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Pelagic Gillnet Modification Trials in Northern Australian Seas

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ABSTRACT

The selection and testing of a range of materials for use as passive acoustic modifications to deter dolphins from pelagic gillnets is discussed. Metallic bead chain and air-filled plastic tubing were selected for incorporation into nets for sea trials to assess the effect of the modifications on dolphin by-catch and fish catch. Trials using commercial gillnet vessels from Taiwan established that neither the bead chain nor the plastic tubing had a significant effect on the dolphin by-catch. Further sea trials compared the dolphin and fish catches of a gillnet set 4.5 m below the surface with a standard surface set net. A significant reduction in cetacean catch rate (cetaceans per set) was observed for the sub-surface net. The fish catch for both shark and teleost species was lower in the sub-surface net, with an overall reduction of approximately 25% in total fish catch. Data on the dolphin and fish catches for the trials are presented.

INTRODUCTION

Several species of small cetaceans are captured incidentally during pelagic gillnetting operations carried out by vessels from Taiwan in northern waters of the Australian Fishing Zone (AFZ). The northern gillnet fishery and the incidental catch are described in Harwood, McNamara, Anderson and Walter (1984). Estimates of the total cetacean by-catch and trends in the cetacean catch rate for the period June 1981 to December 1985 are presented in Harwood and Hembree (1987).

Concern about the incidental catch of cetaceans in the northern gillnet fishery led to the establishment in 1984 of a joint research program to investigate possible methods for reducing the level of the by-catch. Participants in the program were the Australian National Parks and Wildlife Service (ANPWS), the Western Australian Museum under a consultancy agreement with ANPWS, the Australian Fisheries Service and commercial fishing interests from Taiwan. Three series of full-scale sea trials testing modified nets fished by commercial gillnet vessels from Taiwan have been carried out under the joint research program. The intent of this paper is to provide a descriptive summary of preliminary investigations and the design, operation and results of the gillnet modification trials.

SELECTION OF MATERIALS FOR ACOUSTIC MODIFICATION OF GILLNETS

Experimental trials were conducted during 17–20 February 1984 and 8–14 July 1985 using captive bottlenose dolphins (*Tursiops truncatus*) at Atlantis Marine Park in Western Australia. The aim of the trials was to test the acoustic properties of different net mesh types and a range of materials which might be suitable for incorporation into gillnets.

Materials tested included 4 mm chrome plated nickel bead chain, 8 mm air-filled plastic tubing, 2 mm and 6 mm braided stainless steel wire, 1 mm galvanised wire, 4 mm plastic covered copper wire and 15 mm wide plastic coated metal surveyor's tape. Net types tested were panels of Taiwanese 150 mm mesh multifilament nylon and monofilament net (100 mm and 180 mm mesh).

Two immature male dolphins (211 and 214 cm in length) were involved in the trials, with only one animal participating at a time. Suction cups were placed over the dolphin's eyes and it was sent by its trainer to echolocate foreign objects in the training pool. Test materials were suspended from poles and gently lowered into random areas of the pool while the dolphin was partially out of the water being fed. The trainer would then send the dolphin to begin echolocating for the object. The swimming pattern was observed and timed and recognition responses to the objects were noted. A total of 37 trials were run over eight days.

Trial results indicated that under test conditions the dolphins could detect 170 × 80 cm panels of 150 mm mesh Taiwanese net at a distance of at least 4 m. Both 100 mm and 180 mm size monofilament net could be detected, however one of the dolphins had difficulty locating the 180 mm net (panel size 180 × 110 cm), once passing just below the net while still echolocating. Bead chain and plastic tubing elicited a strong behavioural response from both dolphins. They were able to locate both materials consistently at distances of up to 8 m. Galvanised wire (1 mm) proved difficult to locate, with the dolphin making as many as five passes, some less than 1 m from the wire.

Based on the results of the trials with captive dolphins, 4 mm bead chain and 8 mm air-filled plastic tubing were selected for further investigation at sea.

SMALL-SCALE SEA TRIALS USING AN AUSTRALIAN GILLNETTER

During 1984–85 the Australian Commonwealth, Northern Territory, Western Australian and Queensland Governments jointly funded a northern pelagic fish stock research program using the Australian commercial gillnetter *Rachel*. The research program took place in seas ranging across northern Australia and had target fish species comparable to the Taiwanese fishery for shark, tuna and mackerel. The program offered the opportunity to field test bead chain and air-filled plastic tubing in an operational gillnet.

The aim of the trials using the *Rachel* was to assess the operational manageability of nets incorporating the test materials and the effect of the modifications on the fish catch, primarily shark.

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A 500 m net with 150 m of bead chain looped at 8 m intervals was fished for 26 sets. The number of sets for the same net similarly modified with 56 m of 6 mm air-filled plastic tubing was limited to 13 by mechanical difficulties and prolonged poor weather. The diameter of the tubing had been reduced from 8 mm to 6 mm because the wider tubing was inflexible and difficult to incorporate into the net. No effect on fish catch was discernible for either modification.

The short length and soak times for the *Rachel*'s gillnets, and hence the low cetacean catch rate of 0.008 dolphins per set, precluded assessment of the effect of the modifications on the dolphin by-catch. Neither modification affected the operational manageability of the gillnet. A decision was taken to carry out full-scale sea trials of both materials using commercial gillnet vessels from Taiwain.

SEA TRIALS CARRIED OUT UNDER THE JOINT AUSTRALIAN/TAIWANESE RESEARCH PROGRAM

1984 Gillnet modification trials

Design

Two commercial gillnetters from Taiwan participated in the 1984 sea trials. Each vessel was to fish two nets, one modified with alternating full and half length vertical droppers, at 8 m intervals, of either bead chain (vessel *Tai Ho No. 1*) or plastic tubing (vessel *Nong Gong No. 1*) and the other net unmodified but otherwise identical as a control. Net preparation was to be completed in Taiwan before departure to Australia.

The expected net dimensions were, for the *Tai Ho No.1*, two nets 16 m deep and 5 km long and for the *Nong Gong No. 1*, nets 18 m deep and 7.5 km long. The nets were to have a mesh size of 150 mm and were to be fished 3 m below the surface hung from ball floats by strops. The modified net design used during the 1984 trials is shown in Fig. 1a.

Operation

Sea trials commenced with the vessels departing Darwin, Northern Territory on 6 September 1984. Fishing operations started the next day and moved gradually westwards, concentrating primarily on banks and shoals in the vicinity of 60–100 n.miles north of the Kimberley coast of Western Australia (near 13°00'S, 126°30'E). It was soon discovered that the net of the *Nong Gong No. 1* had been incorrectly rigged, missing the half droppers of tubing. Additionally, the power block used to retrieve the net compressed the tubing so it filled with water, thus altering the acoustic properties for which it had been selected. On 28 September the *Nong Gong No. 1* ceased participation in the trials after 14 sets and moved to fish elsewhere. It was replaced by the *Chyun Fure No. 7* which used 16 m × 4,744 m nets, one of which was correctly modified with 6 mm plastic tubing. The flattening of the tubing by the power block continued to be a problem which could not be resolved. The trials concluded on 19 October following 42 monitored sets on the *Tai Ho No. 1* and 21 sets on the *Chyun Fure No. 7*.

Results

A total of 48 dolphins comprising 24 *Tursiops truncatus*, 22 *Stenella longirostris*, 1 *Stenella attenuata*, and 1 *Sousa chinensis* were caught, all dead. The cetacean catch for modified and unmodified nets is shown in Table 1.

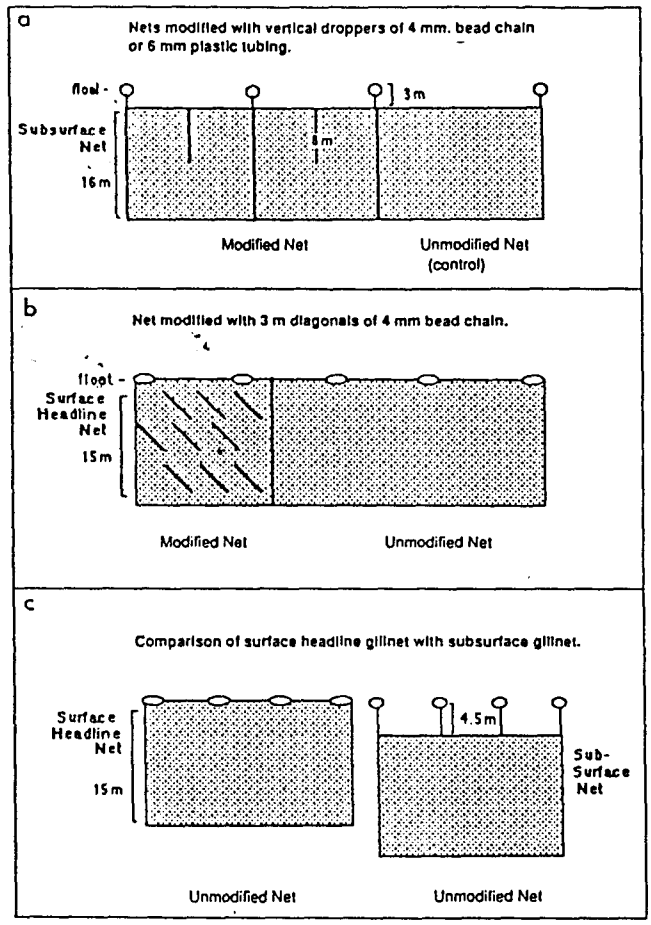

Fig. 1. Representative sections of modified and unmodified gillnets used in dolphin research programmes. a = 1984 trials, b = 1985 trials and c = 1986 trials.

Table 1

1984 gillnet modification trials—Summary of cetacean catch.

	Tursiops truncatus	*Stenella longirostris*	*Stenella attenuata*	*Sousa chinensis*	Total
Bead chain (42 days)					
Modified	0	3	0	0	3
Unmodified	7	13	1	0	21
Plastic tubing (1st 14 days)					
Modified	4	2	0	0	6
Unmodified	5	4	0	0	9
Plastic tubing (2nd 21 days)					
Modified	3	0	0	0	3
Unmodified	5	0	0	1	6

The *Nong Gong No. 1* had the highest overall catch rate of the three vessels with an average of 1.10 dolphins per set (*Tai Ho No. 1: 0.57, Chyun Fure No. 7: 0.43*). This may have been attributable to its large net area, nearly twice the size of that used by either of the other vessels.

The plastic tubing proved operationally unmanageable and did not function in its intended sense (i.e. air-filled). A Wilcoxon paired-sample test showed no significant difference between the cetacean catch rates of the modified and unmodified nets. The tubing was considered to show insufficient promise to warrant further sea trials.

The bead chain showed more promising results, with only three dolphins being caught in the modified net compared with 21 in the control net. However, the results were biassed by a 27.3% greater total fishing time for the control net (449.8 hours compared with 353.9 hours for the

modified net). Also, the nets were not, as intended, equal in length. The control net was in fact 14.2% longer than the modified net. A Wilcoxon paired-sample test showed no significant difference between the cetacean catch rates of the two nets, when catch rates were calibrated for net length and fishing time ($P > 0.05$). Nevertheless it was considered that the bead chain, which proved operationally manageable, warranted further investigation using a refined experimental design.

The fish catch was substantially greater in the unmodified net of the *Tai Ho No. 1*; this may have been attributable to the greater length and consistently greater fishing times for that net. The catch of shark, mackerel and tuna proved to be highly variable during the trials. Black-tipped shark *Carcharhinus limbatus* formed the bulk of the catch. Average fish catches for the 1984 trials are shown in Table 2.

Table 2

1984 gillnet modification trials—Summary of fish catch for *Tai Ho No. 1* (bead chain). * = For the 36 sets for which accurate data on the fish catch were recorded.

	Average catch per set*			
	Modified net		Unmodified net	
	Mean	s.d.	Mean	s.d.
Shark (number)	102.67	238.57	158.33	261.77
Tuna (number)	32.11	113.33	49.31	115.31
Mackerel (number)	4.39	8.67	11.56	33.82
Billfish (number)	0.17	0.45	0.53	0.81
Other (number)	0.14	0.42	0.06	0.33
Total catch (kg)	440.61	712.47	876.03	1,053.61

1985 Gillnet modification trials

Design

The aim of the 1985 sea trials was to further assess the effect of metallic bead chain as a net modification using a single gillnetter from Taiwan, the *Chyun Fure No. 7*. A pattern of alternating one kilometre sections of modified and unmodified net was chosen. The bead chain was woven into the net as nine 3 m diagonals spaced equidistantly (three rows of three) per 15 × 15 m panel of net, to give an even density of bead chain both horizontally and vertically in the modified net.

The nets were marked by painted floats at the junction of modified and unmodified one kilometre sections so the fishing times and catch could be recorded for each section. The *Chyun Fure No. 7* carried the net (mesh size of 140–150 mm) in two pieces, 6,210 m on the stern and 4,290 m on the foredeck. In line with changes observed in the Taiwanese gillnet fleet in late 1984, the nets were fished using a surface set headline. The net modification used in the 1985 trials is illustrated in Fig. 1b.

Operation

In 1985 and 1986 trials took place in an area of intensive gillnet fishing approximately 900 n.miles east of the location of the 1984 trials. The *Chyun Fure No. 7* departed Darwin on 20 September 1985 and steamed eastwards to commence fishing at 10°52'S, 136°03'E on 23 September. Poor fish catches prevailed (average 944 kgs per set) and the vessel moved to east of the Wessel Islands (10°39'S, 138°03'E) where catches improved. The fish catch comprised almost entirely the sharks *Carcharhinus limbatus, C. brevipinna* and *C. sorrah* with very few teleosts being caught.

Table 3

1985 gillnet modification trials—Summary of cetacean catch. * = For the 39 sets in which both nets were set.

	Cetacean catch*	
	Modified sections	Unmodified sections
Tursiops truncatus	16	8
Stenella longirostris	13	9
Total	29	17

A failure of the main generator of the *Chyun Fure No. 7* on 21 October necessitated a return to Darwin for repairs. Fishing recommenced on 8 November northeast of the Wessel Islands, moving slowly back to the region fished prior to the return to Darwin. High catches (average 2,058 kgs per set) filled the freezer holds to capacity (93 tonnes) and the program concluded on 24 November following 42 monitored sets.

Results

A total of 46 dolphins comprising two species, *Tursiops truncatus* and *Stenella longirostris*, were caught incidentally during the 1985 trials, all dead. Unlike the 1984 trials, more dolphins were caught in the net modified with bead chain than in the unmodified net. A summary of the cetacean catch by net and by species is shown in Table 3. A Wilcoxon paired-sample test showed no significant difference between the cetacean catch rates of the modified and unmodified nets ($P > 0.05$). The overall catch rate during the 1985 trials was 1.10 dolphins/set.

Both *Stenella* and *Tursiops* were found throughout the vertical drop of the net. However 64% of the dolphin catch occurred in the top 4 m of the net. It was apparent from the 1985 trials and data gathered in the fishery through the AFZ Observer Program, that the upper third of the surface set nets had been responsible for a disproportionate number of incidental cetacean captures.

The overall fish catch in the unmodified sections of the net was 21.3% higher than in the modified sections. The average fish catches for the 1985 trials are shown in Table 4.

Table 4

1985 gillnet modification trials—Summary of fish catch. * = For the 36 sets for which both nets were set and accurate data on the fish catch were recorded. A set with particularly high shark catches (total number 3,260), but for which the total fish catch in kg was not recorded is not included.

	Average catch per set*			
	Modified net		Unmodified net	
	Mean	s.d.	Mean	s.d.
Shark (number)	196.97	165.19	238.05	249.14
Tuna (number)	34.44	58.61	37.16	70.05
Mackerel (number)	10.91	18.23	15.06	24.98
Billfish (number)	2.06	3.92	1.39	2.25
Other (number)	1.36	1.33	1.25	1.36
Total catch (kg)	811.61	507.63	984.56	843.52

1986 Gillnet modification trials

Design

The trials of passive acoustic modifications in 1984 and 1985 proved unsuccessful in identifying a method for reducing the cetacean by-catch in pelagic gillnets. The 1986 trials adopted another approach, testing the effect of setting the gillnet well below the water surface.

The potential effects of differential current action on the surface and sub-surface nets precluded the use of alternating sections of modified and unmodified net. Two nets of equal length (4,875 m), depth (15 m) and mesh size (140–150 mm) were fished, one with a surface set headline and the other with its headline set 4.5 m below the surface, suspended as for the 1984 trials. Five equal sections of 975 m were marked on each net to facilitate recording fishing times and catch positions in the net. An analysis of the spatial distribution of the fish catch will be presented in a separate paper. The surface and sub-surface nets were set first on alternate nights to give equal overall fishing times for the two nets. A diagram of the nets used in the 1986 trials is presented in Fig. 1c.

Operation

The program commenced on 4 February 1986 when the *Chyun Fure No. 7* left Darwin. Fishing started on 6 February at 10°47'S, 135°54'E, 52 n.miles northeast of Cape Wessel. Operations centred in the southern Arafura Sea, primarily in the region 20–90 n.miles east of the Wessel Islands (near 11°00'S, 138°00'E). The trials concluded in Gove, Northern Territory on 24 March following the monitoring of 41 sets.

Results

A total of 27 dolphins were caught during the trials, all dead. The distribution by net and by species for the 22 which were caught in the 37 sets when both nets were fished is shown in Table 5. During three sets in which only the surface net was set, five *Tursiops truncatus* were caught. No dolphins were caught in the one set during which only the sub-surface net was fished.

Table 5

1986 gillnet modification trials—Summary of cetacean catch. * = For the 37 sets in which both nets were set.

	Cetacean catch*	
	Sub-surface net	Surface net
Tursiops truncatus	3	5
Stenella longirostris	4	10
Total	7	15

A Wilcoxon paired-sample test indicated that the cetacean catch rate was significantly lower in the sub-surface net ($P < 0.05$). The observed reduction in cetacean catch of approximately 50% in the sub-surface net is of the order expected from observations during previous trials.

The average fish catch in the sub-surface net was 25% lower than that of the surface net. The sub-surface net caught 24% fewer black-tipped shark, the main species present in the catch. Although the average catches for each fish class were lower in the sub-surface net, an analysis of variance showed that only the reduction in mackerel catch was significant ($F_{1,72} = 6.31$; $P < 0.05$). A summary of the average fish catches for the 1986 trials is presented in Table 6.

There were no major operational problems with fishing either net. The principal difference in operational terms was the attachment and removal of floats by hand during setting and hauling of the sub-surface net.

Table 6

1986 gillnet modification trials—Summary of fish catch. * = For the 37 sets in which both nets were set.

	Average catch per set*			
	Modified net		Unmodified net	
	Mean	s.d.	Mean	s.d.
Shark (number)	260.78	308.97	353.03	442.48
Tuna (number)	5.08	18.42	7.50	14.55
Mackerel (number)	0.92	1.77	3.97	7.94
Billfish (number)	0.46	1.10	0.86	1.11
Other (number)	0.78	1.16	2.86	3.08
Total catch (kg)	712.05	737.01	956.50	994.43

Biological program

A biological sampling program has been carried out as part of the trials discussed above, including age and reproductive studies, morphometrics, electrophoretic and mitochondrial DNA analysis, and general biology of the incidental cetacean catch. Analysis of the data and materials obtained through the program is underway and the results will be reported on completion.

CONCLUSION

None of the materials tested as acoustic modifications to gillnets were successful in significantly reducing the level of the cetacean by-catch. Air-filled plastic tubing proved to be operationally unmanageable and metallic bead chain, after showing early promise, was shown not to reduce the incidental catch. Air-filled nylon tubing has been incorporated into gillnets in an attempt to reduce the incidental catch of Dall's porpoise (*Phocoenoides dalli*) in the north Pacific salmon fishery. In some trials the modifications have proved ineffective in reducing the cetacean by-catch; in others the results have been inconclusive (National Marine Fisheries Service, 1983; Jones, 1984). Passive acoustic modifications such as air-filled plastic tubing have proved ineffective in deterring whales from traps and nets off Newfoundland (Lien, 1980).

The 1986 trials in the gillnet fishery in northern Australian waters showed a significant reduction in the cetacean by-catch for a net set 4.5 m below the water surface when compared with a surface headline net. The overall reduction in cetacean by-catch for the 1986 trials was approximately 50%. The fish catch for both shark and teleost species was lower in the sub-surface net, with the reduction in the mackerel catch being significant.

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