# <u>AN INVESTIGATION OF LONGLINING ACTIVITIES IN THE WATERS OF TONGA (24 April - 19 May 1985)</u>

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Tuna and Billfish Assessment Programme
Technical Report No.17

South Pacific Commission
Noumea, New Caledonia
January 1986

Original text: English

Prepared for publication at
South Pacific Commission headquarters, Noumea, New Caledonia
and printed at System Press Pty Ltd, Sydney, 1986

# PREFACE

The Tuna and Billfish Assessment Programme is an externally funded part of the work programme of the South Pacific Commission and is the successor of the Skipjack Survey and Assessment Programme. Current responsibilities of the Tuna Programme include compilation and maintenance of a fisheries statistics data base for the commercial fisheries in the region, and biological research on fish stocks which support this fishery. The work of the Programme is presently funded by donations from the governments of Australia, France, New Zealand, and the United States of America. The beneficiaries of this work are the island states of the South Pacific Commission who use the research results in the development and management of fisheries in their Exclusive Economic Zones.

The Technical Report series published by the Tuna Programme documents research results obtained by Programme staff. These reports cover a wide variety of topics and range in content from highly technical material of interest primarily to specialists, to material of much wider interest. The basis for these reports is the ongoing research of the Programme and includes information obtained by Programme staff during the pursuit of their current activities, data contained in the regional fisheries data base, and data obtained during the Skipjack Programme.

Tuna Programme staff frequently have the opportunity to make observer trips on fishing vessels of various nations. SPC observers board fishing vessels at the courtesy of the vessel operators, and the reliability of the information gathered by the observers depends on the willing co-operation of the vessel's crew. Therefore, SPC observers make no attempt to obtain information which could be used for surveillance or enforcement purposes.

The goal of these observer trips is to obtain general information about operations of different types of fishing vessels; to obtain specific information which assists Programme staff in interpreting fisheries statistics; to carry out biological sampling of the catch; and to make other observations which would assist fisheries officers in understanding the operations of the fisheries in their region.

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES

# AN INVESTIGATION OF LONGLINING ACTIVITIES IN THE WATERS OF TONGA (24 April - 19 May 1985)

## 1.0 INTRODUCTION

The occurrence of surface schools of tuna in the waters of Tonga, which extend south of the Tropic of Capricorn, is marked by a strong seasonality. In order to optimise the exploitation of oceanic tuna resources, Tonga joined the ranks of countries in the southwestern Pacific longlining for albacore (*Thunnus alalunga*) and other deep-swimming tunas. After an exploratory phase, the operation has begun its fourth year of commercial exploitation and it was deemed timely to make an evaluation of its performance. The Government of Tonga accordingly made a request for the South Pacific Commission to send an observer on board its longliner to gain firsthand experience of the operation and suggest possible improvements. This report presents the details of the operation, together with the analysis of the data collected on fishing performance and species composition of the catch. The information is then used to compare this operation with other longlining in the region and identify characteristics of longlining relevant to albacore in an attempt to define areas of possible improvement.

## 2.0 SUMMARY OF ACTIVITIES

Observer activities on the *MFV Lofa* were conducted between 24 April and 19 May 1985. During this period, two days were spent in port for refuelling, purchasing bait and other supplies, four days were spent steaming to and from the fishing grounds, and seventeen days were spent fishing. One day was spent idle when no fishing was possible due to bad weather. The ship left from Suva, Fiji where it had completed its yearly maintenance, fished in the waters west of the Tongatapu Group and returned to Nuku´alofa. The areas fished, with the location of each set, are shown in Figure 1.

Previous fishing activities conducted within Tonga´s Exclusive Economic Zone (EEZ) are summarised in Ratcliffe (1983) and in the reports of the fishing adviser from the Japanese International Co-operation Agency (JICA) (Matsumoto 1983, 1984).

## 3.0 RESULTS

### 3.1 Equipment

#### 3.1.1 Vessel

The *MFV Lofa* is a 188-GRT longline training vessel built in 1981 by Uchida Shipbuilding Company, Japan. It is 31 metres in length and 7 metres in breadth with a fish-hold capacity of 128 cubic metres, or between 70 and 80 tonnes of fish. It has a crew of 22 (with two teams of seven fishermen) and, since its second fishing season, an adviser from JICA. In comparison, Japanese longliners of the same size (194 GRT) carry 18 to 20 crew with storage capacity ranging from 133 to 186 tonnes. Taiwanese longliners between 186 and 189 GRT have an intermediate storage capacity of between 90 and 120 tonnes.

### 3.1.2 Longline

Figure 2 represents the configuration of the longline together with the names of its components. The line is up to 130 km in length and spans about 45 nautical miles of ocean, fishing between 110 and 275 metres deep. There is one radio buoy on each end of the line and alternating single and double floats delimit on average 280 coils (or baskets). There are 8 branch lines per coil for a total of about 2240 hooks per set. In addition, 10 light buoys are interspersed on the half of the line that will be hauled at night to facilitate relocation should the main line break. The end of the line from which hauling will proceed extends past the radio buoy to a marker (float with a long mast and flag). When this end is picked up, the line can then be fed directly through the line hauler.

FIGURE 1. POSITION OF EACH SET OF THE LONGLINE

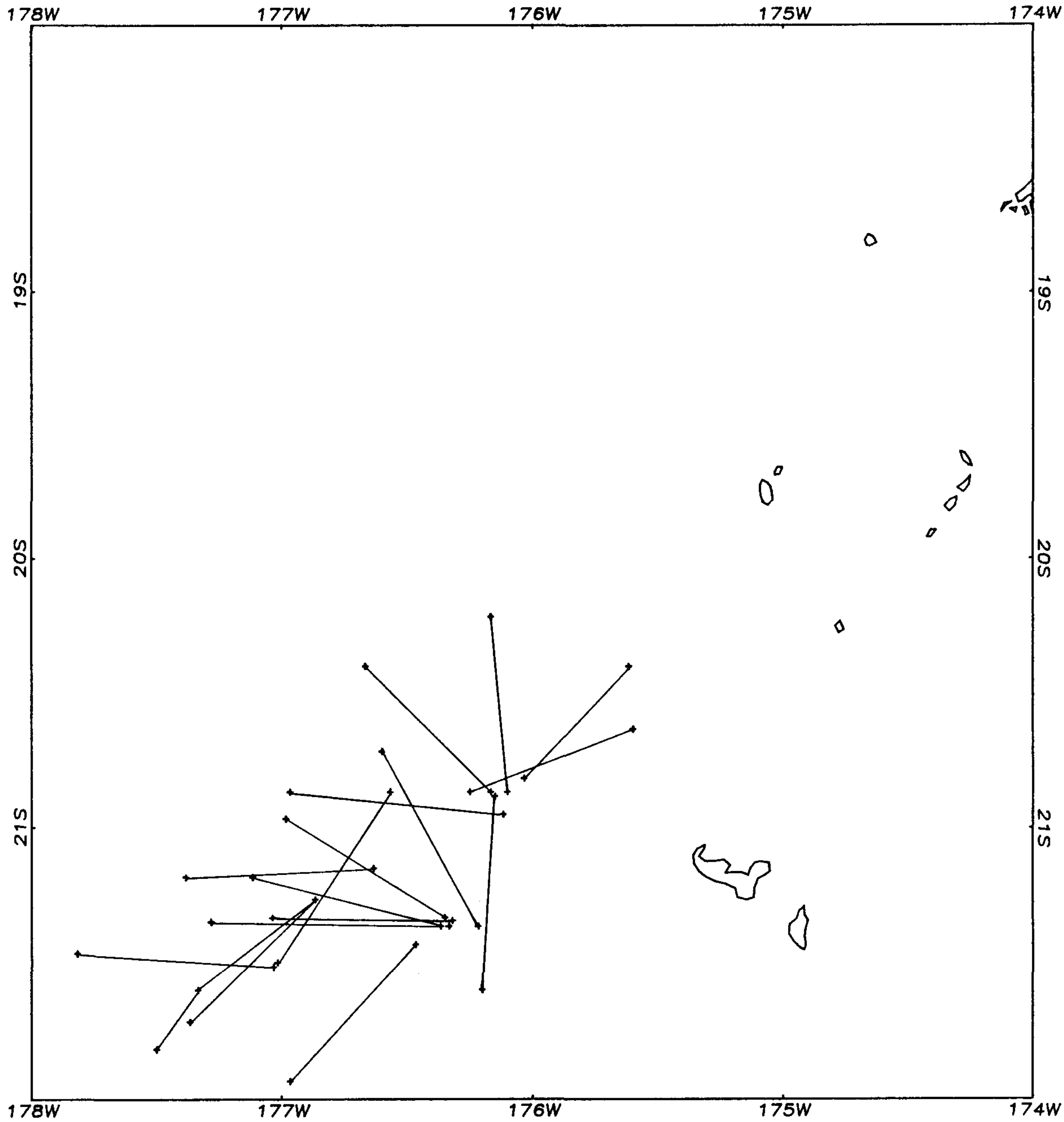
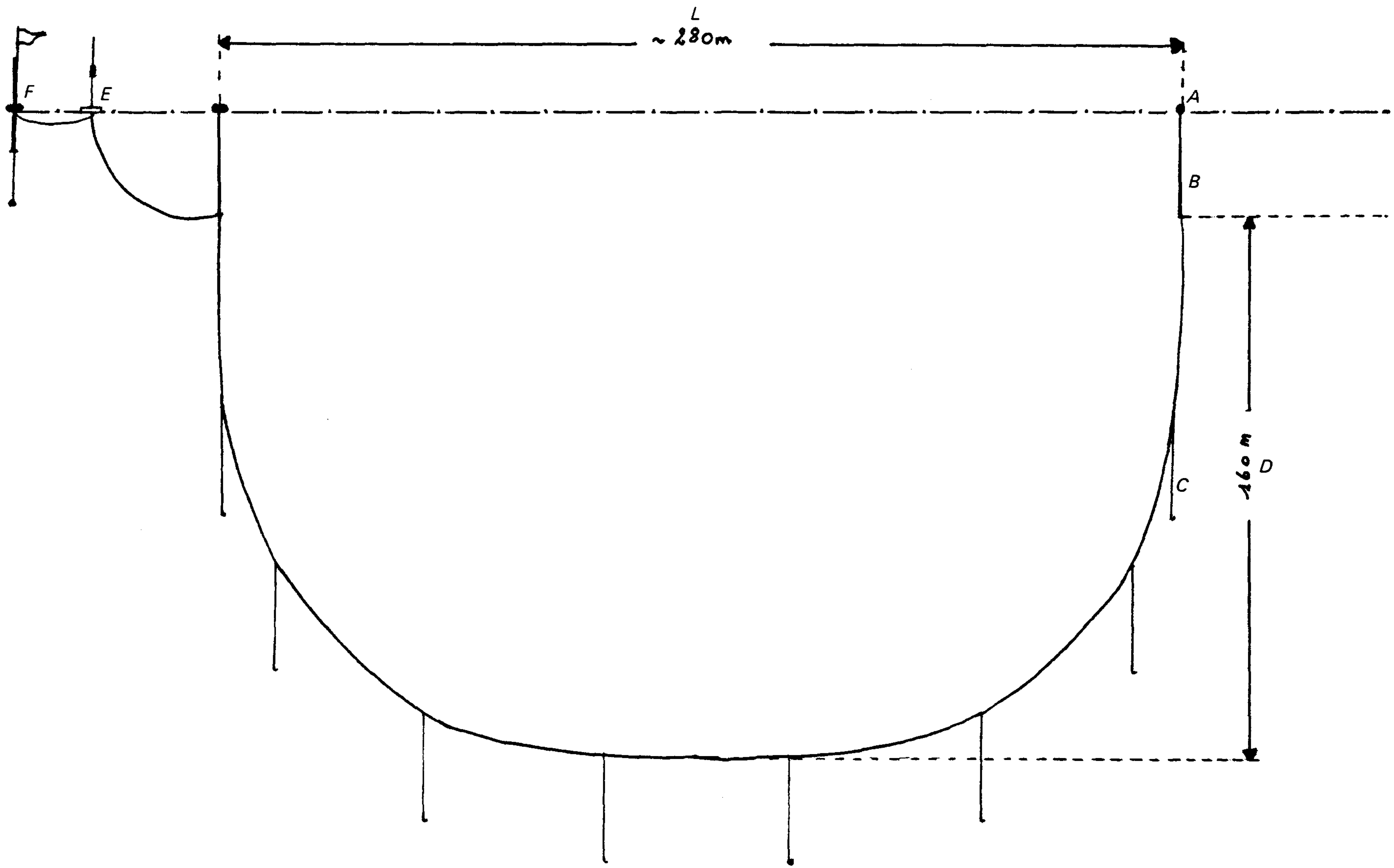


FIGURE 2. THE CONFIGURATION OF THE LONGLINE. A=float, B=float line, C=branch line, D=depth of line, E=radio buoy, F=flag end, L=distance between floats.



## 3.2 Procedures

### 3.2.1 Setting

The observed fishing operation was conducted in the following sequence: upon reaching the fishing grounds, chosen from previous experience and current catches, the line was set. For each set the main line, 6 mm in diameter, is fed from the storage tanks on the upper deck through a PVC pipe to the lower deck and through the line thrower. The revolutions per minute (rpm) of the line thrower, a mechanical roller mounted on the stern of the longliner, can be regulated to adjust the speed at which the line is thrown and thus the amount of line laid.

As the line is laid, a branch line with baited hook is clipped on every seven seconds and a float line with float(s) every eight branch lines. The hooking master, which produces the acoustic signals at set intervals, is used to establish the distance between the branch lines and the number of branch lines per coil. The hooking master also keeps track of the number of coils set. This activity occupies three fishermen: one to bait the hook, one to clip on the branch line, and a third to attach the float(s) to the float line, and then to clip it onto the main line. The other four fishermen in the shift ensure a constant supply of coiled branch lines, bait (an average of 15 cases or 150 kg of bait were used per set), coiled float lines, floats and light buoys, and control the line-throwing speed. The fishermen rotate often to ensure the best concentration for the men working the line. Indeed, this sequence is repeated continuously for about five hours. If the area yielded satisfactory catches, the line is reset immediately after completion of the haul.

### 3.2.2 Fishing depth

The fishing depth can be adjusted in several ways. First, the depth can be adjusted by varying the length of the float or branch lines, quickly reaching a limit, however, because of the handling problems. The alternative is to vary the length of the line between floats. This may be achieved by changing the number of branch lines, the interval between them, or the amount of line laid. The latter option was used on board the Lofa by varying the line-throwing speed and boat speed, with all other variables held constant. The former directly influences the amount of line laid out, and the latter, given the same line length, its sagging rate (distance between floats : length of line). The depth of the line and hence of fishing can be calculated from the formula for a catenary curve:

$$\text{length of arc(s)} = 1 \quad 1 + 2/3\ (2d/e)^2$$

where s is the length of the line, l is the distance between floats and d is the depth.

The depth of fishing is thus

$$D = d + b + f$$

where b and f are the length of the branch and float lines respectively. Table 1 summarises fishing depth for each set according to the formula and, when possible, to other sources (Matsumoto 1984; Suzuki et al. 1977). No estimate of depth could be calculated for set No. 7 because of a missing parameter.

Matsumoto (1984) gives a table of line depth according to boat speed, line throwing speed and the number of branch lines. The conditions for six of the sets are covered in the table. Suzuki et al. (1977) have adapted the basic formula to calculate the depth at each hook. However, this requires the angle between the main line and the float line, which depends on the sagging rate (l/s). The only angle used, approximately 72°, was for a corresponding sagging rate of 0.6 which occurred in five of the sets.

TABLE 1. FISHING DEPTH OF EACH SET OF THE LONGLINE (8 branch lines, 7 second intervals). The number in the first parentheses in the last two columns is calculated from Suzuki et al. (1977) for having a sagging rate ~0.6. The number in the second parentheses is given by the table in Matsumoto (1984).

| Set No.* | Line Speed (m/s) | Boat Speed (knots) | Length of Coil (m) | Distance Between Floats (m) | Depth at Hook Nos. 1 and 8 | Depth at Hook Nos. 4 and 5 |
|---|---|---|---|---|---|---|
| 1 | 8.2 | 8.5 | 517 | 277 | 119 | 220 (271) |
| 2 | 8.2 | 8.9 | 517 | 283 | 119 | 219 |
| 3 | 7.6 | 8.3 | 479 | 269 | 115 | 207 |
| 4 | 7.6 | 8.1 | 479 | 264 | 115 | 207 |
| 5 | 7.6 | 8.7 | 479 | 282 | 115(111) | 205(229) |
| 6 | 8.0 | 8.5 | 504 | 275 | 118 | 215 (264) |
| 8 | 7.4 | 8.7 | 466 | 282 | 114 | 201 |
| 9 | 7.6 | 8.0 | 479 | 259 | 115 | 207 (252) |
| 10 | 7.6 | 9.0 | 479 | 292 | 115(111) | 204(229)(212) |
| 11 | 7.6 | 8.7 | 479 | 282 | 115(111) | 205(229) |
| 12 | 7.6 | 8.7 | 479 | 272 | 115 | 206 |
| 13 | 7.6 | 8.3 | 479 | 269 | 115 | 206 |
| 14 | 7.8 | 8.6 | 491 | 279 | 117 | 211 |
| 15 | 7.4 | 8.5 | 466 | 275 | 114(111) | 202(229)(241) |
| 16 | 7.4 | 8.5 | 466 | 275 | 114(111) | 202(229)(241) |
| 17 | 7.4 | 7.8 | 466 | 253 | 114 | 204 |

* No estimate of depth could be calculated for set No. 7 because of a missing parameter.

### 3.2.3 Hauling

Hauling begins after the line has been fishing for about four hours, proceeding in the reverse order. The first half of the haul is performed by the next shift of seven fishermen.

The vessel steams to the marker to pick up the end of the line. The main line then is fed through the line hauler which piles it onto a slow conveyor. The radio buoy is next to come on board, followed by the first float; the branch lines are only attached thereafter (Figure 2). One fisherman operates the line hauler, regulating its speed with a break to relieve the tension on the main line or to slow it down for oncoming branch lines. Three fishermen work at unhooking and coiling the float and branch lines, recovering approximately two cases of bait at the beginning of each haul. Branch lines are coiled onto the branch reel unless there is a fish on the hook, in which case it is reeled in by hand. Once the fish has reached the opening on the starboard side it is gaffed on board. Large fish may be harpooned to provide another line of traction and lessen the risk of breaking free. Sharks are hoisted on board after their backs have been gashed to prevent excessive thrashing. Two fishermen repair damaged branch lines, make bundles of coils and oversee the return of coils and floats to the rear where they are prepared for the next set. They will also tend to the fish, dressing them for the freezer. The last man regulates the return of the line to the storage tanks where it is laid automatically. He does so when the line accumulates on the slow conveyor and after he has checked or mended it. When the line is tangled, it is allowed to pile up on deck where all available hands will work it loose, but hauling does not stop.

Hauling is only interrupted by a break in the line. The nearest buoy has to be located and picked up before hauling can resume. The "loose" end is brought in first, accumulating on deck until it can be spliced to the rest of the line. As during the setting operation, the men often change work stations. When approximately half the line is in, the men from the second shift (those who had worked during setting) come on deck and, before taking over, move 15 cases of bait from cold storage to the stern for the next set. The men who have been relieved then rest until they are called back for the next set of the line. Hauling lasts an average of 16 hours. A fisherman thus alternating a 5-hour setting shift with an 8-hour hauling shift worked between 8 and 13 hours per working day, 6 days a week.

During the entire operation the fishing master (Captain) and the Chief Officer take turns steering the boat and recording the catch.

### 3.3 Results

Table 2 summarises the number and weight of each species caught during the 17 sets observed. Other species besides tuna, marlin and shark include wahoo (*Acanthocybium solandri*), opah (*Lampris regius*), oilfish (*Ruvettus pretiosus*), spearfish (*Tetrapturus angustrirostris*), and lancetfish (*Alepisaurus* spp.). An average of 21 albacore, 14 yellowfin and 3 bigeye were caught per set. This represents 72 per cent of the catch by weight or about 0.78 tonne/set. Another measure of catch per unit of effort more commonly used is kg/100 hooks. CPUE for all species combined for the period between 29 April and 18 May is 49.3 kg/100 hooks.

TABLE 2. SUMMARY OF THE CATCH COMPOSITION OF EACH SET OF THE LONGLINE. Weight is in parentheses.

| Set No. | Albacore No. Kg | Yellowfin No. Kg | Bigeye No. Kg | Other species No. Kg | Total No. Kg |
|---|---|---|---|---|---|
| 1 | 11(200) | 7(164) | 3(91) | 11(245) | 32(700) |
| 2 | 33(600) | 18(409) | 3(91) | 11(209) | 65(1309) |
| 3 | 32(582) | 17(364) | 3(91) | 14(563) | 66(1600) |
| 4 | 28(509) | 21(436) | 5(136) | 9(168) | 63(1249) |
| 5 | 16(291) | 7(191) | 1(27) | 16(191) | 40(700) |
| 6 | 10(181) | 14(386) | 10(273) | 8(77) | 42(917) |
| 7 | 7(172) | 8(218) | 4(114) | 15(385) | 34(889) |
| 8 | 27(491) | 32(654) | 1(27) | 5(67) | 65(1239) |
| 9 | 20(364) | 12(327) | 1(36) | 5(141) | 38(868) |
| 10 | 15(272) | 8(150) | 3(114) | 18(268) | 44(804) |
| 11 | 15(272) | 5(68) | 4(136) | 20(577) | 44(1053) |
| 12 | 23(418) | 13(227) | 3(68) | 17(296) | 56(1009) |
| 13 | 21(381) | 5(94) | 1(45) | 17(272) | 44(792) |
| 14 | 20(364) | 17(340) | 2(45) | 17(409) | 56(1158) |
| 15 | 31(564) | 20(409) | 2(45) | 11(190) | 64(1208) |
| 16 | 18(327) | 14(341) | 1(27) | 20(931) | 53(1626) |
| 17 | 32(582) | 24(455) | 4(114) | 17(204) | 77(1355) |
| Total | 359(6570) | 242(5233) | 50(1480) | 231(5193) | 883(18476) |

This figure, however, is calculated from the declared catch, recorded in pounds, which is only the product of a set average weight and the number of fish caught. This method is justified for albacore that exhibit a very narrow size frequency distribution, but for yellowfin and bigeye (Figure 3), it can lead to serious underestimations. The only scale on board the vessel proved unreliable and only a check against a length-weight curve and the Japanese adviser's own estimates was possible. Matsumoto (pers. comm.) estimates that total weight is underestimated by about 20 per cent and revises the figures for his own reports accordingly. Recent unloading records showed 40 per cent more than what was estimated to be on board. Length-weight estimates yielded a total weight 32 per cent greater than that declared.

The error is of little consequence for economic purposes (the revenue coming from the weight actually landed), but for assessment purposes, especially monitoring the stocks, it precludes finer analysis.

Other reporting problems are the proper identification of billfishes, reporting spearfishes in the striped marlin column, irregular inclusions of small bigeye in the other species category, only reporting the sharks kept, but not including the others in discard, and including fish lost to shark bites in discards. The implications of these errors will be discussed later in light of more important considerations.

## 4.0 PERFORMANCE

The fishing success of the MFV Lofa during the period observed can be compared with previous data to evaluate its performance. Table 3 summarises data from the first three years of operation (1982-1984) as declared to SPC. The observed CPUE in albacore/100 hooks in May 1985 is less than that obtained the previous years, which also applies to the percentage of albacore in the catch, and the total catch in weight per 100 hooks. The same data summarised from Ratcliffe (1983) and Matsumoto (1984) (Table 4) has slightly different values, due mainly to missing data (number of hooks) and underestimation of weight, but shows the same decrease. The internal reports also show that the number of fishing days has not increased since 1982, but that the percentage of tuna in the catch has increased from 57 per cent in 1982 to 72 per cent in 1984 (Ratcliffe 1983; Matsumoto 1984). In comparison, foreign vessels operating in the waters of Tonga between 1962 and 1977 (Skipjack Programme 1981) achieved greater catch rates (Table 5). The Taiwanese vessels, however, have since experienced a drop in catch rate (Figure 4) and are now at the same level as the Lofa. The local longliners fishing in New Caledonia, although not targeting on albacore, catch slightly less fish per 100 hooks than the Lofa (Table 6).

Figure 5 is a geographical summary of the distribution of catch and effort data for albacore (no. of fish per 100 hooks) as declared to SPC countries since 1978.

The Lofa's performance thus compares quite favourably with the other longliners of the region fishing for albacore. Skillman (1975), however, estimates that the South Pacific albacore fishery has reached its maximum sustainable "average" yield and an increase in catch is thus likely to come only from an increase in fishing days. The potential development of a surface fishery in the southeast and southwest Pacific (Le Gall et al. 1982) by targeting younger albacore could also affect longline catches and should be taken into account in long-term projections.

FIGURE 3. LENGTH FREQUENCY DISTRIBUTIONS OF ALBACORE, YELLOWFIN AND BIGEYE

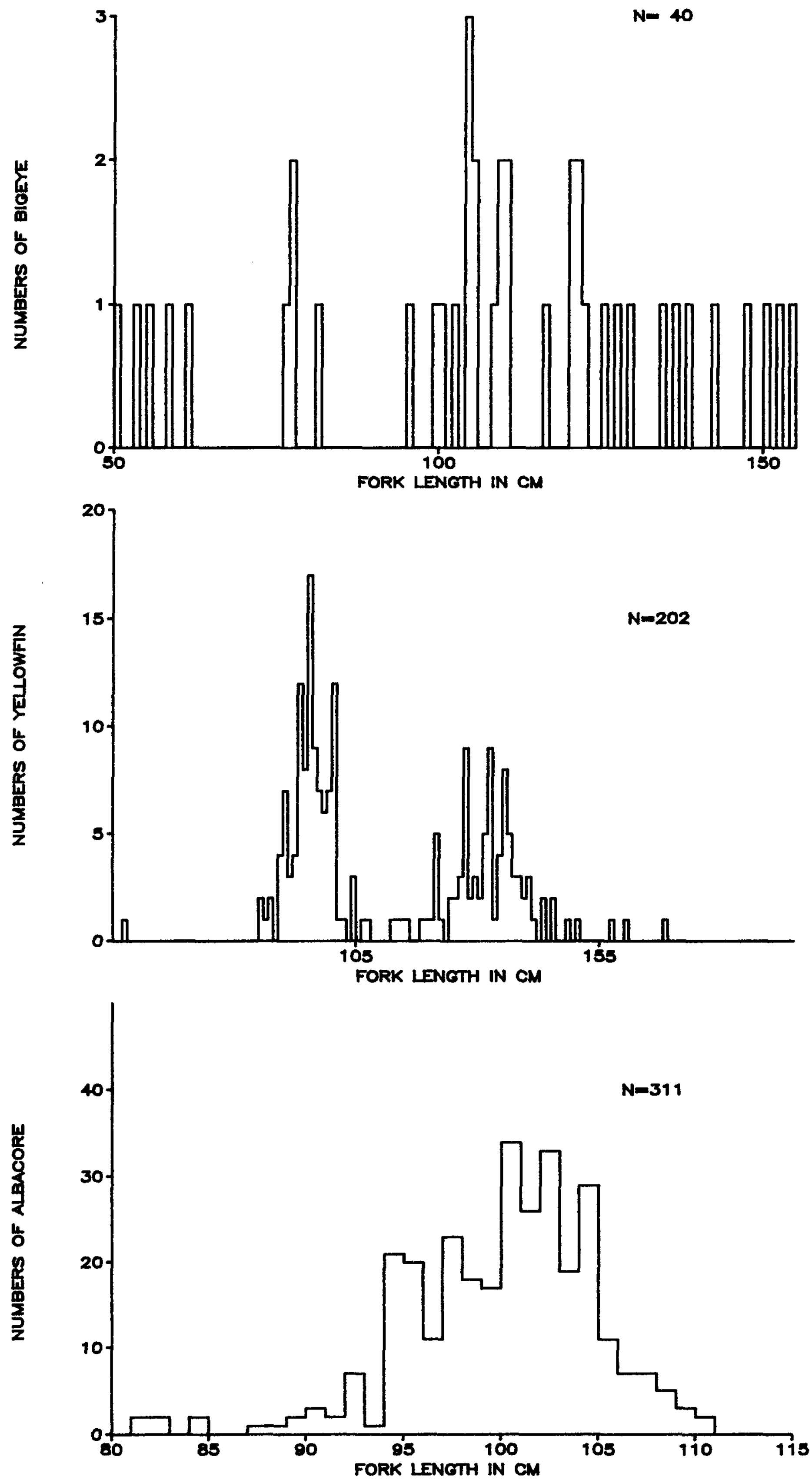


TABLE 3. SUMMARY OF CATCH STATISTICS HELD BY SPC FOR MFV LOFA, 1982-1984

| | Month | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
| No. of albacore/ 100 hooks | | | | | | | | | | | | | |
| 1982 | - | 0.4 | 0.5 | 1.0 | 1.0 | 1.7 | 2.0 | 2.0 | - | - | - | - | 1.2 |
| 1983 | - | - | - | 0.9 | 1.7 | 1.9 | 2.1 | - | - | - | - | - | 2.6 |
| 1984 | - | - | 0.9 | 0.9 | 1.4 | 1.6 | - | - | - | - | - | - | 2.4 |
| 1985* | - | - | - | - | 0.9 | - | - | - | - | - | - | - | - |
| % of albacore in catch | | | | | | | | | | | | | |
| 1982 | - | 20 | 30 | 43 | 48 | 56 | 59 | 66 | - | - | - | - | 50 |
| 1983 | - | - | - | 34 | 64 | 65 | 74 | 79 | 81 | - | - | - | 65 |
| 1984 | 62 | 59 | 34 | 37 | 49 | 45 | - | - | - | - | - | - | 50 |
| 1985 | - | - | - | - | 37 | - | - | - | - | - | - | - | - |
| Total catch (kg)/ 100 hooks | | | | | | | | | | | | | |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - | 57.7 |
| 1983 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1984 | - | - | 58 | 52 | 59 | 71 | - | - | - | - | - | - | 59 |
| 1985 | - | - | - | - | 49 | - | - | - | - | - | - | - | - |

* Declared value.

TABLE 4. SUMMARY OF CATCH STATISTICS FOR THE MFV LOFA COMPILED FROM GOVERNMENT REPORTS, 1982-1984

| | Month | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Total |
| No. of albacore/ 100 hooks | | | | | | | | | | | | | |
| 1982* | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983** | 2.0 | 1.5 | - | 1.0 | 1.7 | 1.9 | 2.0 | 1.9 | 1.8 | 2.2 | 2.7 | 2.8 | 1.95 |
| 1984** | 2.0 | 1.9 | 0.8 | 0.9 | 1.4 | 1.5 | 2.9 | - | 1.9 | 1.6 | 2.8 | 3.0 | 1.88 |
| 1985*** | - | - | - | - | 0.9 | - | - | - | - | - | - | - | - |
| % of albacore in catch | | | | | | | | | | | | | |
| 1982 | - | - | 17 | 43 | 50 | 69 | 60 | - | - | - | - | - | 48 |
| 1983 | 70 | 57 | - | 35 | 65 | 67 | 68 | 68 | 56 | 50 | 65 | 71 | 62 |
| 1984 | 62 | 59 | 33 | 37 | 49 | 44 | 76 | - | 62 | 55 | 68 | 67 | 58 |
| 1985 | - | - | - | - | 37 | - | - | - | - | - | - | - | - |
| Total catch (kg)/ 100 hooks | | | | | | | | | | | | | |
| 1982 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 1983 | 63 | 64 | - | 53 | 61 | 62 | 62 | 66 | 67 | 97 | 98 | 87 | 71 |
| 1984 | 71 | 79 | 58 | 62 | 71 | 80 | 83 | - | 67 | 70 | 85 | 93 | 74 |
| 1985 | - | - | - | - | 49 | - | - | - | - | - | - | - | - |

* Ratcliffe 1983
** Matsumoto 1984
*** Declared value

TABLE 5. ALBACORE CATCH STATISTICS FROM JAPANESE AND TAIWANESE LONGLINERS IN THE WATERS OF TONGA, 1962-1977 (Skipjack Programme 1981)

| | Japanese | | | Taiwanese | | |
|---|---|---|---|---|---|---|
| Year | Hooks/1000 | No. of albacore per 100 hooks | Total No. of fish per 100 hooks | Hooks/1000 | No. of albacore per 100 hooks | Total No. of fish per 100 hooks |
| 1962 | 1643 | 3.0 | 3.9 | - | - | - |
| 1963 | 892 | 3.1 | 4.0 | - | - | - |
| 1964 | 431 | 3.2 | 4.2 | - | - | - |
| 1965 | 881 | 3.9 | 4.8 | - | - | - |
| 1966 | 654 | 3.3 | 4.2 | - | - | - |
| 1967 | 515 | 2.9 | 3.6 | 601 | 4.5 | 5.0 |
| 1968 | 169 | 2.4 | 3.3 | 259 | 4.1 | 5.2 |
| 1969 | 31 | 3.8 | 4.8 | 581 | 6.6 | 7.0 |
| 1970 | 133 | 2.7 | 3.5 | 388 | 4.1 | 4.8 |
| 1971 | 124 | 2.1 | 2.7 | 469 | 3.5 | 4.1 |
| 1972 | 87 | 2.9 | 3.5 | 925 | 2.9 | 3.7 |
| 1973 | 4 | 2.3 | 2.5 | 198 | 2.2 | 3.1 |
| 1974 | - | - | - | 80 | 1.3 | 1.6 |
| 1975 | - | - | - | 189 | 1.6 | 2.0 |
| 1976 | - | - | - | 474 | 1.8 | 2.1 |
| 1977 | - | - | - | 294 | 2.2 | 2.6 |

% of albacore = 77
Av. No. of fish/100 hooks = 4.1

% of albacore = 85
Av. No. of fish/100 hooks = 4.1

TABLE 6. PERFORMANCE OF LOCAL AND DISTANT-WATER FISHING NATIONS' LONGLINERS WEST OF 180° (from Hallier 1984)

| | | | Catch | | CPUE | |
|---|---|---|---|---|---|---|
| Nationality and fishing grounds | Period covered | No. of Hooks/100 | Total No. | Tonnes | No. per 100 hooks | Kg/ 100 hooks |
| Taiwanese | 1977-82 | 523,906 | 1,969,439 | 30,861.5 | 3.8 | 59 |
| 15-30°S, | 1981 | 79,644 | 203,410 | 3,364.2 | 2.6 | 42 |
| 150-180°E | 1982 | 49,439 | 134,250 | 2,247.8 | 2.7 | 45 |
| Korean | 1979 | 9,519 | 22,131 | - | 2.3 | - |
| New Caledonian | 1983-84 | 2,804 | 6,066* | 190.6 | 2.2 | 68 |
| Tongan (Lofa)** | 1984 | 1,410 | 4,044 | 84.0 | 2.9 | 59 |
| Japanese in New Caledonia's EEZ | 1969-77 | 55,330 | 93,688 | - | 1.7 | - |

* 42% albacore
** SPC data

FIGURE 4. CPUE OF LONGLINE VESSELS BASED IN AMERICAN SAMOA (1960-1981), TAIWANESE PACIFIC LONGLINE FLEET (1973-1982), TAIWANESE LONGLINERS FISHING IN VANUATU WATERS (1981-1983), AND THE LOFA (1981-1983)

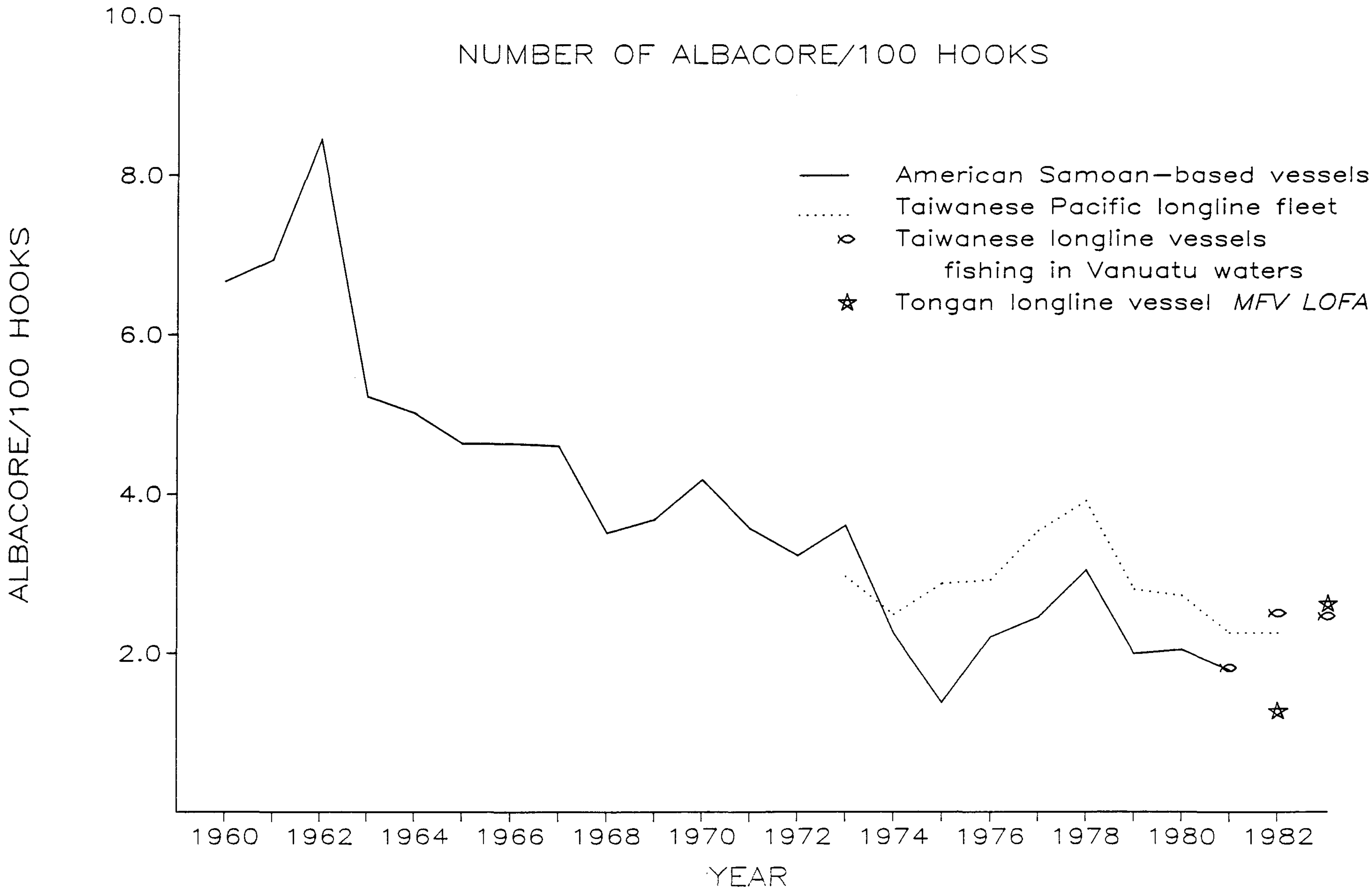
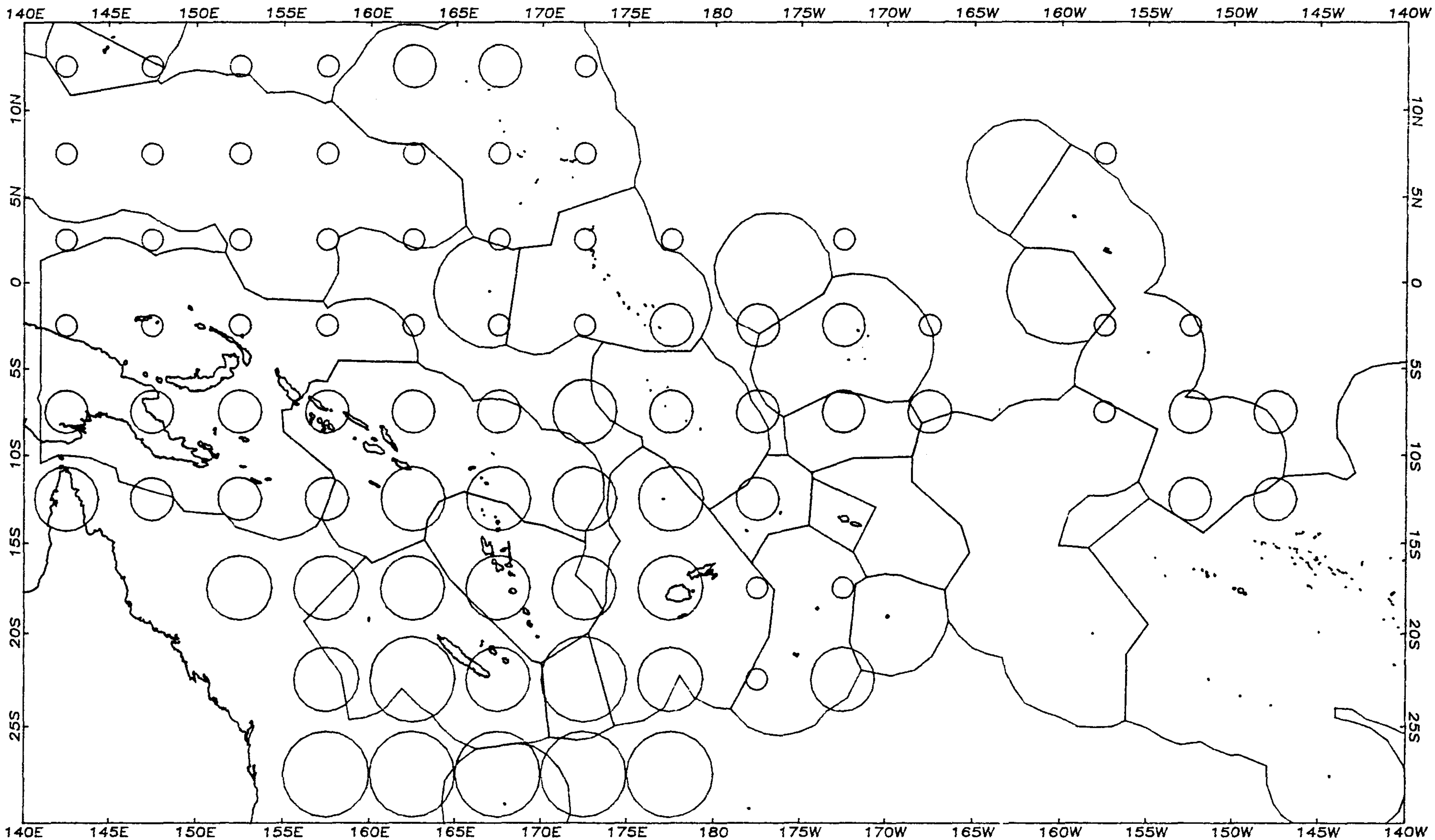


FIGURE 5. ALBACORE LONGLINE CPUE (1978-1985). The circles of four different sizes represent the number of albacore caught per 100 hooks, up to 0.05, 1.25, 2.5 and more than 2.5 respectively, in each five degree square.



## 5.0 NOTES ON ALBACORE BIOLOGY RELEVANT TO LONGLINING

### 5.1 Depth Distribution

The species composition of longline caught tuna exhibit a depth dependent distribution which has been the subject of many investigations (Anon 1981, 1983; Suzuki et al. 1977; Grandperrin 1975; Saito and Sasaki 1974; Grandperrin and Legand 1971; Saito et al. 1970). The results relevant to albacore in terms of success rate with depth, are summarised in Table 7. It appears that the highest catch rates for albacore, either for experimental or commercial fishing, occur between 200 and 375 metres. In only two cases did the hooking rate for shallow (150-175 m) sets exceed those of deeper sets. Although vertical longlines in some cases have produced catches that have increased with depth to 350 metres (Anon 1983; Grandperrin 1975), the peaking around 275 metres observed by Saito and Sasaki (1974) or Saito et al. (1970) is in closer agreement with the results of deep longlining (Anon 1981; Suzuki et al. 1977; Grandperrin and Legand 1971), even with the less reliable depth measurement of the latter. If albacore indeed occur deeper than the greatest depth presently fished by the Lofa (~250 metres), their exploitation would be limited by the feasibility of vertical longlining or by the number of hooks that can be fished deeper. Both methods increase handling time and total yield could be potentially reduced.

In light of these observations, the Lofa's catch composition and yield per depth were analysed for the period observed. Data on catch at each hook are presented in Table 8. Set No. 6 was not sampled and data for set No. 7 was omitted as fishing depth could only be inferred from ship's speed and buoy interval. Regardless of the exact values (the three estimates of depth from Table 1, when all available, varied by about 30 metres), the sets could be separated in deep (Nos. 1, 2, 6 and 14) and shallow (Nos. 3, 4, 5, 7-13 and 15-17) (Table 9). Overall catch from sets Nos. 7 and 7 were included in the aggregate data. The greatest proportion of albacore was caught on hook No. 3(6) in the deepest sets (41%) and on hook No. 4(5) in the shallower sets (37%). This made for an optimum depth for albacore of 200-210, 230 or 237 metres depending on the calculation of depth. Referring back to Table 7, this corresponded to the lower limit of the range of optimum catch rates.

The proportion of albacore in the overall catch is slightly greater for deep than for shallow sets, as was expected from the experimental data (Anon 1981, 1983; Grandperrin 1975). However, the overall hooking rate is higher in shallower sets (52.8 vs. 46.7 kg of fish/100 hooks), and it would appear that on the basis of this small sample, due to the high return of the incidental species relative to tuna, it is more profitable to fish shallower lines (Table 10). The incidental species thus take on a greater importance and the correct reporting of their catches is needed to evaluate the economic impact of different techniques.

### 5.2 The Influence of the Environment

In an effort to determine if the shallower lines would be more profitable all year round, environmental variables thought to affect the distribution and behaviour of albacore were examined. Sund et al. (1981) and Foreman (1980) reviewing the biology of albacore in relation to the environment cite temperature as the factor best known to influence distribution. The preferred temperature range extends between 9.5 and 25.2°C (Foreman 1980), but the best catch rates reported in Table 7 are associated with narrower ranges (e.g. 17-21°C, Saito and Sasaki 1974;

TABLE 7. ESTIMATES OF DEPTH YIELDING THE GREATEST CATCH RATE FOR ALBACORE

| Depth (m) | Year | No. of albacore/ 100 hooks | Deep:shallow | Source |
|---|---|---|---|---|
| 300+ | | - | - | Anon 1983 |
| 250 | | 0.08 | 1.75 | Anon 1981 |
| 250 | | 0.07 | 0.82 | Suzuki et al. 1977 |
| 250-275* | | 2.0 | 4.0 ) | Grandperrin 1975 |
| 350-374** | | 1.7 | 0.63) | |
| 289 | (1967) | 3.4 | 1.8 ) | |
| 289 | (1968) | 1.6 | 1 ) | Saito et al. 1970 |
| 289 | (1969) | 5.4 | 1.8 ) | |
| 243-289 | (1970) | 2.7 | 2.2 ) | Saito & Sasaki 1974 |
| 224 | (1971) | 2.1 | 2.9 ) | |
| 200-224*** | | 2.3 | 1.05) | Grandperrin & Legand 1971 |
| 200-224**** | | 2.3 | 4.1 ) | |

* longline
** vertical longline
*** New Caledonia
**** Tahiti

TABLE 8. NUMBER OF FISH CAUGHT AT EACH HOOK AS OBSERVED FOR EACH SET OF THE LONGLINE. The number of albacore caught is in parentheses.

| Set No.* | Hook Nos. 1 and 8 | 2 and 7 | 3 and 6 | 4 and 5 | Total |
|---|---|---|---|---|---|
| 1 | 2(1) | 13(0) | 14(7) | 9(3) | 38(11) |
| 2 | 13(6) | 11(3) | 24(13) | 16(11) | 64(33) |
| 3 | 14(2) | 13(7) | 20(10) | 17(13) | 64(32) |
| 4 | 8(3) | 20(5) | 16(7) | 25(10) | 69(25) |
| 5 | 7(1) | 14(7) | 10(6) | 9(2) | 40(16) |
| 8 | 13(3) | 12(4) | 16(9) | 17(10) | 58(26) |
| 9 | 3(0) | 10(5) | 14(5) | 21(10) | 48(20) |
| 10 | 0(1) | 15(4) | 17(1) | 18(6) | 59(15) |
| 11 | 12(3) | 14(3) | 16(5) | 17(4) | 59(15) |
| 12 | 19(4) | 14(2) | 14(9) | 15(7) | 62(22) |
| 13 | 10(4) | 11(3) | 14(7) | 12(10) | 47(24) |
| 14 | 7(0) | 22(9) | 18(6) | 16(5) | 63(20) |
| 15 | 7(1) | 24(8) | 28(13) | 23(10) | 82(32) |
| 16 | 13(1) | 17(5) | 16(6) | 13(6) | 59(18) |
| 17 | 9(1) | 27(8) | 27(10) | 22(14) | 85(33) |
| Total | 146(31) | 237(73) | 264(117) | 250(121) | 897(345) |
| % of total catch caught at hook | 16(9) | 26(21) | 29(34) | 28(35) | - |

* Set No. 6 was not sampled and data for set No. 7 was omitted since fishing depth could only be inferred from ship's speed and buoy interval.

TABLE 9. DECLARED CPUE OF DEEP VERSUS SHALLOW SETS OF THE LONGLINE

| | Deep (set Nos. 1,2,6 & 14) | Shallow (set Nos. 3-5,7-13 & 15-17) | Total |
|---|---|---|---|
| No. of hooks | 9088 | 28400 | 37488 |
| No. of albacore/100 hooks | 0.8 | 1.0 | 0.96 |
| % of albacore in catch | 38.8 | 37.9 | - |
| No. of fish/100 hooks | 2.1 | 2.4 | 2.3 |
| Wt. of fish/100 hooks | 44.8 | 52.1 | 49.3 |

TABLE 10. REVENUES ASSOCIATED WITH DEEP AND SHALLOW SETS

| | Deep | US$/tonne* | Shallow |
|---|---|---|---|
| Catch (kg)/100 hooks | 44.8 | - | 52.1 |
| % of albacore | 38.8 | 1800 | 38.1 |
| % of tuna | 34.0 | 1000 | 31.4 |
| % of other species | 27.2 | ~400 | 30.2 |
| $/100 hooks | 51.4 | - | 58.6 |

* approximate price (Forum Fisheries Agency telexes)

13-15°C, Grandperrin 1975; 13-15°C, Anon 1981). The highest catch rates observed on board the Lofa, depending on the calculation of depth, occur in the 19 or 20° isotherms (Figure 6). Since the profile of these isotherms, between 180-170°W and 15-25°S for an "average" year, is characterised by an "upwelling" between February and June, which corresponds to the poorest fishing period (Matsumoto 1984), it is possible that the better performance of the shallower lines (in May 1985) is tied to the shallower distribution of albacore during that time of year.

Other lesser-known factors affecting distribution, such as salinity or dissolved oxygen, did not, within the limits of the data available (Levitus 1981) reach the limiting values (e.g. 2m/l for $O_2$).

Upwelling, fronts and currents also affect local distribution of albacore as long as they occur within the preferred temperature range. Matsumoto (1984) has mapped current speed and direction around Tonga, stressing the seasonal and interannual fluctuations. The identification of a generalised pattern through continuous monitoring of the currents could potentially help to determine the best fishing grounds, provided that such patterns do emerge.

## 6.0 CONCLUSIONS

The fishing success of the Lofa as observed for 17 sets between 29 April and 18 May was slightly inferior to that achieved during the same period the two previous years. This may be due to interannual variations compounded by the limits of a small sample. Overall, the performance of the Lofa compares very favourably with other vessels longlining for albacore in the region.

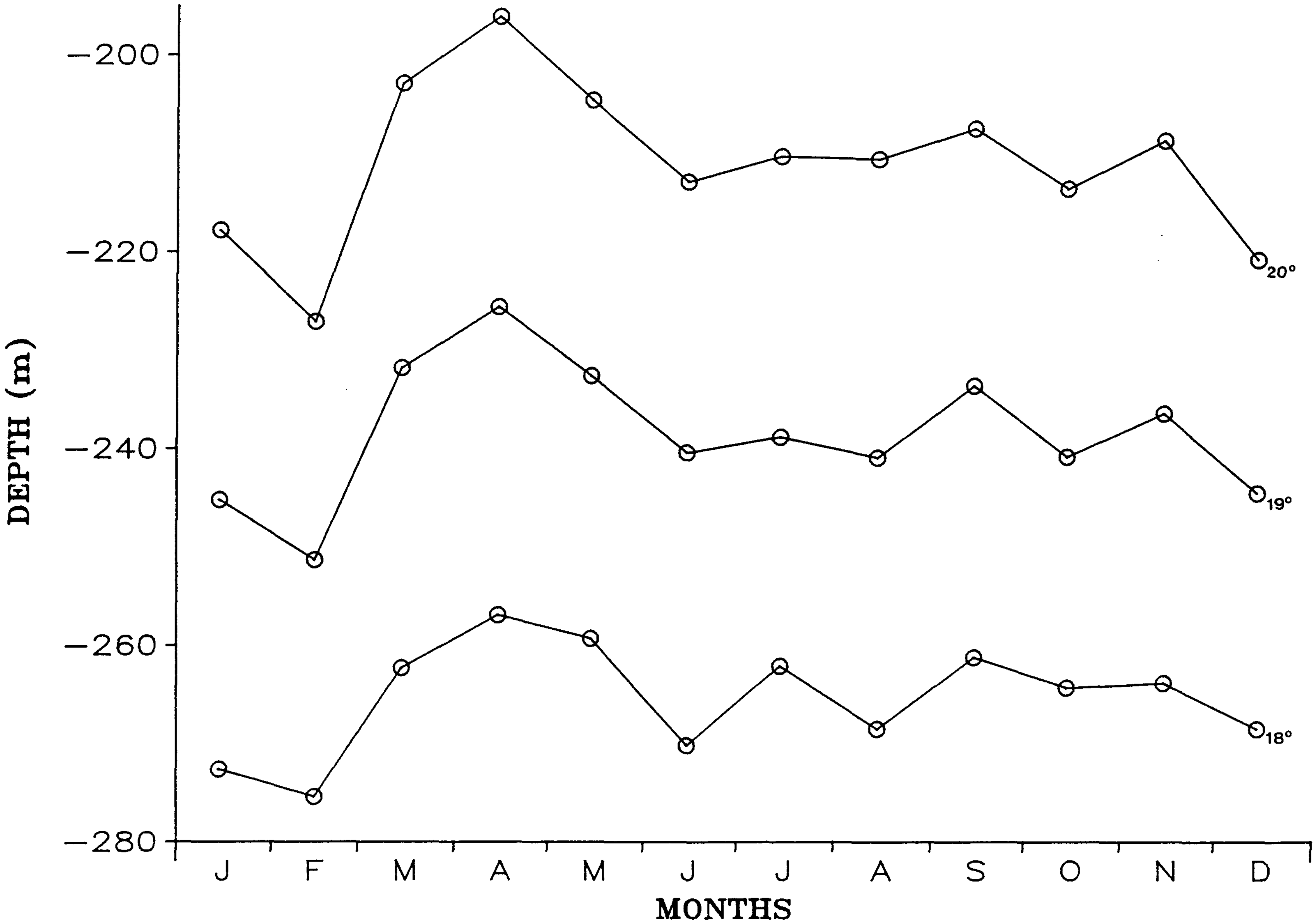
These historical data, however, together with the fact that the South Pacific albacore fishery is thought to be currently at its optimum yield, indicate that a significant increase in the Lofa's catch is unlikely.

A tentative correlation between the 18 and 20° isotherms and fishing rate seems to indicate that offseason (February to June), depth of the isotherm is shallower than during the rest of the year and that catch rates could be optimised by following their profile. Since the fishing master seems to adjust for it instinctively (slowing the line-throwing speed to ~7.4 metres/sec.) after a few sets, the only measure that could improve the performance would be to use the bathytermograph to determine with accuracy the depth of the isotherms, at least when first reaching new grounds.

Until a knowledge of generalised water movement is available, the echo sounders could be used to identify plankton concentration associated with fronts and currents in Tonga's EEZ, helping to identify potentially productive areas. If these measures do not contribute in markedly improving the Lofa's performance, they should prove valuable when exploring new fishing grounds.

The prospection of new grounds, the deployment of additional fishing units or alternative gear (vertical longline) are the logical paths to follow to increasing Tonga's pelagic fish production. However, their development is tied to economic constraints, the review of which is beyond the scope of this report.

FIGURE 6. TEMPERATURE ISOTHERMS FOR AN AVERAGE YEAR BETWEEN 180-170°W AND 15-25°S (courtesy of ORSTOM)



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