Secretariat of the Pacific Community

FIELD REPORT No. 14

on

TECHNICAL ASISTANCE PROVIDED TO THE KINGDOM OF TONGA'S FISHERIES TRAINING VESSEL, FTV *TAKUO*

27 August to 6 October 2001

by

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SUMMARY

The Tongan Government requested technical assistance from the Fisheries Development Section in July 2001. The aim of the project was to undertake an assessment of the overall operation of their fisheries training vessel, FTV *Takuo*. The assessment was to cover the fishing operation, including the finer points of using both the monofilament and rope longlining systems on board, and the shore-based management of the operation. On 27 August 2001, Fisheries Development Officer, William Sokimi, arrived in the Kingdom of Tonga to undertake this assignment.

One fishing trip was undertaken to assess the fishing side of the operation. It was found that the captain and crew were quite proficient in the fishing operation. The Fisheries Development Officer introduced the crew to using the monofilament branchlines for the rope fishing gear, which speeded up the hauling operation considerably, while making the operation easier. The captain was also given some pointers in regard to the operation of some of the vessel electronics, and ways the electronics could be used to better locate suitable fishing grounds.

Catch rates from the fishing trip were low, as the vessel was on its way to Pago Pago to unload some 50 t of frozen albacore tuna in its hold, so less than optimum fishing grounds were fished. The main fleet was fishing in waters to the south of Tonga, and this was the opposite direction to Pago Pago. The fishing strategy was to unload the catch, and then steam south to the better fishing grounds to continue the trip.

Unfortunately problems were encountered with the Coast Guard, and FTV *Takuo* was not given permission to enter the port of Pago Pago, as some of the vessel's seaworthiness certificates had expired. After more than a week drifting, while the problems were being discussed, FTV *Takuo* returned to Tonga. During this time the crew made up new and replacement gear, especially branchlines and carried out repairs to damaged gear.

A new management team had taken over the shore-based management of FTV *Takuo* prior to the Fisheries Development Officer arriving in the country. This team had little to work with, as the old management team had not maintained good records. Part of the problem appeared to be that management of FTV *Takuo* was only part of the responsibility of the management team, and they had other responsibilities regarding their fisheries work. This should change so that the new team only looks after FTV *Takuo,* so there are no competing priorities. The new team will also need to keep good records of all operations, including fish sales and expenses.

As a matter of urgency, FTV *Takuo* needs to be slipped so that all of her certificates can be renewed, which should overcome the problems encountered when trying to enter Pago Pago during this project. Insurance cover should also be assessed, as the Coast Guard had suggested the current cover should be extended to cover disaster expenses, should anything happen while the vessel was in Pago Pago.

FTV *Takuo* is a training vessel, and there is scope for this vessel to be used to train up skippers and engineers for the developing and expanding tuna fishery. Suitable people with seatime and experience could be placed on this vessel while they study for and attain their tickets. Once the qualification is achieved, the person would go back to the private sector and work in the tuna fishery.

RÉSUMÉ

Le gouvernement des Tonga a sollicité l'assistance technique de la section Développement de la pêche en juillet 2001. Le projet consistait à évaluer l'exploitation générale du navire-école tongan, le Takuo. L'étude devait porter sur les opérations de pêche, en particulier les subtilités de l'utilisation des deux systèmes de palangre, la ligne à monofilament et la ligne japonaise, ainsi que sur les opérations à terre. Le 27 août 2001, William Sokimi, chargé du développement de la pêche, s'est rendu au royaume des Tonga pour procéder à cette évaluation.

L'étude des conditions de pêche s'est faite lors d'une sortie de pêche. Il a été constaté que le capitaine et l'équipage étaient très compétents. Le chargé du développement de la pêche a initié l'équipage à l'utilisation des avançons à monofilament pour la ligne japonaise, qui accélère considérablement le virage des lignes tout en facilitant l'opération. Il a aussi donné au capitaine quelques conseils sur la manière d'utiliser l'électronique de bord et de se servir de cet appareillage pour localiser de bonnes zones de pêche.

Les taux de prise réalisés lors de cette sortie ont été faibles. Le navire faisant cap sur Pago Pago pour y débarquer une cinquantaine de tonnes de germon congelé stocké dans ses cales, il n'a pu se rendre sur les meilleurs sites de pêche. La majorité des bateaux de pêche opérait dans les eaux du sud des Tonga. Le projet était donc de décharger la cargaison puis de faire cap au sud pour continuer la marée sur de bons sites de pêche.

Malheureusement, le Takuo a eu des problèmes avec les garde-côte et n'a pas obtenu l'autorisation d'entrer dans le port de Pago Pago, certains certificats de navigabilité du navire ayant expiré. Après plus d'une semaine de dérive, tandis que les discussions se poursuivaient, le Takuo est retourné aux Tonga. Pendant ce temps, l'équipage a confectionné de nouveaux engins ou a remplacé les anciens, notamment des avançons, et a réparé les engins abîmés.

Une nouvelle équipe de gestion avait pris en mains la gestion à terre du Takuo avant l'arrivée du chargé du développement de la pêche aux Tonga. Elle avait peu d'informations exploitables, l'ancienne équipe ayant mal tenu à jour les archives. Cette défaillance s'expliquait en partie par le fait que la gestion du Takuo n'était qu'une des tâches incombant à l'équipe de gestion, investie d'autres responsabilités en matière de gestion halieutique. Les choses devraient changer; la nouvelle équipe devrait être uniquement chargée de la gestion du Takuo et ne pas être partagée entre plusieurs priorités. Elle devrait aussi assurer un bon suivi de toutes les opérations, y compris des ventes de poisson et des dépenses.

Le Takuo devrait être halé en cale sèche de toute urgence afin que tous les certificats puissent être renouvelés et que les problèmes rencontrés lors de la tentative d'entrée dans le port de Pago Pago, dans le cadre du projet ne se reproduisent plus. Il faudrait aussi revoir la police d'assurance du navire, les garde-côte ayant préconisé l'extension de la couverture actuelle aux dépenses occasionnées par un sinistre éventuel pendant le mouillage du navire à Pago Pago.

Le Takuo est un navire-école. Il pourrait donc être utilisé pour former des capitaines et des mécaniciens au profit du développement et de l'expansion de la pêche thonière. Des personnes présentant le nombre d'heures de navigation et l'expérience appropriés pourraient s'exercer sur ce bateau pendant leurs études en vue de l'obtention de leur brevet. Une fois qualifiées, elles retourneraient dans le secteur privé pour pratiquer la pêche thonière.

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1. INTRODUCTION AND BACKGROUND

1.1 The Kingdom of Tonga

Tonga consists of 171 islands of which only 45 islands are inhabited (Anon. 2001a). The islands are spread over and exclusive economic zone (EEZ) of some 705,000 km^2 between latitudes 15º to 23º S and longitudes 173º to 177º W (OFP 1997). The islands are split into three groups, Tongatapu, Ha'apai and Vava'u (Figure 1). The total land area is approximately 649 km^2, and the country's population is approximately 100,200 (SPC 2000).

In 1845, the islands of Tonga were united into a Polynesian kingdom. In 1875 it became a constitutional monarchy and a British protectorate in 1900. In 1970 Tonga acquired its independence and became a member of the Commonwealth of Nations (Anon. 2001b). Tonga remains the only monarchy in the Pacific.

Tonga has a tropical climate throughout the year and is influenced by variations brought about by the trade winds. The warm season is from December to May and the cool season from May to December. Tonga consists of both volcanic islands and coral atolls where most of the islands have limestone base formed from uplifted coral formation and others have limestone overlaying volcanic base (Anon. 2001b).

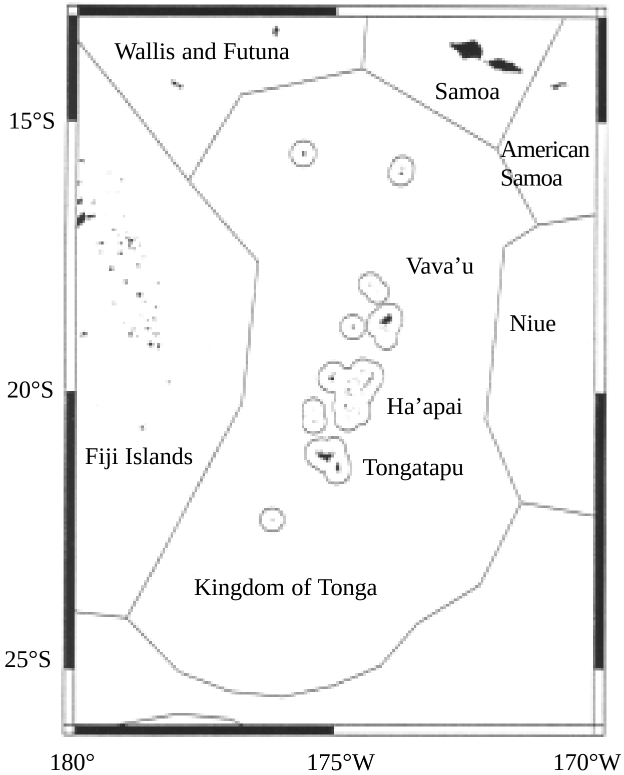


Figure 1: The Kingdom of Tonga

The economy is dependent on agriculture, manufacturing and tourism and more recently, fisheries products. While agricultural products account for over 90 percent of exports, the government is giving strong backing to the development of tourism. A cottage industry also exists for the manufacture of handicraft (Anon. 2001c).

1.2 Offshore pelagic fisheries

In Tonga, as with all Pacific islands, the sea has always been an important source for supplementing domestic nutrition and for generating income-earning activities. While the inshore fisheries have reached a stage where they need to be carefully monitored and managed due to overfishing, the offshore pelagic fishery is under-exploited, and still has the potential for development. This is mainly the tuna fishery for supplying fish to canneries and sashimi markets. Development and management decisions are coordinated with that of other Pacific Island countries, as the pelagic stock is part of the larger tuna stock of the western and central Pacific Ocean.

In the 1980s and the early to mid 1990s, Tonga's main export species were deep-water snappers, caught by deep-water fishing techniques (bottom longlining and reel fishing), using 8.5 to 12 m (28 to 40 foot) vessels. Exports of deep-water snappers continue today, although exports from the tuna fishery are more significant at present.

The Government of Tonga commenced tuna fishing in 1982, when the Government of Japan donated a 30 m tuna longline vessel, F/V *Lofa*, to them. F/V *Lofa* targeted albacore tuna (*Thunnus alalunga*), and landed this fish frozen to canneries in the region. In 1991 Sea Star Fishing Company was established, which was 70 per cent government owned. The company purchased several vessels from Japan. The fishing operations were only marginally successful.

Private sector development in the tuna fishery commenced in the mid-1990s, with several local companies being established. These companies focused on fishing for the higher priced yellowfin tuna (*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*), exporting these fish fresh to markets in Japan, the US and New Zealand. The tuna longline fleet has steadily grown to sixteen vessels. A tuna management plan is currently in place to manage this fishery to be sustainable and consistent in its outputs.

Most of the local fishing vessels are crewed by Tongans, but recently there has been an influx of expatriate skippers to fill a void at this level. As the number of vessels increases, the number of Tongan skippers remain the same or is being reduced. Most of the expatriate skippers are from Korea, Fiji, New Zealand and Australia. Some foreign crew have also been employed, although this is expected to be a short-term measure to meet the current need, while more Tongans are trained.

1.3 Training requirements to meet the industry's needs

The expanding tuna longline fishery is now experiencing a shortage of manpower to crew fishing vessels at all levels. In the development of the offshore pelagic fishery around the region, most of the officers who readily filled the gap were recruited from the merchant shipping sector. These officers were either given crash briefings on the intricacies of mechanised tuna longline fishing or a fishing master was recruited to perform the fishing operations while the captain concentrated on vessel management. In some cases, those who were already involved in the fishing industry were jumped up to skipper level without any formal training.

The current trend is to combine the duties of both positions to be incorporated into the skipper's duties. This eliminates friction that usually develops between the captain and the fishing master and makes for an easier solution to vessel management. While it is generally understood that the captain is the overall commander of the vessel, fishing masters tend to be given a more important stature in the company ranks, and this often leads to disputes between the two.

The combining of the two positions and the growing need to address safety issues on board fishing vessels are among some of the many reasons that courses or training schemes should be addressed to improve standards in the offshore tuna longline industry.

The standardisation of fishing courses is still in the discussion stages as no international agreement can be reached to standardise subjects that would fully address the overall fishing industry requirements. Some countries have gone ahead and implemented fishing courses that would certify the successful candidates to fish within the countries' territorial waters while most other Pacific Island countries are remaining with merchant-based qualifications.

Nautical training in Pacific Islands maritime training institutions is mainly centred on merchant shipping background except for New Zealand and Australia, where fishing ratings courses for all fishing vessel manning levels have been developed.

Previously, the Pacific islands did not have a need to develop skippers for fishing vessels, as only small craft were used to perform the fishing operations that were conducted close offshore. Now, properly trained skippers are required to command the growing fleet in Tonga, and around the region, which consists of larger vessels (15 to 35 m long) engaged in oceanic fishing trips.

Economically, it is cost effective to crew the fishing vessels with locals. Employment of foreign skippers burdens the fishing companies with the welfare and air fares costs. The catch here is that the local skippers and crew must be up to standard to be competitive with their overseas counterparts.

On-board crew training can easily be achieved by the private sector and in most cases is absorbed in the normal operations of a vessel. The normal pre-sea courses and able seaman's courses are sufficient at this stage to cater for seamanship training. Fishing practicals can be done on fishing vessels in the industry.

The FTV *Takuo* on the other hand, should be considered as the base for training officers for the industry, mainly in providing practical experience in the utilisation of the modern electronic equipment on board and the advanced use of monofilament and rope tuna longline fishing equipment. If the need urgently arises that deck crew are lacking to man the vessels within the industry, FTV *Takuo* can easily accommodate trips for able seaman and ordinary seaman level, which are easier to conduct than fishing practicals. These men may then board vessels in the private sector for fishing experience.

1.4 Initiation of the project and its objectives

The tuna longline industry in Tonga has progressed steadily over the years. This has resulted in foreign investments through the establishment of fishing companies that operate tuna longline vessels and processing facilities which prepare and export fresh tuna to the sashimi markets in Japan and the United States and frozen tuna to the canneries in Pago Pago, American Samoa and Levuka, Fiji.

The escalation of the industry opened job opportunities for local fishermen and fish processors, and induced government to consider initiating training options that would provide sufficient local personnel to participate in the industry. A request for assistance to achieve this goal was forwarded to the Japanese Government by the Government of the Kingdom of Tonga. This resulted in the delivery of the fisheries training vessel FTV *Takuo*.

Part of the Ministry of Fisheries scheme in the management of the vessel was a periodic assessment of the overall operation of the vessel. In July 2001, the Government of Tonga requested technical assistance from SPC to undertake such an assessment.

On 27 August 2001, SPC Fisheries Development Officer, William Sokimi, was assigned to assist the Tonga Ministry of Fisheries following the request from the Secretary for Fisheries, ‘Akau’ola. The objective of the project was to assist in revitalising the operation of FTV *Takuo*, focussing especially on vessel operations management and advising the crew on the finer points of using the two longline systems on board: Japanese rope gear system and monofilament reel system.

2. FTV *TAKUO* AND ITS NORMAL OPERATION

2.1 FTV *Takuo*

This vessel was built for tuna longline training and research purposes with several of the latest amenities set up on board to achieve this. The vessel was constructed and delivered in 1998 to the Government of Tonga under a Grant Aid Fund from the Government of Japan. The operation and management of the vessel was handed over to the Ministry of Fisheries. FTV *Takuo* (Figure 2) is 39.5 m long, with a beam of 7.5 m and a draft of 3.1 m. Detailed information on FTV *Takuo* has already been published in SPC Fisheries Newsletter No. 84 (Capture Section 1998) and details of the vessel characteristics are at Appendix A.

Figure 2: FTV Takuo

One of the interesting features on the vessel is the installation of two separate longline systems, the rope gear system (basket gear) and the monofilament longline reel system. The vessel also has an appealing array of electronic equipment (Appendix A) that contributes immensely to improving ship to shore communications, enhancing the possibilities of selecting better fishing grounds, performing longline fishing research, assisting the master in monitoring weather conditions and providing him with the ability to detect extreme weather conditions that may endanger the vessel. The equipment was well appointed in the wheelhouse (Figures 3 and 4), with everything easily accessible.

Figure 3: Electronic equipment mounted in wheelhouse

Figure 4: Communication equipment mounted in wheelhouse

2.2 Crew manning structure and watchkeeping duties

The vessel normally operates with a crew of 19 but is approved to accommodate a full complement of 26. The present manning structure is sufficient to organise two shifts for working during the fishing operations. A full longline set of 2500 to 3000 hooks can cover some 35 to 40 nm. This can take 12 to 18 hours to haul back so the two shifts will ensure that the crew are sufficiently rested and alert when back on the job.

The manning ranks are: captain, mate, chief engineer, second engineer, bosun, leading hand, two oilers, cook, and nine deckhands. Appendix B provides a crew list for FTV *Takuo* for the fishing trip beginning on 4 September 2001.

While on passage to and from fishing grounds, the master and mate alternated watches every six hours. This also applied to the engine room crew, between the chief engineer and second engineer. In close channels and passages, the captain took command. Out in the open sea, stand-in crew were put on duty during the master and mate's watches.

Sea watches on fishing vessels are sometimes delegated to the more senior or experienced crew and a junior crew. Any discrepancies during the stand-ins watches are immediately reported to the officer who is supposed to be on duty at the time. This allows the captain and mate to get in more rest periods and cut the monotony of sticking to routine attendance on the bridge.

2.3 Fishing operation duties

The present manning arrangement was in place mainly to support the work requirements that accompany the use of the rope gear system — especially during line hauling. The 19 personnel were divided into two groups of nine per shift. The cook was left free to ensure that meals and refreshments were adequately prepared and on time.

A fishing operation shift for hauling rope gear required at least seven deck personnel to be on duty while the engine room department rotated two per shift. The monofilament system required five deck personnel per shift but despite this the seven crew grouping was maintained to avoid complications. During the hauling in of the monofilament gear, idle crew were assigned other duties to perform on the vessel. This mostly involved repairing outstanding defective gear, steward duties — cleaning accommodation and heads, sprucing up the wheelhouse etc, and rounding up refreshments for those on shift.

During the hauling operation, the crew were involved in unsnapping the branchlines from the mainline as the mainline was hauled in, collecting and coiling the branchlines and floatlines then storing them in manageable bunches (Figure 5), transferring the branchline and floatline bunches aft in preparation for the line setting operation, landing and preparing fish for storage in the fish holds, relaying the mainline from the conveyor tray to the mainline bin (Figure 6), keeping a check on the bin level and transferring incoming mainline to the next bin when one was full, and repairing damaged gear.

Figure 5: Hauling the rope gear, unsnapping and coiling the branchlines

Figure 6: Transferring the mainline to the storage bin

The line setting operation required at least five persons to comfortably carry out the work required. The duties performed included preparation of bait and ensuring that a constant supply was available to the person baiting the hook (one person), unhitching the branchlines (Figures 7 and 8), baiting and deploying the hook (one person), preparing floats for deployment (one person), snapping on branchlines and floats (one person), and a watchkeeper to ensure that the fishing operations were performed correctly and to maintain sea watch for the safety of the vessel. The Skipper usually stayed on watch throughout the line setting operation.

Figure 7: Making branchlines ready during the setting of the rope gear

Figure 8: Unhitching a branchline during the setting of the monofilament gear

The preparation of the vessel prior to the fishing trip was performed efficiently. The shore personnel and ships captain, engineers and crew worked together to ensure that the vessel was sufficiently equipped and adequately replenished to pursue the coming trip. The captain and chief engineer both had checklists that were followed through before departure. Although the captain and chief engineer were fully aware that all the certificates had already expired, every effort was made to maintain the equipment on board in pristine condition.

3. PROJECT OPERATIONS AND ACTIVITIES

The project operations and activities included the conducting of one fishing trip, which was scheduled around the vessel needing to go to Pago Pago in American Samoa to unload the stored catch on board from previous fishing trips. Gear was made up for both the rope and monofilament longline systems, and training was provided in many areas to the skipper and crew. An assessment of the fishing and shore-based operation of FTV *Takuo* was also undertaken.

3.1 Fisheries Development Officer's checklist

Upon arrival in Tonga, the Fisheries Development Officer proceeded to set in motion activities listed in a checklist that he had prepared to examine the present operation of the vessel and to suggest improvements where necessary. The checklist included examinations into the following:

- Preparation of the vessel prior to departing on a fishing trip;

- The effectiveness of shore personnel (operations management) in dealing with the affairs of the vessel including assisting the vessel's captain in arranging quick turn around for the vessel;

- The captain's management abilities in making decisions concerning crew discipline, vessel movements, dealing with port clearance and maintaining the vessel's seaworthiness;

- Update of deck logbook, fishing records and the on board placement of ship's publications relevant to managing the vessel safely and efficiently at sea. These include publications pertaining to communication, navigation, meteorology, operation manuals for equipment on board, first aid medical guide and port information;

- The deck officer's navigational skills, leadership qualities and watchkeeping arrangements;

- Filing of ship particulars. These include seaworthiness certificates, stability information, engine details, cargo stowage details, outgoing and entry clearance papers, fuel bunkering information, provisioning details and details of fish cargo handling procedures at the port of discharge;

- Engineer's abilities and management of engine room duties and maintenance schedules including the filing of records relevant to the engine room operation;

- The maintenance and upkeep of safety equipment and safety requirements aboard the vessel;

- Proficiency of the captain and the crew in conducting tuna longline operations using the rope and monofilament systems and the captain's understanding of selecting suitable fishing grounds;

- The storage and monitoring process of extra fishing gear on board;

- On board handling and storage of the catch;

- Fish offloading procedures;

- Documentation of income and expenses accrued during the trip and the filing of these records by the shore personnel and the vessel's captain;

- Allocation of shares for the payment of crew; and

- Management of funds in planning consecutive trips.

3.2 Fishing operations and gear

There are two horizontal longline systems used worldwide with slight variations to the gear used in each system. These are the rope gear system, sometimes referred to as the Japanese longline system or basket gear, and the monofilament reel longline system that was introduced by the Americans. Both these systems are installed onboard the FTV *Takuo*.

Tuna longline fishing generally involves a lot of fish tracking. A skipper with experience and good local knowledge is a great advantage. With the introduction of modern machinery and electronic gadgets, the movement of fish can be tracked much more easily but would still need the co-operation between fishermen, skill, and knowledge, on how to fully utilise the equipment for information gathering. Fish detection can now be done through radio communications with other vessels on fishing grounds, perusal of previous data collected, compilation of data while in search of fishing grounds, and satellite images of sea surface temperature and sea surface anomalies.

After selecting a fishing area and before proceeding with a tuna longline fishing operation, the skipper has to consider several factors that may enhance his catch return. Some of these factors are the weather condition, currents in the area, wind direction, thermocline level, period in which to conduct the line setting and hauling operation, type of baits to use and the fishing method to employ — shooter speed, vessel speed and basket configuration. The ability to calculate the approximate hook settling depth and the RPM to set on the shooter to achieve this depth, would be an advantage to the skipper.

3.2.1 Calculations for shooter speed, setting depth, and spacing of gear on mainline

Calculation of shooter RPM was one of the requests forwarded by the vessel's skipper and is a common request from skippers around the region. Basic geometry was used in calculating the settling depth of the mainline. This should portray the maximum depth that the deepest part of the mainline should settle at if all the lines were stretched out tight and the centre of the triangle formed coincided with the centre of the distance between two floats. With this in mind, the use of basic geometry should be sufficient to assist the skipper in managing his line setting operation.

Weather conditions and currents will play an important role in deciding the actual settling depth. There are also more scientific methods of working out the mainline catenary curve using the catenary curve formula and computer programmes, but the following methods should make it easier for the average skipper. A table compilation would be ideal to have on board the vessel. The Pacific Ocean Producers Commercial Fishing and Marine Supplies Catalogue has a table that works out the line setter speed provided the distance between floats and the desired sag are used as inputs (Anon. 2001d).

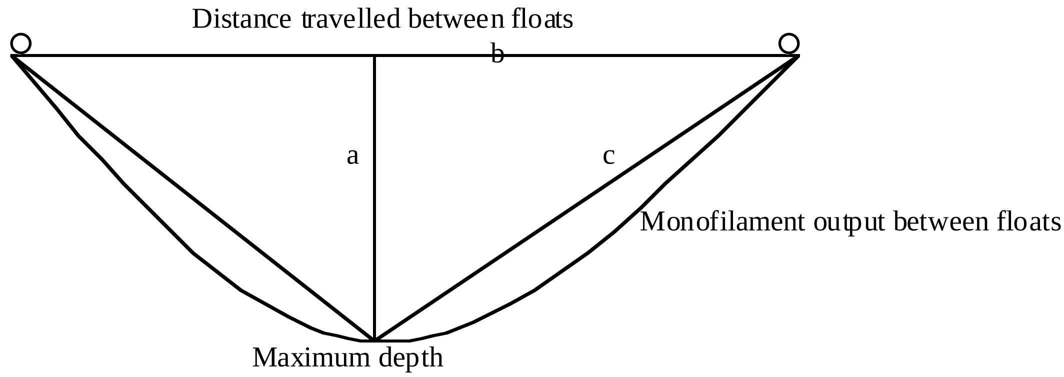
The factors contributing to the settling depth of the hooks are: boat speed, current in the area, the diameter or circumference of the line setter drive wheel, the distance between hooks and floats (this is determined by the line setter speed, time interval between snapping on branchlines, length of floatline and length of branchline) and the total sinking weight of the gear attached to the mainline — this affects the angle at which the catenary curve is formed. Other factors may also have to be taken into consideration but for practical purposes, only the above factors may be considered. The weight of the gear attached to the mainline will also be disregarded in this instance.

The circumference of the drive wheel on the rope gear line shooter differed by 25 cm to the monofilament line shooter on FTV *Takuo*. The drive wheel on the monofilament line shooter had a circumference of 100 cm, while the drive wheel on the rope gear line shooter was 75 cm, which means that with every turn of the drive wheel on the monofilament line shooter, one metre of line will be thrown out, while the rope gear shooter drive wheel will discharge 0.75 m per turn. This is an important factor to take into account when calculating the RPM to pre-set on the line shooters.

Calculating depth and line shooter RPM

For the purpose of working out examples, the following parameters will be used:

Shooter main drive circumference	=	1 m
Vessel speed	=	7 knots
Branchline timer	=	7 seconds
Number of hooks between floats	=	30
Length of branchline	=	15 m
Length of floatline	=	30 m
One nautical mile	=	1852 m



Pythagorean theorem: $a^2 = c^2 - b^2$

$a = \sqrt{c^2 - b^2}$

From RPM to depth

Calculating the settling depth of the mainline and hook using a known shooter RPM.
The calculations will be done in several stages in order to understand how the end result is achieved.

1. Surface distance between floats

Vessel speed x time travelled between floats
where the time travelled between floats
$= \frac{\text{(Number of hooks between floats + 1) x Timer seconds}}{60}$

Example: 7kts x {(30+1) x 7secs ÷ 60}
= 7 kts x {(31 x 7 secs) ÷ 60}
= 7kts x 0 hour 03 min 37 sec
= 0.42 of a nautical mile
= 0.42 x 1852 = 781.44 m : this is the surface distance between floats.

2. Calculation of mainline output rate

Shooter RPM x main drive wheel circumference = line output rate per minute

Example: Shooter RPM = 390

Shooter drive wheel circumference = 1 m

Mainline output rate = 390 x 1 m = 390 m/minute, which is 390 ÷ 60 = 6.5 m/second.

Should the shooter drive wheel circumference be 75 cm or 0.75 m, then the mainline output at 390 RPM will be 292.5 m/minute, which is 4.875 m/second.

3.Calculation of monofilament line between hooks and floats

Shooter RPM x main drive wheel circumference ÷ 60 = monofilament output per second.

Monofilament output per second x time between hooks = Monofilament output between hooks.

Monofilament output between hooks x (number of hooks between floats +1)

= monofilament output between floats. (This forms the catenary curve)

Example: 390 x 1 ÷ 60

= 6.50 m/second x 7 seconds

= 45.5 m between hooks x (30+1)

= 1410.5 m of monofilament line between floats

A simple variation of this formula is :

$$\text{Dist. between floats} = \frac{\text{RPM of shooter x shooter time x Drive wheel circumference x (hooks+1)}}{60} \quad (m)$$

(Drive wheel circumference = Drive wheel diameter x π)

4. Calculation of maximum line settling depth

Line settling depth = {√(1/2 the measurement of monofilament line between floats^2 – 1/2 surface distance between floats^2)}.

This can also be written as:

$$\text{Line settling depth} = \frac{\sqrt{\text{measurement of monofilament line}^2 - \text{surface distance between floats}^2}}{2}$$

Example:

1/2 measurement of monofilament line output = 1410.5 ÷ 2 = 705.25 m

1/2 measurement of surface distance between floats = 781.44 ÷ 2 = 390.72 m

∴ Maximum line settling depth = $\sqrt{705.25^2 - 390.72^2}$ m = 587.12 m or 587 m

Note: The actual depth may be slightly different to this based on currents and oceanic conditions.

5. Approximate maximum hook depth

Maximum line settling depth + floatline length + branchline length

Example: 587 + 30 + 15 = 632 m

The deepest hook will settle at approximately 632 m.

From desired depth to RPM

Calculating the RPM to set on the shooter to achieve the maximum desired settling depth.

Desired line settling depth: 587 m

Total output of monofilament line = (√Desired depth^2 + 1/2 surface distance between floats^2) x 2

= ($\sqrt{587^2 + 390.72^2}$) x 2

= 1410.29 m

Therefore,

Total output of monofilament line by the shooter ÷ (number of hooks + 1) = Rate of discharge per minute. Divide this by the branchline timer rate

= rate of discharge per second x 60 ÷ Drive wheel circumference

= Shooter RPM

Example:

1410.29 ÷ (30+1)

= 45.49 m/minute ÷ 7seconds

= 6.5 m/second x 60

= 389.94 ÷ 1 m

= 389.94 RPM.

Therefore, given the above parameters, the required shooter RPM to achieve the final settling depth of the mainline at 587 m is 390 revolutions per minute.

Note: Lindgren Pitman line setter digital speed readouts measure the shooter speed in knots. If hand held tachometers are used or the line shooter has RPM readings then the conversion to knots is as follows:

$$\frac{\text{Shooter RPM x circumference of drive wheel } (\pi \text{ x diameter of wheel}) \text{ x } 60}{1852} = \text{shooter speed in knots}$$

There are several advantages in being able to calculate the line shooter RPM to achieve a certain depth and vice versa. A consistent operation can be maintained through out the fishing trip, especially after a particular line setting pattern returns a good catch. The abilty to deal with the factors relating to this calculation will enable the skipper to reverse the process from setting RPM to finding the approximate settling depth.

In most cases the approximate hook settling depth is not known, but the skipper has a favourite line setting RPM to match his boat speed. In this case, the approximate depth can be calculated. The spacing between branchlines can also be calculated to ensure sufficient spacing is kept between branchlines to avoid line tangling.

Note: Although the procedures listed seems like a long and drawn out affair, the calculations will only take a few seconds once a person become proficient with the calculations using a scientific calculator.

3.2.2 Minilog temperature/depth monitors used to measure fishing depth of gear

Temperature/depth (T/D) monitors were used during the fishing operations to get an insight into the hook settling depths of the two systems and to make a comparison between the actual depth and the calculated depth using basic geometry. The T/D monitors were attached as close to the centre of the mainline between floats as possible. For the 22 hook deployment the monitors were attached between hook Nos. 11 and 12, for 30 hooks the monitors were attached between hook Nos. 15 and 16 and for 15 hooks, the monitors were attached next to hook No. 8.

It has to be remembered, that the monitors were attached to the mainline and not to the ends of branchlines. Therefore, in the retrieved reading of the monitors, the length of the floatline should be considered.

This is especially important when making comparisons between the calculated depth and the actual depth. The floatline lengths have to be deducted from the actual reading to make a comparison with the calculated depth, or added to the calculated depth to be compared with the actual reading.

The percentage of difference was derived from these comparisons to achieve an average that can be applied to the calculated depth to obtain a better approximation of the settling depth. Results of the settling depth of the rope mainline and the monofilament mainline showed a marked difference compared to the calculated depth. The rope gear settled deeper than the calculated depth, while the monofilament gear settled shallower than the calculated depth.

Of three samples, the rope gear settled at 6.7, 10.8, and 14.9 per cent (average of 10.8%) deeper than the calculated depth, while from twelve monofilament samples, the settling depth ranged from 2.2 to 29.6 per cent (average of 17.9%) shallower than the calculated depth. Appendix C, provides a summary of the data and calculations for each monitor set.

3.2.3 Tuna longline gear

Most skippers set the basket range according to the target species but for most tuna fresh fish boats the bigeye tuna depth is sought. Lines can be set as deep as 600 m at times, but the 400 to 500 m range is more common for these vessels. The common range of baskets for rope gear is between 5 hooks per basket and 18 hooks per basket, although 20 to 25 hooks have also been used at times. On FTV *Takuo*, 12 and 15 hooks per basket were used during the project fishing trip. For monofilament gear, baskets of 5 to 30 hooks are used, but for tuna longline fishing 15 to 30 hooks per baskets are common. On FTV *Takuo*, prior to the arrival of the Fisheries Development Officer, 20 to 25 hooks per baskets were preferred, but during the project fishing trip, 30 hooks per basket were used.

Branchline length is an important factor in determining the spacing between hooks. Shorter branchline lengths will enable the skipper to fit more hooks between floats while the longer branchlines will have fewer hooks between floats — for a selected depth. Normally the space between hooks is at least twice the length of the branchline. This reduces the chances of the two branchlines meeting and getting tangled. A safer spacing would be at least 2.5 times the length of the branchlines, but practically, most line setting is done according to the proficiency of the crew deploying the line and the space can be more than 2.5 times the distance.

It takes a proficient crew at least seven seconds to clear a branchline from the bin, bait the hook, deploy the baited hook and snap the branchline onto the mainline. Six seconds can be achieved without any distractions.

For a vessel travelling at six knots, the free spooling line output will have to be at least six knots, but practically it is more than this because of a slight line sag. This would mean an approximate line output of 185.2 m/minute or 3.09 m/second for a vessel travelling at six knots, while free spooling the line over the stern of the vessel. Therefore in 7 seconds, at least 22 m of line would have been paid out with this free-spooling action. The spacing should increase when a line shooter is used and this will depend on the speed of the line shooter (refer Section 3.2.1). Normally, a spacing of around 30 to 70 m is applied — 50 m is more popular.

Rope Gear System on FTV Takuo

The mainline on FTV *Takuo* is made up from coils of red vinyl tarred 7 mm Kurolon rope spliced together to form a continuous length. The branchlines are 24 m in length and are constructed of three different sections. The top section has 17 m of 3.9 mm red polyester rope spliced onto a 38 gram leaded barrel swivel with a 0.148 swivel snap attached to the other end. Onto the leaded swivel was attached 6 m of Sekiyama wire, which ends in a loop covered with a Kanseki spring. The lower section was a one metre length of 3 x 3 leader wire with a loop in one end covered with a Kanseki spring, and a 3.6 tuna hook crimped onto the other end. Figure 9 depicts the construction of the branchline and the setting arrangement between floats for the rope gear.

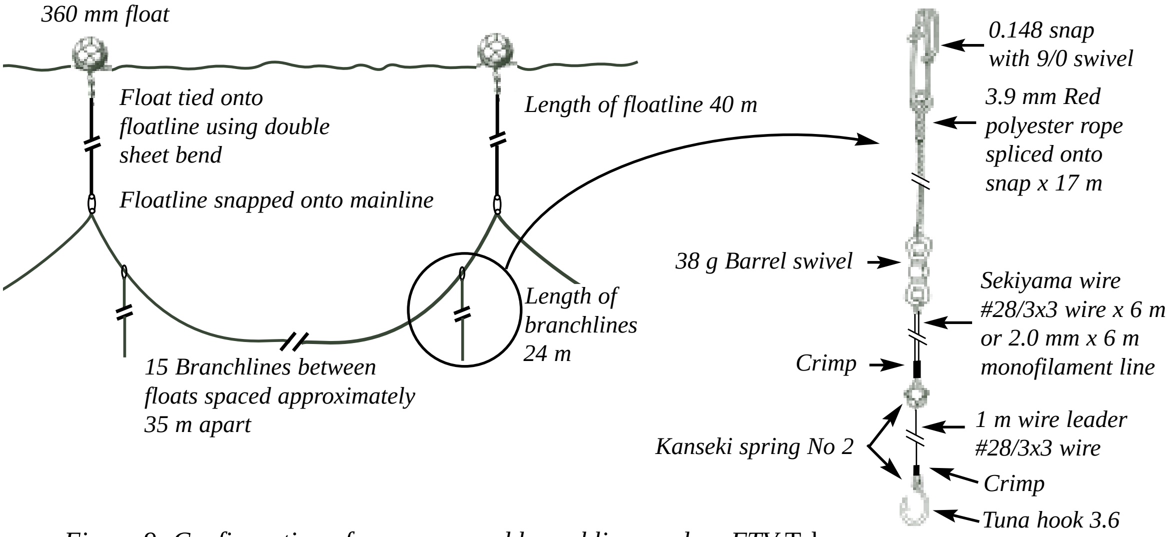


Figure 9: Configuration of rope gear and branchline used on FTV Takuo

The system installed on the FTV *Takuo* is the modernised version of the coiled rope mainline system. The mainline is flaked out in a master bin located on the aft upper deck (refer Figure 6). A level wind flaking machine collects and flakes the line into the master bin that is divided into 3 longitudinal sections. This division prevents the stored mainline rope from roaming over a larger free surface area, thus reducing the chances of creating tangles.

During line setting, the mainline rope is rove through a pipeline guide leading to a line shooter situated on the centreline of the transom. Branchlines are unhitched from the storage piles and made ready on the setting conveyor (refer Figure 7), which is manually operated to transport the branchline to the person snapping them onto the mainline. The branchlines are baited and attached as the mainline is paid out.

The hauling operation is performed almost similarly. A line hauler retrieves the stressed mainline via a hauling port and flakes it out on a conveyor tray (Figure 10) as the branchlines are unsnapped. A relay machine then transports the slack line to the master bin via a pipeline guide and blocks (Figure 11), while the retrieved branchlines are coiled by a line hauler then hitched and stored in a manageable pile to be transported aft in preparation for line setting.

Figure 10: Hauled rope mainline being coiled onto a conveyor tray

Figure 11: Rope mainline transported to master bin via pipeline guides and blocks

Compared to the coiled rope system, this method is faster, safer and requires less crew to perform the operation but it is still inferior, operation wise, to the monofilament reel system. Part of the difficulty and cause of delays in handling this system is the requirement of having to haul in the long 24 m branchlines and having to stack them in a pile ready to be transported aft. The hauling speed has to be adjusted to the crew's proficiency in performing this duty. Boarding and processing fish at the same time, and crew fatigue towards the end of a shift, can slow this process down.

To modify this, the 16 m monofilament branchlines for the monofilament reel system were used with the rope mainline. This enhanced the work efficiency to be almost on par with the reel system and made no difference to the catch per unit of effort (CPUE). The extra work effort here is in transporting the mainline from the conveyor tray to the bin. The mainline relay machine had to be manually operated periodically to clear the conveyor tray.

In the development stages of tuna longlining in the region, the same modified system was used on some of the vessels. The CPUE of these vessels were no different to that of tuna longliners with reels.

Setting parameters for rope gear on FTV Takuo

The rope gear line setting operation was conducted with the vessel travelling at a speed of 7 knots. Shooter speed was set at 400 RPM and the branchline spacing timer set to beep every 7 seconds. Each basket consisted of 15 hooks. With these parameters and the formula: depth = {√(1/2 shooter mainline output^2 – 1/2 surface distance between floats^2)} + floatline length + branchline length (204 + 30 + 24 m), the calculated hook settling depth would be approximately 258 m. Experiments with depth monitors revealed that the rope gear actually settled at approximately 11 per cent deeper than the calculated depth. Therefore, a closer approximation of the hook settling depth would be 286 m.

At 400 RPM the rope mainline output will be 5 m/second. This would result in a space between hooks of 35 m for a timer set at 7 seconds. The line output between floats would therefore be 560 m. With a vessel speed of 7 knots and the same timing between floats, the straight surface distance travelled between two consecutive floats would be approximately 404 m.

Monofilament longline reel system

The vessel was outfitted with a Lindgren Pitman reel capable of holding up to 30 nm of 3.5 mm monofilament mainline. This system is easier and safer to operate than the rope gear system, takes up less space and requires fewer crew to carry out the fishing operation. As the tuna fishing industry in the region developed, so too did the performance rating of some of the reel systems.

The branchlines used on the monofilament system were similar in construction to those used on the rope gear, although only 16 m long. The top section was 14 m of 2.0 mm monofilament, with a 0.135 swivel snap crimped on one end and a 38 gram leaded barrel swivel on the other. Onto the leaded swivel was attached 1 m of 2.0 mm monofilament, which ended in a loop covered with a Kanseki spring. The lower section was a 1 m length of 3 x 3 leader wire with a loop in one end covered with a Kanseki spring, and a 3.6 tuna hook crimped onto the other end. Figure 12 depicts the construction of the branchline and the setting arrangement between floats for the monofilament gear.

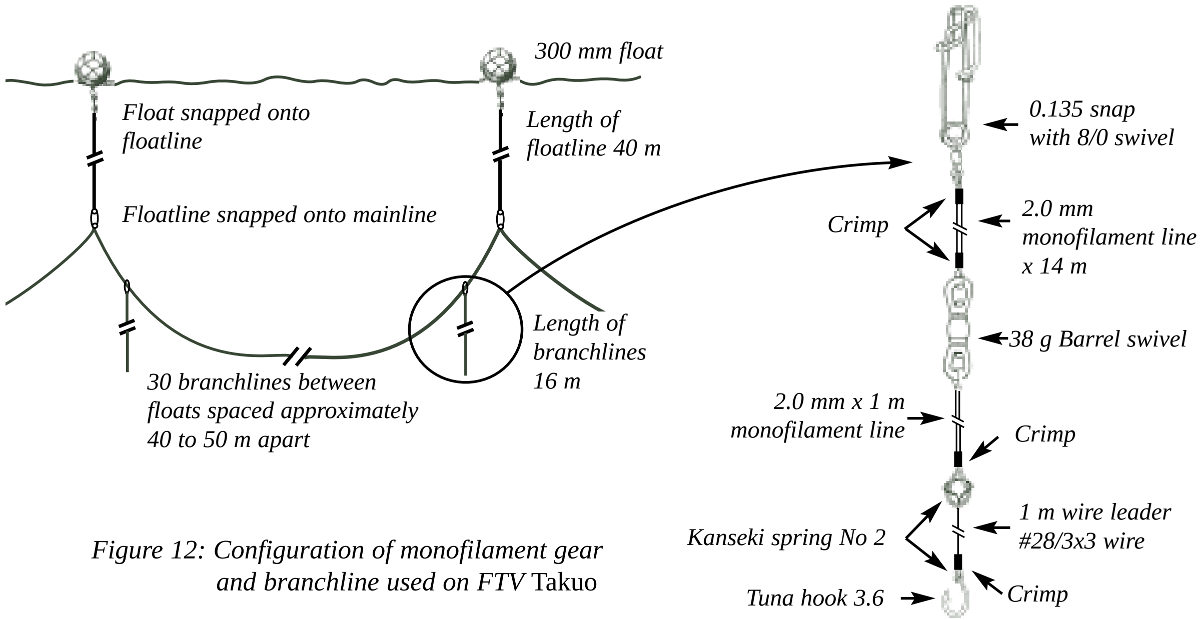


Figure 12: Configuration of monofilament gear and branchline used on FTV Takuo

Line setting was a two stage operation. The first stage involved the setting of the monofilament mainline until all the line had been deployed from the reel, then the rope gear system was connected up and the balance of the hooks deployed. The total number of hooks deployed varied with each set. This was due to the timeframe available in which to carry out the operation. As the vessel was on passage to Pago Pago to discharge its cargo, a search was conducted for better fishing grounds along the way. This sometimes limited the time in which the fishing operations could be carried out, so fewer hooks were set. The target number of hooks per normal set was between 2200 and 2500.

The monofilament mainline gear was of an earlier model that required the mainline spool to be controlled manually while deploying the line in a freespooling mode, and with the use of the shooter. The beginning of the set was the critical moment when a coordination between the shooter and the spool was established. Once this had been accomplished the operation ran smoothly all the way.

3.2.4 Fishing trip and catch results

Due to unforeseen developments, only one trip and eight sets were carried out. These were done while on passage to Pago Pago for offloading approximately 50 t of albacore that was already caught on previous trips. Information obtained from other fishing vessels identified the grounds south of Tonga as the hot-spot at that time.

Although the fishing operations were not carried out in choice fishing grounds, they were sufficient to make an assessment of the gear and to recommend changes that would enhance fishing operations using both rope and monofilament gear in a single fishing operation.

The fishing technique applied during the fishing trip was standard procedure for tuna longline fishing employed worldwide, with slight variations depending on the skipper.

The FTV *Takuo* crew displayed good seamanship and were proficient in performing the fishing operations. Several of the crew were beginners, but with the guidance of the experienced hands, this was easily corrected. One of the issues discussed with the crew was the gaffing and handling of fish. Although the vessel supplies fish to canneries, the fish should be gaffed in the head whenever possible and care taken not to bruise fish.

During the eight sets, 214 saleable fish were caught weighing approximately 3356 kg (weights were estimated whole weights for each fish). In addition, 28 sharks were caught with an estimated weight of 1120 kg, although the sharks were only finned with the trunks discarded. Other discarded bycatch included lancetfish (13 fish for 23.5 kg), snake mackerel (11 fish for 19 kg), cookie cutter shark (1 fish for 2.6 kg), and 1 sunfish weighing 20 kg. The total number of hooks set was 13,990, which equated to a CPUE for the saleable catch of 1.53 fish/100 hooks, or 24 kg/100 hooks. Appendix D provides detail of the catch and effort by set for the project fishing trip.

All fish were stored in the vessel’s freezer cargo holds and stockpiled for the next unloading. The storage temperature was set at –40º C.

3.3 Vessel operations

The operation or management of FTV *Takuo* is a big job that requires careful coordination of many staff to ensure that all goes smoothly. Fishing is only one component of the overall operation of the vessel, although it is the only income-generating activity. However, if the operating costs of the vessel are higher than the income generated, then the operating costs need to be carefully assessed to ensure the complete operation at least breaks even financially. This section looks at some of the non-fishing operations or management of the vessel.

3.3.1 Fuel Consumption

Fuel is one of the major expenses of any fishing operation. Appendix E contains a record of the daily fuel consumption during the trip, with a summary of this provided below in Table 1. The rate of fuel consumption for the auxiliary engines and the main engine showed a daily fluctuation and did not have a consistent pattern. This is because on a fishing trip, the use of the auxiliary engines and the main engine is dependent upon the mode of activity of the vessel at that time.

Table 1: Summary of total running hours and fuel consumption for FTV *Takuo*'s main and auxiliary engines

Engine	Total running hours	Total fuel consumption(litres)	Rate of fuel consumed (litres/hour)
Main	525	14325.4	27.3
Auxiliary	299	8289.8	27.7
Overall total	824	22615.2	27.44

When travelling to and from or when changing fishing grounds, the main engine fuel consumption differs from the consumption during fishing operations. During fishing operations, the main engine fuel consumption is lower than at steaming time. The auxiliary on the other hand, consumes more during fishing operations than when steaming. Daylight fishing operations consumes less fuel than night operations.

The factors that contribute to this inconsistency are the irregular and slow speeds required of the vessel during hauling and setting, more effort required of the auxiliaries when using the hydraulics for hauling or setting, and the use of work lights at night either for setting or hauling.

Another factor to consider is the freezer system. When chilling down to a required temperature, the freezer compressor normally runs continually until the temperature is achieved. From then on, the motors will kick in periodically to maintain the required temperature. During the daylight hours as the sun rises overhead the frequency of freezer motor operation is more recurrent than at night. During the day, the vessel's superstructure heats up thus offering less support to the freezer insulation. At night the opposite occurs.

3.3.2 Pago Pago port clearance difficulties

When arrangements were made with the agents in Pago Pago to make bookings for the FTV *Takuo* to discharge its cargo of approximately 50 t of albacore tuna, the date of discharge was forecasted to be about two weeks from the time of request. With this factor in mind and considering the remaining fuel on the vessel, it was decided to fish towards Pago Pago, discharge the fish, replenish the vessel then return to choice fishing grounds for further fishing.

The on passage fishing trip was carried out as planned, but upon arrival at the entrance to Pago Pago at the designated time for discharging the fish, the vessel was refused clearance from entering the harbour by the Coast Guard. The reason being that the vessel's paperwork and certificates were not in order or expired.

This resulted in an extremely expensive delay that had the vessel spend more time drifting and awaiting clearance than fishing. Altercations by the previous captain and management team with the Coast Guard authorities in Pago Pago set a precedent where the vessel was marked as a vessel with expired seaworthiness and safety certificates. To permit the vessel to obtain clearance while waiting for slipping, the Coast Guard required that the vessel's insurance coverage be updated to cover disaster expenses should anything happen while the vessel was in port.

3.3.3 Vessel management

The management of the vessel by the captain and the chief engineer was along typical maritime guidelines and was professionally executed. On-board duties were well organised and the crew performed as a team to keep their daily routine from faltering.

The master of the vessel was an experienced fisherman who has spent his entire career in the commercial fishing industry and was one of the pioneer fishermen in Tonga's fresh fish tuna longline industry. He had ample knowledge in tuna longline fishing techniques using rope and monofilament systems, sound navigational skills and good leadership and vessel management qualities. Several additional technical details were conveyed to him during the fishing trip that should further enhance his abilities. These included instructions on the use of all bridge equipment for aiding in navigational purposes, communications, monitoring of weather, temperature and currents, the necessity of updating maritime publications and the importance of maintaining documentation on all ships activities for better vessel management control. For upgrading in fishing operations, the captain was instructed on methods of calculation for determining the approximate line settling depth and to produce the line setter speed to achieve this approximate depth. Methods of fishing ground selection and fishing operations techniques were also discussed.

3.3.4 Shore-based vessel operations management

The shore-based operations management of FTV *Takuo* was an important backup in the overall running of the vessel. This office had just recently undergone a change in management and was still in the process of getting organised. The present management needed to drastically overhaul the system used by the previous management in order to achieve positive results in the future. An efficient functioning of this office will open up a lot of potential for the marketing of fish caught by the training vessel, augment the chances of increasing catches and put in place training schedules that should train fishermen to partake in the industry on vessels in the private sector.

Among the responsibilities of the shore management was the monitoring of tuna prices offered by the tuna markets for canned tuna and sashimi fresh tuna. With updated information, the viability of supplying either market can be ascertained and the longline operation altered to preserve fish for the selected market, that is, frozen fish for the canneries and fresh fish for the sashimi markets.

Other duties included organising the port entries and departures, keeping contact with overseas agents appointed to service the vessel in a foreign port, monitoring fuel prices and dollar fluctuations, keeping in touch with the vessels maintenance programme and ensuring that the safety, communications, quarantine and seaworthy certificates are current. Updating insurance policies was another important factor. All these certificates complement each other. If one of these certificates become void, a great risk exists in that the vessel could be delayed in port until the certificate is updated. The updating of these certificates require a survey to be carried out by the principal surveyor from the Government's Marine Department or similar organisation. It is the captain's duty to oversee the validity of the vessel's certificates, but an efficient management team should also share the responsibility in order to keep one step ahead.

3.3.5 Slipping, annual maintenance and updating ship's certificates

Annual maintenance programmes are important in a ship's operational agenda. The full year's operations depend on the vessel being laid up and overhauled at least once a year. It is advisable to update all certificates together so that it would be easier to keep track of the expiry dates. Most certificates are updated during the slipping of the vessel and are expected to be renewed yearly at each slipping.

FTV *Takuo's* last slipping was in January 1999, a lapse of two-and-a-half years. While some companies tend to slip their vessels every three years, the vessel has to be laid up for at least two weeks every year to carry out top overhaul and maintenance of safety and working gear. The normal deck and engine room survey will have to be carried out and the appropriate certificates updated accordingly with a new expiry date recorded. An underwater survey has to be carried out every year by a professional diving surveyor who will submit a report to the Maritime Authority survey department. The decision on whether to slip the vessel or not will depend on this report. Slipping the vessel in the third year is compulsory regardless of the hull condition. This is the standard ruling in most countries, although several countries have slight variations.

3.3.6 Global Maritime Distress and Safety System (GMDSS) and Inmarsat C communications

FTV *Takuo* was fully compliant to meet the maritime requirements for distress and routine communications. The vessel had a GMDSS system approved by the International Maritime Organisation (IMO) for safety at sea watches, distress communications and normal communications. It operates on the basic concept that search and rescue operators ashore and vessels in the immediate vicinity of a distressed vessel, can be alerted and efficiently assist in a coordinated search and rescue operation. For normal and routine functions, the system also provides safety and urgency communications and propagates Maritime Safety Information (MSI) including meteorological and navigational warnings.

The Inmarsat C system that is also a part of the GMDSS unit should enhance the management and operations of the vessel. Faxed communications will ensure that the written information is communicated between shore base and ship, reducing the chances of miscommunication and bad reception, as is sometimes experienced with direct single side band (SSB) communications. The system also allows for complete privacy between two parties and group working systems. This is handy for fishing operations when fishing information needs to be conveyed. Only the selected parties will receive the information.

When a message is sent from the ship's unit, known as the Mobile Earth Station (MES) unit, it is directed to a satellite, which redirects the message on to a Land Earth Station (LES), which then sends the message on to the recipient. A standard charge is paid to the LES for this service. The charges are economic provided the system is used responsibly by the ship's crew. The captain should keep a proper log and establish strict rules in the use of this system. A compulsory logbook record is required for the use of communications systems on the vessel.

The captain and mate of FTV *Takuo* were encouraged to get to know the full operations of this system. At the time of the fishing trips, the system could not be put to its full use as there was a problem with communications between the MES unit and the satellite. This was probably due to a faulty carrier power module within the MES unit.

4. DISCUSSION AND CONCLUSIONS

With the current team onboard, fish capture should not be a major issue to be dealt with in this instance of rehabilitating the operations of the vessel. Of course, it is one of the prime reasons besides crew training for having the vessel in the first place, but it should not be the dominating focus in correcting the overall operations of the vessel. The present Captain and crew had an organised fishing operation that was symptomatic of professionals.

There are several areas where training can be focused or targeted to better use FTV *Takuo*. One of these areas is to use this vessel for training skippers and engineers so they can sit for their appropriate qualifications. At present, there is sufficient crew with adequate fishing experience and seatime still working in the industry that should be eligible for such training. This group should be targeted and given trainee positions on the FTV *Takuo* so they could work towards gaining their qualification. Once the qualification has been gained, they could return to the private sector.

To assist in the training of skippers and engineers, the Tonga Ministry of Fisheries should liase closely with Maritime Training Administrations in the country and around the region to formulate fishing-related nautical courses that would effectively produce much needed skippers and engineers for the fishing industry. The courses should be based on STCW requirements, so that if someone from the fishing industry wants to move to the merchant marine, they only have to do bridging courses to get their qualification upgraded and recognised under STCW.

The availability of extra berths on FTV *Takuo* will make it easier to accommodate extra crew engaged on a training scheme. The crew structuring system can easily be restructured to allow more training positions. For training purposes only, eight positions can be retained for crew and the rest of the berths given to the trainees. These trainees should go through a pre-sea and pre-longline course before boarding the vessel. The positions to retain are captain, mate, chief engineer, second engineer, one oiler, bosun leading hand and cook.

For commercial operations, the personnel in the leading positions on the vessel should be paid a regular retainer in addition to a share of the catch. These positions are captain, chief engineer, mate, second engineer, bosun and leading hand. These personnel are expected to maintain the vessel, to keep it seaworthy all year round and to be available in times of storm or other phenomenon that may endanger the vessel in port or at sea. The basic payment is for their commitment to the vessel as seafarers and is separate from their efforts as fishermen. It ensures that these personnel are bound by law to tend to their maritime duties. The rest of the fishing crew would be paid according to the fishing effort. In FTV *Takuo's* case, this involves 13 fishing crew.

The funding for the permanent positions can be made available in several ways. Funding could be provided in the annual budgeting of the vessel without deducting from the crew shares allocation. Payment of bonus is taken from the fishing effort. This should give the leaders of the vessel an added incentive to increase fish catches and not be concerned with their domestic affairs while they are out at sea. An alternative is to include the funding for these positions in the trip expenses when the vessel is out at sea and supplement this with a daily payment when the vessel is in port. The first option is preferable.

The allocation of owner/crew shares from fishing effort can be done in several ways. Several Pacific island fisheries have adopted a system to split the income, with the owner taking 60 per cent and the crew splitting 40 per cent, after deduction of trip expenses. Note that the percentages may vary, with most companies in the region using 50/50, 60/40, 65/35 and less popularly, 70/30. Working on a 40 per cent share for the crew, this could be divided into shares where the captain gets 4 shares, chief engineer 3, mate 2.5, second engineer 2.0, bosun 1.7, leading hand 1.3, and the crew (13 people) get 1.0 share each. This gives a total of 27.5 shares. With this system, the portion of a single share reduces as more crew is taken on a trip and increases with fewer crew, while the 40 per cent allotment remains the same. The 40 per cent also has a higher value when the catch and value of the catch is high.

In preparing a vessel for an ocean passage or fishing trip, checklists should be divided into several areas or departments. Usually this is the galley stores, engine room requirements, wheelhouse requirements, deck gear, and fishing gear. The items for each of these departments can be further categorised. The galley categories are mainly dry, frozen and garden stores, cutlery and eating utensils, dish soap and garbage disposal requirements. The engine room checklist categories are mainly fuel, engine parts (including electrical and electronics), lubrication oils, safety equipment (fire extinguisher, CO2 system, etc) and pending defects. The bridge checklist deals with navigation requirements (chart, 2b pencils, parallel rules, etc), communications equipment (SSB and VHF Radio, Inmarsat C system, etc), publications (operation and service manuals for wheelhouse equipment, communications and piloting information manuals, etc) bridge safety equipment, and electronic navigation aids equipment (radar, GPS, echo sounder, etc). The deck checklist should include all cleaning fluids and accessories, paint stock, sea survival raft, toilet utensils, etc.

Although all categories of checklists are important, special attention should be given to compiling and adhering to the fishing gear checklist. The revenue earning capability of the vessel depends on fishing operations so the availability of sufficient quality and quantity of fishing gear on board should enhance the chances of increasing the catch rate. In all cases, the people responsible for going through the checklists should do this methodically and ensure everything is on board or repaired before each trip commences.

For the time being, the tuna longline rope system should be retained and be used in conjunction with the monofilament system. The modifications carried out on the rope system are sufficient to reduce its fishing operation time and manpower needs, while maintaining the same fishing integrity as previously experienced. As the financial situation improves and funds are made available, the rope gear can be replaced with an all monofilament system. A second monofilament longline reel can be obtained and installed to achieve this end, after the rope gear has been used to it's full lifespan.

All of the vessel operators in the tuna fishery in Tonga would benefit from accurate satellite data that would assist in locating good fishing grounds. The Ministry of Fisheries should consider pooling the local fishing companies together by providing funds for subscribing to remote sensing organisations that produce sea surface temperature or altimetric (sea level anomaly) maps. These provide a synopsis of currents, eddies and fronts. It is useful to fishermen when selecting suitable fishing grounds before departure or while at sea. The latest information on these services can be obtained through the Internet.

Shore operations management has been identified as the problem area contributing to the difficulties now being experienced in operating the vessel. The legacy of poor record keeping and accumulated debts handed down by the previous management has put the present management team in a difficult position. An immediate review should be undertaken to reconstruct the management system of the FTV *Takuo*.

In looking at a management system, there seems to be four options available. The first and possibly the preferred option would be to reconstruct the Ministry of Fisheries managerial procedures for the vessel by putting in place a team that is capable of efficiently carrying out the management duties bestowed upon them. The second option is to appoint an experienced shipping agency to manage the vessel for a set fee to be agreed on at the drawing up of a contract. (Not a fishing company that already manages its own vessels). The next option is to lease the vessel to a reputable fishing company from the private sector. Lastly, appoint a reputable fishing company, which operates its own vessels, to manage the vessel on behalf of the Ministry of Fisheries for a set fee or percentage of the catch. Although the above comments may seem a bit blunt, the reality of the situation is such that a drastic overhaul needs to take place to arrest the current rate of deterioration.

To meet the objectives of this project and with the current situation in a salvageable state, focus will be concentrated on the first option, and the remaining discussions will be aimed at improving the management system of the vessel through a reconstructed managerial group at the Ministry of Fisheries.

To start, the person in charge of shore operations should be fully dedicated to the affairs of the vessel. This is not the case at present, where fisheries staff carry out a dual role of tending to the management of the vessel and performing their other fisheries duties as well. This will hinder the person's performance in carrying out any one duty to his best ability. Managing FTV *Takuo* is a full time position, as it requires the person to co-ordinate all aspects of the operation. These include: maintaining all records and documentation that apply to the operation of the vessel and ensuring that the financial transactions and records are appropriately kept; arranging particulars for the vessel's fishing trips; within reasonable bounds, attending to the crew's welfare while the vessel is at sea; maintaining daily contact with the vessel and providing any information that may be beneficial to the fishing operation; liasing with agents at the port of unloading and keep updated information on the price of fish, berthing and stevedoring procedures, port clearance procedures, Coast Guard and Port Maritime regulations; monitoring fishing industries within the region to capitalise on price increase, being in tune with fluctuations, and being able to predict approaching instabilities in marketing issues; and organising training schedules, crew movements and personnel academic progress.

The present captain of the vessel should be given a dominating role in management issues. His views should be sought in advising on documentary compilation, record keeping and the general organising of operations. Being an experienced fisherman and maritime officer, the present captain may be considered as one of the local experts and his judgement should be trusted and respected. The captain should work closely with the shore-based manager, to ensure there is no overlap or confusion in the management of the vessel. One area where the two would work closely is in the maintaining of a damage repair or emergency action plan to cope with difficulties that might be experienced by the vessel.

One of the big problems at present is the insufficient capital budget to turn the vessel around, while waiting for the income from fish sales to be received after offloading. Much of the income received from the sales of fish goes directly into settling the debt owed in financing the previous fishing trip, leaving insufficient funds to finance the vessels next fishing trip. This has resulted in a cycle where the current management is continually trying to catch up on commitments. Lack of funds will also endanger the maintenance programme of the vessel, which will lead to the vessel being refused insurance coverage and port clearance, as is now being experienced. The vessel will also lose credibility with its suppliers for bait, fishing gear, victuals, fuel supply and other necessities that make a trip successful.

If it is too late to lodge a budget for the vessel through the Ministry of Finance, a loan application to the Development Bank or similar lending institution should be considered. The purpose of this is to obtain funds to square off all outstanding debt and to make available an operating fund to see the vessel through to the next government budget allocation.

The effect of limited funds, and limited fuel as a result of the funds, on fishing operations will be such that the master of the vessel will not be able to move freely to fishing grounds of his choice. The vessel needs to be constantly on the move until a suitable fishing ground is located. The threat of having to minimise on fuel consumption by cutting down on travelling time will influence decision-making when searching for better catches. With insufficient fuel to begin with, the master will be dictated by the remaining capacity of fuel on board to fish second choice fishing grounds, most likely en-route or closer to the port of discharge and replenishment — as was the case during this project.

The lack of funds also resulted in delays in slipping the vessel promptly thus causing management and the captain to face difficulties in obtaining an entry clearance for discharging fish in Pago Pago. All of the vessel's seaworthiness, communications and safety certificates have expired. The vessel needs to be slipped as soon as possible in order to renew these certificates. An agent will have to be appointed at the slipping destination to organise the details and allocate assignments to reliable shore services. It would be advisable to obtain beforehand a slipping defect list from the captain and chief engineer. This will enable the agent to obtain quotations from interested parties and a selection can be made on whom to allocate the work to. This will also produce a close estimate of the costing of the work to be carried out.

In a situation where a vessel had previously encountered difficulties in a particular port, the vessel's management team (including the captain) should investigate the matter and immediately implement procedures that should counter the problem at the next entry. The matter should not be left to chance and should not be dealt with when the captain puts through a request for port entry. There should have been a detailed report filed by the last management to record the first altercation and the preventative action and procedures put in place to correct this. This should still be done in the case of Pago Pago, so that hopefully the vessel will not encounter problems the next time it requests to enter this port.

5. RECOMMENDATIONS

Based on the work conducted, the objectives of this project, and the observations and experience of the Fisheries Development Officer, it is recommended that:

(a) FTV *Takuo* be used as a training vessel for skippers and engineers to gain their qualifications and then move into the private sector for employment in the fishing industry;

(b) The Tonga Ministry of Fisheries liase closely with Maritime Training Administrations in Tonga and around the region to formulate fishing-related nautical courses appropriate to the fishing industries needs;

(c) Any fishing-related nautical courses developed be based on STCW requirements, so that people from the fishing industry can move to the merchant marine, by doing bridging courses to get their qualification upgraded and recognised under STCW;

(d) The extra berths on FTV *Takuo* be used to accommodate trainees for skipper and engineering qualifications, after the trainees have completed a pre-sea and pre-longline course;

(e) The positions of captain, chief engineer, mate, second engineer, bosun and leading hand be paid a retainer in addition to their share of the catch, as basic payment for their commitment to the vessel as seafarers in times of storm or other phenomenon that may endanger the vessel in port or at sea;

(f) Funding of the retainer preferably be made through the annual budget or alternately through trip expenses when the vessel is out at sea and supplement this with a daily payment when the vessel is in port;

(g) The allocation of owner/crew shares be set at 60/40 after the deduction of trip expenses, with the 40 per cent crew share split where the captain gets 4 shares, chief engineer 3, mate 2.5, second engineer 2.0, bosun 1.7, leading hand 1.3, and the crew (13 people) get 1.0 share each;

(h) The people responsible for the different checklists for stores and equipment, especially the spare fishing equipment, ensure they go through the list methodically and ensure everything is on board or repaired before each trip commences;

(i) The current rope gear be used in conjunction with the monofilament gear until it has reached the end of its working life, with it replaced at this time with a full monofilament system, which would include the purchase of a second reel;

(j) The Ministry of Fisheries consider subscribing to remote sensing organisations that produce sea surface temperature or altimetric (sea level anomaly) maps and provide this information to all local vessel operators in the tuna fishery to assist them in locating good fishing grounds;

(k) The present management needs to drastically overhaul the system used by the previous management in order to achieve positive results in the future;

(l) One person be appointed as overall manager of FTV *Takuo*, and this position be full time with the person responsible for all shore-based management of the vessel including marketing of the catch;

(m) The present captain of FTV *Takuo* be given a dominant management role, where he works closely with the shore-based manager to ensure there is no overlap or confusion in the management of the vessel;

(n) The shore-based manager and captain work closely together in maintaining a damage repair or emergency action plan to cope with difficulties that might be experienced by the FTV *Takuo*;

(o) The shore-based manager for FTV *Takuo* endeavour to get a new budget in place that will allow funding to be available to cover the costs in advance for the next fishing trip, and not be dependent on income from fish sales;

(p) If the shore-based manager is not able to get a new budget in place to cover costs in advance, that a loan application be considered to the Development Bank as an interim measure to square off all outstanding debt and to make available an operating fund to see the vessel through to the next government budget allocation;

(q) When adequate funding is available, FTV *Takuo* keep its fuel tanks full to allow it to move around freely to locate the best fishing grounds, which will hopefully result in larger catches;

(r) Arrangements be made urgently to have FTV *Takuo* slipped and have all of its expired certificates renewed and repairs made where necessary;

(s) The captain and chief engineer make up a slipping defect list for work that needs to be done during the slipping operation;

(t) As part of the slipping arrangement, an agent be appointed in the port to be visited so that all arrangements can be made ahead of time to any planned repair work;

(u) In a situation where the vessel has previously encountered difficulties in a particular port, the vessel's management team and captain investigate the matter and immediately implement prodedures that counter the problem for the next entry; and

(v) In the case of Pago Pago, FTV *Takuo's* shore-based manager and the vessel's captain should try to resolve any unfinished problems, so that hopefully the vessel will not encounter further problems the next time it requests to enter this port.

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Appendix A

Specifications of and equipment on FTV *Takuo*

Owner:	Ministry of Fisheries, the Government of the Kingdom of Tonga
Port of registry:	Nuku’alofa
Kind of vessel:	Tuna fishing research and training vessel
Keel laid:	August 25, 1997
Launched:	October 30, 1997
Completed:	January 28, 1998

Principal particulars

Length (OA):	39.39 m
Length (PP):	33.50 m
Breadth (Mld):	7.50 m
Depth (Mld):	3.10 m
Designed load draft (Mld):	2.70 m

Capacities

Fish hold (bale):	137.63 m^3
Fuel oil tanks:	147.44 m^3
Fresh water tanks:	24.07 m^3
Lub. Oil tanks:	6.88 m^3

Gross tonnage:	337 t	
Net tonnage:	102 t	
Speed (trial max):	11.03 knots	
Main engine:	600PS x 420/309 rpm	1 set
Generator engine:	204PS x 1500 rpm	2 sets
Generator:	170 kVA	2 sets

Complement: total	26 p
Master	1 p
Chief engineer	1 p
Chief officer	1 p
Second engineer	1 p
Radio officer	1 p
Supervisor	1 p
Crew	14 p
Trainee	6 p

Classification NK (NS* and MNS*)

Appliances

Windlass:	(Hydraulic) 3.0 tf x 15 m/min	1 unit
Capstan:	(Electric) 1.5 tf x 10.8 m/min	1 unit
Steering gear:	(Elec. Hyd.) 2.0 tf – m	1 unit
Cargo hoist:	(Elect.) 0.9 tf x 25 m/min	2 units
Line hauler:	15 kW	1 unit
Line throwing machine:		1 unit
Line spool:		1 unit
Line setter:		1 unit
Tender boat:	L x B x D = 5.6 m x 2.03 m x 0.78 m	1 unit
Boat davit:		1 unit
Air conditioning plant:		1 unit
Fresh water generator:	(Distilling type) 2 t/day	1 unit
Bilge oil separator:	0.5 m^3/hour	1 unit
Gyro compass:		1 unit
Radar:	25 kW x 96 nm	2 units
GPS navigator:		2 units
Weather facsimile receiver:		1 unit
Anemometer and anemoscope:	Propeller type	1 unit
Echo sounder:	Depth range 2000 m	3 units
Current indicator:	Measurement range 200 m	1 unit
Radio and GMDSS equipment		
MF/HF radio equipment:	250 W	1 unit
VHF radio telephone:	25 W	2 units
INMARSAT–C ship earth station:		1 unit
NAVTEX receiver:		1 unit
Two-way radio telephone:		2 units
Emergency position indicating radio beacon (EPIRB):		1 unit
Radar transponder:		1 unit
Radio direction finder:		1 unit

The vessel has been constructed and supplied under the Grant Aid Fund
to the Government of the Kingdom of Tonga from the Government of Japan

Appendix B

FTV *Takuo* crew list for fishing trip beginning on 4 September 2001

Master	Paea Tuangalu Tai
Chief engineer	Sione Vaimaali Taunga
Fisheries Development Officer — SPC.	William Sokimi
Mate	Samuela Falosita Loaloa
Second engineer	Hopoate Finau
Bosun	Heamoni Tukuafu
Leading hand	Ofa-ki-Muli Napaa
ABS (able bodied seaman)	Efoti Sosaia V. Ngu Tupou
ABS	Sione Silatolu Tonga
ABS	Paulo Minoneti
ABS	Ofa-ki-Pulotu Mahe
ABS	Tevita Latakivaha Peaua
ABS	Viliami Talakai Fifita
ABS	Neti Cook
ABS	Arthur Clover Savieti
ABS	Aisea Tuikolovatu Vaka
ABS	Lusitania Nikisoni Tongi
Greaser	Nikisoni Fosita
Greaser	Kula Tangimana
Cook	Siosiua Finau

Appendix C

Comparison of calculated depth and actual settling depth for each Minilog set

Type of gear	Actual depth from Minilog	Hooks between floats	Shooter speed (RPM)	Vessel speed (knots)	Time between hooks (seconds)	Calculated depth + floatline length	Percentage difference: actual to calculated
Mono	608.3m	30	390	7	8	688.0 m	**11.6% shallower**
Mono	557.2m	30	390	7	8	688.0 m	**19% shallower**
Mono	512.3m	30	350	7	8	586.0 m	**12.6% shallower**
Mono	400.4m	30	330	7	8	532.5 m	**24.8% shallower**
Mono	484.3m	30	380	7	7	582.3 m	**16.8% shallower**
Mono	442.0m	30	380	7	7	582.3 m	**24.1% shallower**
Mono	416.4m	30	380	7	7	582.3 m	**28.5% shallower**
Mono	488.3m	30	380	7	7	582.3 m	**16.1% shallower**
Rope	250.0m	15	**400x0.75 = 300**	7	7	234.3 m	**6.7% deeper**
Mono	548.0m	30	370	7	7	560.2 m	**2.2% shallower**
Mono	456.3m	30	370	7	7	560.2 m	**18.5% shallower**
Rope	259.6m	15	**400x0.75 = 300**	7	7	234.3 m	**10.8% deeper**
Rope	106.0m	15	**400x 0.75 = 300**	7	7	**Probe placed**	**After floatline**
Mono	272.0m	22	350	7	7	386.4 m	**29.6% shallower**
Rope	269.2m	15	**400x0.75 = 300**	7	7	234.3 m	**14.9% deeper**
Mono	496.3m	30	370	7	7	560.2 m	**11.4% shallower**

Appendix D

Summary of catch and effort for the project fishing trip

System	Monofilament and rope tuna longline gear.																	
Date	5/09/01		6/09/01		7/09/01		8/09/01		10/09/01		11/09/01		12/09/01		13/09/01		**TOTAL**	
Bait																		
Hooks	600		2220		1200		1736		2430		2300		2410		2830		13,990	
Species	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**	**No.**	**kg**
Albacore	-	-	25	450	9	162	-	-	22	396	15	270	17	306	25	450	113	2034
Bigeye	3	75	5	125	-	-	-	-	7	175	-	-	4	80	1	20	20	475
Yellowfin	-	-	6	120	1	5	-	-	2	40	-	-	2	40	2	40	13	245
Skipjack	-	-	-	-	1	3	-	-	2	16	1	3	8	24	8	24	20	70
Striped marlin	-	-	1	40	-	-	-	-	-	-	-	-	-	-	-	-	1	40
Blue marlin	-	-	-	-	1	30	-	-	-	-	-	-	-	-	-	-	1	30
Black marlin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Swordfish	-	-	-	-	-	-	-	-	-	-	1	30	-	-	1	20	2	50
Spearfish	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	10	1	10
Sailfish	-	-	-	-	-	-	-	-	-	-	1	15	1	20	-	-	2	35
Mahi mahi	1	7	2	14	2	14	-	-	6	42	8	40	2	10	3	15	24	142
Opah	-	-	4	60	1	15	-	-	1	15	1	15	-	-	2	30	9	135
Wahoo	-	-	1	15	-	-	-	-	1	15	2	20	1	10	3	30	8	90
Whitetip shark	-	-	1	40	1	40	-	-	4	160	1	40	1	40	4	160		
Blue shark	-	-	-	-	1	40	-	-	4	160	2	80	3	120	5	200		
Mako shark	-	-	1	40	-	-	-	-	-	-	-	-	-	-	-	-		
TOTAL	**4**	**82**	**44**	**824**	**15**	**229**	**-**	**-**	**41**	**699**	**29**	**393**	**35**	**490**	**46**	**639**	**214**	**3356**

Note: All weights are estimated with the sharks finned and the trunks discarded.

Appendix E

Daily fuel consumption records for FTV *Takuo* during project fishing trip

Date	Purpose	Engine	Total hrs	Litres	Daily Total
04.09.01	Steaming	Main	7.0	430.5	
		Auxiliary	7.0	112.0	542.5
05.09.01	Steaming	Main	13.0	780.0	
		Aux	13.0	182.0	
	Set Mono	Main	1.0	50.0	
		Aux	1.0	19.0	
	Drifting	Main	0.0	0.0	
		Aux	3.0	42.0	
	Haul Mono	Main	5.0	112.0	
		Aux	5.0	95.0	
	Steaming	Main	2.0	134.0	
		Aux	2.0	32.0	1446.0
06.09.01	Steaming	Main	6.0	558.0	
		Aux	6.0	128.0	
	Set Mono	Main	2.7	121.0	
		Aux	2.7	43.5	
	Set Rope	Main	2.3	118.8	
		Aux	2.3	37.4	
	Drift	Main	0.0	0.0	
		Aux	3.0	48.0	
	Haul Rope	Main	6.5	136.5	
		Aux	6.5	110.5	
	Haul Mono	Main	3.5	80.5	
		Aux	3.5	66.5	1448.7
07.09.01	Haul Mono	Main	5.0	115.0	
		Aux	5.0	92.5	
	Steaming	Main	4.0	268.0	
		Aux	4.0	64.0	
	Set Mono	Main	2.5	130.0	
		Aux	2.5	43.8	
		Main	0.0	0.0	
		Aux	4.5	74.3	
		Main	8.0	200.0	
		Aux	8.0	148.0	1135.6
08.09.01	Haul Mono	Main	1.0	23.0	
		Aux	1.0	18.5	
	Steaming	Main	3.0	204.0	
		Aux	3.0	48.0	
	Set Mono	Main	2.5	130.0	
		Aux	2.5	45.0	
	Set Rope	Main	2.0	108.0	
		Aux	2.0	34.0	
	Drift	Main	0.0	0.0	
		Aux	2.0	32.0	
	Haul Rope	Main	5.0	115.0	
		Aux	5.0	85.0	
	Haul Mono	Main	8.5	226.3	
		Aux	8.5	148.0	1216.8

Date	Purpose	Engine	Total hrs	Litres	Daily Total
09.09.01	Drift	Main	0.0	0.0	
		Aux	7.0	112.0	
	Steaming	Main	17.0	1045.5	
		Aux	17.0	272.0	1429.5
10.09.01	Steaming	Main	1.0	61.5	
		Aux	1.0	16.0	
	Drift	Main	0.0	0.0	
		Aux	2.5	40.0	
	Set Rope and Mono Gear	Main	6.5	326.6	
		Aux	6.5	107.3	
	Drift	Main	0.0	0.0	
		Aux	1.5	24.0	
	Haul Rope and Mono	Main	12.5	312.5	
		Aux	12.5	231.3	1119.2
11.09.01	Haul Rope and Mono	Main	4.0	100.0	
		Aux	4.0	74.0	
	Set Rope and mono	Main	4.0	192.0	
		Aux	4.0	68.0	
	Drift	Main	0.0	0.0	
		Aux	3.5	56.0	
	Haul Rope and Mono	Main	12.5	281.3	
		Aux	12.5	231.3	1002.6
12.09.01	Haul Rope and Mono	Main	3.5	87.5	
		Aux	3.5	64.8	
	Set Rope and mono	Main	5.0	257.5	
		Aux	5.0	82.5	
	Drift	Main	0.0	0.0	
		Aux	3.0	46.5	
	Haul Rope and Mono	Main	12.5	293.8	
		Aux	12.5	225.0	1057.6
13.09.01	Haul Rope and Mono	Main	5.0	115.0	
		Aux	5.0	90.0	
	Set Rope and Mono	Main	5.5	261.3	
		Aux	5.5	88.0	
	Drift	Main	4.0	216.0	
		Aux	4.0	64.0	
	Haul Rope and Mono	Main	9.5	218.5	
		Aux	9.5	171.0	1223.8
14.09.01	Haul rope and Mono	Main	7.0	161.0	
		Aux	7.0	126.0	
	Steaming	Main	17.0	1309.0	
		Aux	17.0	272.0	1868.0
14.09.01 Retard clocks to American Samoa time. GMT –11hrs					
	Standby off Pilot Station	Main	10.0	659.0	
		Aux	10.0	160.0	
	Drift 20’ off Pago Pago	Main	7.0	198.0	
		Aux	14.0	224.0	1241.0
15.09.01	Drift off Pago Pago	Main	7.0	166.0	
		Aux	24.0	367.0	533.0
16.09.01	Drift off Pago Pago	Main	6.0	147.0	
		Aux	24.0	310.5	457.5

Date	Purpose	Engine	Total hrs	Litres	Daily Total
17.09.01	Drift off Pago Pago	Main	0.0	0.0	
		Aux	24.0	297.0	297.0
18.09.01	Drift off Pago Pago	Main	0.0	0.0	
		Aux	24.0	316.5	316.5
19.09.01	Drift	Main	0.0	0.0	
		Aux	24.0	364.1	364.1
20.09.01	Drift	Main	0.0	0.0	
		Aux	24.0	361.0	361.0
Advance Clocks to Tonga time. GMT + 13 hrs					
22.09.01	Drift	Main	0.0	0.0	
		Aux	24.0	363.0	363.0
23.09.01	Drift	Main	0.0	0.0	
		Aux	24.0	362.0	362.0
24.09.01	Drift and Steam to Tonga	Main	14.0	1092.6	
		Aux	24.0	392.0	1484.6
25.09.01	Steaming to Tonga	Main	24.0	1890.0	
		Aux	24.0	384.0	2274.0
26.09.01	Steaming & Arrival Tonga	Main	14.0	893.2	
		Aux	14.0	178.0	1071.2
	Total for main engine		**525.0**	**14,325.4**	
	Total for auxiliary engine		**299.0**	**8289.8**	
	Total consumption				**22,615.2**