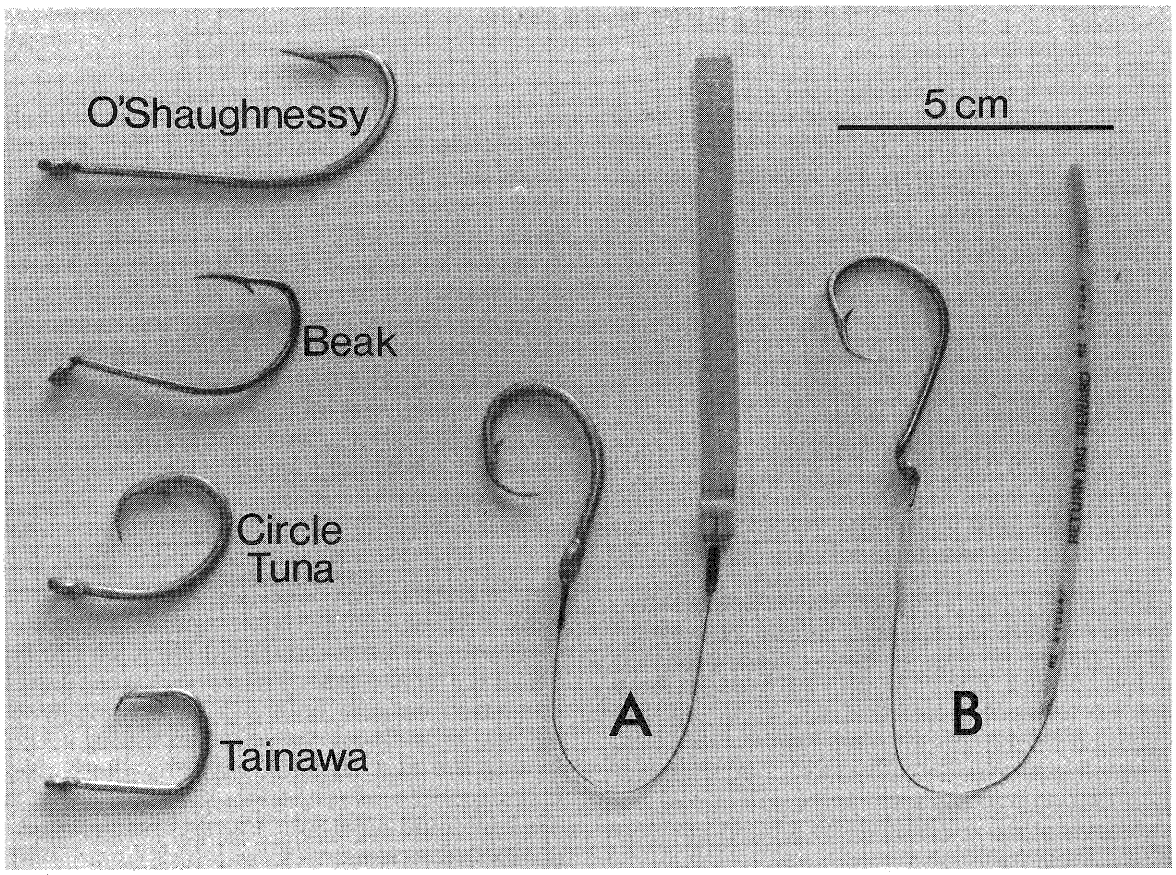


Figure 3: The four hook types which were compared for fishing efficiency. (A, the best hook and tag design as shown by the pilot survey; B, the hook and commercially made tag used in the detachable tagging survey.)

Results

Hook selection. A total of 597 fish were caught, and the fishing efficiencies of the four hook types were compared. The catch by hook type, and by fish size and species, showed that the Circle Tuna hook retained the most fish (Table 1), though fishing efficiencies varied substantially between replicates (Table 2). The Circle Tuna No. 9 hook was the most efficient of the four tested, particularly for fish shorter than 60 cm. For larger fish, the O'Shaughnessy 7/0 hook appeared to be marginally more effective. The Tainawa size 17 hook was the least efficient for bluenose fishing.

Most fish were hooked in the lip, particularly at the side of the mouth, or in the soft mouth lining just inside the lip. Foul-hookings did not often occur, and they were never recorded with the Tainawa or Circle Tuna hooks. Alfonsino appeared more likely to be throat-hooked than bluenose, though the sample size for alfonsino was small (Table 3).

Tag selection. The four tag types tested appeared to have little effect on fishing success, and no tag design was clearly superior (Table 4). The yellow tag on a 10 cm wire had a marginally higher fishing efficiency.

Trace selection. When the different breakable trace strengths were tested (Table 5), the catch on the control gear comprised 64 bluenose, 2 rubyfish (*Plagiogeneion rubiginosus*), 2 spiny dogfish (*Squalus acanthias*), 5 sea perch (*Helicolenus* sp.), and 6 lucifer dogfish (*Etmopterus lucifer*). No alfonsino were caught. Many hooks were detached from the breakable lines, though some small fish

Table 1: Catch by size and species* for the four hook types

		No. of fish caught					
			BNS		Other species		
Hook type	No. of hooks set	BYX	< 60 cm	≥ 60 cm	< 60 cm	≥ 60 cm	Total
O'Shaughnessy	450	11	58	68	4	2	143
Beak	450	15	71	53	4	1	144
Circle Tuna	447	22	104	55	18	3	202
Tainawa	443	12	58	31	5	2	108

* BYX, alfonsino; BNS, bluenose.

(sea perch and lucifer dogfish) were retained on this gear. Even small bluenose had no difficulty breaking the 4 kg trace.

Comparison of the effectiveness of different breakable trace strengths to set hooks in bluenose suggested that 3 and 4 kg traces are too weak for detachable tagging in the bluenose fishery (Table 6). This result was supported by the lack of returns of tags lost in the pilot survey (127, 110, and 79 tags on 2, 3, and 4 kg traces, respectively, were lost on grounds that have since been fished).

Discussion

The conclusion that circle hooks retain more fish than straight-shank (J-shaped) hooks is supported by articles in popular magazines (e.g., Anon. 1986, Buls 1987). The study by Grimes *et al.* (1983) showed that of the 158 J-shaped and 226 circle hooks with tags that were detached, all 7 of the tags returned were on circle hooks. In addition, though J-shaped hooks may be reasonably efficient when a fish is pulling against them, the tag will stream along the fish's body after the weak trace breaks, and the hook point could be rotated out of the flesh. Circle hooks are much harder to pull out. The retention of relatively more large fish by O'Shaughnessy 7/0 straight-shank hooks than by Circle Tuna No. 9 hooks may be explained by hook size; if larger circle hooks had been used, they may have been more efficient. Therefore, circle hooks were used for the detachable tagging study in the alfonsino-bluenose fishery.

Although foul-hooked bluenose were uncommon, alfonsino appeared to be susceptible to foul-hooking. Any fish foul-hooked externally with detachable hook tags may not be adversely affected, but if a fish is throat-hooked, its feeding would probably be impaired. Circle hooks were the most favourable hook type because no fish were foul-hooked with them in the hook comparison trials. There were some foul-hookings on control lines in the trace strength trials and in the main detachable tagging programme, but these data were not recorded. Susceptibility to foul-hooking appears to vary between species, and it may be related to feeding behaviour. Fish that strike hard at a bait are more likely to be lip-hooked, whereas those that attempt to gulp their food may be more susceptible to throat- or gut-hooking. Bluenose are probably in the former category and alfonsino in the latter. Foul-hooking may also be influenced by hook size relative to fish size, and by the degree of hardness of the mouth tissue.

Fishing efficiencies of all of the tested tag designs were similar. However, yellow appeared to be more visible against alfonsino and bluenose (and other fish) than green. In addition, the shorter

Table 2: Fishing efficiencies of the four hook types

Hook type	O'Shaughnessy 7/0	Beak 6/0	Circle Tuna No. 9	Tainawa size 17
	0.67	0.83	0.77	0.50
	0.30	0.40	0.63	0.30
	0.27	0.33	0.50	0.13
	0.07	0.10	0.47	0.27
	0.13	0.17	0.10	0.07
	0.60	0.63	0.50	0.37
	0.07	0.27	0.57	0.00
	0.60	0.33	0.17	0.30
	0.47	0.23	0.17	0.27
	0.37	0.27	0.33	0.27
	0.00	0.17	0.20	0.27
	0.13	0.10	0.67	0.40
	0.17	0.40	0.60	0.20
	0.47	0.23	0.63	0.10
	0.47	0.33	0.43	0.17
Mean	0.32	0.32	0.45	0.24

Table 3: Summary of foul-hooked* fish

Species	No. of fish caught	Throat hooked No.	Throat hooked %	Externally hooked No.	Externally hooked %
Alfonsino	40	3 (1B, 2O)	7.5	1 (1B)	2.5
Bluenose	293	6 (6B)	2.0	2 (1B, 1O)	0.7

* B, Beak; O, O'Shaughnessy.

Table 5: Percentages of traces broken, and numbers of fish retained, in trials to compare traces of three breaking strengths

		Fish retained	
Trace strength (kg)	% broken	Bluenose	Other species
Control (20 and 33)	1.9	64	15
4	17.4	0	4
3	23.1	0	4
2	28.2	0	3

Table 6: Comparison of the effectiveness of traces of different strengths to firmly set hooks in the mouths of fresh dead bluenose

Trace strength (kg)	No. of firmly set hooks*
3.0	2
4.0	16
5.5	20

* $n = 20$ for each trace strength.

Table 4: Fishing efficiencies by species* for the four tag designs and control gear

		No. of fish caught			Fishing efficiency	
Tag type	No. of hooks set	BNS	BYX	All species	BYX + BNS	All species
Control	351	58	7	73	0.19	0.21
Yellow 10 cm	352	56	5	65	0.17	0.19
Yellow 20 cm	355	54	1	59	0.15	0.17
Green 10 cm	354	38	10	61	0.14	0.17
Green 20 cm	356	50	5	60	0.15	0.17

* BNS, bluenose; BYX, alfonsino.

wire appeared to ensure the tag streamed out of the fish's mouth, and it was less likely to tangle or impede the movement of small fish than the longer wire. Therefore, the tag design chosen for detachable tagging work was yellow with a 10 cm wire.

Even small bluenose had no difficulty breaking the 4 kg trace, but the tests with dead fish suggested that this strength was inadequate to consistently set the hook. A strength of 5.5 kg did appear adequate. However, the intention to tag alfonsino and bluenose (which are very different in size) in the same survey complicated the choice of trace strength. It seemed unlikely that many alfonsino could break a 5.5 kg trace. It was resolved to use a 5.5 kg trace in the main tagging survey, but to set some tags on 3 kg traces in areas where many alfonsino were being retained on the breakable gear.

Detachable tagging survey

Methods

The second phase of the programme was carried out in August-October 1987 from a chartered Napier-based vessel, *Sir Allan McNab*. Target fishing was conducted on six commercial grounds for alfonsino and bluenose at depths of 300–600 m (*see* Figure 1). The aim was to lose at least 350 tags on each fishing ground (except the Kaiwhata Bank). On most grounds the trot lines from the pilot survey were used (*see* Figure 2). However, the Kaiwhata Bank could only be fished with drop lines because it was small and undulating. Generally, trots of 6 (or 12) droppers were fished, 5 (or 10) carrying detachable hook tags on 5.5 kg breakable traces, and 1 (or 2) carrying full strength gear (to show the composition of fish being tagged). Trots of other than 6 or 12 droppers were occasionally fished, depending on bottom topography and available gear, but at least 1 full strength dropper was fished with every trot. The gear was usually left to fish for about 3 h, from 0700 to 1000 and 1600 to 1900 New Zealand Standard Time.

Tag and hook design. Results from the pilot study showed that circle hooks should be used. Unfortunately, at the time of this study, no hook manufacturers made circle hooks in stainless steel; all used plated metals. Plated hooks are unsuitable for detachable tagging because they would eventually rust and possibly cause infection in the fish. (Two Mustad circle hooks kept in sea water for 6 months had suffered substantial loss of plating and had corroded down to 80% of their original thickness in parts.) Hook manufacturers were prepared to make a special batch of stainless steel circle hooks, but costs were prohibitive (e.g., about NZ$600 per 1000 hooks, with a minimum order of 20 000).

Mustad Beak 6/0 hooks could be transformed into reasonable replicates of Circle Tuna No. 9 hooks by further bending the shank around a metal rod and turning the point inward with curved pliers. Hooks modified in this way were used in the detachable tagging survey.

Commercially made yellow tubular polythene tags, labelled and numbered consecutively, were attached to hooks by a 10 cm length of malleable stainless steel wire. The decision to use tubular polythene, rather than flat PVC tags, and solid stainless steel, rather than multistrand stainless steel wire, was made after consulting a fish tag manufacturer on the likely resistence of these materials to corrosion and prolonged exposure to sea water (Figure 3).

Results

Species caught. Between 347 and 496 tags were lost on each of the four main alfonsino grounds (Palliser bank, Motukura Bank, Paoanui Ridge, Tuaheni Bank), and 323 and 30 tags were lost at the Madden Canyon and the Kaiwhata Bank respectively. In total, 313 fish (260 of which were bluenose) were caught on control lines. The rest of the catch comprised commercial and non-commercial species, including 10 alfonsino (Table 7). In addition, fish that had not broken the 5.5 kg traces were often landed. They were generally small non-commercial species, e.g., sea perch, and several species of dogfish. However, larger fish were also retained at times, and they included dogfish up to 92 cm, 2 small bluenose, and 13 southern boarfish (*Pseudopentaceros richardsoni*).

The control line catch from each set was used to estimate the composition of fish that were being tagged in the same set. Some species taken on the control lines were not thought capable of breaking the 5.5 kg traces and, consequently, were not considered tagged. These species are given in Table 7. Therefore, in a set that produced a control catch of 19 bluenose, 1 alfonsino, and 4 sea perch, 95% of tags lost were assumed to have been taken by bluenose and 5% by alfonsino. Table 8 gives the estimated composition of fish tagged on each ground.

Recaptures. Tagged fish were caught as soon as a week after tagging. By 31 May 1989, 47 (2.2%) of the 2122 tags lost had been returned; 40 from

Table 7: Fish landed during the detachable tagging survey on control lines and detachable hook lines

Species	No. (and size*) of fish landed			
	Control lines		Detachable lines	
Bluenose (*Hyperoglyphe antarctica*)	260	(47–79)	2	(49, 51)
Alfonsino (*Beryx splendens*)	10	(28–46)	1	(29)
Southern boarfish† (*Pseudopentaceros richardsoni*)	9	(44–47)	13	(44–54)
Sea perch† (*Helicolenus* sp.)	9	(all < 20)	43	(all < 20)
Bass (*Polyprion americanus*)	4	(65–75)	0	
Ling (*Genypterus blacodes*)	3	(81–102)	0	
Swollenheaded conger (*Bassanago bulbiceps*)	3	(90–98)	0	
Lucifer dogfish† (*Etmopterus lucifer*)	3		17	
Hapuku (*Polyprion oxygeneios*)	2	(62, 79)	0	
Gemfish (*Rexea solandri*)	2	(73, 75)	0	
Northern spiny dogfish† (*Squalus mitsukurii*)	2	(74, 80)	1	(82)
Spiny dogfish† (*Squalus acanthias*)	2		6	(56–83)
Smooth skate (*Raja innominata*)	1		0	
School shark (*Galeorhinus galeus*)	1	(120)	0	
Shovelnosed dogfish† (*Deania calceus*)	1	(92)	1	(92)
Hagfish† (*Eptatretus cirrhatus*)	1		4	
Ribaldo† (*Mora moro*)	0		2	(40, 50)
Rattail† (*Coelorinchus* sp.)	0		1	
Cucumber fish† (*Chlorophthalmus nigripinnis*)	0		2	

* Size range of fish caught (cm).
† Species not thought capable of breaking the 5.5 kg trace.

Table 8: Estimated numbers of fish tagged in each fishing ground, based on the observed catch from the control lines

	Tuaheni Bank	Paoanui Ridge	Motukura Bank	Madden Canyon	Kaiwhata Bank	Palliser bank
Bluenose	462	462	394	323	30	306
Alfonsino	–	28	7	–	4	24
Bass	23	–	–	–	–	–
Hapuku	4	–	–	–	–	7
Ling	–	6	–	8	–	5
Gemfish	–	–	–	11	–	5
Northern dogfish	–	–	–	2	–	–
Smooth skate	–	–	–	3	–	–
Conger	6	–	–	–	2	–

bluenose (45–85 cm) (Figure 4), 2 from alfonsino (27 and 44 cm), and 1 from a sea perch (42 cm). Four detached tags were found hooked in the codend mesh of midwater trawlnets, presumably having been torn from the fish as they entered the net or as they were tipped from the codend. Of the 47 tags, 42 were recovered from the grounds on which they were set. One hook (from a bluenose) had lost its streamer, so its place of release was unknown. Four bluenose had moved from the grounds on which they were tagged. The greatest movements were from the Madden Canyon to White Island, about 490 km in 137 days, and from the Paoanui Ridge to the Conway rise, about 450 km in 231 days. None of the alfonsino or the sea perch had moved from where they were tagged.

Thirty-five of the returned tags were discovered at sea by crew on commercial trawlers, and three were recovered by commercial line fishers. Nine tags were found during the processing of trawl landings. Fishing crew members who found tags commented that they were easy to see. The tagged fish I saw were in good physical condition, though all of them had been tagged for less than a month. Tags were attached to the lip (most frequently at the corner of the mouth) in all bluenose seen. The sea perch and large alfonsino were also tagged at the corner of the mouth, but the small alfonsino was throat-hooked. It was in good condition because it had been tagged for only a week, and the food in its stomach showed that it was still able to feed.

Discussion

Bluenose can be successfully tagged with detachable hooks on 5.5 kg breakable traces. Alfonsino can also be tagged with this gear, but there are problems in tagging sufficient numbers of this species. Experimental fishing with different bait, and at different times and depths, may show whether alfonsino can be more effectively targeted. The capture of tagged fish by trawling can also cause problems because the tags can be ripped from the fish's mouth when it is crushed in the codend. There is no apparent solution to this problem.

Patterns of migration are not yet apparent, but most bluenose appear fairly sedentary in the short term (6–8 months). However, these fish are capable of long and fairly rapid migrations.

No fish have yet been caught carrying more than one tag, though this was expected to occur. It was thought that the attraction of the food (the detachable baits were only 0.9 m apart) would

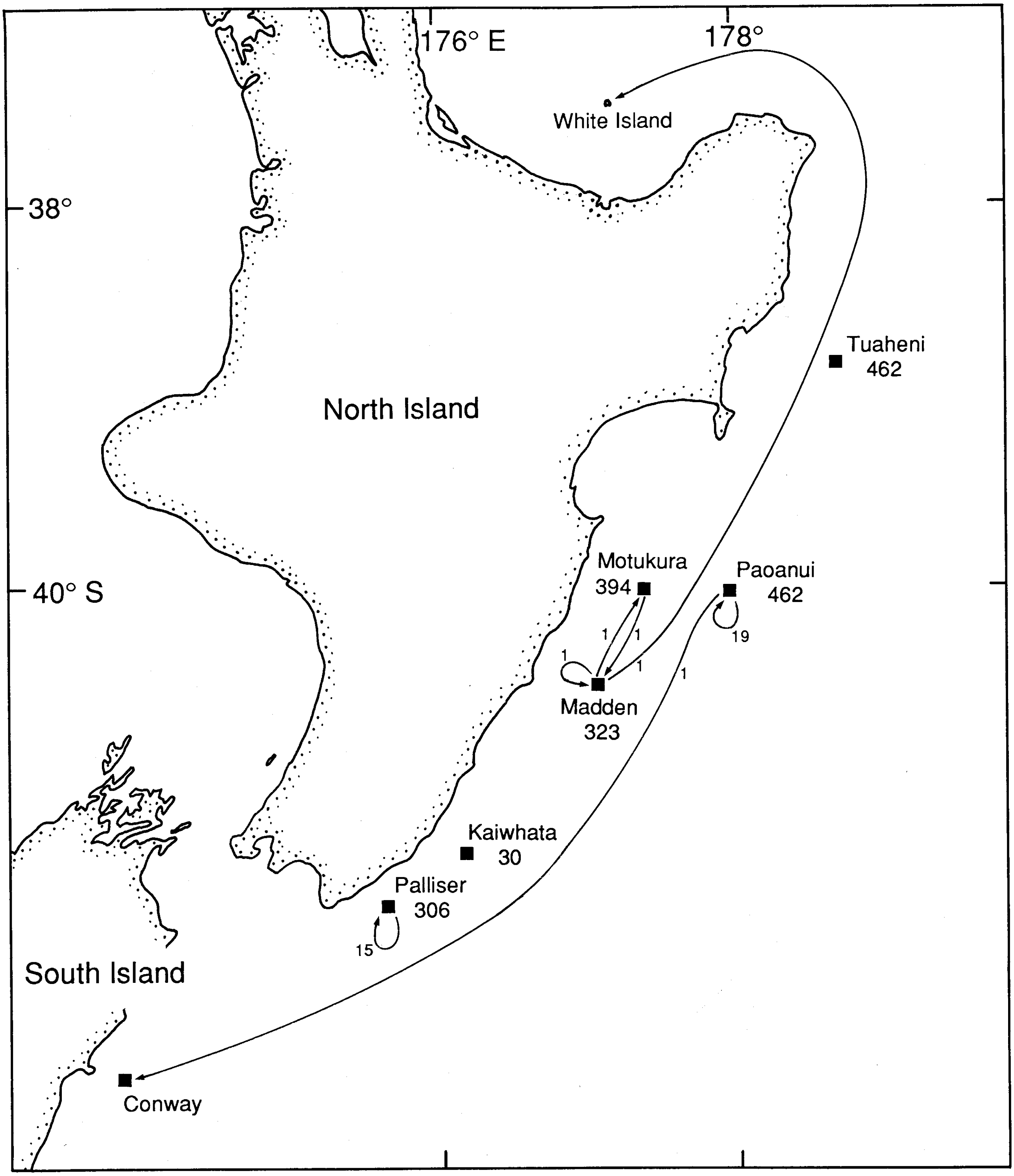


Figure 4: Distribution and movement of recaptured tagged bluenose as at 31 May 1989. (The estimated number of bluenose tagged is shown for each ground (large numbers); place of capture and numbers of recovered tagged fish are shown by arrows and small numbers.)

probably override any discomfort the fish had due to the hook. However, during the detachable tagging survey, only 3 of the 260 bluenose caught on control lines had tags. (These fish could have taken the tag and control hook in the same set by swimming from a trot of detachable gear to a control trot, or they could have taken the control hook in a different set up to 2 days after taking the tag.) Nevertheless, the capture of three fish with tags on control lines suggests that some fish should have more than one tag.

The Palliser bank and the Paoanui Ridge were commercially target fished for alfonsino and bluenose in the month immediately after tagging on these grounds. Tentative estimates of the biomass of bluenose on these grounds can be made if it is assumed that: the estimated numbers of fish tagged are equal to the actual values (*see* Table 8), tagged fish were evenly distributed over the grounds, there was no mortality due to tagging, no fish had migrated to or from these grounds, and the tags found in the gear were from bluenose. On the Palliser bank, 4 tags out of the 306 lost were recovered from bluenose landings of about 36 t, which gives an estimated available biomass of about 2800 t. On the Paoanui Ridge, about 63 t of bluenose yielded 21 of the 462 tags lost, which gives an estimated biomass of about 1300 t. However, these estimates are probably higher than the actual biomass values. The populations on both grounds are unlikely to have remained static for a month after tagging. Some tag loss at the time of setting, and subsequently, would have probably occurred, and some fish may have more than one tag. Therefore, the actual level of exploitation is probably higher, and the biomass lower, than the values given. These examples demonstrate the possibilities and pitfalls of estimating biomass from detachable tag return data.

Technique evaluation

Detachable hook tagging as described here appears to be an effective method of tagging bluenose without removing them from their habitat. It is definitely useful as a means of determining stock boundaries and movement patterns, and it may be used to provide tentative estimates of stock size. This technique may also be useful over fairly long periods. Hook-tagged fish have been recaptured 1.6 y (Grimes *et al.* 1983) and about 2 y (Phillips 1968) after tagging. The longest period at liberty for a recaptured fish tagged in this study was 410 days.

This tagging technique could be successfully applied to other species, given certain provisos. Most importantly, the species must readily take a hook, and it should be susceptible to target fishing. Tagging fish from single species fisheries, or tagging the primary species of a multispecies fishery, should not pose many problems. However, successful target fishing for a secondary species in a multispecies fishery (e.g., alfonsino) could be difficult. The successfulness of any detachable tagging survey could be increased by examining landing statistics to determine seasonal and areal concentrations and by consulting with fishers to establish the best bait, gear configuration, and times and places to set the gear.

It is also essential to establish the most suitable breakable trace strength for each tagging programme. This could be done quickly before a survey by fishing with a variety of trace strengths. The use of a "lazy line" around the breakable traces (Figure 5) would enable the sizes and species of fish which can and can not break each strength of trace to be determined. This method was not tested. (The method of trace selection used in the pilot survey showed only which fish could not break the weak trace.)

The ideal breakable trace strength appears to vary greatly between species, even for fish of similar size. Alfonsino as small as 27 cm, and sea perch as small as 42 cm, can break a 5.5 kg trace, but southern boarfish ranging from 44 to 54 cm, and various species of dogfish up to 92 cm, can not break traces of this strength. A steady pull of about 4.7 kg was needed to break the knotted traces of 5.5 kg nylon. It is unlikely that a 27 cm alfonsino weighing about 0.4 kg could exert such a force, and it is difficult to imagine why a boarfish weighing about 3.5 kg could not break the trace. Fish behaviour probably accounts for these differences. When caught, alfonsino and bluenose spin about their anterior-posterior axes and tightly twist the snood. The presence of some "empty" twisted snoods suggests that they sometimes escape by this means. Tests showed that a 5.5 kg trace experiencing a steady pull of only 0.25 kg would break after less than 100 twists. This was probably the mechanism used by alfonsino to break the traces. In comparison, southern boarfish were sluggish when landed and did not appear to have twisted the snood. Their reaction to capture may be the eversion of their large dorsal and anal spines, rather than twisting or struggling violently.

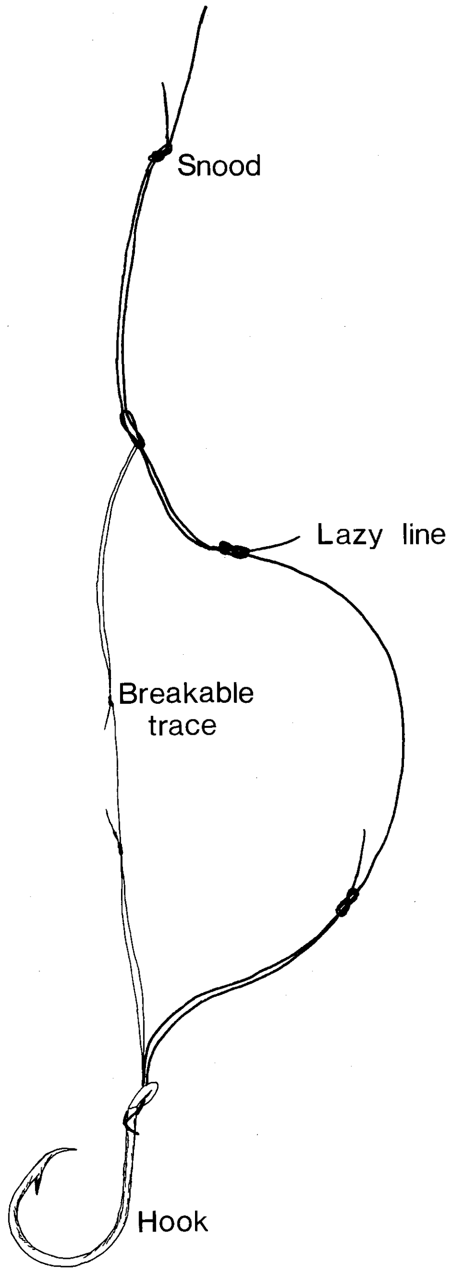


Figure 5: Snood and breakable trace with full strength lazy line. (Fish capable of breaking the weak trace are still retained on this gear.)

The detachable tagging technique could be used to tag species which can not be successfully surface tagged. In this study it was used to tag bluenose, a moderately deepwater species that suffers serious physiological complications when brought to the surface. Ling and hapuku, which suffer similar complications when landed, could also be tagged in this way because they can be target fished by line.

Commercial deepwater species are usually caught by trawl, but some are known to take baited hooks (e.g., cardinal fish, oreos, alfonsino). Orange roughy were not line-caught, but their diet (primarily bioluminescent crustacea, fish, and squid) suggests that it is possible that they would take a bait. It is not known how orange roughy detect their prey, but if movement is the primary stimulus, then dead bait on static lines may not be successful. Trials using live bait (myctophids or small squid), luminescent bait (small cyalume capsules attached to bait), or moving bait (deepwater trolling) could be done to try to find a successful method. Orange roughy have been found in feeding and non-feeding aggregations, apparently depending on reproduction and location, so it would be important to conduct line trials on the feeding aggregations.

Detachable hooks could also be used to tag delicate fish which can suffer serious external damage when they are caught or handled, e.g., hoki and barracouta. Both of these species will take a baited hook and could be targeted at times and in places where they congregate. However, the recovery of tags from hoki taken by bulk fishing methods, particularly by surimi vessels, may be minimal.

Tagged detachable hooks could possibly be used as a way to introduce oxytetracycline via ingested baits, so that age validation data could be obtained. However, some difficulties are likely to be encountered with this technique. Oxytetracycline could leach out of the baits, or the bait could fall from the hook and not be swallowed. It would also be impossible to tailor dosages of oxytetracycline to fish size.

Collection of data on tagged fish taken by bulk fishing methods could be difficult. Hook tags could be dislodged from fish when they enter the net or are tipped from the codend. This would not be a great problem when fishing in a single species fishery, but there is no way of being certain which species a tag was lost from in a multispecies fishery. Tags dislodged in the codend could also fall from the net and never be discovered.

As the major use of detachable tagging appears to be in studies of fish movement, it is essential that the place of capture be recorded for all tagged fish. The problem of tagged fish being overlooked can be minimised by ensuring that all skippers and crews on vessels in the fishery are aware of the possible occurrence of tagged fish, know what information is required from each tag, and are encouraged to look for tags. Prompt feedback with information on any returned tags is a good way to develop interest in the tagging programme and to ensure the search for, and return of, more tags.

Conclusions

Detachable hook tagging appears to be an effective way to tag bluenose. However, the durability of this tagging method has yet to be proven. Detachable tagging has applications in studies of migration and movement. Estimates of stock size could be calculated from tag return data, but they would be tentative because of the unknown composition of tagged fish and the unknown extent of tag loss and mortality due to tagging. This method is applicable to species other than bluenose, and it could be useful in tagging deepwater or delicate fish. However, any species to be tagged in this way must be able to be caught by hook and line, and be easily targeted. A suitable breakable trace strength would have to be determined for each species.

Acknowledgments

I thank Ian Heays (who skippered the FV *Kotare* and the FV *Sir Allan McNab*) and Fuzzy Smith whose experience and ability ensured that we caught and tagged fish. I am particularly grateful to Ian for buying a new boat before we started the second survey. Craig Petherick, Brendon Massey, and Michael Stevenson assisted with field work. Michael Hall (Hallprint Pty. Ltd., South Australia) provided advice on tag materials. The efforts of people involved in the alfonsino-bluenose fishery who returned tags is also acknowledged. Larry Paul and Bob Gauldie of Fisheries Research Centre, and several members of the MAFFish Central Region science group, reviewed and greatly enhanced an earlier draft of this paper.

References

Anon. 1986: Circle hook success. *World Fishing 35 (12)*: 20.

Buls, B. 1987: Mustad's E-Z Baiter circle hook makes automatic baiting possible. *National Fisherman 67 (9)*: 40.

Graham, D. H. 1953: "A treasury of New Zealand fishes". A. H. and A. W. Reed, Wellington. 404 p.

Grimes, C. B., Turner, S. C., and Able, K. W. 1983: A technique for tagging deepwater fish. *Fishery Bulletin 81*: 663–666.

Horn, P. L. and Massey, B. R. (in press): Biology and abundance of alfonsino (*Beryx splendens*) and bluenose (*Hyperoglyphe antarctica*) from the lower east coast North Island, New Zealand. *N.Z. Fisheries Technical Report No. 15.*

Ikenouye, H. and Masuzawa, H. 1967: A study on effect of tagging on weight-length relationship of the Japanese alfonsin, *Beryx splendens* Lowe. *Journal of the Tokyo University of Fisheries 54*: 35–42.

Ikenouye, H. and Masuzawa, H. 1968: An estimation on parameters of growth equation basing on the results of tagging experiments of the Japanese alfonsin fish. *Bulletin of the Japanese Society of Scientific Fisheries 34*: 97–102. (In Japanese, English translation held in Fisheries Research Centre library, Wellington.)

Phillips, J. B. 1968: Review of rockfish program. *Californian Department of Fish and Game, MRO Ref. No. 68-1.* 73 p.