CAPTURE SECTION REPORT

OF

TECHNICAL ASSISTANCE TO THE NEW CALEDONIAN TUNA LONGLINE FISHING COMPANY, NAVIMON

19 August – 23 December 1996

by

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SUMMARY

Following a request from the High Commissioner of New Caledonia in June 1996, Masterfisherman Steve Beverly was assigned to work with the local tuna longline company, Navimon, for a period of four months. The main objectives of this project were to improve the catch rates of the company's fleet; to improve the on-board handling of the catch, including appropriate icing techniques; and to provide advice to vessel captains and management on issues pertaining to fishing strategies, gear use and fish handling practices, both on board the vessels and on shore. Once the project commenced, the objectives were expanded to allow the Fisheries Development Adviser, Lindsay Chapman, to familiarise himself with the use of monofilament tuna longlining equipment, as well as monitoring all aspects of the operation and catch, as an observer.

The Masterfisherman participated in four longline fishing trips on three of Navimon's vessels, while the Fisheries Development Adviser conducted one observer trip. Overall the catch rates recorded by the Masterfisherman were 49.6 kg/100 hooks of saleable species, with the catch rate of the main target species (yellowfin and bigeye tuna) being 22.6 kg/100 hooks overall.

On the first two longline trips made by the Masterfisherman (F/V *Ca Pakhade* and F/V *Melita*) several problems were identified. These included: poor condition of gear (branchlines); insufficient gear (not enough mainline on reel); wrong gear configuration for the target species (floatlines too short for targeting bigeye tuna); vessels not using all available technology for maximum fishing efficiency (not using sea-surface temperature indicators, plotters or remote-sensing data); insufficient quantities of ice taken on board or produced on board; and inappropriate on-board fish handling and icing techniques. Furthermore, the duration of the fishing trips (often only five days of fishing) was considered too short.

It was apparent that the same problems were being experienced by both these vessels, and probably the other vessels in the fleet. It was then decided to make a second trip on F/V *Melita* after effecting some changes in gear configuration, fishing strategy, and product handling and icing, and to pass the results on to the other vessels if the changes enhanced productivity and product quality. The results of this trip and the following trip (F/V *Kirikit*) were promising, although inconclusive. CPUE (catch per unit of effort) was increased on these two trips, when compared with past CPUEs, but the timing also coincided with a peak in fishing. Also, observation suggests that ex-vessel product quality had improved, but this was not necessarily reflected in the market performances of the catch.

Observations during vessel off-loading and export packing procedures following each of the four trips indicated that improvements needed to be made in Navimon's shore operation as well as the fishing operation. The entire plant and operation need a revamp, so that maximum value can be attained from export fish. There was also room for improvement in the handling of local fish sales. Furthermore, Navimon needs to secure a dependable and affordable supply of fresh-water ice—preferably with an output of 15–20 t daily.

ACKNOWLEDGEMENTS

The South Pacific Commission acknowledges with thanks the former management team at Navimon, Mr Yves Thierry-Mieg, Manager, and Mr Didier Caillard, Director, for initiating the project and for all their cooperation and assistance. SPC is also grateful to the new management team of Mr Paul Giovannoni, Manager, and Mr Florent Pithon, Director, for letting the project continue during the management transition, and for putting in place some of the recommendations made by the Masterfisherman.

SPC also thanks the captains of F/V *Ca Pakhade*—Patrick Fievet, F/V *Melita*—Vincent Puluiuvea, and F/V *Kirikit*—Daniel Pydo, and the crew of each of these vessels, for their hard work and cooperation.

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1. Introduction and Background

1.1 New Caledonia

New Caledonia is in the south-westernmost portion of the area served by the South Pacific Commission, bounded roughly by 15–25°S latitude and 156–170°E longitude, and lies just within the tropics (Figure 1). The main island of New Caledonia, or Grande Terre, is a large cigar-shaped island and at 400 km by 50 km is the largest island in the South Pacific after New Zealand and New Guinea (Fullerton, 1990). Many of the smaller islands of New Caledonia lie within the barrier reef that surrounds the main island, including the Isle of Pines to the south and the Belep Islands to the north. The reef surrounding New Caledonia is the second largest barrier reef in the world and encloses the largest lagoon in the world—8,000 km^2. The Loyalty Group—Ouvea Atoll, Lifou, Mare and Tiga—is east of the main island and is totally outside the barrier reef. To the west is the Chesterfield Island Group, which consists of several small, uninhabited islets and reefs; to the north are the Récifs d'Entrecasteaux; and to the south-east are Walpole Island and the disputed islands of Matthew and Hunter. Altogether New Caledonia has a land area of 19,103 km^2 (Fullerton, 1990).

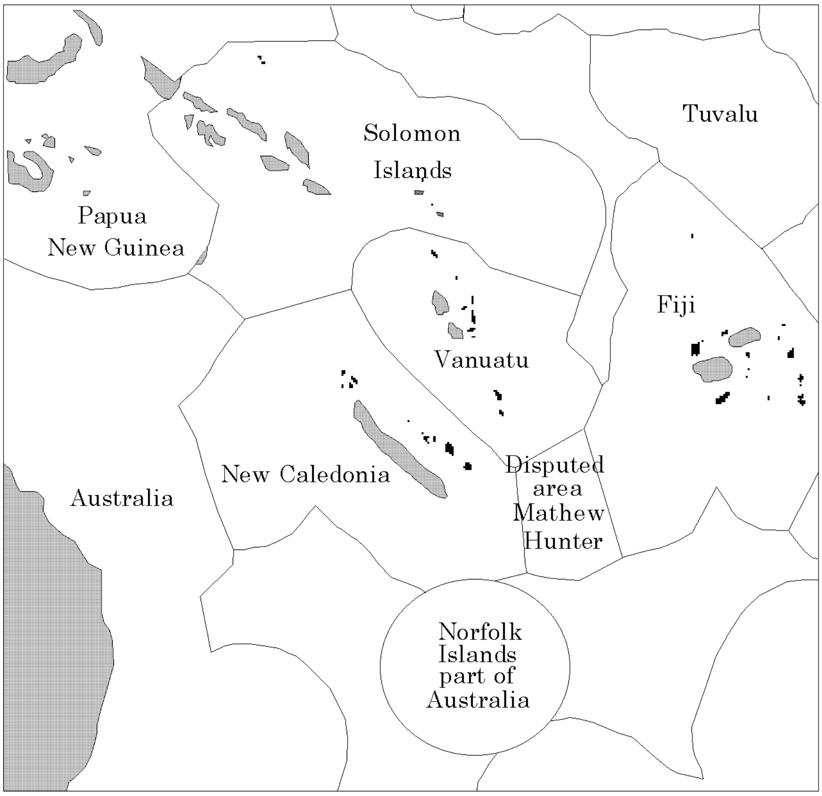

Figure 1: The New Caledonian EEZ with adjoining countries

New Caledonia's Exclusive Economic Zone, or EEZ, has an area of 1.7 million km^2 (or 1.4 million km^2 if the disputed portion surrounding Matthew and Hunter Islands is excluded). New Caledonia's EEZ was declared in 1978 and shares common marine boundaries with Australia, Fiji, Vanuatu and Solomon Islands (Figure 1). The sovereignty over Matthew and Hunter Islands is claimed by both France and Vanuatu and no agreement has been reached. The ocean bed within New Caledonia's EEZ is made up of a series of ridges and deep basins running in a roughly north-west to south-east direction parallel to the main island (Figure 2). The EEZ overlaps the tropical zone to the north and the more temperate zone to the south, and this is reflected in the relatively modest longline catches of yellowfin tuna and bigeye tuna and the rather high percentage of albacore tuna (Virly, 1996).

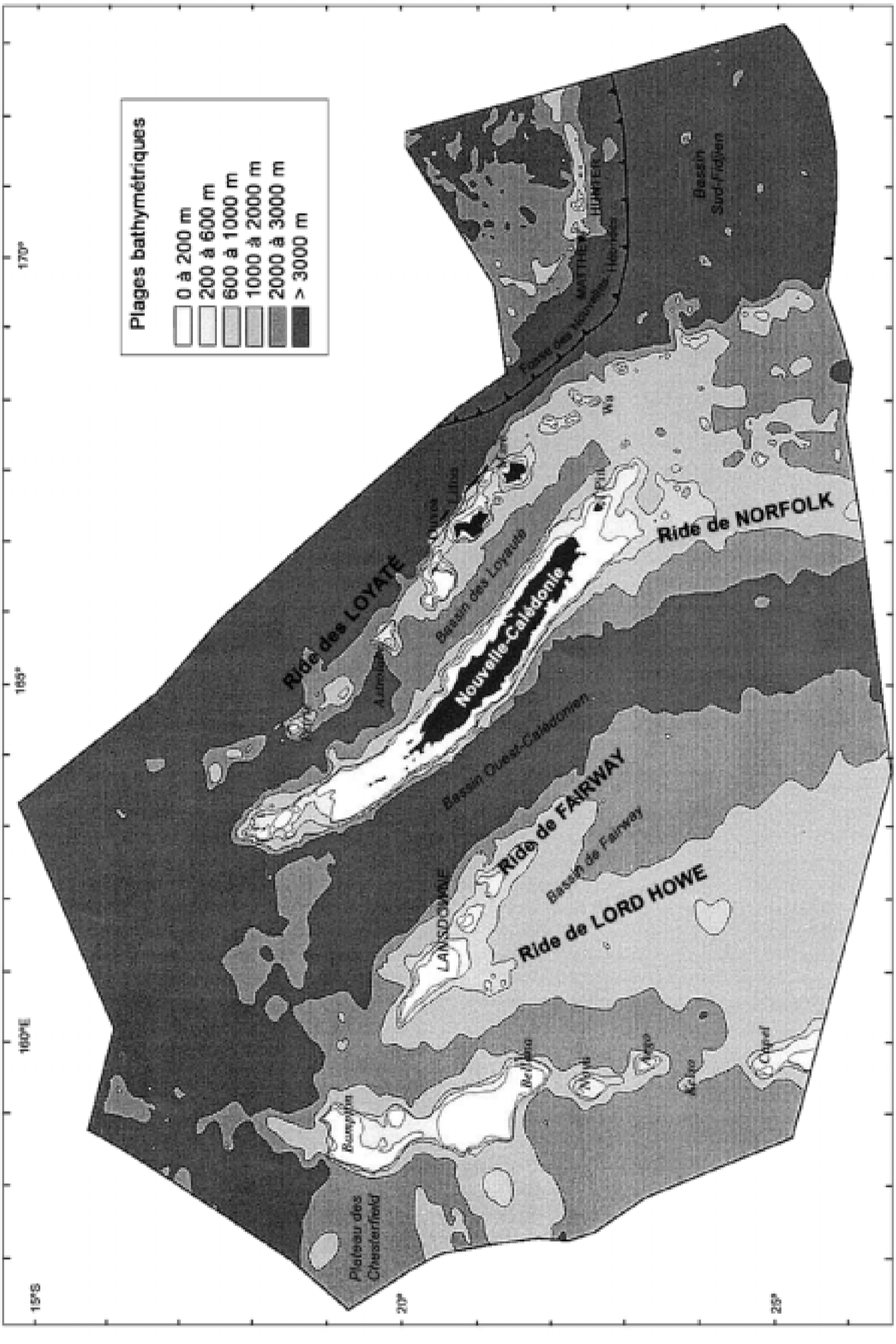

Figure 2: Bottom topography of New Caledonia's EEZ (map provided by ZoNéCo [Zone Économique de Nouvelle-Calédonie] programme, from Virly, 1996 [ORSTOM])

1.2 THE FISHERY

Japanese, Taiwanese, and Korean longline fleets have operated in New Caledonian waters in the past, the Japanese since 1962 and the Taiwanese and Korean fleets from 1967 and 1975 respectively. However, only the Japanese signed an access agreement after implementation of the EEZ in 1979 (Virly, 1996). As many as 40 Japanese longliners fished in New Caledonia's EEZ up to 1992, when no agreement was signed. In 1962 the Japanese fleet had a catch exceeding 11,000 t in an area surrounding New Caledonia's EEZ.

Virly (1996) refers to 'Zone A' as the area enclosed by the boundaries: 10–15° S and 160–165° E, 15–20° S and 155–170° E, and 20–30° S and 155–175° E (the adjacent five-degree squares that overlap New Caledonia's EEZ—refer Figure 3). Until 1982, the longline catch (all species) from Zone A (Figure 3) averaged almost 6,000 t annually.

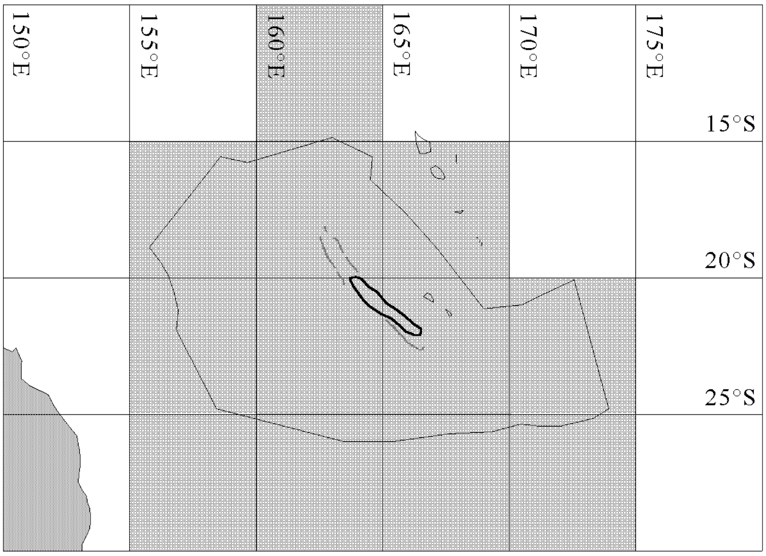

Figure 3: Five-degree squares (shaded) that overlap New Caledonia's EEZ—'Zone A' (map provided by ZoNéCo [Zone Économique de Nouvelle-Calédonie] programme, from Virly, 1996 [ORSTOM])

Virly's (1996) data for 1983 to 1994 are for a smaller area, 'Zone B', which is comprised of one-degree squares overlapping New Caledonia's EEZ (Figure 4). From 1983, the first year that domestic longline vessels operated, the catch has averaged about 3,000 t.

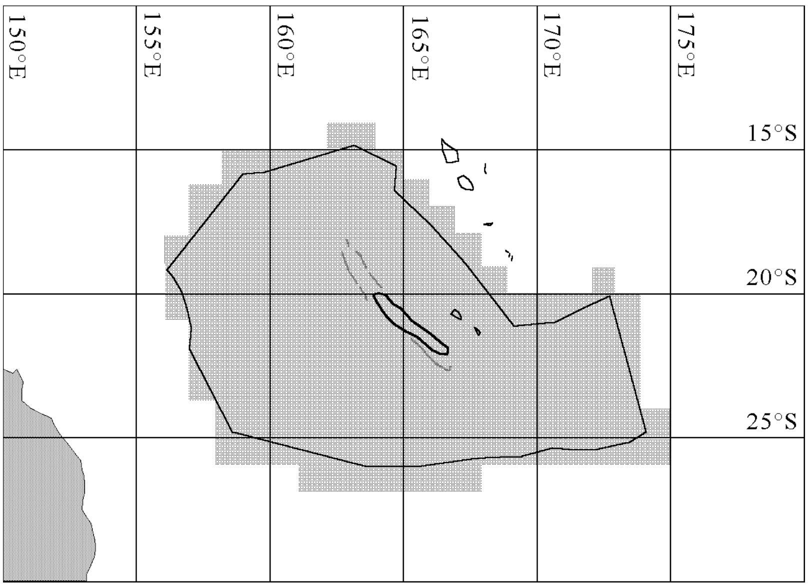

Figure 4: One-degree squares (shaded) that overlap New Caledonia's EEZ—'Zone B' (map provided by ZoNéCo [Zone Économique de Nouvelle-Calédonie] programme, from Virly, 1996 [ORSTOM])

Virly (1996) made some other general observations based on a detailed analysis of the combined Japanese and New Caledonian fleets operating between 1983 and 1994, including the following:

Fishing effort

- Japanese boats stayed out longer than New Caledonian boats and set more hooks per day;
- The Japanese fleet moved from west to east (south of the main island) at the beginning of the year and then from east to west (Chesterfield area) during the third quarter;
- New Caledonian longliners fished in the south-east and off the west coast of New Caledonia during the first quarter, then fished in the east and north-east of the Chesterfield Islands between May and August, following which they spread out between the Chesterfield Islands and New Caledonia for the rest of the year.

Overall catches

- Since 1987 the annual tonnage for New Caledonia longliners has exceeded 1,000 t, most of which was exported to Japan;
- Annual catches for the Japanese boats have roughly followed the same fluctuations as those for New Caledonian longliners;

Species composition for average annual catch

- The percentage of tuna has gradually increased while the percentage of billfish has decreased;
- Albacore tuna (*Thunnus alalunga*) has always been the predominant species in catches (78% in 1994), with yellowfin tuna (*Thunnus albacares*) the second species;
- The predominant billfish species was striped marlin (*Tetrapterus audax*), whose percentage varied between 25 and 60 per cent depending on the year.

Seasonal fluctuations

- Yellowfin tuna were particularly abundant in February and March (65% of the weight of tuna catches) while bigeye tuna (*Thunnus obesus*) did not show a significant peak in catches in any month;
- Striped marlin accounted for the largest percentage of billfish between August and December.

Average weight

- The average weight of yellowfin tuna increased significantly between 1993 and 1994 (from 28 to 37 kg);
- The average weight of striped marlin and broadbill swordfish (*Xiphias gladius*) was higher in October and November than in March;
- North of 21° S, average weights of albacore surpassed 20 kg while south of 24° S they varied between 10 and 18 kg;
- The largest yellowfin tunas were mainly caught in one of three areas corresponding to basins or trenches (with depths greater than 3,000 m) south of 25° S, in the north-east of the EEZ along the boundaries with Vanuatu's EEZ, and south of Matthew and Hunter Islands.

Catch rates and yields

- The catch per unit of effort (CPUE) by number and weight was 2.76 fish/100 hooks and 74.34 kg/100 hooks—CPUEs generally increased over the period considered;
- Average monthly yields for albacore showed two significant peaks—in July and December (50 and 45 kg/100 hooks);
- Monthly variations in yellowfin tuna CPUEs were noticeable—45 kg/100 hooks in April and 12 kg/100 hooks in October;
- Average monthly yields for bigeye tuna reached their maximum in May and June but varied little over the rest of the year;
- The best yields for albacore were found in the north-west of the EEZ;
- Yellowfin tuna seemed to be most abundant in the south-east of the main island; and
- The highest CPUEs for bigeye tuna by weight were found mainly between New Caledonia's east coast and the Loyalty Islands.

SPC has data for the domestic fleet in New Caledonia from 1983 to 1995 (Lawson, 1996). In 1983 one vessel caught just 60 t of all species. The domestic fleet peaked at seven vessels in 1990; the catch that year was 1,985 t. In 1992 four vessels caught 930 t. In 1995, there were three domestic tuna longline companies in New Caledonia: Navimon with five vessels, Toho Calédonie with two vessels and Megu Calédonie with one vessel. The total catch of these eight vessels in 1995 was 1,419 t.

The domestic catch between 1983 and 1995 was made up of 43 per cent albacore tuna, 28 per cent yellowfin tuna, 4 per cent bigeye tuna, and 25 per cent other species. However, in 1995 the total catch was only 23 per cent albacore tuna, with 53 per cent yellowfin tuna and 6 per cent bigeye tuna. The best year for bigeye tuna was 1992, when 110 t were caught by the domestic fleet (12% of the total catch).

Hallier (1984) reported on a new longline fishery in New Caledonia, and that two Japanese vessels (presumably fishing as domestic vessels) caught a total of 221 t of fish during 145 fishing days, from 1 November 1983 to 19 July 1984. A total of 323,910 hooks were set representing 2,234 hooks/day (the second of these two vessels was purchased in June 1984 so most of this catch must be attributed to one vessel only, although Hallier does not make this clear). The total number of fish caught was 7,342, which corresponds to 51 fish per fishing day (1.5 t) and a CPUE of 2.3 fish/100 hooks. The CPUE by weight was 68 kg/100 hooks. Albacore tuna was the main species caught, followed by yellowfin tuna and striped marlin. Hallier did not mention bigeye tuna in his paper.

The domestic tuna longline company, Navimon, caught a total of 384 t of all species with its five vessels in 1995 (Y. Thierry-Mieg, personal communication). During this time three of the vessels were active for twelve months and the other two for nine months. The overall CPUE by weight for the Navimon fleet during this year was 38.9 kg/100 hooks. The composition of the catch was 30.8 per cent albacore tuna, 32.2 per cent yellowfin tuna, 14.3 per cent bigeye tuna, and 22.7 per cent others. Forty per cent of the catch was exported to Japan, with an average gross value of CFP 953/kg. Sixty per cent of the catch was sold locally and had a value of CFP 480/kg. The total average gross value of all fish was CFP 668/kg. On average each Navimon vessel had an annual gross revenue of CFP 51,333,346. Total gross revenue for all five vessels was CFP 256,667,291 in 1995.

1.3 Observer coverage

Several countries in the region and SPC have established Observer Programmes to check catches on the spot and collect scientific data not normally available to scientists. From 1989, SPC placed some observers on albacore troll vessels working in international waters south of French Polynesia. This increased to six observers in the 1990/91 season, with reduced numbers in subsequent years.

As part of the regional move towards improved fisheries monitoring, SPC spent several years establishing the South Pacific Regional Tuna Resource Assessment and Monitoring Project (SPRTRAMP), which commenced in June 1994. The SPRTRAMP project has enabled the Oceanic Fisheries Programme (OFP) of the SPC to implement continuous scientific monitoring of the region's tuna fisheries, now the world's largest, and to refine tuna assessment work based on the results of the Regional Tuna Tagging Programme (RTTP). (The RTTP targeted skipjack tuna from 1977 to 1980 and yellowfin tuna from 1989 to 1992, tagging and releasing these tuna after measuring their length, to allow their migratory pattens and growth rates to be studied over time, based on the return of tags with length, capture position and the date of capture.) Eventually, SPC's OFP will be able to consolidate and extend this scientific work to the stage where rational and biologically sustainable management of regional tuna stocks becomes possible, and the impact of various fishing regimes predictable.

Some of the tuna longline companies in New Caledonia have been cooperating with the SPRTRAMP programme, allowing port sampling of their catch when it is unloaded. The Navimon company has also had comprehensive SPRTRAMP observer coverage on board its vessels, especially in 1996.

1.4 Initiation of the project and its objectives

Early in 1996, Mr Y. Thierry-Mieg, the manager of the New Caledonia domestic tuna longline company, Navimon, along with a member of the board of directors, Mr P. Fortier, and a representative of Paribas Pacific Bank, approached the South Pacific Commission Fisheries Programme's Capture Section with a request for technical assistance in the form of a Masterfisherman attachment to the Navimon fleet. The aim was to help the captains and crew improve fishing effort, productivity, and product quality, as Navimon was finding it difficult to operate its vessels at a profit.

In order to remain viable, Navimon had to increase productivity and improve product quality, while reducing operating expenses. Subsequently, on 18 June 1996 an official request was submitted to SPC by the High Commissioner of New Caledonia, asking that SPC offer technical assistance to Navimon in the form of a Masterfisherman attachment. The request was approved, and it was agreed that the Commission's Masterfisherman, Steve Beverly, would begin with Navimon in mid-August 1996. The objectives of the project were to:

- observe fishing procedures, fishing strategies, gear and equipment components, and implement changes to these to improve the vessel(s) fishing effort, catch and productivity;
- observe on-board fish-handling procedures and techniques and suggest changes, training crew in all aspects of proper handling techniques, including icing, to improve product quality;
- instruct the captain(s) of the vessel(s) in some of the finer points of setting and hauling monofilament longline gear in order to further increase productivity; and
- advise Navimon's management, through informal consultations, on all issues pertaining to improving fishing effort and catch, and to enhancing product quality, both on board the vessels and on shore.

When the project commenced, the objectives were broadened slightly to allow the Fisheries Development Adviser (FDA), Lindsay Chapman, to participate in the field operations. The additional objectives were to:

- allow the FDA to familiarise himself with the use of monofilament tuna longline gear; and

- monitor the fishing activities by having the FDA complete the standard SPRTRAMP Observer forms.

2. The New Caledonian Tuna Longline Company, Navimon

2.1 General

Navimon is a New Caledonian domestic tuna longline company that was established in 1989, with private capital. The original goal was to build up a fleet of eight longliners, fishing mostly for the lucrative fresh sashimi tuna market in Japan. The Loyalty Islands Province (SODIL, or Société de Développement et d'Investissement des Îles) later became the principal shareholder (51% of stock in 1995). In March 1993, the Tax Department gave Navimon its approval for 'tax-free investment' funding for eight vessels, based on the Pons Act (a tax-free investment programme for French entrepreneurs investing in French overseas territories). As part of this scheme, four vessels were constructed in France, with two delivered in 1994 and the other two in 1995. An Australian-made vessel had been purchased previously from an Australian company that had been involved in deep-bottom fishing. In December 1996, a sixth vessel, purchased from a company in French Polynesia, was added to the fleet.

The four French-made boats now belong to a maritime cooperative (joint owners) and the vessels' shares are managed by the ARPECAL company (Armement de Pêche Calédonien), which has a separate lease agreement with Navimon for each of the vessels. The other two vessels are owned by Navimon. Both ARPECAL and Navimon are owned by SODIL. Navimon plans to have four additional vessels made in 1997: two in France and two in French Polynesia.

Prior to 1996, Navimon had experienced a wide variety of problems: delays in delivery of vessels—the French shipbuilder went bankrupt while constructing the last two vessels and, as a result, these had numerous defects; an accountant embezzled large sums of money; operating costs were higher than expected; fishing effort and catch were lower than expected; and the Yen was devalued (Mr D. Caillard, personal communication). On 20 December 1995, the Noumea Court of Commerce placed Navimon in receivership. 1995 losses totaled 34 m CFP. On 15 May 1996 a plan was approved whereby Navimon would repay its debt at the rate of 1.8 m CFP per month over a five-year period.

In November 1996, Navimon had a change in management. The manager, Mr Yves Thierry-Mieg, was replaced by Mr Paul Giovannoni and the Director, Mr Didier Caillard, was replaced by Mr Florent Pithon.

The company occupies an office and warehouse complex on the wharf at Quai des Pêches in Noumea. All fish from Navimon's vessels are off-loaded at the wharf and carried by forklift on padded pallets to the processing room, where they are sorted, graded, and either packed for export to Japan, sold directly to local wholesalers, or marketed in Navimon's own retail fish shop, which is in the same complex. Navimon markets its export fish through an agent in Japan—some of the fish are put on the various auction floors in Japan (Tsukiji, Nagoya, Ishikawa) and some are sold at fixed prices in the 'supermarket' trade. Export fish are flown directly to Japan on twice-weekly flights, on Mondays and Wednesdays.

The captains and crew of Navimon's fleet are paid a monthly base salary and a bonus. The bonus is based on weight of catch, not on market value and is CFP 5,000/t of catch per person. They also receive a share of all proceeds from the sale of shark fins. Navimon markets all shark fins to a local cash buyer and retains 50 per cent, while the crew share the other 50 per cent. Each vessel has a captain, a bosun, and an ice master, as well as two or three deckhands. The vessels are looked after while in port by a regular maintenance team of five technicians.

2.2 Navimon's vessels

At the end of 1996, Navimon had six vessels working, with plans to purchase additional vessels as described above. F/V *Tanya J* originated from Australia whilst F/V *Seahorse II* was purchased from French Polynesia. As the Masterfisherman did not conduct any fishing activities on these two vessels, discussions and descriptions will deal only with the French-made vessels.

F/V *Ca Pakhade* and F/V *Iaai Pêche* were delivered in 1994, with F/V *Melita* and F/V *Kirikit* delivered in 1995. The vessels were designed by Stagnol (France) and were made by Chantiers Vergoz at Concarneau, near Lorient in Britanny, France. The vessels are forward wheel-house, whale-back designs, fabricated in aluminium and are basically identical (Figures 5 and 6). They are 16.08 m length-over-all, have a beam of 5.62 m, with the depth to main deck being 2.72 m. Fuel capacity is about 10.3 t and fresh-water capacity is 1.3 t.

... vessels from France

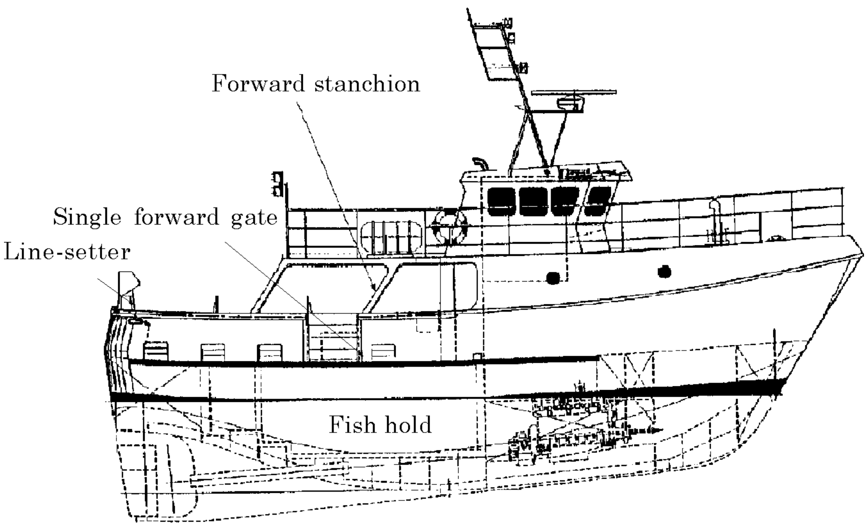

Figure 6: General design of the French-made tuna longliners operated by Navimon

The fish holds have a volume of 38 m^3 which means that they can carry 8–10 t of product. The icing method is used to chill the product to 0° C. The fish hold is also cooled with refrigerated coils mounted overhead, to maintain a temperature of 0° C. Each vessel is equipped with a desalinator and a flake-ice machine that can make 1.5 t of ice daily, if everything is working properly, and a bait freezer with a capacity of 6 m^3.

After fishing for one season with the first two vessels, F/V *Ca Pakhade* and F/V *Iaai Pêche,* Navimon had identified some inherent problems with the general arrangement of these vessels, so some modifications were made on the next two vessels, F/V *Melita* and F/V *Kirikit*. One thing that was changed was the arrangement of the auxiliary engine. On F/V *Ca Pakhade* and F/V *Iaai Pêche* the auxiliary engine powers a generator of only 3.6 kW and also runs several refrigeration compressors and pumps via belt-drives. The main engine drives two 3.6 kW alternators, as well as a hydraulic pump. On F/V *Melita* and F/V *Kirikit,* a simpler system was installed, with the auxiliary engine powering a bigger generator and running all of the machinery with electric motors, rather than with power take-offs. The result is a less cluttered engine-room, with fewer things to go wrong—a definite improvement.

Two arrangements on deck were changed from the original design. F/V *Ca Pakhade* and F/V *Iaai Pêche* each have one gate on the starboard-side bulwarks. These are in an awkward position and actually get in the way of a smooth operation when fish are being landed during hauling. F/V *Melita* and F/V *Kirikit* have two gates each, one in the original position and one further aft. Possibly the decision to add the aft gate was made after the first gate had been fabricated. In any event, the forward gate is left permanently blocked while fishing, and only the aft gate is used for landing fish.

On F/V *Ca Pakhade* and F/V *Iaai Pêche* the line-setter is on the centre line of the transom. This arrangement leaves little room for the crew to work while setting the longline. The problem is compounded by the presence of the lazerette hatch, which is just to the port side of the line-setter and is in the way during setting operations. On F/V *Melita* and F/V *Kirikit*, the line-setter has been shifted slightly to starboard on the transom, which gives much more room to work during setting (Figure 7).

***Figure 7: Mounting of line-setter on transom (starboard side of centre) on F/V* Melita**

2.3 Longlining equipment

All Navimon's vessels were equipped with the USA-made Lindgren-Pitman (LP gear), monofilament longline systems (Figure 8) when they arrived in Noumea. Each vessel had a 0.9 x 1.8 m Super Spool (marketed as a 36 x 72 inch Super Spool), that was originally packed with 75 km of 4.0 mm nylon monofilament mainline. Part of the system is the LS-4 line-setter which allows the depth of set to be controlled. Both the Super Spool and the LS-4 line-setter are hydraulically powered. The vessels each have four branchline bins capable of holding 440 branchlines each, for a total of 1,760 branchlines. The branchlines are 16–20 m in length, and are made up of 2.1 mm monofilament. They consist of the following parts (from the snap): an 8/0 or equivalent swivel snap with a 4.7 mm jaw (marketed as a 3/16 in jaw), 14–18 m of 2.1 mm monofilament, a 45 g leaded swivel, 1.5 m of 2.1 mm monofilament, a 1.0 mm stainless-steel trace wire of approximately 0.5 m, and a No. 3.6 Japanese tuna hook with ring. All monofilament connections are made with swages and are protected against chafing by clear plastic tubing. The monofilament and wire are connected eye to eye, for ease in changing hooks. There is no chafing protection on the wire-to-hook connection.

Figure 8: Lindgren-Pitman monofilament reel with reduced amount of mainline

Each vessel had a full set of hard plastic buoys (360 mm) with floatlines attached. The floatlines were relatively short, 10–12 m and were made up of 6.4 mm tarred Kuralon rope with a 9/0 swivel snap. Each vessel also had four radio buoys, or beepers, with 13 mm polypropylene bridles.

3. Observations

The observations presented in this section are based on the four trips conducted on three of the French-constructed vessels, during the course of the project. Unless otherwise noted, the following observations apply to all four of the Stagnol (French) vessels.

3.1 General

Fishing trips followed a set schedule, that is, the boats left and returned on pre-arranged dates and times. This was mainly done so that vessel off-loadings corresponded to airline departure dates. The result, however, was that fishing trips were relatively short; often only five sets were made in a trip.

Only small amounts of ice were taken aboard from the ice supplier at Quai des Pêches (Chamber of Commerce). The ice supply was crushed ice that was bagged in 20 kg plastic bags. The cost of this ice was reportedly CFP 20,000/t. Sometimes the vessels did not take any of this ice, if, as in the case of F/V *Kirikit*, the desalinator and ice maker were working properly. However, if the machinery was not working well, as in the case of F/V *Ca Pakhade*, then anything from 500 to 2,000 kg of bagged ice was taken on a trip (F/V *Ca Pakhade* made salt-water ice only, as the desalinator was not working).

Aside from the bagged ice and the flake ice made by the on-board ice machine, each vessel depended on its on-board refrigeration system to keep fish cool. Refrigeration coils in the overheads of the fish holds kept the ambient temperature at around 0°C. However, it was noted that the actual temperature in the fish holds was often as high as 6.0°C during fishing operations.

The main fish holds were divided into six separate bins with permanent baffles or walls (two on either side) running athwartships to the centre compartment. There were removable bin-boards or pound-boards running fore and aft which give the fish holds some versatility. However, fish could not be packed lying fore and aft because of the permanent baffles, which meant that there was some wasted space in the fish holds.

The bait used on all fishing trips was the European sardine, *Clupeus harengus*. The bait came frozen in 20 kg boxes and was generally in poor condition as compared with bait from Japan or Taiwan. However, it did work fairly well.

There were two stanchions on the starboard side supporting the upper deck aft of the wheel-house (see Figure 6). The forward-most of these got in the way of a smooth operation during hauling. The operator and the first coiler were forced to hand branchlines around this stanchion. On F/V *Ca Pakhade* and F/V *Iaai Pêche,* there was only one gate for landing fish. The gate was just aft of the forward stanchion. One crewman had to stand in this spot during hauling and pass branchlines around the stanchion to the second and third coilers (Figure 9). The forward stanchion was in the way on all four vessels but the problem is worse on F/V *Ca Pakhade* and F/V *Iaai Pêche*.

Figure 9: Crewman standing in front of gate to pass branchlines around stanchions

Generally all of the Lindgren-Pitman equipment was being looked after properly. However, most of the hydraulic hose ends and hydraulic fittings on the reel and line setter were badly rusted, as they were not wrapped with protective tape (Denso Tape or equivalent), or painted properly with galvanised paint.

As previously mentioned, the line-setters on F/V *Ca Pakhade* and F/V *Iaai Pêche* were on the centre line on the transom. There was little room for the crew to work as there was a raised hatch going to the lazarette just to port of the line-setter. It took three men to do what would normally be a two-man operation because of this. One man had to remove branchlines from the branchline bin, hand the hook to the baiter, and the clip to the snapper (Figure 10). On F/V *Melita* and F/V *Kirikit,* the line-setter was offset to starboard, so there was more room to work during setting (refer Figure 7).

Figure 10: Crewman taking branchlines from bin to pass the clip to the snapper and the hook to the baiter

The line-setters were also in need of some repairs. The upper idler-roller on F/V *Kirikit*, for example, was so badly worn that the mainline slipped and could not be set deep on the first 4–5 km (new line). There were no spare rollers on board.

The 4.0 mm monofilament mainline on the vessels was generally in poor condition and the reels were not filled to capacity (see Figure 8). Often the mainline would part three or four times during one haul. The branchlines were also in poor condition and would often break, resulting in lost fish. Branchlines that were chafed or badly kinked or twisted, usually from being wound around the mainline by a shark or other by-catch species, were not being replaced. The crew had many problems as a result of using worn-out branchlines—especially during setting. Badly kinked branchlines would not leave the bin smoothly during setting, but would tangle with others, causing a mess that was potentially dangerous as someone could have been hooked or injured.

The hooks on all of the branchlines were 3.6 Japan tuna hooks with ring (galvanised hook with stainless-steel ring). There was no chafing protection on the ring to wire connections. The eye-end of many of the hooks was rusted through, or nearly through, as a result of electrolysis between the galvanised steel of the hook and the stainless steel of the ring. Many fish were lost as a result of hooks breaking off at the eye.

Floatlines on all vessels were relatively short, 12–14 m. This reduced the fishing depth of the gear.

3.2 Fishing strategy and techniques

Selection of a fishing area by the Navimon captains was based on only a small number of all the available criteria: historical knowledge, bottom topography and performance of other vessels. Although these are important, there are other factors that can influence choice of fishing area; Navimon captains did not take advantage of these.

The fishing techniques used generally followed the Japanese way of fishing: setting in the morning and hauling back in the afternoon. Setting was done going with the wind (so hauling would be into the wind) on F/V *Ca Pakhade* and F/V *Kirikit*. The captain of F/V *Melita*, however, preferred to set going against the wind so that hauling would be with the wind. Baskets usually had either 25 or 30 hooks and the interval was eight seconds on the setting timer. Vessel speed was usually seven to eight knots so the hook spacing was approximately 50–60 m (the line went about twice as fast as the vessel). On F/V *Ca Pakhade* the captain used a hand-held tachometer to adjust the speed of the line-setter. On F/V *Melita* and F/V *Kirikit*, however, the line-setter speed was set at a random speed faster than the vessel, but with no real monitoring method.

Several large broadbill swordfish were caught during the project (see Appendix). These were considered to be by-catch species and were marketed locally. One of the fish weighed over 200 kg. Swordfish were not targeted nor were they exported when caught.

3.3 ON-BOARD FISH HANDLING AND ICING

Generally the gaffing, landing, spiking, gilling and gutting, and cleaning of fish on deck were satisfactory, with the following exceptions: fish were sometimes gaffed in the body—this usually happened because the side fishing lights did not illuminate the area at the waterline right next to the gate; sometimes fish were handled too roughly; there was only one small piece of carpet on the deck for cleaning fish—fish were landed on the bare metal deck; active fish were not stunned with a club or fish bat; fish often were not spiked properly—they were still moving when placed in the fish hold; the Taniguchi method (Blanc, 1966) was not used; often fish were not allowed to bleed long enough to rid the fish of all blood; albacore tuna were generally not bled; blood and rinse water were not completely drained from fish before they were put in the fish hold; and on one vessel, the crew were scrubbing the outside of the tunas with a brush.

Probably the most important task, and the area in which all of the vessels were weakest, was in icing the catch. The following incorrect procedures were being carried out by the ice masters and crew: no padding (carpet) was put over the edge of the hatch coaming—often large fish were lowered over this edge, resulting in skin damage; fish were placed on bare wood (no carpet or ice) in the centre compartment of the fish hold (Figure 11); large fish were landed in the centre hold by lowering them with a slip line (rope wrapped around tail) with no one in the fish hold to catch or guide them; fish were often left uncovered in the centre compartment for one to two hours (see Figure 11); fish were placed on their sides in fish holds and often were not covered up straight away (eg. on F/V *Ca Pakhade*, three bigeye tuna landed on a Friday (Figure 12) were not covered up with ice until Sunday—two days later); the starting layer of ice in each bin was not sufficiently thick to last for the entire trip; sharks (makos) and other by-catch were being placed in the same bin as tunas; shark fins were thrown into the centre compartment and were left lying alongside tunas and other fish; fish were iced lying on their sides (Figure 13) rather than with backs up; fish were not completely covered with ice, even after initial cooling had taken place; fish were not re-buried after pre-icing; fish were often in contact with other fish in the ice; on F/V *Ca Pakhade*, fish were iced with salt-water ice after a plastic bag had been placed over the fish; and the refrigeration system, rather than ice, was being depended upon to cool fish. The refrigeration coils in the overhead area of the fish hold ideally cooled the ambient air to 0º C. However, the temperature often reached 6.0º C in the fish hold. The skin on some fish dried out as a result of being air-cooled and not completely covered with ice.

Figure 11: Processed catch lying on wood floor of ice room

Figure 12: Bigeye tuna left on top of ice for two days before being iced

Figure 13: Fish incorrectly iced, lying on their side and touching each other

3.4 ON-SHORE HANDLING OF THE CATCH

The way that Navimon processed fish for export was adequate; however, the following undesirable practices were observed. When fish were unloaded from the fish hold they were rinsed with ambient-temperature water (25˚C and above) from the wharf supply, which warmed the fish; temperatures (body core) of the fish were not being measured; fish were left at ambient air temperature for long periods before being packed and put into a cool-room; the pallets that were used to carry fish from the vessels to the packing house were covered with carpet—this cannot be properly cleaned; the table where fish were measured and graded prior to packing was also covered with a carpet that cannot be properly cleaned (actually the grading table is a large platform where the port samplers and graders were allowed to walk—Figure 14); grading of tunas was done as 'Yes' or 'No' rather than 'A', 'B' or 'C' and 'Fat' or 'No Fat' grades; wet ice in plastic bags was used in the packing boxes, and then only in small quantities; there was no foam insulation in the packing boxes; boxes were two-piece boxes and not the usual overlapping lid style; and no tape was used to seal boxes.

Figure 14: Tuna laid on platform for grading, measuring and packing

Generally the whole process of unloading, grading, and packing of export fish was done in a relatively slow and haphazard manner, with the fish being handled many times—from the fish hold to the deck, from the deck to the pallet, pallet forklifted to the packing house, from the pallet to the scale, from the scale to the grading table, and from the grading table to the packing boxes. Full packing boxes were then forklifted to a cool-room (refrigerated container). Fish were packed without being rinsed of slime, unless they had been rinsed on the vessel.

Fish that were retained for local sale (by-catch species and reject tunas) were sorted andprocessed on the floor of the retail, processing and sales outlet. There are tables on the perimeter walls on three sides of the retail sales room, but most fish were initially dumped on the floor (Figure 15). Vessel crew, workers, and customers were all allowed to walk in and out on the floor, where and while fish were being processed.

Figure 15: Fish on floor of retail, processing and sales area, awaiting processing

4. Results of Fishing Activities

Table 1 summarises the catch of saleable species during the project's activities, while Appendix 1 gives a more detailed breakdown of the catch and effort by set. The weights in Table 1 and Appendix are estimates made by the Masterfisherman at the time of recording the catch. Table 2 summarises the catch per 100 hooks, based on the estimated weight for the saleable catch and the two main target species for export: yellowfin tuna and bigeye tuna. The percentage these two species represent in the total catch by weight and the average weight of these species are also presented.

Table 1: Total catch retained and number of hooks set during project fishing activities, with the catch of the two target species for export, yellowfin tuna (YFT) and bigeye tuna (BET) presented separately.

Trip number	No. of hooks set	All species No. of fish	All species Weight (kg)	Yellowfin tuna No.	Yellowfin tuna Weight (kg)	Bigeye tuna No.	Bigeye tuna Weight (kg)
1	6,840	117	2,920	38	570	15	540
2	6,660	71	1,910	6	185	13	470
3	7,225	169	3,855	53	1240	1	25
4	7,500	313	5,305	146	3175	5	190
Total	**28,225**	**670**	**13,990**	**243**	**5,170**	**34**	**1,225**
Observer trip							
1	**9,010**	**307**	**7,143**	**72**	**2,029**	**8**	**237**

1. Catch from the observer trip has not been included

Table 2: CPUE for the total saleable catch and the target species for export, yellowfin tuna (YFT) and bigeye tuna (BET), with their percentage of the catch and average weight.

Trip number	CPUE (kg/100 hooks) Total catch	CPUE Yellowfin tuna	CPUE Bigeye tuna	Yellowfin tuna Per cent by wt.	Yellowfin tuna Ave. wt. (kg)	Bigeye tuna Per cent by wt.	Bigeye tuna Ave. wt. (kg)
1	42.7	8.3	7.9	19.5	15.0	18.5	36.0
2	28.7	2.8	7.1	9.7	30.8	24.6	36.2
3	53.4	17.2	0.3	32.2	23.4	0.6	25.0
4	70.7	42.3	2.5	59.8	21.7	3.6	38.0
Total	**49.6**	**18.3**	**4.3**	**37.0**	**21.3**	**8.8**	**36.0**
Observer trip							
1	**79.3**	**22.5**	**2.6**	**28.4**	**28.2**	**3.3**	**29.6**

1. The data from the observer trip are presented separately from the project activities

As Table 2 shows, the overall catch rate was 49.6 kg/100 hooks, although the catch rate for the target export species, yellowfin tuna and bigeye tuna, was only 18.3 kg/100 hooks and 4.3 kg/100 hooks respectively. However, yellowfin tuna still made up 37 per cent of the catch by weight, whilst bigeye tuna only accounted for 8.8 per cent of the catch by weight. The average weight of these species was also relatively small at 21.3 kg and 36 kg respectively.

It should be noted that all weights for opah (*Lampris guttatus*) are estimated whole weights. At the time of unloading, opah were filleted with a recovery rate (fillet weight to whole weight) of around 25–35 per cent (see Appendix).

4.1 Trip one—F/V *Ca Pakhade*

Five sets were made on this trip in the waters along the west coast of New Caledonia. The Masterfisherman worked alongside the captain and crew but did not influence the fishing strategies or techniques. A total of 6,840 hooks were set in 30-hook baskets, resulting in an actual catch of 117 saleable fish with an estimated weight of 2,920 kg. The main species caught were yellowfin tuna (32% by number and 20% by weight), bigeye tuna (15% by number and 19% by weight) and opah (25% by number and 40% by whole weight) (see Appendix).

4.2 Trip two—F/V *Melita*

Five sets were made in the waters just off the east coast of New Caledonia on this trip. Again, the Masterfisherman worked alongside the captain and crew but did not influence fishing strategy or techniques. A total of 6,660 hooks were set in 30-hook baskets, resulting in a catch of 71 saleable fish with an estimated weight of 1,910 kg. The main species caught were bigeye tuna (18% by number and 25% by weight) and opah (20% by number and 37% by weight) (see Appendix).

Also on this trip, 127 unsaleable fish were taken and discarded. The main discard species were long-nosed lancet fish (*Alepisaurus ferox*), short-nosed lancet fish (*A. brevirostris*), and snake mackerels (family Gempylidae). Shark-and killer-whale-damaged tunas were also recorded under this category. All sharks were discarded, with the fins retained, except that the trunks as well as the fins were retained for smaller mako sharks (Family Lamnidae).

The Masterfisherman provided a summary of his observations, with suggestions for improvement, to the management of Navimon. The management agreed to implement some of the suggested changes and it was agreed that the Masterfisherman would conduct a second trip on board F/V *Melita*.

4.3 Trip three—F/V *Melita*

On this trip, the Masterfisherman acted as 'fish master'. In other words, he made some changes in gear configuration and directed all setting operations as well as all fish handling and icing. The floatlines were doubled in length to approximately 28 m. Different setting strategies, including setting in the standard way, with the wind, so that hauling would be into the wind, were introduced (during Trip two, F/V *Melita* had set the line going into the wind). Also, the following technique was used to control the depth of set: first the line-setter speed was monitored by gripping the line and counting elapsed time until it tightened again; then the setter-speed was adjusted accordingly (see Section 5.2 for more detail).

A Furuno 2000-T temperature indicator was temporarily mounted in the wheel-house, so that sea-surface temperatures (SST) could be monitored. On this trip six sets totaling 7,225 hooks in 25-hook baskets were made in the waters around Fairway Ridge (off the west coast of New Caledonia). Setting was done over any SST edges that had been identified, following isobath lines on the chart, or targeting spots where fish had been caught on the previous set. The line was also set at an angle to the current so that the maximum area of sea would be fished as the line drifted. Currents, however, were not strong in the area fished.

The total catch was 169 fish with an estimated weight of 3,855 kg. Two SST edges were located on the second and sixth sets, and significant catches of target species were associated with these edges (16 and 17 yellowfin tuna respectively). On this trip the main species caught were yellowfin tuna (31% by number and 32% by estimated weight), albacore tuna

(38% by number and 33% by estimated weight) and striped marlin (10% by number and 18% by estimated weight). Some of the striped marlin were exported, along with the export-quality tunas. One hundred and ninety discard species were caught, with a similar species mix to that on the previous trip (see Appendix).

The Masterfisherman instructed the ice master in proper icing techniques and directed all icing of the catch. After the fish had been off-loaded and processed the director of Navimon commented that the grade of fish had improved over past results.

The use of longer floatlines and SSTs to be able to work along temperature fronts/edges, may have contributed to the improved catch rate (almost double) over the previous trip (53.4 kg/100 hooks compared to 28.7 kg/100 hooks).

4.4 Trip four—F/V *Kirikit*

Fishing activities on this trip were concentrated in the waters just off the south-east coast of New Caledonia. Five sets were made, with combinations of 20-, 25-, and 30-hook baskets. Unfortunately, there was not sufficient time before the trip to change the floatlines or to install the Furuno SST indicator. However, all of the other techniques and strategies introduced to the F/V *Melita*, including proper icing of catch, were introduced to F/V *Kirikit* on this trip.

A total of 7,500 hooks were set, resulting in a catch of 313 fish with an estimated weight of 5,305 kg. The catch of yellowfin tuna increased dramatically on this trip (47% by number and 60% by estimated weight). This increase was in part due to the seasonal increase in the yellowfin tuna abundance in the area. Associated with the season was the high number of mahi mahi (*Coryphaena hippurus*) caught (113 fish, 36% of catch by number or 14% by estimated weight). Striped marlin were also present in the catch (4% by number and 9% by estimated weight). Discards numbered 159 fish, with a species composition similar to that of Trips two and three (see Appendix).

4.5 Observer trip—F/V *Ca Pakhade*

This trip was conducted in September 1996, in the area between New Caledonia and the Chesterfield group, two days' steaming from Noumea. Seven sets were made, using 25-and 30-hook baskets. The skipper also used a slower vessel speed to get the gear to fish deeper.

The observer's role was to record the entire catch by time of day and hook number (position between floats), as well as measuring and sexing (where possible) all fish landed, saleable and unsaleable. Other data, such as the vessel's position each hour and climatic and sea condition, were also recorded. The observer also assisted in the fishing operations when needed, and the crew assisted with the measuring and sexing of the catch.

A total of 9010 hooks were set, resulting in a catch of 307 saleable fish for an estimated weight of 7,143 kg. The main species caught were albacore tuna (57% by number and 48% by estimated weight), yellowfin tuna (23% by number and 28% by estimated weight) and opah (12% by number and 19% by estimated weight). The discard species were similar in composition to those recorded above during project trips, and totalled 181 fish (see Appendix).

5. Discussion and Conclusions

5.1 General

On Trips one and two, fish were not found in any significant numbers until the last one or two days of fishing (see Appendix). The vessels returned to port just as things were going well. There were two reasons for returning to port: to meet an airline schedule and because the ice supply was running low. Typically, a longline trip should involve a few days steaming to look for fish and then ten to twelve sets, or days fishing. Movements may have to be made after each set or after two or three sets in one area.

In this regard, the first two or three days were 'search' days on Trips one and two. When the fish were finally found the boats returned to port. From a fisherman's point of view, that is incredible. Both trips would have been much more productive if the vessels had stayed out fishing for at least another week. More ice could have been taken and the following week's airline schedule could have been met.

The Navimon vessels took either very little ice or no ice at all on the four trips during the project. On all of the trips ice either ran out completely or was a deciding factor in trip length (F/V *Melita* and F/V *Kirikit* were forced to stop fishing, F/V *Melita* returned to port during Trip three, F/V *Kirikit* had ice delivered by F/V *Ca Pakhade*). Two tonnes is a relatively small amount of ice for a longline trip. Typically, in other parts of the Pacific, ice vessels take anywhere from 10–30 t of ice for one trip. However, the ice available from the Chamber of Commerce at Quai des Pêches, at CFP 20,000/t is about two to three times more expensive than at other locations in the Pacific, so the cost is prohibitive. The combination of desalinator and flake-ice machines on the vessels was never working at full enough production to supply sufficient ice. Adequate ice is critical for fresh-chilled sashimi export tunas, and Navimon has to ensure that its ice needs are met through being able to purchase cheaper ice or produce its own.

All of the vessels were depending on the on-board refrigeration system to chill fish. The systems were designed to keep ambient air in the fish holds at 0º C. However, during fishing operations when the fish hold was being opened and closed regularly, the ambient temperature often rose to as high as 6.0º C. Product temperature in the chilled fish industry should never be allowed to rise above 4.4º C (FDA, 1996). The refrigeration systems on the Navimon vessels were designed to maintain the ice supply at 0º C. They were not designed to chill product.

The four vessels have built-in baffles, or walls, in the fish holds, permanently dividing the hold into six compartments (seven if the centre compartment is counted). These baffles are made of fibreglassed plywood and run athwartships (side to side) from the edge of the centre compartment to the outer walls of the hold. Removable bin-boards or pound-boards that run fore and aft and athwartships in the centre compartment allow some versatility in the fish-hold configuration. However, fish could not be packed in ice lying fore and aft in the bins on either side of the centre compartment, as the space between the baffles was relatively short—too short for the length of most longline-caught fish. Fish must be packed athwartships on the Navimon vessels. It is preferable to pack fish fore and aft as more fish can be packed in a given space—heads and tails can overlap and large fish can easily be accommodated. Also, fish that are packed side-to-side tend to move in the ice as the vessel rocks, particularly when the vessel is drifting and lying side-on to the sea. This can cause damage to the fish.

The bait used on all of the trips was the European herring (*Clupeus harengus)*. Although this herring was fairly good as a longline bait, it was probably not the best choice. Most longline vessels operating in the Pacific use either iwashi (sardine—*Sardinops melanosticta*), muro aji (mackerel—*Decapterus muroadsi*), or sanma (saury—*Cololabis sairi*). Taiwanese vessels typically fish on the full moon and use squid. Longliners targeting broadbill swordfish use a combination of squid and chemical lightsticks.

On the starboard side of the vessels, the forwardmost stanchion (support post going from the cap rail on the bulwarks to the upper deck—Figure 16) prevented smooth operation during line hauling. It appears that this stanchion was more cosmetic than functional, as there is little weight on the deck above. One man could actually be eliminated from the hauling operation on F/V *Ca Pakhade* and F/V *Iaai Pêche* if this stanchion were not in the way. The extra man was needed to hand branchlines around the stanchion to the coilers (see Figure 9).

F/V *Melita* and F/V *Kirikit* have two gates on the starboard side for landing fish (see Figure 16). F/V *Ca Pakhade* and F/V *Iaai Pêche* have only the forward one. It appears that the design was changed as the two newer boats were being built. The forward-positioned gates on F/V *Ca Pakhade* and F/V *Iaai Pêche* were in an awkward position for landing fish, as they were in the way of the branchline coilers. On F/V *Melita* and F/V *Kirikit* the forward gates were blocked off and were not used to land fish during hauling. Only the aft gates were used.

Figure 16: Stanchions on the starboard side of a French-built vessel

The line-setters on F/V *Ca Pakhade* and F/V *Iaai Pêche* were mounted on the centre line on the transom. On F/V *Melita* and F/V *Kirikit* the line-setters are on the starboard side of the centre line and the setting operation was relatively smooth. By contrast, on the former two vessels, a third man was needed to hand branchlines to the baiter and snapper (see Figure 10). There was not enough room for what would otherwise have been a two-man job. Figure 17 depicts the optimal position for the line-setter on these vessels and the position of the block required during the setting operation.

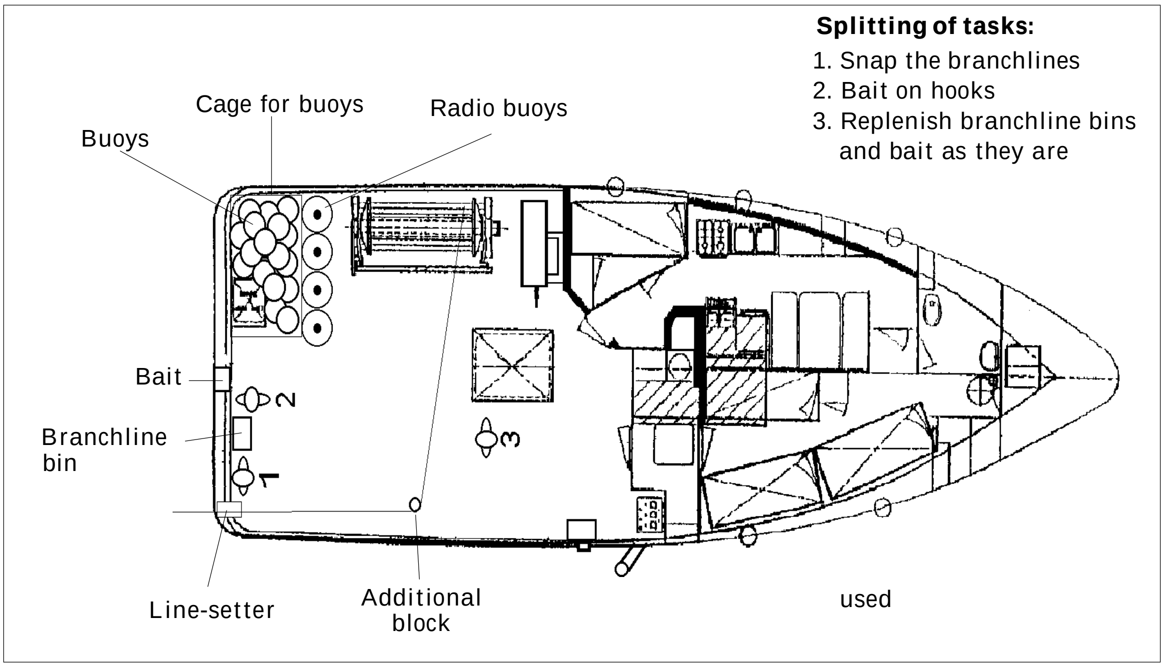

Figure 17: Proposed deck layout for setting with line-setter mounted on starboard side of the transom

The Lindgren-Pitman mainline reel can hold up to 92 km of 3.6 mm monofilament, but only 75 km of 4.0 mm monofilament. The vessels could set and haul about 20 per cent more gear if they were equipped with 3.6 mm monofilament mainline. Furthermore, 3.6 mm longline offers less resistance in the water during hauling operations and it is easier to work with than 4.0 mm monofilament. The breaking strengths are not very different—545 kg for the 4.0 mm and 454 kg for the 3.6 mm.

In the last two years or so, vessels in the longline fleet in Hawaii have been using 3.0 mm tarred red polyester line for branchlines. It has also been trialled successfully in Pohnpei, FSM (Beverly & Chapman, 1997) and it has proved to be very successful. It does not retain kinks or twists and generally outlasts monofilament branchlines. It is also easier to set, haul and handle with fish.

Many fish were being lost on the vessels because the hooks were rusting/corroding and eventually breaking at the eye. The problem was one of electrolysis between the stainless-steel hook rings and the galvanised steel of the hooks. This was aggravated by the fact that there was no thimble or tubing separating the stainless-steel wire traces from the hook rings.

During the hauling operation on F/V *Ca Pakhade* the mainline was hauled by the mainline reel, via a single block mounted over the starboard side. This meant the line entered the line-guide on the level-wind at an acute angle which placed a lot of strain on the line-guide. Through the addition of a second block, as depicted in Figure 18, unnecessary strain would have been removed and the gear would last longer without the need for repair.

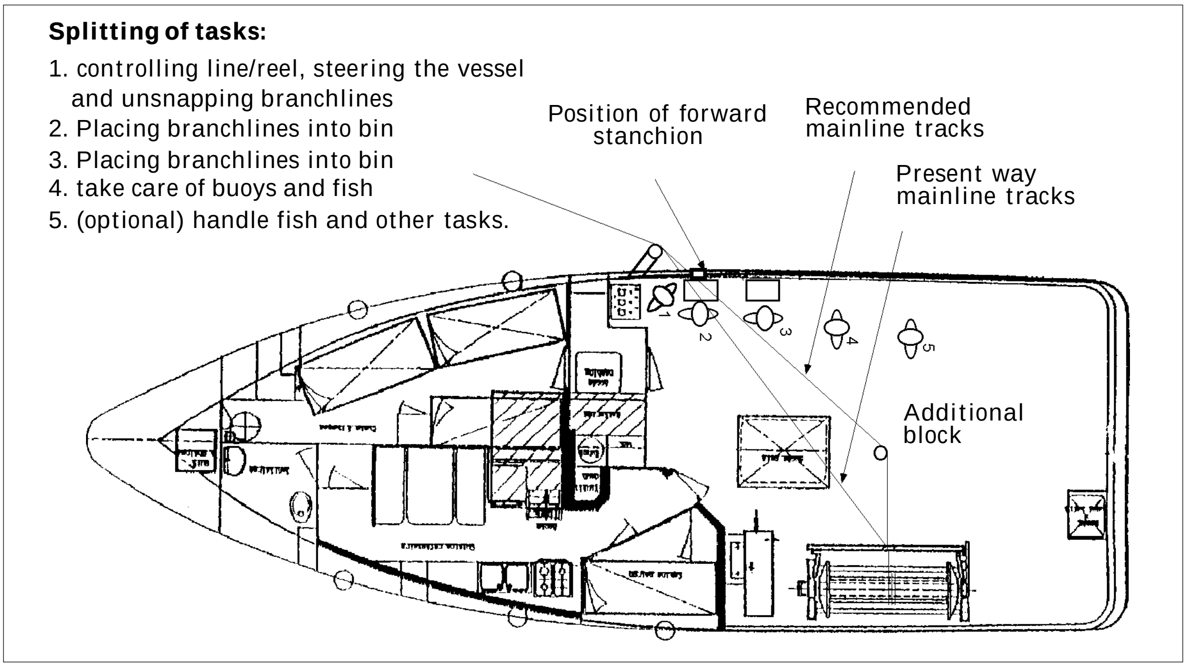

Figure 18: Proposed deck layout for hauling with an additional block mounted square to the mainline reel

Maintenance on fishing vessels is a never-ending task. Aside from the propulsion machinery and the safety gear, the most important equipment is the fishing gear. A broken hydraulic fitting or hose can put a stop to fishing operations and can even result in gear loss, which could cost thousands of dollars. The hydraulic fittings and hose ends on all of the vessels were in poor condition, and the line-setters needed spare parts.

In the Japanese style of fishing, with basket gear and all of its variations, deep sets are achieved by having very long branchlines and short floatlines. This is done because the 6.4 mm tarred mainline (Kuralon) is difficult to pull if it is set deep. This type of gear is labour-intensive, as coiling long branchlines is hard work, even when aided by machinery. One of the big advantages of the compact monofilament system is that a deep set can be achieved by using longer floatlines together with shorter branchlines, while putting more branchlines in each basket (section between floats). Monofilament mainline comes up from the deep with less resistance than does tarred Kuralon. Also, monofilament systems are less labour-intensive than basket-gear systems—it is relatively easy to coil short branchlines into branchline bins. Monofilament systems are also more efficient at fishing than basket-gear systems.

The Navimon vessels are using monofilament systems, but fishing them more like the traditional basket gear. This probably came about because most of the experienced longline fishermen in New Caledonia learned by fishing on Japanese vessels. However, using short floatlines and long branchlines with monofilament gear defeats some of the purposes and functions of the gear. Monofilament gear fishes better if the mainline (backbone) is deep, away from the effects of surface currents and turbulence. On the second trip on F/V *Melita* (Trip 3) the floatlines were doubled in length. Although no direct conclusions can be drawn, the CPUE for this trip was twice that of the previous trip (see Section 4).

5.2 Fishing strategies and techniques

Navimon's four vessels, although equipped with Furuno Model FCV-Colour Video Sounders that have sea-surface-temperature (SST) monitoring capabilities, do not monitor SST as part of their fishing strategies. SST is the single most important environmental factor that can be measured to aid longline fishermen in locating target species. It has long been known by fleets from the distant-water fishing nations (e.g. Japan) that fish have temperature preferences that affect their abundance. In 1972 the Japan Fisheries Information Service Center (JFIC) was established to, among other things, monitor and pass on to fishermen SST data in the form of surface isotherm maps, with forecasts for fishing (Tomczak, 1977). Tomczak states:

> '... it has been shown that fish tend to concentrate at certain surface isotherms, particularly in areas of strong horizontal temperature gradients. Therefore, best fishing grounds are frequently located in the boundary regions of different water masses or current or in areas of divergence by upwelling processes'.

Map A from this report (reproduced here as Figure 19) shows isotherms for a section of the North Pacific, south of Japan, with a translation of the Japanese text. Such maps were relayed to fishing vessels by radio transmission and were picked up by facsimile receivers.

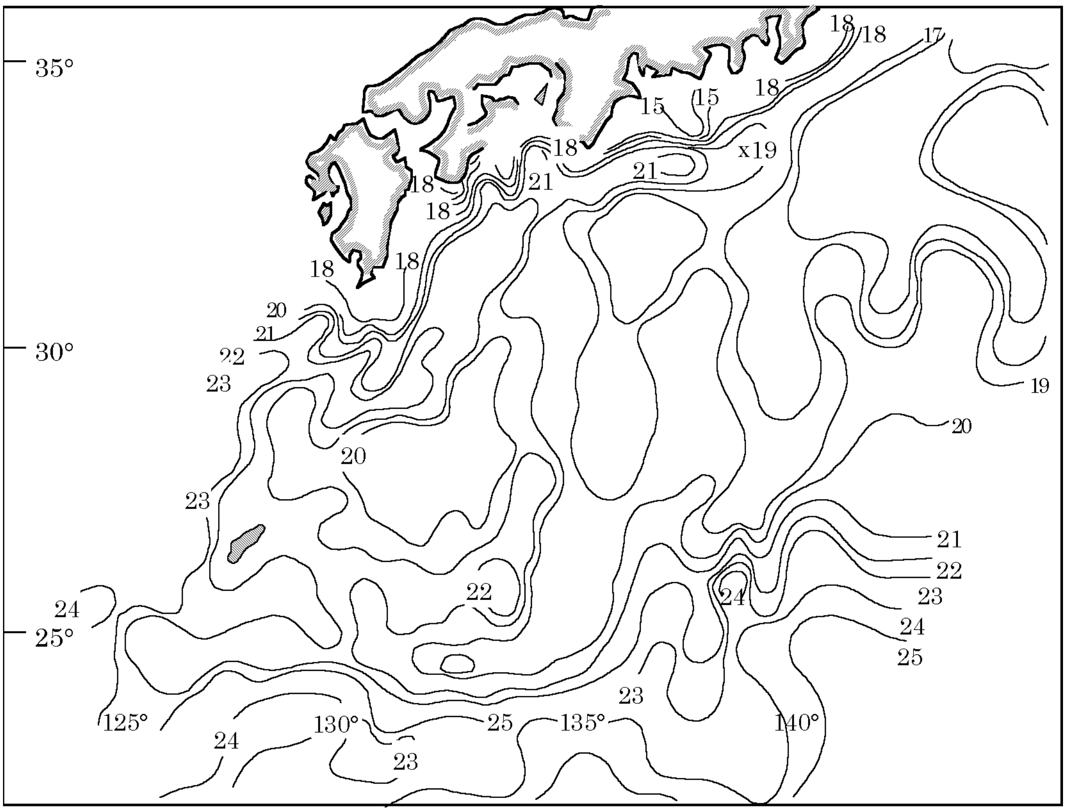

Figure 19: Sea-surface temperature chart for waters south of Japan (reproduced from Tomczak, 1977)

In Australia in the 1970s, CSIRO started a service of monitoring SST by overflights with aircraft carrying infra-red radiation thermometers (Williams, in Tomczak, 1977). Isotherm maps were drawn (reproduced here as Figure 20), temperature fronts were located and this information passed on to the fishermen targeting southern bluefin tuna (*Thunnus maccoyii*). Williams states that southern bluefin tuna have a preferred temperature range of 17°–20° C and that within that range they tend to congregate around areas where there is a large temperature change (usually greater than 1° C and sometimes up to 4° C), over a short horizontal distance—a temperature 'front'. Prior to 1968, the southern bluefin tuna fishery off the coast of New South Wales, Australia was a coastal fishery only. With the use of isotherm maps the fishery was able to extend out to 200 miles.

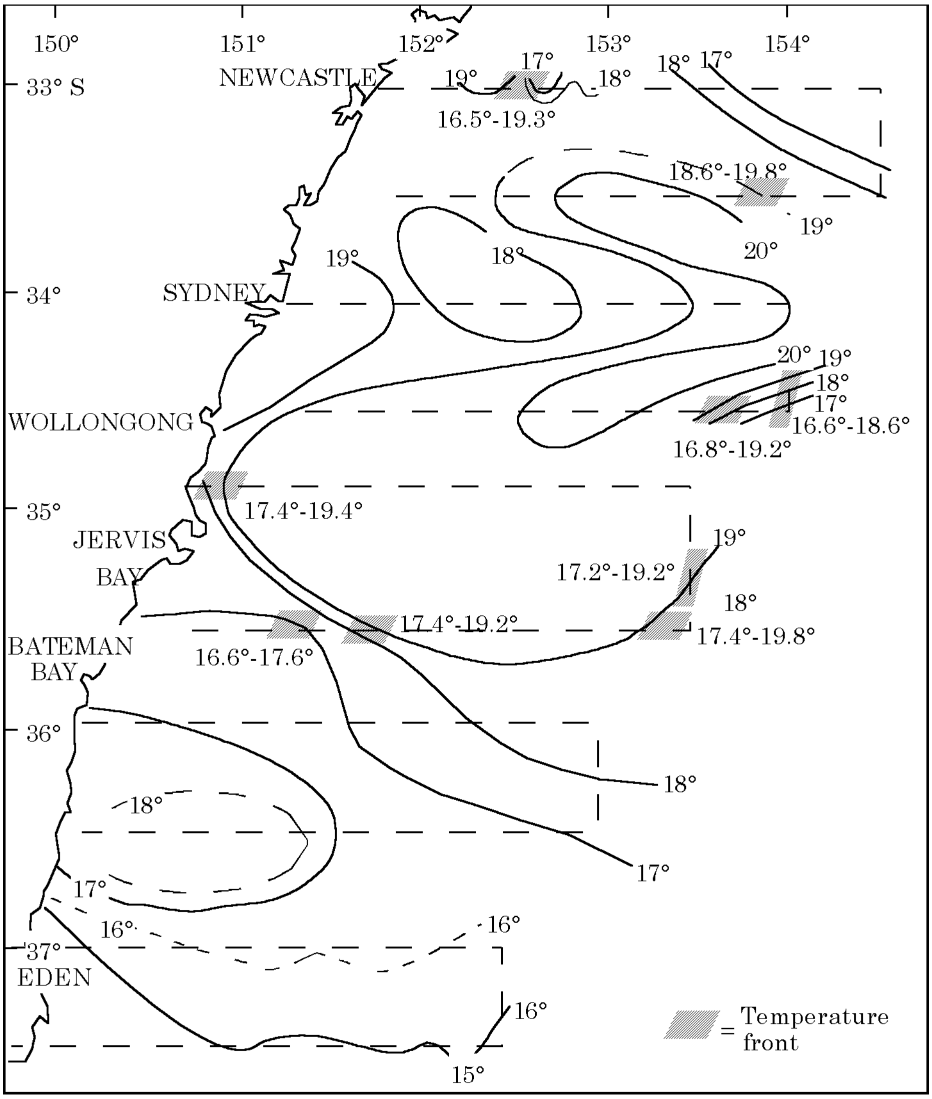

Figure 20: Sea-surface temperature chart for waters east of Australia (reproduced from Williams, in Tomczak, 1977)

Today longline fisherman can take advantage of remote sensing data (SST, weather, etc.) that is broadcast in real time from satellites such as the National Oceanographic Atmospheric Administration's (NOAA–USA) polar orbiting satellites. Receivers are available that can be installed on fishing vessels or at a shore base so that SST profiles can be received on a continuous basis. SST is important for longlining for tuna, but it is critical for longline fishing for broadbill swordfish.

On the second trip on F/V *Melita* the Masterfisherman temporarily installed a Furuno T-2000 Digital SST Indicator in the wheel-house. The sensor for this unit was placed in a bucket on deck that was continuously filling with sea-water from the wash-down pump. In this way, SST was monitored while the vessel was underway. Two SST fronts were identified (0.6º C during Set No. 2 and 1.3º C during Set No. 6). Significant increases in catch of target species were associated with both of these temperature fronts. The fronts may have indicated the presence of upwellings.

The colour video echo-sounders were not observed to be used at all in the fishing operations. Echo-sounders are used widely in tuna longlining to locate bait schools and 'feed layers' associated with the thermocline. This information is then used as another factor in the location and setting depth (number of hooks in the basket or line-shooter speed) of the gear.

Although all four boats were equipped with Furuno GPS receivers for navigation, none of the vessels had a colour plotter. A plotter is a very useful tool for longline fishing. Its screen shows a portion of the area in which the vessel is travelling, along with the vessel's position—like electronic plotting paper or an electronic chart (in fact, some plotters have charts installed in the form of CD-ROMs). A plot can be drawn on the plotter screen showing the vessel's movements. One line can be drawn for setting, in one colour, and another line can be drawn for hauling, in another colour. This way, valuable information, such as set and drift (current direction and speed), can be determined by comparing the different positions of the lines after hauling is finished.

Current convergences and eddies can also be identified by the plot. Events, such as catch of a large fish or several fish, can be entered onto the screen for future reference. Sets that did very well can also be saved on the screen for future trips. Geographic features, such as sea-mounts or reefs, can also be entered into the plot. A colour plotter is a basic tool for a longline vessel for both fishing and general navigation.

The catenary, or dip, that is achieved while setting the longline determines the depth at which the hooks fish. This depth is controlled by the speed of the vessel during setting, the length of the floatlines, the length of the branchlines, and the speed of the line-setter. During setting it is usually the line-setter speed that is adjusted to control depth of set. The captain of F/V *Ca Pakhade* was the only operator who used a hand-held tachometer for monitoring the line-setter speed during setting. The other captains merely made sure the line was paid out faster than the speed of the vessel. They had no way to monitor the speed.

The Masterfisherman introduced them to an alternate method of monitoring the speed of line being set, as follows: as the line is being set, the operator takes hold of the mainline just as it comes from the line-setter and just after a branchline has been snapped on. He grips the mainline and counts seconds elapsed until it becomes too tight to hold. If the line-setter speed is too slow, the mainline will come tight in one or two seconds. If the line-setter speed is too fast, it will not come tight for many more seconds. The Masterfisherman has found (by experimenting) that a time of about eight seconds for the mainline line to come tight is about right when monofilament gear is being used to target tunas (with a vessel speed of about eight knots). This time can be increased or decreased for variation in set depth.

Other factors that can be considered when looking for the 'best' fishing spot are the moon phase, which affects the currents, and the use of a bathythermograph for locating the depth of the thermocline (the place in the water column where temperature drops rapidly with depth). Attention to these factors can greatly assist an operator, especially when species such as bigeye tuna are being targeted.

There are good markets in Japan, and the USA for broadbill swordfish. A fisheries survey conducted in New Caledonia in 1992 and 1993 by Service Territorial de la Marine Marchande's vessel, F/V *Dar Mad,* showed that there is a real potential for a swordfish fishery in New Caledonia (Desurmont, 1993). The F/V *Dar Mad* had catch rates of about 70 kg/100 hooks. During the current project, marketable swordfish (over 50 kg) were caught on three of the four trips and one of them was over 200 kg before dressing. No fishing vessels are currently targeting swordfish in New Caledonian waters.

5.3 On-board handling of fish

5.3.1 Gaffing, spiking, bleeding and cleaning fish on deck

Generally, the landing or gaffing of fish was done correctly on all vessels, with the following exceptions. Fish were sometimes gaffed in the body rather than the head. One reason for this is that there is a shadowy area right under the gate that is not illuminated by the fishing lights, just where the fish come up, making it difficult for the crew to see; and gaffed fish were landed—sometimes roughly—on the bare metal deck as there was only a small piece of carpet on deck, aft of the hatch, for cleaning fish, and none on which to land fish.

Very active fish were often allowed to flop around on the deck prior to spiking and bleeding. This can cause scale loss and damage to the skin, but it can also cause the meat to burn in tunas. Fish, particularly export tunas, should be stunned immediately with a club or fish-bat before spiking if they are active (Blanc, 1996). Often spiking was done incorrectly—fish were not completely killed. This can also cause the meat to burn and care should be taken to ensure that it does not happen. Additionally, the commonly used Taniguchi method (Blanc, 1996) of eliminating the fish's nervous system was not used on board the Navimon vessels. Taniguchi should assist in increasing fish quality for export tunas.

Fish were generally bled properly, but often they were not allowed to bleed long enough, to rid the body of all the blood before being placed in the fish hold. This was partly because there was only one wash-down hose available for cleaning and rinsing fish, and fish were often coming up three and four or more at a time. Most by-catch fish were gilled and gutted however, albacore tuna was. Also, there was only a small (about 4 m^2) piece of carpet for cleaning fish.

Often blood was not rinsed completely from the body cavities of fish before they were lowered into the fish hold. Blood and rinse-water drained into the hold as fish were being lowered. On F/V *Kirikit* it was the practice of the crew to wash down the centre compartment of the fish hold at the completion of each haul—this was necessary as there was always lots of blood just below the hatch. However, it caused the temperature to rise in the fish hold after two or three days fishing, and the fish hold began to smell badly. In this case, prevention would have been a better remedy. The ice and the fish hold should be kept as clean as possible. Common practice is to hold the fish in a vertical position, head down, thus allowing the blood and rinse-water to run out of the gut and gill cavity.

On one vessel, tunas were being scrubbed on the outside with a nylon brush, which can damage the scales and skin and potentially reduce the value of the fish. Also, large fish were often being lowered into the fish hold, in such a way that the fish was allowed to come into contact with the edge of the hatch coaming. This also can cause scale loss and skin damage. These practices should be discontinued.

One man working alone can lower fish into the fish hold by using a slip-line. However, for large sashimi-grade tunas this is not a good practice, as the fish may come loose and drop into the hold, causing damage. Also, fish should always be landed on a soft surface—either carpet and/or a bed of soft ice, not a bare wood surface. On all the vessels, fish were being lowered with slip-lines and were landed on the wood gratings in the centre compartment of the fish hold (Figure 21), often on top of one another (see Figure 11), which can also damage the scales and skin.

Figure 21: Fish lowered onto wood grating in centre compartment of fish hold

5.3.2 Icing fish

Besides safe navigation and catching fish, icing the catch properly is the most important activity on a tuna longline vessel. None of the 'ice masters' or crew on the Navimon vessels were icing fish properly. Fish were landed on wood, fish were left uncovered for long periods, fish were iced lying on their sides rather than with backs up, sharks were buried with tunas, and too little ice was used (usually there was not enough ice available). Navimon has done well in the Japanese market in the past, but not consistently. Poor handling and icing of the catch is reflected in the market performance. In August 1996, Navimon received a fax from its Japanese agent that said:

> '... The colour of some fish is whitish or brownish, especially big size of yellowfin. Some yellowfin have soft meat and colour is white...' (Personal communication from M. Caillard).

There is obviously room for improvement in the way that fish are handled, both at sea and on shore.

Basically, there are two steps to icing fish: 'pre-icing', or chilling, and 'icing', or storing the chilled fish on ice. During pre-icing the body core of the fish is brought down to 0º C as quickly as possible, by completely covering the fish with soft, clean, crushed or flake ice (some vessels use a slurry or refrigerated sea-water for this, but this is not covered here). During pre-icing, large volumes of ice melt and carry away heat from the fish. It takes several hours (up to 12–16 for very large fish) for this process to be completed. After a fish is cooled there will be large pockets of air in the remaining ice around the fish (Figure 22). These are often called 'igloos' and they must be removed or filled. Generally fish will be stiff when they are properly chilled. Some vessels use the centre hold for pre-icing and then bury the fish in one of the side bins. When this is done, the centre hold is called a 'slaughter bin'.

Figure 22: Air pocket or ‘igloo’ around fish after pre-icing

On longline vessels it is a typical practice to ice (bury) fish the day after they were caught and pre-iced. This is usually done in the morning by one of the crew while the others are setting the gear. On vessels that use a slaughter bin, fish are dug out of the slaughter bin and re-buried in one of the side bins in the same way that they were buried for pre-icing. They will then stay there until off-loaded at the wharf. Since the fish are at 0^{o} C, no more ice will melt except for a little at the bottom and sides of the bins and on the very top layer. On vessels that do not use a slaughter bin because of space constraints, like Navimon’s boats, fish are pre-iced and iced in the same bins. This means that they are left in the position where they were pre-iced, but all igloos are removed and additional ice is packed around and on top of the fish, the day following pre-icing. Igloos can be removed by using a wooden club or the handle of a shovel to tap them down, then more ice is added.

Before any fish are landed in the fish hold, the ice has to be prepared. The centre compartment where fish are to be landed should be covered with a thin layer of soft, clean ice. Ice can be made soft by first chopping it with a shovel and then stomping on it. Some vessels use large wooden mallets to break up chunks of ice. It is important to break up all large chunks of ice—otherwise fish can be dented or bruised. A starting layer has to be made in the first bin, where fish are to be pre-iced and buried. The starting layer needs to be sufficiently thick so that there will still be ice under the first layer of fish by the time the vessel reaches port. The depth of the starting layer depends on many factors: the thickness of the insulation in the fish hold, the time spent at sea, whether or not there is refrigeration in the fish hold, the size of the fish being buried, etc. It takes some experience and experimentation to get the starting layer right. Obviously, the first day’s catch will need a thicker starting layer than the last day’s catch. On the Navimon vessels the starting layer should be at least 25 cm thick. It should always be kept in mind that enough ice should be used—but not too much. If all the ice and space are used up burying a small number of fish, then those fish will be cold but the fishing trip may be prematurely ended.

As fish are lowered into the fish hold they should be gently placed in the bin, side by side, facing in the same direction. Tunas and most other fish should be buried with their backs up and bellies down (Figure 23). Some ice should be packed into the gill cavity on larger fish. There should be about a finger-width’s room between any two fish. Heads and tails can touch, but not bodies. When one row is full, the next row can overlap the first, with heads laid next to tails—this is the most economical way to use the room in the bin. Heads and tails of the fish may touch the sides of the fish hold or the bin-boards; however, their bodies should not touch the wood.

Figure 23: Icing fish belly down (back up) in ice-hold bin

After fish are placed on the starting layer, they should be covered with enough soft, clean ice to completely cover the bodies. It does not matter if tails and fins are sticking out. For pre-icing on vessels that do not use a slaughter bin, it is best if only one layer at a time is buried. However, this is not always practical as there may not be room. It should be kept in mind, however, that if two or three layers of fish are buried, and the fish are going to stay in the same bin, then the igloos on the bottom have to be filled in on the following day, as well as the igloos on the top layer. After one layer is filled with fish, more soft ice should be put on top before the next layer of fish is buried. This layer does not have to be as thick as the bottom starting layer, but should be thick enough for the fish not to touch each other. About 5 cm should be enough.

It is sometimes difficult to position large fish belly down in the ice in the starting layer, especially for one man working alone. There is a simple procedure for icing large fish. First the fish are placed in a row on the starting layer, on their sides. Ice is then shovelled over them, but not enough ice to completely cover them—just a little ice. Then the fish are turned over one at a time by twisting their tails. As the fish turn over onto their bellies, the ice around their bodies falls into the spaces under them and holds them in position. More ice is then shovelled over the fish to completely cover them. One way to make sure that the bodies are not touching is to slip a gloved hand between the fish and then shovel ice over them. This will keep the fish about a finger's width apart.

The following day all igloos have to be filled in and a 'cap layer' should be put over the top. When travelling back to port, iced fish should be checked at least once daily and a new cap layer added as necessary. No backs or heads should be showing through the ice. All melt-water should be pumped from the fish hold daily.

As many as four layers of tuna can be buried in a bin. However, if the fish are all large (say 40–50 kg or more) then only three layers should be buried in one bin. It is better to put larger fish on the bottom layer and smaller fish on top, but it is not good to bury too many fish on top of the best sashimi fish. Very large fish such as swordfish and marlins should go on the bottom layer. Small by-catch fish, such as mahi mahi, can be placed on the top of a full bin on their sides and covered with a little ice.

Salt-water ice should only be used for icing tunas if it is mixed with at least equal volumes of fresh-water ice, or if there is no other choice. Salt-water ice is several degrees colder than fresh-water ice and will freeze the outside of the fish, making them unmarketable. Salt-water ice can be used for swordfish, however, if they are first put into a plastic (visqueen) body-bag.

Sharks should never be buried in the same bin as other fish. Sharks, even when they have been cleaned, continue to ooze body fluid. Shark blood can contaminate other fish and give them a bad smell. For this reason, shark fins should also be kept away from all other species. On all the vessels, it was the practice to drop wet shark fins into the fish hold in the centre compartment, right where the other fish were being landed. Often this compartment held a mix of tunas waiting to be buried, by-catch fish, and bloody shark fins. Shark fins should be bagged on deck and should not be put into the fish hold until after the line has been hauled and all fish have been buried in ice. Then the bagged fins should be kept away from the bins containing tunas.

Some vessels, particularly in Fiji (where they have a good market reputation), put all tunas in a gauze body-bag made of cotton (mutton cloth). These bags protect the skin from damage during icing and when the fish are being transported to the packing house. The bags are removed prior to weighing, grading and marketing.

When the fish are off-loaded it is important to keep the body core temperature at 0º C. The best way to remove fish from ice is to use water to melt the ice and a shovel, wooden club or mallet to break the ice up. Care must be taken not to heat or damage the fish. Water should not be sprayed directly on the fish, only on the ice surrounding the fish. Care must also be taken not to hit the fish with a shovel or club when breaking up ice. Fish should not be rinsed on deck unless this is done with chilled (0º C) slurry water—ice and water mixed for a sponge bath. It is best, however, if the fish are rinsed in the packing house with water that is piped through a brine tank so that it is near to 0º C. One way to ensure that fish stay at 0º C on the way from the vessel to the packing house is to transport them by forklift in a slurry tank, filled with ice and water.

5.4 ON-SHORE PROCESSING

New rules and regulations for fish packing houses are in place, or soon to come into effect, in a number of key markets around the world (e.g. Canada, USA and the European Union). They will be modeled on a quality assurance system called HACCP, which means Hazard Analysis and Critical Control Point. For the fresh-chilled tuna industry, the most important HACCP parameter or hazard will be the formation of histamine in the flesh of the fish. The proper management of time/temperature handling of the fish soon after its capture will be critical to minimise histamine and therefore meet HACCP food safety requirements. For raw unfrozen fish, the basic parameter will be that fresh-chilled fish will have to be maintained at a temperature as close as possible to 0º C, but not exceeding 4.4º C (FDA, 1996).

In Navimon's processing operation—from the time the fish leave the fish hold until they reach the market (local and export)—there are several points in the chill-chain where product temperatures may exceed 4.4º C. If Navimon does not make some changes in its packing house, in both equipment and procedures, it runs the risk of having its products rejected by markets and countries that require HACCP quality assurance plans to be in force. By 1998, for instance, all imports into the USA must meet HACCP standards and regulations.

Body-core temperatures should be monitored on selected or random fish. An electronic digital probe thermometer would be good for this, but a mechanical thermometer such as a dial thermometer would suffice. During the whole processing operation, body-core temperature should be kept as close to 0° C as possible (but not below this temperature as the flesh will start to freeze), and not exceed 4.4º C.

The packing house should be as close as possible to the vessels for unloading, but if fish must be transported, this should be done when it is cool (evening or morning). Fish should be transported either in a slurry tank or on ice in the bed of a covered truck, out of the sun.

However transport is done, all surfaces with which fish come into contact with should be washable.

Fish should be sorted, rinsed, graded, cut, weighed, etc. on a washable table, preferably stainless steel. Fish should not be left on the floor or on a carpeted platform where any workers are allowed to walk. Fish should not be on the sorting table for more than one or two minutes. The time from unloading to packing should be as short as possible. One operation that was previously observed by the Masterfisherman on Guam had a fish weighed, graded, packed in the export carton and loaded into an aircraft LD-3 container within five minutes of the time it left the fish hold of the unloading vessel.

Fish should be rinsed with fresh water that is at close to 0° C. This can easily be done by running tap water through coils of copper tubing that are immersed in a slurry tank (ice and water). Fish should never be rinsed with ambient-temperature water or sea-water pumped from the harbour.

Handling should be reduced to a minimum. Fish should enter the process at one end and exit at the other—in a box—with as little handling as possible and as quickly as possible. Many tuna exporting facilities use a 'production line' approach to achieve this. Additionally, all processing staff should be wearing gum boots, overalls, aprons and cotton gloves. No smoking should be allowed, and the public should be kept out of the processing/packing area at all times.

Navimon should look into alternative boxes. Most fish export operations use one-piece boxes that have a two-piece overlapping lid, that fully extends to both sides of the box. Styrofoam liners for insulation should also be considered. Gel ice should be used in the boxes rather than wet ice. Some airlines will not accept wet ice. Boxes should be sealed with tape or strapping.

In the processing area that handles fish for local sales, all fish should be weighed, sorted, cut, packaged, etc. on stainless-steel tables and not on the floor. This also should occur as quickly as possible to maintain product quality.

6. Recommendations

Given the objectives and focus of this project, there are many recommendations covering different areas in the fishing operation. The recommendations presented here follow the same headings as Section 5 for ease of reference, and are based on the observations and experience of the Masterfisherman.

6.1 General

It is recommended that:

(a) All vessels take longer fishing trips, of up to ten days fishing;

(b) Navimon secure a dependable and affordable shore-side ice supply for its fleet. The best option for this would be that Navimon purchase one or two self-contained flake- or shell-ice machines with a combined output of 15 to 20 t per day. The machine(s) should be mounted on an insulated container with a capacity of at least 20 t. The ice-maker should be as close to the wharf as possible, preferably right alongside so that a delivery system can be utilised for loading ice onto the vessels. If this is not possible at Quai des Pêches (because the Chamber of Commerce holds exclusive rights to ice-making), an alternative site should be sought for ice production. Ice could be delivered by truck to Quai des Pêches or the vessels could steam to another wharf to pick up ice, just prior to leaving for fishing;

(c) The on-board refrigeration systems not be relied upon to chill fish;

(d) The fixed baffles in the fish holds on all four vessels be removed and replaced with removable bin-/pound-boards;

(e) Alternative sources of bait be located and tried, with different bait species being tested—especially sanma (*Cololabis sairi*);

(f) The forward stanchions on the starboard side be removed on all four French-built vessels;

(g) Aft gates be installed on F/V *Ca Pakhade* and F/V *Iaai Pêche*, similar to the ones on F/V *Melita* and F/V *Kirikit*;

(h) Navimon shift the LS-4 line-setters on F/V *Ca Pakhade* and F/V *Iaai Pêche* to the starboard side of the transom (see Figures 16 and 17).

(i) All vessels eventually have the 4.0 mm monofilament mainline replaced with 3.6 mm monofilament mainline;

(j) Over time, all of the monofilament branchlines be replaced with 3.0 mm tarred red polyester branchlines of about 10 m length;

(k) All hooks be replaced with either a totally stainless-steel hook or a galvanised hook with a galvanised ring, and that protective thimbles be added to all new branchlines, separating the trace wires from the hooks;

(l) A second block be mounted on *Ca Pakhade* square to the mainline reel during hauling, to reduce the strain on the mainline and the level-wind apparatus;

(m) All hose ends and fittings be rust-treated and either sprayed with rust-inhibiting paint such as cold galvanise, or be wrapped in grease tape such as Denso Tape; all fishing equipment be serviced regularly; and a supply of spares be kept on board each vessel, for all hydraulics including the reel, the line-setter, the capstan, and all hoses and fittings; and

(n) The gear configuration on all the vessels be changed by shortening the branchlines to 10 m while lengthening the floatlines to 30 m, which will allow the basket size to be reduced to 20–25 hooks rather than 25–30 hooks per basket.

6.2 Fishing strategies and techniques

It is recommended that:

(a) Sea-surface temperature (SST) monitoring become part of the regular fishing strategy of the Navimon fleet, through the purchase and installation on all four vessels of an appropriate SST gauge, such as a Furuno Temperature Sensor Type T-02MSB Code No. 000-040-044, for use with their colour video echo-sounders;

(b) Navimon look into acquiring remote sensing data, either through a technical organisation such as ORSTOM, or by purchasing its own receiver;

(c) The Furuno colour video echo-sounders be used to identify bait schools and feed layers for setting purposes;

(d) Colour plotters that can interfaced with the Furuno GPS receivers be purchased and installed on each of the vessels;

(e) All vessels be equipped with a hand-held tachometer for setting the speed of the line-setter;

(f) All Navimon captains and bosuns experiment with the method of holding the mainline and counting the seconds until the mainline becomes tight, as an alternative way to adjust and closely monitor line-setting speed;

(g) Moon phase and the location of the thermocline be considered as part of the fishing strategy for locating likely fishing areas; and

(h) Navimon explore the possibility of developing a swordfish fishery for overseas markets.

6.3 On-board handling of fish

It is recommended that:

(a) Flood lights that overhang the starboard side over the gate be installed on all vessels, so that there are no shadows during night-time hauling;

(b) More carpet be used on deck, particularly just next to the gate where fish are landed;

(c) All vessels be supplied with clubs or fish bats and the crews be instructed to stun all active fish prior to spiking;

(d) All of the crews be instructed to spike fish properly and the Taniguchi method be tried on large export tunas;

(e) All fish, including by-catch species, be bled for at least five minutes;

(f) A 'Tee' fitting be placed into the wash-down discharge line so that two hoses can be fitted for cleaning fish;

(g) The crews be instructed to drain all blood and rinse water from freshly cleaned fish by holding them in a vertical position on deck before lowering them into the fish hold;

(h) The centre compartment of the fish hold not be washed down with sea-water each night as this will cause the temperature in the fish hold to rise;

(i) Tunas never be scrubbed on the outside (skin) and only the gill cavity and backbone just inside the gill cavity be scrubbed;

(j) A small piece of carpet be used on all vessels to cover the edge of the hatch coaming, to protect the fish (skin) when being lowered into the fish hold;

(k) The crews be instructed to always have one person in the fish hold to 'catch' fish, and the surface of the centre hold always be covered with a layer of soft ice (if ice is in short supply, a piece of carpet could be used);

(l) Navimon instruct the captains, ice masters, and all crew in the correct icing procedures as described in Section 5.3.2, with particular emphasis on recommendations m – y below;

(m) The practice of pre-icing the catch be implemented on all vessels;

(n) The practice of removing the air pockets, 'igloos' from around the fish after pre-icing be implemented, and adequate ice be used for the expected duration of the fishing trip;

(o) The starting layer of ice be at least 25 cm thick in each bin or compartment used;

(p) All fish be buried with the belly down (back up), with ice packed in the gut and gill area of larger fish;

(q) The bodies of fish not touch one another or the walls of the bin, with at least one finger-width of space (ice) between fish or the fish and the wall;

(r) Fish be completely covered/surrounded with ice;

(s) Fish being stacked in layers in a bin be restricted to a maximum of four layers of small fish, or three layers of larger fish, with adequate ice between the layers;

(t) When small and large fish are to be stacked in the same bin, the larger fish be in the bottom layers;

(u) An adequate layer of ice (cap layer) be maintained over the top layer of fish to ensure that no part of the fish is exposed from the ice (tail and fins excluded);

(v) Care be taken when using salt-water ice, which should be mixed with fresh-water ice in equal proportions;

(w) Components of shark not be stored in the same bins as other species such as tunas;

(x) Navimon trial the use of 'mutton cloth' or gauze body-bags to protect export-quality fish, especially if salt-water ice is to be used in chilling; and

(y) Water be used to melt the ice between fish, but not sprayed onto the fish themselves, when fish are being unloaded at the end of the trip.

6.4 On-shore processing

It is recommended that:

(a) If Navimon is to export product to a country that will have HACCP requirements in the future, it work towards the development of a HACCP quality-assurance plan to meet these requirements now;

(b) The practice of random monitoring of the core temperature of fish be introduced, from the time fish are unloaded to when they are packed, ensuring that the core temperature is as close to 0° C as possible, but does not exceed 4.4° C;

(c) The catch be unloaded into a tank of ice slurry at the wharf to maintain the temperature of product going into the shore facilities for grading, processing and packing;

(d) All surfaces with which the fish come in contact be washable and tables made of stainless steel;

(e) The whole unloading, grading and packing process be streamlined into a 'production-line'-type process, and conducted in as short a time as possible;

(f) Fish not be placed on surfaces where people walk;

(g) Only chilled fresh water be used for rinsing off fish once it comes out of the vessel's ice hold;

(h) One-piece packing cartons with insulation be trialled for exporting fish, with all cartons sealed with tape or strapping;

(i) Gel ice be used when packing fish for export; and

(j) All processing staff be clothed according to health requirements, with no smoking allowed in the processing area.

8. Appendix

APPENDIX: Summary of catches taken during tuna longline fishing activities in the waters off New Caledonia.
All weights for yellowfin and bigeye tuna are gilled and gutted, and for marlin are headed and gutted, while all other species are whole weights.
Other saleable catch consisted of skipjack tuna, broadbill swordfish, mahimahi, wahoo, blue marlin, shortbill spearfish, sailfish and pomfret.
Unsaleable species consisted of sharks, lancetfish, snake mackerel, escolar, pelagic ray, barracuda and shark/killer-whale-damaged tunas.
* On these sets, by-catch (unsaleable species) were not recorded.

Trip and set No.	Position Lat (S)	Position Long (E)	Hook Nos.	Time set	Time haul	Yellowfin tuna No.	Yellowfin tuna Weight (kg)	Bigeye tuna No.	Bigeye tuna Weight (kg)	Albacore tuna No.	Albacore tuna Weight (kg)	Strip. marlin No.	Strip. marlin Weight (kg)	Opah No.	Opah Weight (kg)	Other saleable No.	Other saleable Weight (kg)	Total No.	Total Weight (kg)	Unsaleable species No. only
Trip 1: F/V *Ca Pakhade* (21 to 27 August 1996)																				
* 1/1	22°00'	163°45'	1380	0330	1245	1	15	3	90	3	50	2	40	6	240	2	120	17	555	
* 1/2	21°57'	163°31'	1380	0420	1400					10	170	3	50	6	240	1	60	20	520	
* 1/3	21°57'	163°57'	1380	0440	1400	1	15	4	120	3	50			6	240	4	40	18	465	
* 1/4	22°19'	164°59'	1350	0725	1515	8	120	2	60					3	120			13	300	
* 1/5	22°25'	165°55'	1350	0640	1515	28	420	9	270	4	70			8	320			49	1080	1
Total for Trip 1			**6840**			**38**	**570**	**18**	**540**	**20**	**340**	**5**	**90**	**29**	**1160**	**7**	**220**	**117**	**2920**	**1**
Trip 2: F/V *Melita* (9 to 15 October 1996)																				
2/1	21°02'	165°51'	1260	0710	1645			4	135					5	250	6	75	15	460	14
2/2	20°54'	165°43'	1350	0620	1630			2	85					3	150	3	100	8	335	22
2/3	20°11'	165°11'	1350	0610	1645	2	35	1	40	2	40			3	150	5	50	13	315	34
2/4	20°55'	165°44'	1350	0630	1635	2	100	6	210	1	15			3	150	5	50	17	525	37
2/5	20°55'	165°44'	1350	0630	1750	2	50			1	15					15	210	18	275	20
Total for Trip 2			**6660**			**6**	**185**	**13**	**470**	**4**	**70**	**0**	**0**	**14**	**700**	**34**	**485**	**71**	**1910**	**127**
Trip 3: F/V *Melita* (20 November to 1 December 1996)																				
3/1	22°00'	163°44'	1225	0545	1500	7	140			5	100	4	160	1	50	4	130	21	580	23
3/2	21°49'	163°29'	1225	0600	1600	16	360			7	140					7	85	30	585	31
3/3	21°57'	163°32'	1225	0555	1600	11	260			7	140	1	40	1	50	4	35	24	525	40
3/4	21°48'	163°24'	1200	0600	1520	2	40	1	25	25	500	4	160			7	160	39	885	36
3/5	21°46'	163°40'	1175	0700	1650					5	100	3	120			4	50	12	270	21
3/6	21°40'	164°45'	1175	0610	1600	17	440			15	300	5	200			6	70	43	1010	39
Total for Trip 3			**7225**			**53**	**1240**	**1**	**25**	**64**	**1280**	**17**	**680**	**2**	**100**	**32**	**530**	**169**	**3855**	**190**

Trip and set No.	Position Lat (S)	Position Long (E)	Hook Nos.	Time set	Time haul	Yellowfin tuna No.	Yellowfin tuna Weight (kg)	Bigeye tuna No.	Bigeye tuna Weight (kg)	Albacore tuna No.	Albacore tuna Weight (kg)	Strip. marlin No.	Strip. marlin Weight (kg)	Opah No.	Opah Weight (kg)	Other saleable No.	Other saleable Weight (kg)	Total No.	Total Weight (kg)	Unsaleable species No. only
						Catch by species														
Trip 4: F/V *Kirikit* (5 to 13 December 1996)																				
4/1	21°52'	167°02'	1500	0510	1600	27	560	1	40	1	20	2	80	1	50	17	230	49	980	28
4/2	21°46'	166°57'	1500	0500	1445	31	660	3	110	1	20	2	80			20	175	57	1045	41
4/3	22°00'	167°20'	1500	0515	1500	27	600			3	60	4	150			31	260	65	1070	27
4/4	22°00'	167°19'	1500	0500	1515	39	860			4	80	1	40			34	230	78	1210	40
4/5	22°00'	167°19'	1500	0500	1445	22	495	1	40	3	60	3	140			35	265	64	1000	23
Total for Trip 4			**7500**			**146**	**3175**	**5**	**190**	**12**	**240**	**12**	**490**	**1**	**50**	**137**	**1160**	**313**	**5305**	**159**
Total for all project fishing activities																				
			28225			**243**	**4370**	**37**	**1225**	**100**	**1930**	**34**	**1260**	**46**	**2010**	**210**	**2395**	**670**	**13990**	**477**
Observer trip on board F/V *Ca Pakhade* (12 to 22 September 1996)																				
1	19°51'	161°20'	1300	0415	1430	9	200			18	356			3	120	3	38	33	714	23
2	19°38'	160°50'	1300	0522	1430	4	130			45	876							49	1006	25
3	19°37'	160°41'	1300	0535	1415	10	385	3	80	25	477			10	355	3	17	51	1314	24
4	19°28'	160°34'	1290	0552	1512	10	360			22	422			3	110	3	24	38	916	21
5	19°12'	160°30'	1280	0615	1520	17	474			31	620			3	105	2	13	53	1212	24
6	19°13'	160°18'	1275	0630	1510	6	128			19	381			7	245	4	34	36	788	34
7	19°12'	160°28'	1265	0625	1500	16	352	5	157	14	264			12	420			47	1193	30
Total for trip			**9010**			**72**	**2029**	**8**	**237**	**174**	**3396**	**0**	**0**	**38**	**1355**	**15**	**126**	**307**	**7143**	**181**