TARGET LONGLINING FOR BROADBILL SWORDFISH USING CHEMICAL LIGHTSTICKS

REPORT ON FIRDC PROJECT NO. 88/62

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Summary

Twenty five test longline shots utilizing chemical light sticks were made off the NSW south east coast between May 1989 and May 1991. The primary aim of the trials was to investigate whether catch rates of broadbill swordfish *(Xiphias gladius)* were improved. All sets used 50% of hooks with a light stick attached and 50% without, in the format two baskets with, then two baskets without.

Preliminary analyses suggest that there is a significant increase in the catch rates of broadbill swordfish when using light sticks as an aid. The total catch was 37 broadbill on 'light stick' hooks and one on a 'dark' hook.

The catch rate by the test vessel outside the trials over an extended period was 0.68 fish/'000 hooks while during the trials it was 3.42 overall and 6.66 on the light stick hooks directly.

The Japanese longline catch rate off the Australian east coast was 1.68 fish/'000 hooks when assessing only shots in which at least one broadbill was caught. The test vessel returned catch rates of 5.29 overall and 10.32 on the light stick hooks when using the same criteria.

Yellowfin tuna *(Thunnus albacares)* catch rates showed a significant bias of 3:1 in numbers of fish caught on 'light stick' hooks vs 'dark' hooks. However overall catch rates were relatively similar to non test shots and to other vessels, indicating perhaps a degree of competition between light and dark hooks. This remained true over all moon phases.

Catch and catch rates of both species were better over the first quarter - full moon - last quarter moon phases compared with the new moon phase. During the trials broadbill catch rates on light stick hooks were comparable to or better than overseas longline fisheries specifically targeting broadbill.

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The proposal sought funds to assist in carrying out a series of longline fishing operations off the NSW coast to determine fishing strategies particularly with respect to the use of chemical light sticks that would increase the catch of broadbill swordfish, *Xiphias gladius*. The study was proposed to supply comparative catch data between the test vessel and other local longliners to evaluate broadbill catch and effort.

Objectives

The objectives of the program were to investigate

1) the effects of using chemical light sticks on the catch rates of the target species - principally broadbill swordfish,

2) to devise suitable bait presentation in conjunction with the light sticks,

3) to perfect a system of hooks to increase the hook-up and holding rates of broadbill, and

4) to investigate catch rates around sea mounts and submarine canyons and establish areas of aggregation.

In the planning and early implementation of the program it was recognised that the fishing operations must be carried out close to the centre of activity of the rest of the longline fleet to allow comparisons of various catch rates. Catch rates could then be compared between the experimental vessel and other longliners working nearby. A more distant comparison can be carried out using the entire fleet (NSW) figures - using pooled data from the AFMA log book system.

Justification

In the years up to and including 1988 broadbill swordfish were an important and high unit value by-catch of the NSW based longline fishery. At this time a mandatory test for mercury levels was applied and as a majority of the fish were over the prescribed limit, interest in catching this species subsided. The price on the Sydney fish market averaged between $8 and $10/kg from 1984 to 1988. The maximum quantity sold in any one year being 16,000kg (av. $10.48). Export markets are considered to be available and largely untouched due to the small quantities so far accessed and the attractive local price. Exports to Japan always return a good price.

The Japanese longline catch of broadbill swordfisn off eastern Australia (in the AFZ) has been as high as 1,300T (25,000 fish) and the average over 1984-1990 was 800T (16,800 fish) indicating a substantial local resource.

Light sticks have become a normal part of the fishing gear in overseas fisheries for broadbill. In the Hawaiian swordfish fishery, vessels targetting broadbill use a light stick on every hook. Landings of broadbill swordfish in Hawaii rose to approximately 1.5 million kg in 1990 from ~20,000kg in 1988. Before this time it was solely an incidental catch.

Operational procedures

When the proposal was first mooted the intentions were:-

- to set the gear with the terminal tackle as described in the original proposal
- to set hooks near sea mounts, canyons etc.
- to set all hooks in the vicinity of the main fleet so as comparisons were able to be made
- to set hooks with chemical light sticks attached in such a way that catch rates could be compared between hooks (with and without light sticks) and between the test vessel and other vessels in the area.

After the proposal was presented, but before approval, the company manufacturing the light sticks offered to donate some of the sticks to the program. This offer was subsequently accepted and the program approved. The thrust of the program was then, therefore, to test the light stick technique in comparative situations as thoroughly as possible.

At the same time as the program was due to commence, a significant change in the market place for broadbill swordfish took place. This was the imposition of a mandatory test for mercury levels in each broadbill sent to the NSW market. Because of the high cost of the test and the fact that so many fish were above the NSW limit (0.5ppm) the domestic fishery for broadbill virtually shut down.

NSW Fish Marketing Authority Figures For Broadbill Swordfish Sales

Year	Total Amount	Price/kg
Apr '88 - Mar '89	15,600 Kg	Av $10.48
Apr '89 - Mar '90	1,118 Kg	Av $13.88
Apr '90 - Mar '91	341 Kg	Av $12.22
Apr '91 - Mar ' 92	150 Kg	Av $ 8.68

With no vessels specifically targetting or semi-targetting broadbill, which up until then had been gaining wide acceptance (indeed preference as a gourmet food) in the market place, comparisons can only be obtained by test fishing with the main body of the local fleet and only changing one variable at a time - in this case utilizing chemical light sticks.

Hence the prime methodology was to make the set, over different areas with the main fleet and over different moon phases using light sticks. Comparisons can then be done of catch and catch rates by species, moon phases, vessel and hopefully the effectiveness of light sticks.

Because of the vagaries of the weather, very slow fishing periods and the desire to only test fish when comparisons were possible and sufficient quantities of fish were available, the survey period ran for 24 months. This however ensured fishing was carried out at the best possible times and the light sticks were not wasted in barren water or when comparisons were impossible.

Operational set-up

The line was set with six to ten hooks between floats (hooks per basket). This design of line is fairly common throughout the fleet. Differences depend largely on fishermen's personal preferences.

The light sticks tested were standard 6" yellow Cyalume* light sticks. They were always attached to every second two baskets of gear i.e. two baskets of hooks were set with light sticks attached to the leaders then two baskets with no light sticks attached. The reasoning behind this set-up was that this structure separated the 'light' and 'dark' areas of the line by a sufficient distance such that a glow effect was not taking place i.e. if light sticks were put on every second hook the attraction of the lighted area (if any) may lead to a fish biting on a hook nearby therefore making it almost impossible to tell if the light sticks were attracting fish. By setting the sticks two baskets apart an approximate separation of 1 - 1.5 km is obtained between light and dark areas.

Just before setting took place the light sticks were taken from their foil packets and a standard commercial rubber band attached through the loop of each light stick. While setting, the light sticks were broken (to mix the chemicals) and the band was looped around the leader of the branch line, 2 - 3 fathoms above the hook and pulled tight. This was done for each of the light stick hooks until setting was completed. Sets varied between 400 and 550 hooks averaging 450 hooks.

The sticks are attached above the hook to keep very small fish that may be attracted to the light away from the bait so no 'nibbling' takes place. This is common overseas and was recommended by the manufacturers.

In almost all cases the sticks were still glowing when the line was retrieved some 8 - 15 hours later.

Results

Twenty five shots were carried out using the test light sticks between 19/5/89 and 7/5/91 in the general area Sydney - Bass Strait. A map showing each shot by number is attached as Figure 1.

A total of 400 - 550 hooks (average 450) were set each shot - half with light sticks and half without, as described earlier. Basically all shots were just over the edge of the continental shelf in each of the areas fished. A table of catch for all shots by hook, species and whether on a light stick hook or not is attached as Table 1.

Summary tables 2 and 3 show the catches grouped by species, light stick and moon phase for all shots combined. All the main commercial species are included although bigeye tuna *(Thunnus obesus)* and southern bluefin tuna *(T. maccoyii)* were caught in very small numbers (as was the case throughout the fleet).

Albacore, an important, incidental catch of the NSW longline fishery, appear to show no preference for lighted hooks and there is little difference shown between moon phases.

However the other two species listed broadbill swordfish and yellowfin tuna *(T. albacares)* do show noticeable trends. Broadbill swordfish, the species under primary investigation, were caught much more selectively on the lighted hooks, 37 : 1. Interestingly the fish taken on the dark hook was the first one of a dark group and hence the next hook to a lighter area.

Yellowfin tuna were also caught much more often on the lighted hooks with an overall catch rate of 146 : 48 or a 3 : 1 ratio in favour of the light stick hooks. Catch rates for all species were lowest during the new moon period.

Discussion

As well as comparisons between the hooks with light sticks attached and those without, there are other useful comparisons to be made. For example it is necessary to compare the test vessels record before, during and after the test period (excluding the test shots) with the test shots themselves.

It is also possible and desirable to compare the test vessel's record when not using light sticks with other east coast vessels (pooled data). Similarly this can be done using data from the same area and time as the test vessel during the period of the trials.

To further expand the comparisons the test vessel data is shown against the Japanese longline data from AFZ records for their broadbill swordfish catch. This is primarily to expand the broadbill data available as only small numbers generally are taken by the Australian fleet.

Moon phase is generally thought to have a marked effect on pelagic longline catch rates - particularly for tunas and billfishes. Accordingly an analysis of catch and catch rates for the light stick data is also presented by moon phase.

As can be seen from Table 2, of the commercial species taken in the test shots, only broadbill swordfish, yellowfin tuna and albacore are taken in substantial numbers. Of these albacore show no real variation in capture on light or dark hooks. This was the case throughout the trials either in individual sets, by moon phase (Table 3) or in grouped data. Hence further discussion will be limited to broadbill, the primary species under investigation, and yellowfin tuna.

1) **Broadbill Swordfish**

On initial examination of the raw data for broadbill catches during the trials it would seem there is a significant preference to the light stick hooks 37:1. While numbers were still quite small this bias was evident throughout the trials and over all moon phases.

Tables 4 and 5 show broadbill catch rates in number of fish caught per one thousand hooks set and these clearly demonstrate the greatly increased catch on hooks with light sticks attached. In all the test shots the overall broadbill catch rate was 3.42 fish/'000 hooks while on light stick hooks it was 6.66 fish/'000. (Only one fish was caught on a dark hook at a catch rate of 0.18). These catch rates when compared with the test vessel itself over an extended period 1987 - 1991 when not using light sticks of 0.68 fish/'000 hooks show a significant difference. There is a ten fold increase in broadbill catch rate on the test vessel itself.

The raw data ratio of 37:1 at catch rates of 6.66 : 0.18 probably indicates that the light stick hooks also compete with the dark hooks and bias the preference even further. The numbers are however too small to be certain of such conclusions e.g. another two fish on the dark hooks during the trials would give a catch rate similar to the test vessel outside the trials and also similar to the Australian fleet overall.

The test vessel catch rate over 1987 - 1991 of 0.68 compares well with the Australian fleet overall of 0.56 and the Australian fleet in the area of the test vessel and at the same time, of 0.63. (Australian fleet in area and time is defined as vessels setting in the same or an adjoining grid square - 1/4 degree - 1/2 degree latitude x 1/2 degree longitude - within one day of the test vessel). This data is pooled and is obtained from the Australian east coast longline log book data base. (AL02)

While comparisons between the test vessel and other Australian vessels offer interesting and significant results the catch of broadbill off the Australian east coast by Australian vessels is still small. The total recorded in the log book system 1989 - 1991 was approximately 45 tonnes. It is mostly an incidental catch and particularly since the imposition of the stringent mercury level ceiling, broadbill is very much a <u>non-target</u> species.

The Japanese longline fleet operating off eastern Australia has taken substantial numbers of broadbill for many years. The total catch, from log book data, for the period 1983 - 1990 being in excess of 5,600 tonnes (processed weight) and 117,000 fish. This catch was taken over a wide area of the AFZ between 10 degrees south latitude and 50 degrees south latitude off the east coast.

Broadbill is not a primary target species of the Japanese fleet, particularly in the most southern regions where effort is very high for southern bluefin tuna and catch of broadbill is low. Therefore when assessing comparative catch rates some allowance should be made for this. One way of doing this is to include, in catch rate analyses, only shots where at least one broadbill is taken.

When this allowance is made, the Japanese longline vessel catch rate off eastern Australia is 1.68 fish/'000 hooks. Even in areas where the broadbill catch is highest, 20 degrees- 40 degrees S, the catch rates very seldom exceed two fish per 1,000 hooks. When finer scale time data - e.g. one month - are used, even then 2.38 fish/'000 hooks is the greatest catch rate recorded in any area.

Japanese catch rate data for broadbill can be difficult to assess given that the fishing areas generally overlap fishing areas favourable for other species, mainly tunas (yellowfin and bluefin). This tends to dilute the catch effort figures for broadbill as it is not possible to sort out the numbers of hooks expressly targeted at each species. But, because broadbill is mainly a valuable by-catch and not usually primarily targeted, the catch rates do serve for useful comparisons.

This is particularly true when used in comparison against Australian data that are generated from longlining that is similarly targeted in the same areas. In the case of the test vessel during the trials, the overall catch rate on the light stick hooks was 6.66 fish/'000 hooks. But this became 10.30 fish/'000 hooks when only shots where at least one broadbill was taken, are included in the analyses. This represents a greater than six times increase over the Japanese catch rate in similar geographical areas and time.

While numbers of the order of 6 - 10 fish per thousand hooks may still seem small, the fish are quite large. During the survey they averaged 62.7 kg headed and gutted, which is how they are sold. The Japanese average size (1983 - 1990) was just under 50 kg/fish processed weight and in more southern areas it reached over 70 kg/fish processed. Hence at catch rates of 6 - 10 fish/'000 and prices of $10/kg, the dollar value (gross) is of the order of $3000 - $6000 per 1,000 hooks. Currently, markets in other parts of Australia are paying $7 to $10/kg for longline caught broadbill and recent prices on the Japanese market have been up to $20/kg although both markets have handled only small quantities at a time. At light stick prices of $1.50 - $2.00 per stick the benefits are potentially substantial.

Catch rates of around 6 - 10 fish/'000 hooks compare favourably with catch rates in established swordfish fisheries in other parts of the world. For example in Hawaii catch rates are of the order of 10 - 15 fish/'000 hooks in a now well established longline fishery specifically targeting swordfish. The incidental catches of other species, e.g. tunas, are at less than half this catch rate.

In the Mediterranean, catch rates for swordfish in specifically targeted longline operations are about 3 - 4 fish/'000 hooks.

2) **Yellowfin**

The analysis of the yellowfin catch and catch rate data is less clear. While it would seem that at a catch ratio of 3 : 1 for light stick hooks vs non - light stick hooks, a significant increase in catch of yellowfin could be gained by the use of light sticks.

However closer examination of catch rate trends reveals a much cloudier picture. In most cases the catch rate on the 'dark' hooks is much less than

a) the rest of the fleet, and
b) the test vessel itself when not using any sticks.

The test vessel had an overall catch rate of yellowfin of 21.1 fish/'000 hooks from 1987 to 1991 when not using any light sticks. Yet in the trial shots a catch rate of 8.64 fish/'000 hooks was recorded on the dark hooks. This may indicate a large degree of competition between light and dark hooks.

Also the overall catch rate was 17.46 fish/'000 down on the catch rate in non - trial shots of 21.1 fish/'000. The overall catch rate of the Australian east coast fleet from 1989 - 1991 was 18.5 fish/'000 very similar to the test vessel outside the trials. The Australian fleet setting in the same area and time (see definition earlier) as the test vessel during the trials showed a catch rate of 21.6 fish/'000. This was more than the overall catch rate in the trials, of 17.5 fish/'000 but significantly less than the light stick catch rate of 26.3 fish/'000 hooks.

Individual catch rates of yellowfin (Table 6) over the different moon phases did reach very high values for the light sticks during the trials. A maximum of 50.78 fish/'000 hooks was attained during the last quarter moon phase (but overall was 36.33). This is quite a high figure when compared with overall rates around 20 fish/'000 hooks. However the catch rates of other vessels in the area at the same time during this moon phase also reached 40 fish/'000 hooks. (Remember the numbers are still small - only six shots are in the analysis).

These figures are, relatively, very similar to the catch rates overall of 17.5 fish/'000 hooks, 21.6 fish/'000 hooks and 26.3 fish/'000 hooks when comparing the test shots combined, the other vessels in the area and the light stick catch rates. This again probably indicates a marked degree of competition between the 'light' and 'dark' hooks.

Detailed experiments would need to be designed to analyse this problem more precisely. This may require the co-operation of more than one vessel so very detailed shot by shot analyses can be carried out.

Conclusions

The trials caught only three species in sufficient numbers for meaningful analysis. These were broadbill swordfish, yellowfin tuna and albacore. The first two of these were caught preferentially on hooks with light sticks attached. The catch numbers 'light' vs 'dark' for these two species were 37:1 and 146:48 respectively.

Closer analysis of catch and catch rate data indicates that light sticks could be of significant benefit in the capture of broadbill and that greater dollar returns could be gained by their utilization. More extensive tests specifically targeting broadbill and not constrained by being nearby to the main fleet might generate more specific data on the economic benefits of broadbill fishing with light sticks. Fishing off NSW however will be constrained by the lack of an effective local (NSW) market due to the mercury level problem and other alternative local or overseas markets e.g. Japan, will need to be established.

While yellowfin were caught preferentially at a 3:1 ratio on light stick hooks the situation is less clear. It appears as though competition between hooks may cause the bias as overall catch rates are little changed. A more detailed and specifically designed approach may be needed to fully test the effectiveness of light sticks on yellowfin catch and any subsequent financial benefits.

Test Vessel

The test vessel was a typical, small NSW east coast longliner : overall length 12.8m, beam 4.3m, depth 1.4m and HP 350. The crew is usually the skipper and one deckhand. Maximum carrying capacity on ice is 2.5 tonnes.

Acknowledgements

The patience and diligence of the owner/skipper Mr Stephen Donohue in carrying out the trials to the specifications required is acknowledged. Mr Albert Caton (BRS) assisted greatly with the retrieval of the Japanese longline broadbill data and Mr Thim Skousen (AFMA) was of great assistance in supplying detailed data and catch breakdowns from the east coast longline log book data base.

The American Cyanamid Company donated the chemical light sticks (CYALUME*) to the project.

* Cyalume is a registered trademark of American Cyanamid Company.

TABLE 1

CATCH SUMMARY OF MAJOR SPECIES (NO. OF FISH) FOR ALL TEST SHOTS BY LIGHT STICKS AND HOOK NO. (IN BASKET).

	LIGHT											DARK								
	1	2	3	4	5	6	7	8	9	10		1	2	3	4	5	6	7	8	9	10
BROAD *	5	6	4	4	3	2			1	1	*	1									
BILL **	6		1	2		2					*										
TUNA *	15	13	11	16	7	14	4	1	1	4	*	9	10	3	4			2		1	3
YELLOWFIN **	10	10	8	11	5	4	6	1	1	4	*	3	1	2	1		4	3		1	1
TUNA *	2	1		1							*	2									
BIGEYE **	1										*								1		
TUNA *			1		1						*		1	1							
BLUEFIN **			1	1							*										
TUNA *	3	3	3	2	3	4	2	1		3	*	3	7	3	6	2	2		3		2
ALBACORE **	3			2	2	3	2			1	*	1	5		1	1	1	1	1		1

COMMENTS:	*	1ST BASKET OF GEAR
	**	2ND BASKET OF GEAR
	TOTAL HOOKS 11,110	400 - 550 HOOKS/SET
	TOTAL SETS	AVERAGE 450 HOOKS

TABLE 2

TOTAL NUMBERS OF FISH, COMMERCIAL SPECIES CAUGHT DURING LIGHT STICK TRIALS

NUMBERS OF FISH

	HOOKS WITH LIGHT STICKS	HOOKS WITHOUT LIGHT STICKS
BROADBILL SWORDFISH	37	1
YELLOWFIN TUNA	146	48
BIGEYE TUNA	5	3
SOUTHERN BLUEFIN	4	2
ALBACORE	37	40

25 SETS
TOTAL HOOKS 11,110 400 - 550 HOOKS/SET AV. 450

TABLE 3

CATCH BY SPECIES, MOON PHASE AND LIGHT STICK

NUMBERS OF FISH

		FULL MOON (11 SETS)	LAST QTR (6 SETS)	NEW MOON (5 SETS)	1ST QTR (3 SETS)
BROADBILL	-L	18	10	7	2
SWORDFISH	-D	-	1	-	-
YELLOWFIN	-L	50	65	10	21
TUNA	-D	12	28	2	6
BIG EYE	-L	2	1	1	1
TUNA	-D	-	1	-	-
SOUTHERN	-L	4	-	-	-
BLUEFIN	-D	2	-	-	-
ALBACORE	-L	9	15	7	6
	-D	16	10	9	5
HOOKS (Total 11,110)		4,980	2,560	2,220	1,350

L HOOK WITH CYALUME LIGHT STICK ATTACHED TO LEADER
D HOOK WITH NO LIGHT STICK

ALL SETS WERE MADE WITH 2 BASKETS (DISTANCE BETWEEN FLOATS) OF GEAR WITH LIGHT STICKS THEN 2 BASKETS WITHOUT LIGHT STICKS

TABLE 4

CATCH RATES BY MOON PHASE AND LIGHT STICK

		F.M.		L.Q.		N.M.		F.Q	
		No	No/000	No	No/000	No	No/000	No	No/000
BROADBILL	L	18	7.23	10	7.61	7	6.31	2	2.96
SWORDFISH	D	-	0	1	0.78	-	0	-	0
	T	18	3.61	11	4.30	7	3.15	2	1.48
YELLOWFIN	L	50	20.08	65	50.78	10	9.00	21	31.11
TUNA	D	12	4.82	28	21.87	2	1.80	6	8.88
	T	62	12.45	93	36.33	12	5.40	27	20.00
HOOKS		L	2,490	L	1,280	L	1,110	L	675
		D	2,490	D	1,280	D	1,110	D	675
		T	4,980	T	2,560	T	2,220	T	1,350

TABLE 5

BROADBILL SWORDFISH CPUE'S No/'000 HOOKS

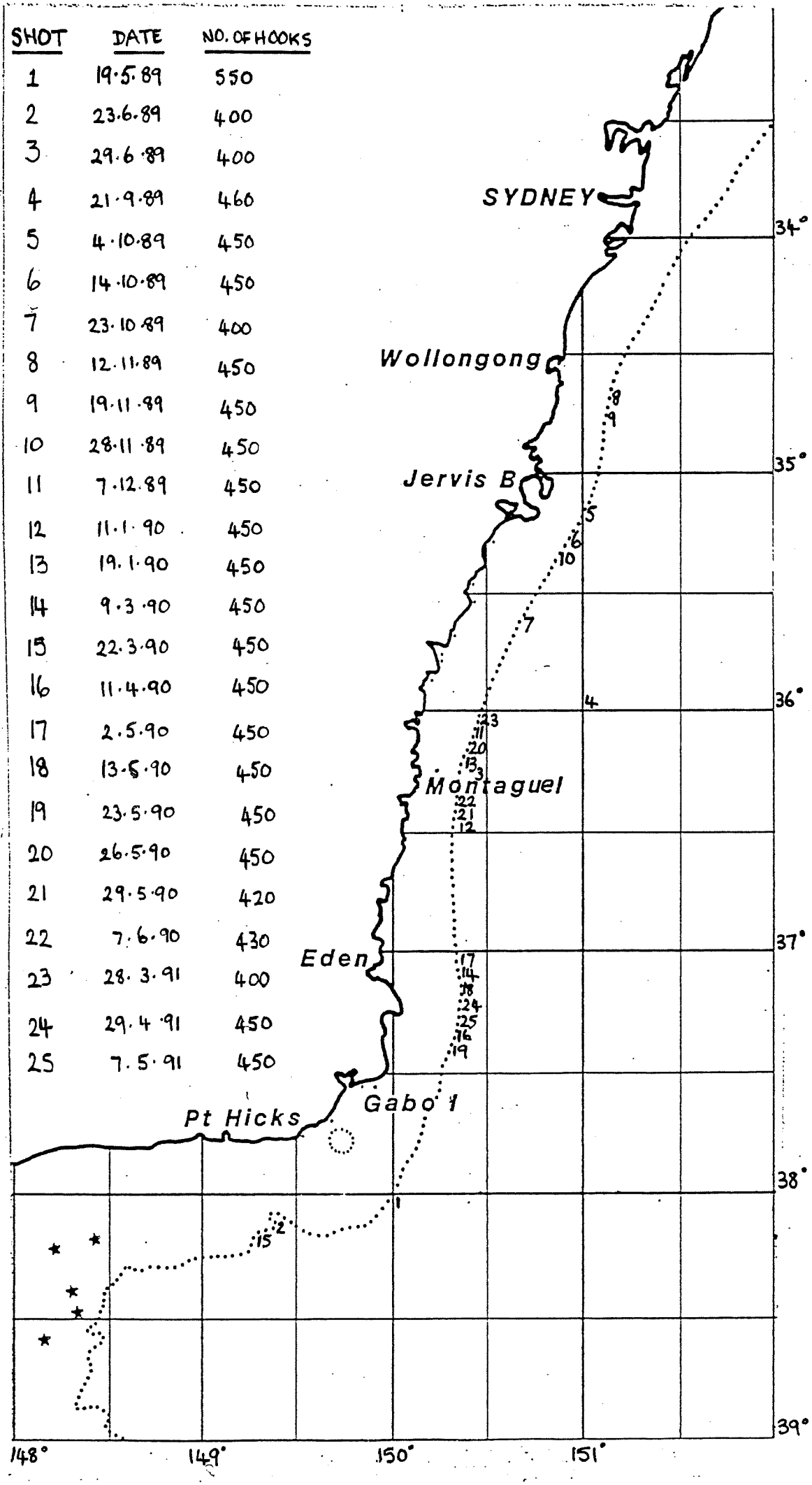
	O/ALL	LIGHT HOOKS
TEST VESSEL '89-'91 TEST SHOTS ONLY	3.42	6.66
TEST VESSEL '87-'91 EXCL. TEST SHOTS	0.68	-
AUST FLEET COMBINED '89-'91	0.56	-
AUST FLEET IN AREA AND TIME	0.63	-
JAPANESE FLEET WHEN ONE B/B CAUGHT	1.68	-
TEST VESSEL WHEN ONE B/B CAUGHT. TEST SHOTS ONLY	5.29	10.32

TABLE 6

YELLOWFIN TUNA CPUE'S No/'000 HOOKS

	O/ALL	LIGHT HOOKS
TEST VESSEL '89-'91 TEST SHOTS ONLY	17.5	26.3
TEST VESSEL '87-'91 EXCL. TEST SHOTS	21.1	-
AUST FLEET COMBINED '89-'91	18.5	-
AUST FLEET IN AREA AND TIME	21.6	-

Figure 1


SHOT DATE NO. OF HOOKS
1 19·5·89 550
2 23·6·89 400
3 29·6·89 400
4 21·9·89 460
5 4·10·89 450
6 14·10·89 450
7 23·10·89 400
8 12·11·89 450
9 19·11·89 450
10 28·11·89 450
11 7·12·89 450
12 11·1·90 450
13 19·1·90 450
14 9·3·90 450
15 22·3·90 450
16 11·4·90 450
17 2·5·90 450
18 13·5·90 450
19 23·5·90 450
20 26·5·90 450
21 29·5·90 420
22 7·6·90 430
23 28·3·91 400
24 29·4·91 450
25 7·5·91 450
SYDNEY
Wollongong
Jervis B
Montaguel
Eden
Gabo I
Pt Hicks
34°
35°
36°
37°
38°
39°
148°
149°
150°
151°

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