NOTES ON LONGLINE VESSEL PARAMETERS FOR PACIFIC ISLAND COUNTRIES

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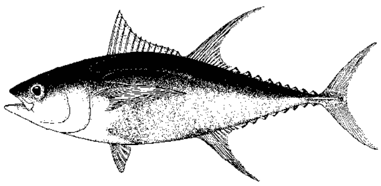
Longline fishing vessels come in a range of sizes, have different deck layouts, are made from either steel, aluminium, fibreglass or wood, and are equipped with a variety of machinery and fishing gear.

Choosing a suitable vessel, either new or second-hand, presents a plethora of problems to anyone interested in entering into commercial tuna longline fishing. Costly mistakes can be made when selecting a vessel. The wrong choice can mean failure just as the right choice can increase the chances for a successful venture.

Furthermore, the 'right' boat in one fishery may not be the most suitable boat in another area. Local sea conditions and resource availability, technical expertise of prospective crew members, and land-based infrastructure should also be considered as they all have a bearing on suitability of a vessel.

The whole idea of fishing is to make money. If the cost of a vessel is so great that no return can be made on the investment, then the 'best' boat may not be the most *suitable* boat.



Vessel size and range

Tuna longline trips (for chilled tuna) can last anywhere from one to three weeks. After three weeks the first caught fish will start to spoil and will be of little value.

However, for safety purposes a vessel should have the capability to steam for about four weeks without refuelling. Typically, a vessel has to steam for several days to get to the fishing grounds, fish for about ten sets, and then return to port.

Tuna are highly migratory, so during any one trip vessel movements of one or two days duration may have to be made to follow the fish, and even after each set smaller movements are usually made to adjust for currents and drift.

In areas where commercial longline fishing is just starting and the resource is very abundant, the above may not necessarily be true, but following the first few 'gold rush' seasons the resource will start to feel the pressure of fishing and vessels will have to range further and further from home ports to catch full loads. It may be all right to start out with a 'mini' longliner (15 m [50 ft], or less) but in the long run it would prove to be *unsuitable* as it could not adapt to a changing situation.

When considering vessel size and other parameters, both suitability and *versatility* need to be considered. A versatile vessel could adapt to other fisheries like albacore trolling in the southeast Pacific, and would have a higher resale value if it was adaptable to fish in areas where the EEZ is bigger and longline vessels need to have a longer range.

A vessel of 18 to 23 m (60 to 75 ft) length overall and of 50 to 80 gross registered tonnes (GRT) with a fuel capacity that would allow it to steam for four weeks without refuelling would probably be suitable in most situations and versatile enough to adapt to changes.

A suitable 20 m (66 ft) longline vessel would be equipped with a main engine of probably not more than 300 or 400 horsepower (220 to 300 kW) and a generator with an output of about 25 to 30 kW. A vessel so powered could probably be expected to burn about 900 litres (250 US gallons) of fuel per 24 hours of operation.

Therefore it would need to have a fuel capacity of at least 25,000 litres or 25 t* (7,000 US gallons). At 10 knots (maximum speed necessary for a longliner) this would give it an operating range of over 6,000 nautical miles (11,000 km).

These are only the very basic parameters, however, and there are several more things to consider. The next most important size parameter of a longline vessel is fish hold capacity (assuming beam and depth correspond to length, i.e., a 20 m [66 foot] vessel with a beam of about 5 m [16.5 feet] and a depth of about 2.5 m [8.25 feet]).

* Actually one tonne of fuel is not equal to one tonne of tank volume. Fuel is less dense than water so one tonne of fuel might have a volume of 1100 litres or so. The specific gravity of fuel depends upon its temperature so this number varies considerably. For this report, however, one tonne of fuel will be considered to occupy approximately one tonne of tank volume.

If a vessel is capable of making at least ten sets of 1,500 hooks during a trip it would expect, on average, to catch about 7.5 t of all species of fish (target species and by-catch). This is based on a rough Pacific average CPUE of 0.5 kg/hook (50 kg/100 hooks) for tuna longline vessels.

Obviously, fewer fish will be caught on some trips and during some times of the year, and more fish will be caught during other trips, particularly during the peak fishing seasons. As much as 15 t of fish could be caught on ten sets during one trip.

Therefore, for a longline vessel to be both suitable and versatile it should be capable of carrying up to 15 t of chilled tuna and by-catch. The actual size of the fish hold(s) depends largely on the type of chilling system used. Refrigerated sea water (RSW) systems and slurry systems need about 2 t (1 t = 1 m^3) of hold space to chill one tonne of fish while 'ice' boats need anywhere from 3 to 5 t of fish hold space to chill one tonne of fish (depending on the configuration of the fish hold).

Hold space is also needed to store ample bait for ten sets—about 1.5 to 2 t. If live bait is used then holds need to be adaptable to holding circulating sea water.

Other less obvious but equally important parameters include fresh water holding capacity and crew complement. A vessel that stays at sea for up to four weeks should be able to hold sufficient fresh water for four weeks with a reserve.

A typical crew complement for a tuna longliner would be in the range of four to eight people, including captain (in some operations the captain serves as engineer and fish master). Each man on a fishing vessel would be expected to consume about 25 litres (6.5 US gallons) of fresh water per day. For a crew of six (average) this would add up to over 4000 litres, or 4 t (1200 US gallons) for a four-week time period (three weeks plus one week's reserve).

The trend throughout the region is for longline vessels to be required to take along a scientific or compliance observer on certain trips. Ample berthing and fresh water capacity needs to be considered for such contingencies. A suitable and versatile long-line vessel should have a crew complement of six to eight persons and should have a freshwater capacity of at least 700 litres (200 US gallons) per person. In lieu of a 4 t fresh water tank, a vessel could be outfitted with a desalinator capable of producing sufficient volumes of fresh water.

Hull material

Although there are a few good wooden boats in service in the longline fishery, most vessels are either steel, fibreglass, or aluminium. Each of these three materials has its advantages and disadvantages, and the choice is largely a matter of preference. However, a case can be stated for each.

Steel vessels are probably the most versatile as they are relatively easy to fabricate and repair. Steel is also very forgiving to captains who make navigation errors and miss the pass through the reef. Steel is malleable and tends to dent or bend rather than crack or break as a result of collisions. At sea repairs and gear adjustments can be done if a welding machine and oxyacetylene set are part of the boat's tools and machinery. Most shipyards are set up to work with steel and steel is relatively inexpensive and available almost everywhere. On the other hand, steel rusts and steel boats need constant upkeep to prevent them from rusting away.

Fibreglass vessels come as fibre-glassed plywood, fibreglass reinforced plastic (FRP, GRP), or fibreglassed foam (composites, foam sandwich, etc.) or a combination of these materials. The main advantage to fibreglass is that it is relatively maintenance free. There is no chipping and painting, no rust, no corrosion.

Fibreglass is also fairly easy to work with and small repairs and modifications can be done easily with materials that are available in most places (resin, catalyst, and glass cloth or mat).

Fibreglass is also compatible with almost any other material—steel, aluminium, brass, wood, silicon, rubber, etc.). The main disadvantages to fibreglass are that it is flammable, that it cracks, and that it can have a tendency to absorb water (osmosis). Osmosis occurs particularly when poor workmanship is involved in laying up the fibreglass or when foam-fibreglass composites are made without using pressure.

Under these conditions fibreglass and composites (fibreglass and foam) can become porous. Water soaks through the fibreglass and into the foam. Aside from that, if a fibreglass vessel collides with another vessel or with the reef, major hull damage can occur—the hull can be holed quite easily compared to steel.

The worst case, however, would be a fire on a fibreglass vessel.

Once resin and foam (in the presence of fuel oil, hydraulic oil and motor oil) are ignited it is very difficult to put out the flames. Burning resin and polyurethane foam (as in foam sandwich vessels) give off toxic fumes that can be lethal. Steel and aluminium, on the other hand, do not burn, although there can be fires on board steel or aluminium vessels.

Aluminium has two main advantages as a hull material. One, it is light weight and thus an aluminium vessel is more fuel efficient than a similar sized steel vessel. Two, aluminium, like fibreglass, is relatively maintenance free.

Aluminium, although it corrodes under certain conditions, does not rust. There is no chipping or painting to be done, and often aluminium vessels are not painted at all above the water line. An annual wash down with phosphoric acid is all that is usually needed.

There are two main disadvantages to aluminium vessels, however. One, marine grade aluminium, unlike steel, is not very malleable and tends to crack under extreme stress, as during an encounter with the reef or another vessel. Two, aluminium is difficult to work with and expensive as compared to steel.

A special welding machine is needed, along with a highly-trained welder, to work with aluminium. Most small shipyards and slipways do not work with aluminium so major repairs or modifications could be very costly.

Aluminium plate is also not available in most places. Furthermore, aluminium does not get along very well with other metals. If stainless steel fittings are used on an aluminium vessel, for instance, care must be taken to isolate the two metals from each other with rubber or silicon. If they are not isolated and in the presence of sea water, electrolysis will take place and the aluminium will corrode away and be reduced to a white powder.

Lastly, aluminium is a very good conductor of heat which means that heat can be easily transferred from machinery to crew's quarters or the fish hold. In the tropics, aluminium decks can get quite hot. This not only causes discomfort to the crew but can affect quality of fish landed on the deck.

All in all, steel is probably the preferred material for a longline vessel unless the vessel will be operating in a very remote locality with a crew that may not keep up on regular hull maintenance. In that case, fibreglass, because of its ease of maintenance, would be the preferred hull material. It may be wise on fibreglass vessels to have more than the necessary minimum number of fire fighting devices.

Hull configuration

The best hull for longline fishing is a deep displacement type hull with a single (hard) chine. Planing or semi-planing hulls or hulls with round or multiple chines should be avoided. These type of vessels are more suited to coastal (near shore) fisheries, such as the Australian west coast cray fishery. It is also good to have a skeg with a foot plate and pintle bearing for the rudder rather than shaft struts and a free-standing rudder.

A smooth, uninterrupted line from stem to rudder is the ideal as there should be few places for the mainline to get caught on during hauling of the longline. Keel coolers and transducers should be on the port side if possible and all zinc anodes should be mounted so that they will not snag the mainline. Bilge keels (roller chocks) should be avoided.

The other main consideration is where to put the wheelhouse. Most Asian longline vessels have stern houses. There are several advantages to having a stern house. One, the vessel operator has a clear view of all deck operations, including machinery, during hauling. He can clearly see the mainline coming up, and he can monitor all crew activities as well, including fish handling and chilling procedures.

Two, all fish holds are forward of the engine room and shaft tunnel on a stern-house vessel. This allows more room for hold space and also reduces the transfer of heat from machinery to fish hold. It is easier to make the fish hold water tight if there is no shaft tunnel running through it. Another advantage to having the machinery behind the holds is that access to the shaft packing gland (stuffing box) is usually via the engine room, where it can be easily viewed and repaired as necessary. On a forward-house vessel it is often very difficult to gain access to the packing gland (to tighten the gland or add packing) while at sea fishing.

The shaft tunnel on a forward-house vessel is usually under the main fish hold and the packing gland may be buried under layers of fish and ice, which would make monitoring and repairing difficult. This could be critical during an emergency.

Lastly, a short tail shaft as on a stern-house vessel is less expensive than a long shaft as on a forward-house vessel. Often, on forward-house vessels, two shafts are necessary: an intermediate shaft that runs from the gear box coupling to just forward of the packing gland; and a tail shaft that exits to the propeller. Additional bearings (*Babbit* bearings) are usually fitted along the way to support this extra weight. A long shaft would add considerable cost to a vessel as compared to a short shaft.

There are many forward wheelhouse vessels in longline fisheries in the Pacific, however. Most of these started out as something else, like shrimp draggers (prawn trawlers) or net boats, in which case a forward house might be advantageous.

The main advantage for a forward house to longline fishing is that the crew is out of the weather. Forward-house vessels are also probably better during setting operations, as the line can run unobstructed from reel or baskets to the stern, where baiting takes place.

Many operators of forward-house longline vessels have added an outside station on the back deck, usually on the after-bulkhead of the house, where the operator can both drive the vessel and control the hauling of the mainline and the removal of branchlines simultaneously. (Hauling is usually done from the starboard side so that the vessel operator can have a clear view of the so called ‘danger zone’ which is the area around his vessel from dead ahead to 11 1/4 degrees aft of the beam on the starboard side, or nine points off the starboard bow. International Rules prohibit one vessel from crossing the port bow of another vessel).

FISH HOLD(S) AND CHILLING SYSTEM

There are several options for fish-hold configuration and chilling systems. Fresh-chilled sashimi-grade tuna can be produced by icing the fish in layers of crushed or flake (or shell) ice, by immersing the fish in a slurry made up of crushed ice and sea water, or by immersing the fish in refrigerated sea water (RSW) or a mix of sea water and fresh water.

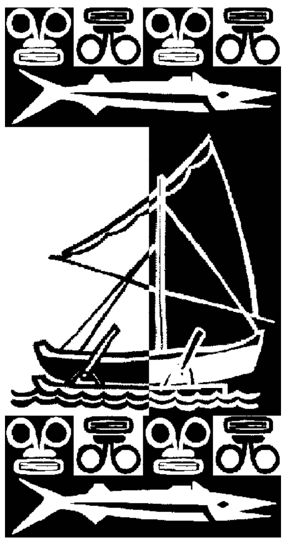
The common goal of all these systems is to reduce the body temperature of the fish to 0°C (32°F) and to keep the fish at or near this temperature for the duration of the fishing trip.

Each system has its advantages and disadvantages and the choice of system has a direct bearing on the type of fish hold(s) a vessel would have and the type of refrigeration machinery necessary to support the function of the fish hold(s). The availability of land-based infrastructure and market demands also play a role in choice of chilling systems.

Icing fish has several advantages over RSW and slurry systems. One, the product is usually better than fish that have been chilled in a liquid system. Properly-iced fish do not come into contact with other fish or with the structure of the fish hold. There is little skin damage to iced fish as compared to fish chilled in a liquid.

Damage can occur, however, if ice is not broken up into very fine pieces or if the starting layer of ice is not of sufficient depth. Iced fish will also keep longer than fish stored in a liquid system. Iced fish (tuna) can be kept as long as three weeks and still be marketable as export-grade fish. RSW or slurry fish start to bleach out (soak-up water) after one to two weeks.

Furthermore, iced fish require only one large fish hold that is usually divided into separate bins with removable boards. RSW and slurry systems require that the vessel have several fish holds up to a maximum size of about 2 t each. If the holds are too large the fish will move around, especially in rough weather, and become damaged.



Ice boats, if there is sufficient ice available from a shore facility, do not need an on-board refrigeration system. This is also true of slurry systems but not true of RSW systems. Ice boats or slurry boats could have an on-board flake ice machine or the holds could be refrigerated as a supplement to the ice in the holds, but this is not always necessary. RSW boats, by contrast, are wholly dependent on on-board machinery (generator and refrigeration system).

The main advantage that RSW and slurry systems have over icing is that they are less labour intensive. Digging graves in the ice is hard work and requires a certain degree of skill and usually has to be done twice for each day's catch—once for pre-chilling in a slaughter bin and again the following day in one of the main bins in the fish hold. RSW and slurry fish are merely dropped into the tank after cleaning (bleeding, gilling and gutting, bagging). Some vessels use a combination of slurry for pre-chilling and ice for storing fish.

However, this requires that the vessel have at least two tanks, or holds. Multiple tank systems have the advantage, however, that since there are several tanks on the vessel as opposed to one main fish hold, at least one of these tanks can be used for live bait storage; or in the case of RSW boats, supplementary fresh water or fuel supply.

One disadvantage to RSW systems is that temperature variations are more likely to occur than with ice or slurry systems. Another disadvantage to both RSW and slurry systems is that fish must be bagged in either plastic body bags or mutton cloth (gauze) tubes to prevent skin damage. This adds to the operating expenses.

Notwithstanding the preferences of the captain, fish master, crew, and fish buyers, the selection of a chilling system is mostly dependent on available infrastructure. If there is sufficient shore-side ice available, then icing would probably be the best choice.

Second to this would be a slurry system. Neither of these systems depend on on-board machinery (except for pumps to remove melt water). If there is no shore-side ice available, or if it is too expensive or the supply is unreliable, then some sort of on-board refrigeration system would be necessary. This could be an on-board flake ice machine for icing or for a slurry system, or an RSW system.

The main disadvantages to having on-board refrigeration systems are that initial capital costs are higher and product quality is wholly dependent on keeping on-board machinery operational. Consider the following scenario:

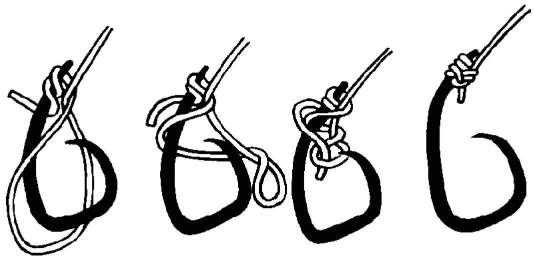
> *A company has a choice of five ice boats supported by a shore-side, five tonne/day flake-ice machine or five RSW boats and no shore-side ice facility. Which should they choose? The ice boats would require that only one piece of refrigeration machinery be looked after as opposed to five pieces of machinery. Furthermore, the ice machine would be on land where it could be monitored 24 hours a day by one qualified technician. The choice of RSW boats would require that the company have five qualified technicians and each of the very expensive machines would be subjected to a harsh environment far away from parts stores and support infrastructure.*

Capital expenditure for five ice boats would be substantially less than for five RSW boats—only one fish hold as opposed to several on each vessel, and no refrigeration system needed. However, ice boats with no refrigeration system are wholly dependent on a reliable and affordable shore-side ice supply.

With every system of chilling fish it is important to have well-insulated fish holds. Fish holds should have at least 5 inches (13 cm) of polyurethane foam insulation. This may have to be thicker on a bulkhead shared with the engine room or a machinery space. Hatches should also be well-insulated and on some vessels additional *plugs* are necessary (insulated hatch cover that fits underneath the deck hatch).

Machinery

If a longline vessel is going to be equipped with some sort of **refrigeration system** there are several options to choose from. Ice machines can make either sea water ice, fresh water ice, or both. If a fresh water ice machine is selected (fresh water ice is better as it doesn't freeze the fish) then the vessel would probably also need a water maker,



or desalinator. It takes a tonne of water to make a tonne of ice. A one tonne per day ice machine would soon use up all of the ship's supply of fresh water if the vessel did not have a desalinator. Flake ice machines usually use R-22 refrigerant (Freon).

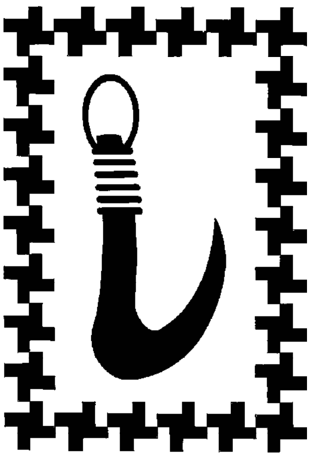
Sea water in RSW systems can be cooled by chillers with the evaporators in a remote chiller tank away from the fish holds or it can be cooled by having the evaporators installed in the fish holds either as coils or as plates. Temperature is controlled by thermostatic expansion valves.

Most RSW vessels use R-22 refrigerant (R-12 refrigerant is being phased out world-wide to be replaced by A-134) and R-502 is very expensive. R-717, ammonia, is usually only used on freezer vessels). The compressor for either an ice machine or an RSW system can be run from an electric motor, a belt drive from the main engine, or a hydraulic motor.

The most important piece of machinery on a fishing vessel, however, is the **main engine**. There are a multitude of brands, configurations, horsepower, and types to choose from. The most important considerations are initial cost, fuel efficiency, dependability, and availability of parts and service.

It is not necessary to have two main engines on a longliner, nor is it necessary to have an engine rated at over 400 horsepower (A general formula to use is three horsepower for every tonne of displacement—one horsepower equals approximately 0.75 Kw).

High-powered vessels capable of speeds in excess of 20 knots are more suited to coastal fisheries where trip duration is relatively short, i.e., one-to-three days. Generally speaking, four stroke six cylinder in-line naturally or turbo-aspirated diesel engines are preferable to eight or twelve cylinder supercharged V8 or V12 engines; popular name brand engines and gear boxes with local distributors or agents are more suitable than exotic brands; dry exhaust systems are more suitable than wet exhaust systems; electric starters are more trouble-free than air or hydraulic starters; and simple, unsophisticated engine setups are preferable to 'high tech' systems with lots of 'bells and whistles'.



Engine start and stop buttons should be on the engine, or at least in the engine room, and not in the wheelhouse or on the flybridge. This necessitates at least two trips into the engine room daily and hopefully would mean that sump oil levels, engine coolant levels, gear box oil, and bilge water levels would be checked.

Cable controls (e.g. **Morse Cables**), for engine throttle and marine gear shifting are preferable to electronic or hydraulic controls as they are easier to maintain or replace. Good engine choices would be **Caterpillar** (USA), **Gardner** (UK), **Yanmar** (Japan) or **Baudouin** (France). **Twin Disc** is probably the most popular marine gear box.

However, there are many other good brands of marine diesel engines and marine gear boxes. One important consideration is availability of parts and service. Before an engine and gear box are selected it would be good to try to identify sources for spares like fuel and oil filters, injectors, starter motors and alternators, and rebuild kits for pumps and cylinder heads. If these basic items cannot be accessed then it may be best to find a more suitable engine for which parts and service are readily available.

One very important piece of machinery, especially in the tropics, is an engine room **exhaust fan**. Ambient engine room temperatures can become quite hot during hauling of the longline gear when the main engine may be operating at peak RPM and the hydraulic pump operating at peak output.

Exhaust fans should be mounted somewhere near the exhaust stack so that hot air is expelled while cool air is being drawn in from a vent somewhere in the forward end of the engine room. An on-off switch for the exhaust fan should be mounted in the wheelhouse so the fan can be switched off in case of fire.

Propellers should be fixed pitch, not variable pitched—and nozzles are not necessary. Shaft packing glands should be the simple, water-cooled-type using Teflon or graphite-type packing and not oil-filled, although grease fittings on shaft glands are probably a good idea.

Another important piece of machinery on a longline vessel is the **hydraulic system**. The most suitable hydraulic system is one that is the most depend-able. Care should be taken so that the output of the hydraulic pump matches the minimum ratings of the hydraulic motors on the reel and line setter (indicated by **pressure**—in pounds per square inch, *PSI*; *Bars*, atmospheres; or *Kilopascals*, 0.01 atmosphere; and **capacity** in *GPM*—gallons per minute or litres per minute).

A typical hydraulic system for operating a longline reel might be rated at 1500 PSI and 10 GPM. A hydraulic pump that runs from a power take off (*PTO*) on the main engine is probably the best choice. Electrically-powered hydraulic systems are fine until there are problems with the generator set. Consider the following scenario:

> A *vessel has all of its gear in the water and then experiences a generator breakdown. If the main engine is still operational then the vessel would be capable of returning to port, even if the fishing trip had to be cut short. If the vessel has a hydraulic system that runs off of the main engine then there would be no trouble in recovering the gear. However, if the hydraulic system is electrically powered, the entire set of fishing gear could be lost as the vessel would not be capable of hauling the fishing gear.*

Ideally, a vessel would have a backup system to cover such situations. Additionally, a hydraulic system that operates a longline system should have some sort of built in heat exchanger, either sea-water or keel cooled. Hydraulic line haulers and reels work under a fairly heavy load for eight to twelve hours during hauling. Hydraulic fluid can become quite hot and if it is not cooled, damage can occur to motor and pump seals in the system.

Wheelhouse electronics

The following electronic appliances are either basic necessities for longline fishing, or are highly recommended. Although it is possible to operate without all of them, each has a function that makes navigation safer or fishing more productive or both:

Global Positioning System (GPS) receiver: Gives exact position in latitude and longitude at intervals of every second—accurate to within about 30 m. A GPS navigator is essential for both longline fishing and general navigation.

Colour plotter: this can be separate from the GPS or can have a built-in GPS receiver. A plotter gives more detailed information about the longline set. The plotter actually draws a picture (plot) of how the line was set and how it was hauled.

A comparison of the two gives the captain important information about set and drift (current direction and speed) and the presence of eddies or convergences. Events like fish catches can be entered on the plotter easily by pushing the 'event' button. Geographical features like reefs can also be entered onto the plotter.

Radar: essential for navigation, especially in areas where there are abundant reefs or where there may be other vessels. If fishing is done within radar range of shore, radar can be used to plot positions of longline set. A thirty-six mile range radar should be sufficient for a longline vessel.

Autopilot: autopilot is not essential but it is highly recommended as during setting it relieves one man from steering the vessel. Often this man is needed on deck to help with the set or to bury fish. An autopilot also gives a much straighter set than hand-steering would. Some autopilots can also be used during hauling.

Single side band (SSB), or high frequency (HF) radio: an HF radio is essential for communication both for general navigation (ship-to-ship and ship-to-shore) and for fishing. Longline vessels can share catch and fish location information with each other, and can relay catch data and ETA (estimated time of arrival) to agent or manager on shore. With an export fishery depending on air links to Japan and other international markets, good communications are critical.

VHF radio: short-range radio communication is essential for communications with harbour authorities, agents, and with other vessels in crossing situations to avoid collisions.

Colour sounder: a sounder is important for navigation, especially in strange waters when entering harbours or going through passes in outer reefs. Another function of a sounder that is important in longline fishing is its ability to 'find' fish. In fact, sounders are often called 'fish finders'. This is not so important for locating schools of tuna but for locating bait that tuna may be feeding on. Some sounders have the capability of reading the depth of the thermocline, thought to be an optimum place for deeper-water tunas (bigeye). Some sounders are equipped with sea-surface temperature sensors and are able to display this information graphically on a time line.

Sea surface temperature (SST) monitor: SST data is important information for longline fishing, both for tunas and for broadbill swordfish. Fish are often found on either side of a 'temperature break' or an area where temperature drops or rises rapidly in a short distance. Temperature breaks are thought to accumulate bait as bait schools move from cooler water into warmer water or vice-versa. These accumulations of bait attract schools of larger fish like tuna or broadbill.

Radio direction finder (RDF) and radio buoys: this is not an essential item as longliners operated throughout the world for years using only lights and coloured flags on bamboo poles to locate their lines.

However, using radio buoys and RDFs makes life a lot easier for the fisherman as he gets to rest between setting and hauling. Radio buoys are also useful when the mainline parts during hauling. If a buoy cannot be located after a break in the line then the vessel can always steam to the next radio buoy.

Usually several radio buoys are attached to the mainline, at intervals and at either end. RDFs can also be useful as navigation aids. A Taiyo Model TD-L1100 (the most popular model RDF) is capable of tuning to land-based airport beacon transmitters and to AM radio stations. This information could tell the captain which way to go to return to port in the event all other systems failed. More sophisticated RDFs allow for eavesdropping on other vessel's positions, thus gaining information about location of other fishing vessels and hopefully fish schools.

Weather fax receiver: weather information is faxed worldwide on a number of frequencies. The information comes as a weather map and is much more detailed than reports given on HF radio or Inmarsat-C systems. Also available on some frequencies are remote-sensing data like sea-surface temperature maps. A weather fax is an essential item on any longline vessel operating in the cyclone belt.

Inmarsat-C: satellite communication between vessels and also ship-to-shore is possible in a fax mode with Inmarsat-C (Inmarsat-A has voice communication capabilities but is too expensive for longline operations). In Hawaii Inmarsat-C systems are mandatory on all longline vessels as GPS position data of each vessel in the fleet is monitored to insure compliance with fisheries regulations.

As an aside, the fleet has been able to use the Inmarsat-C system to greatly improve communications with the added benefit that all communications are secure. No one can eavesdrop on a fax transmission so two boats can share confidential fishing information with each other.

Bathythermograph: a bathythermograph is an instrument that enables the vessel's crew to measure the depth of the thermocline. The thermocline is that place in the water column where sea water temperature changes abruptly and is generally thought to be an optimal depth for targeting bigeye tunas. There are available on the market, portable-disposable bathythermographs that are affordable as well. A bathythermograph is probably an optional instrument.

PC or personal computer: computers are becoming more and more desirable on fishing vessels. A PC is necessary for Inmarsat-C two-way communications using software like **Galaxy**; and software is available with charts for course plotting, for monitoring weather, and for getting real-time satellite oceanographic data like sea-surface temperatures.

Furuno (Japan) is probably the most popular maker of marine electronics for longline fishing vessels. However, there are several other good brands to choose from including: **Raytheon** (USA), **JRC** (Japan Radio Corporation), **Koden** (Japan), **SEA** (Stephens Engineering Systems, USA), **Icom** (Japan), **Taiyo** (Japan) to name but a few.

Fishing gear

There are two main types of longline gear—traditional, or **basket gear**, and compact, or **monofilament gear**—with many combinations and variations in between. Basket gear refers to the original gear as developed by Japanese fishermen decades ago. It derives its name from the fact that the mainline (tarred *Kuralon* or polyvinyl alcohol, and/or tarred *Tetron* or polyester) was stored in baskets.

Typically traditional gear is hauled by a hydraulically, electrically, or mechanically (shaft driven) line hauler and the branchlines are coiled by hand. The sections of mainline are either coiled into some type of basket or tub or are tied up into a bundle, and then stowed in a cage or in bins.

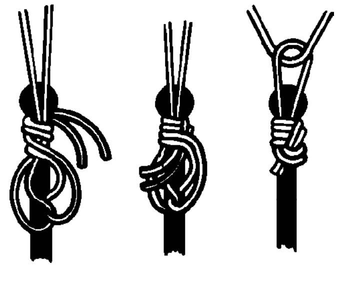
Branchlines are usually left connected to the mainline and are placed on top of each successive coil of mainline. Branchlines are made from tarred *Kuralon*, a sekiyama or middle wire, a leaded swivel, and a galvanised trace, or leader, with hook. Refinements to this system include the use of electric coilers for coiling branchlines and hydraulic line coilers (line arranger) for arranging the mainline in a large bin. This type of system is referred to as an 'automatic' system and is very popular especially with the Okinawan fleet. Branchlines are usually separated from the mainline on automatic gear, then coiled and stowed in separate baskets.

The line is usually set with a line setter, or shooter. This gives the crew better control over depth of the mainline. With traditional basket gear the mainline is hand thrown over the stern as the vessel steams ahead. Depth of set in this case is variable. The most popular manufacturer of traditional basket gear fishing machinery is **Izui Iron Works** (Japan).

Both traditional basket gear and more modern automatic basket gear are excellent fishing systems. However, both basket gear systems have two definite disadvantages:

- One, the systems are very expensive. New automatic basket gear systems cost, on average, about 25 per cent more than what a monofilament reel fishing system would cost with equal setting capabilities.

- Two, the systems are very labour intensive and require a higher degree of skill than is required for monofilament systems. Hand-coiling branchlines, or even coiling with an automatic coiler and stowing in baskets, is much more difficult than coiling branchlines into a tub as is done with monofilament systems. Making up the gear is also much more time consuming than making up monofilament gear. Typically it takes a crewman several seasons before he is proficient with basket gear, while monofilament gear can be mastered after only a few trips.



Some vessels, particularly Taiwanese, use a combination of the two systems—monofilament mainline is hauled using a basket-gear-type hauler. Usually on these systems branchlines are still coiled by hand or with automatic coilers. Mainline is usually stored in large plastic or bamboo baskets.

Another system that is somewhere in between basket gear and monofilament reel gear is the Japanese **Magu-reel** made by Izui Iron Works. The Magu-reel is a cassette-type monofilament system. That is, the mainline is stored on not one, but several small reels, or cassettes.

The line is hauled with a hydraulic line hauler much the same as is used with basket gear. There is a separate hydraulic machine called a line winder that spools the mainline onto the reels after it has been pulled aboard by the hauler. The branchlines are removed from the mainline and are coiled either by hand or with an electric branchline coiler. Magu-reel systems use line setters and fish very well.

However, they are much more expensive than single reel monofilament systems. The only advantage is that the Magu-reel hauler takes up little room on deck. However, the reels (usually about 10 or 12) need to be stowed somewhere and moved forward and aft on a daily basis. Both the Magu-reel systems and the automatic basket gear systems require three pieces of hydraulic machinery and one or two electric branchline coilers, while basket gear requires only one piece of hydraulic machinery and monofilament reel systems require only one or two. Branchline coilers can be used with monofilament reel systems but they are not a necessary piece of equipment.

Probably the most popular system in established and newly-developing Pacific Island longline fisheries is the compact, or monofilament longline system that uses one large reel to store and haul the monofilament mainline.

The system was developed on the east coast of USA about 15 years ago (**Lindgren-Pitman**) but now there are systems being made in Australia, Europe, and Fiji (**Leahy Engineering** in Australia, **Bopp** in France and **Seamech** in Fiji). The system is composed of a large hydraulically-operated reel made of steel or aluminium that can contain as much as 68 nautical miles (125 km) of nylon monofilament—depending on the diameter of the line and the size of the reel. Lindgren-Pitman has recently come out with a two-reel system that is capable of holding over 100 nautical miles (185 km) of line.

The line is set from the stern of the vessel, usually with the aid of a line setter (shooter) although it can be set without a shooter. If the line is set without a shooter—this is called 'towing' the line—then the length of mainline set is equal to the distance that the vessel travels and the baited branchlines do not reach into very deep water.

With a shooter the depth of the set can be increased, as the length of mainline paid out is greater than the distance travelled by the vessel. Depths of 100 fathoms (200 m) or more can be reached. This is important when deep-swimming tunas (bigeye) are being targeted. As the line is paid out over the stern during setting, baited branchlines are attached at intervals usually controlled by an audible signal from a setting timer.

The number of branchlines set between floats is called a 'basket' and can vary from 5 or 6 to as many as 30 or 40. Length of floatlines can vary from 5 fathoms (10 m) to as much as 30 fathoms (60 m). A typical or average tuna longline set would have floatlines of 15 fathoms (30 m) and 20 branchlines of 5 to 6 fathoms (10 to 12 m) in each basket. Radio buoys would be attached at either end and at intervals in between.

The monofilament nylon (polyamide) mainline can range from 3.0 mm to 4.5 mm in diameter. The branchlines (snoods, gangions) can be made from 1.8 mm to 2.1 mm diameter monofilament, 3.0 mm tarred Kuralon, 3.0 mm tarred red polyester, or a combination.

Branchlines can also have swivels (barrel, bullet, or leaded) and wire traces. Hooks can be Japan tuna hooks with or without rings, big-game hooks, or circle (rotating) hooks. Connections are usually made with crimps or swages, but sometimes knots are used. Connected ends are protected from chafing with aimata, thimbles, green springs, or plastic tubes.

The line is hauled usually from the starboard side of the vessel and stored directly back onto the reel. Branchlines are removed as the line is moving and coiled into branchline bins or tubs. Floatlines are also detached and floats and floatlines are stowed somewhere on deck.

Monofilament reel systems have three main advantages over other longline systems:

- One, the initial cost is substantially less than for Japanese basket gear systems. A complete tuna longline system with a monofilament reel for a medium-sized vessel (16 to 18 m) would cost about US$ 60,000, while an automatic basket gear or Magu-reel system would be about 25 per cent more.
- Two, monofilament reel systems are simpler than other systems. It is easier for an operator and crew to learn how to master a monofilament system and it is easier for the captain or engineer to maintain as well. Making up the gear for a monofilament system is relatively simple and can be learned in a short time.
- Three, fishing effort can be increased, at least as compared with most other systems, when monofilament systems are used.

Arguably, the automatic basket gear systems, as used by most Okinawan vessels, are as efficient as monofilament systems, but monofilament systems are markedly more efficient than traditional basket gear or Taiwanese basket gear systems. Cost, simplicity, and efficiency make monofilament reel systems the best choice for Pacific Island longline fisheries.

Vessel costs

The main idea of commercial tuna longline fishing is to make money. If a good return cannot be made from the initial investment then fishing efforts are probably a waste of time and resources (fish and money). Money in the bank, with adjustments for inflation, can probably be expected to earn at least 5 per cent annually. If a fishing venture does not give investors a return of at least 5 per cent in the long run then it is probably not worth the effort. In order to optimise the chances of getting a good return several things need to be considered: there are probably ceilings on vessel effort, catch, and market performance; expenses—variable, fixed, and marketing—are probably going to be greater than expected; and Murphy's law was written by a fisherman: 'If something can go wrong, it will go wrong'. One other thing: financial projections, especially in the longline fishing industry, are fiction. Proposed profit-loss scenarios rarely correspond even remotely to reality after the fact. The following oversimplified financial scenario is offered as an example of what might be expected:

A medium-sized longline vessel with gear cost US$ 500,000. It makes 1.5 trips per month of 10 sets each setting 1,500 hooks each day of fishing. An average of 5 t of fish are caught each trip (90 t annually). The market value of this catch averages US$ 10,000/t. Annual gross receipts are, therefore, US$ 900,000. Marketing expenses in an export fishery are about 50 per cent of gross receipts so there is a net back to the company of US$ 450,000. Variable costs, or operating expenses (expenses shared by the boat and the crew) are deducted from this net. Variable expenses (fuel, bait, ice, food, etc.) are in the range of US$ 10,000/trip or US$ 180,000 annually (not counting salaries and wages). This leaves another net of US$ 270,000. This amount is then *divided between the boat and the crew, usually in a 50/50 ratio unless the crew are paid on a base wage with bonuses. The crew share is thus US$ 135,000 (for a crew of six this would amount to annual wages of US$ 38,571 for the captain and US$ 19,285 for each of the deckhands). The balance is the boat share—US$ 135,000. All fixed costs have to be paid out of this amount. Fixed costs are based on mortgage, interest, depreciation, hull insurance, maintenance reserve, license fees, wharf charges, etc. Without going into all the details, fixed costs could be expected to be in the range of 20 per cent of the original investment, or US$ 100,000 annually. This leaves a final net back to the operation of US$ 35,000, or 7 per cent. Slightly better than what the original investment would make if the money was just left in the bank and everyone stayed home.*

This oversimplified picture does not take into account the spin-off benefits that this boat would produce: some of the money earned is foreign export money, so the local economy would benefit and the vessel would help to create employment both in the fishery and in local goods and services. With more fine tuning and better luck the net return might be expected to grow over time to a higher figure.

If more than US$ 500,000 is invested in the vessel initially will the returns be higher? Probably not. At higher levels of investment fixed costs become too high in relation to gross receipts. A diminishing set of returns is the result. On the other hand, if initial investment can be kept low, as with the purchase of a second-hand vessel, the profit-loss picture might look brighter.

In the case of second-hand vessels a substantial risk is added to an already very risky venture so a high degree of caution should be used. Vessels that have gone bankrupt once should probably be avoided (there are usually good reasons why they go bankrupt).

Vessels that are offered on tender after being seized for illegal activities can be real bargains, on the other hand. Other ways to improve the profit-loss picture are to seek 'soft' loans usually offered through development banks or international assistance organisations; or to make an outright purchase, in which case the vessel could be 'self insured', saving the company five or six per cent annually of capital costs.

Average annual Hawaii-based domestic longline vessel characteristics [1 pound = 0.454 kg]

	Mean
Vessel length (ft)	69
Gross tons	94
Total horsepower	457
Purchase price (US$ 1,000)	267
Additional investment (US$ 1,000)	106
Value of electronics (US$ 1,000)	34
Number of trips in 1993	10.8
Travel days per trip	9.6
Fishing days (sets)/trip	10.6
Total pounds sold per trip	18,021

Average annual Hawaii-based domestic longline vessel economic information

	Annual mean (x US$ 1,000)	Range (x US$ 1,000)	Median (x US$ 1,000)
Revenue	504	58–1,153	481
Variable costs	377	40–831	361
Fixed costs	100	31–239	98
Net return	27	(219)–253	28
Add back non-cash depreciation charge	12	3–36	11
Cash return	40	(205)–262	38

The tables showing average profit-loss from 95 Hawaii-based longline vessels for the year 1993 are extracted from: Hamilton, M, R. Curtis & M. Travis. 1996. Cost-Earnings Study of the Hawaii-Based Domestic Longline Fleet. Joint Institute for Marine and Atmospheric Research.

Other considerations

Other things to consider are what type of survey is necessary and what type of registry is required. Depending on local rules and/or requirements of lenders and insurance companies, a vessel may have to be under a particular survey such as those proscribed by American Bureau of Shipping (USA), Uniform Shipping Laws (Australia), or Bureau Veritas (French).

Flag of registry is equally important. After a vessel is purchased and imported into a country it may have to undergo a new survey and be re-flagged. This can be quite expensive, and so should be looked into beforehand so costly mistakes can be avoided.

Lastly, aside from suitability and versatility, *simplicity* is also something to be sought in a longline fishing vessel. Some wise business manager years ago came up with this appropriate acronym to describe a universal management approach to most situations: the 'KISS Principle' or 'Keep It Simple, Stupid'.

The more complicated a longline vessel and its systems are, the more likely it is to experience costly breakdowns. An example of this is hydraulic leader carts for winding in and stowing branchlines and floatlines. The job of pulling in floaters and floatlines can be done by hand, and it is on most longline vessels.

Some vessels use hydraulically-operated reels, called leader carts, to wind in branchlines or float lines and floats. Hydraulic leader carts add a needless complication to an already fairly complex piece of machinery, and more problems as well: one more hydraulic motor to break, one more set of hoses and fittings to wear out and be replaced, one more thing to paint and grease.

This is not to mention the additional initial expense and the room they take up on deck. There are countless other examples of bits and pieces that could be avoided or simplified on a fishing vessel including engine room layout, machinery, deck layout, fishing gear configuration and components, pumping systems, alarm systems, etc.

The Masterfisherman's ideal longline vessel

The ideal longline vessel for fishing in Pacific Island countries would be 21 m length over all by 6.5 m beam and 3.6 m depth. It would be made from steel and have a single hard chine, a stern wheelhouse, and a raised bow (see appendix A for general arrangements).

The main engine would be a **Caterpillar 3406** with a **Twin Disc** gearbox, electric starter, keel cooler, and dry exhaust. It would have a thirty kW generator set with a name brand like **Onan** or **Northern lights**. The fuel tank capacity would be 25,000 litres and the fresh water capacity would be 4,000 litres. Crew complement would be eight men.

The fish hold would be a single 40–50 t hold for icing fish (fifteen tonne chilled-fish capacity). It would be separated into several compartments with aluminium or wooden bin boards. One bin could serve as a freezer room for bait storage. There would be a hydraulic boom for offloading fish.

The wheelhouse would be equipped with mostly **Furuno** electronics including 36 n.mi. radar, SSB radio, VHF radio, GPS with colour plotter, echo sounder with sea surface temperature monitor, and a weather facsimile receiver.

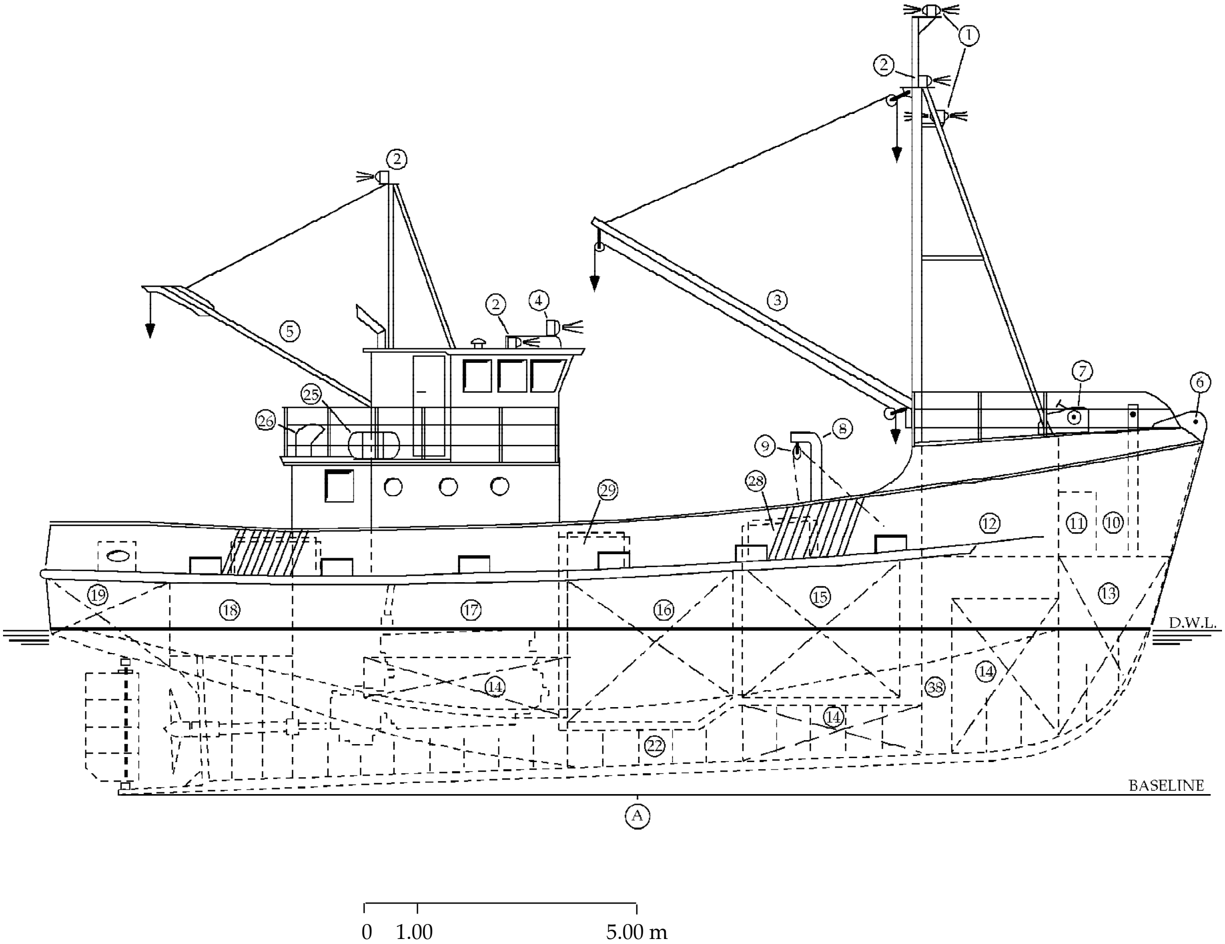
It would also have an auto pilot and a **Taiyo** Model TD1100 radio direction finder. Optional gear would be an **Inmarsat-C** transceiver, a PC or personal computer (486 with **Windows 95**), and a bathythermograph.

Fishing gear would consist of a **Lindgren-Pitman** Super Spool and LS-4 line setter. Hydraulics for the fishing gear would run off of a belt-driven power-take-off from the main engine and would run through a heat exchanger. The LP reel would have 50 n.mi. of 3.6 mm monofilament mainline. There would be 4 branchline tubs each holding 440 branchlines (10 m long).

The branchlines would be made from tarred red polyester 3.0 mm line with 45 g leaded swivels and one metre of stainless steel wire leader ending in a **Mustad** 3.6 stainless steel tuna hook with ring. Other gear would include at least four radio buoys, about one hundred 360 mm plastic floats, about 10 strobe lights, gaffs, grapples, spikes, etc. and spare parts for everything.

Last but probably most important is **safety equipment**. The ideal vessel would be equipped with an eight-man life raft, two or three life rings with strobe lights, a 406 EPIRB (emergency position indicating radio beacon), a well stocked medical kit, ample fire extinguishers, emergency signal devices (hand-held flares, rocket flares, and smoke signals), and a separate battery for the HF radio located outside the engine room. Expiration dates on all safety equipment would be current.

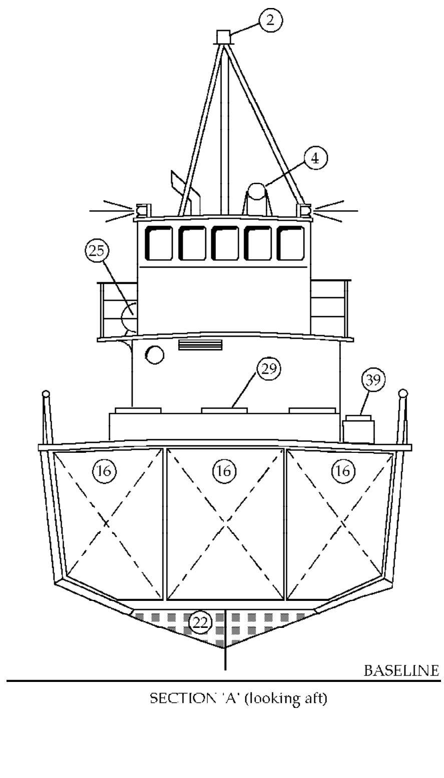
General arrangements of an ideal mid-sized steel longline vessel. Adapted from: Eyres, D. J. 1984. Fishing boat designs: 4. Small steel fishing boats. FAO Fish. Tech. Pap. (239): 33p.



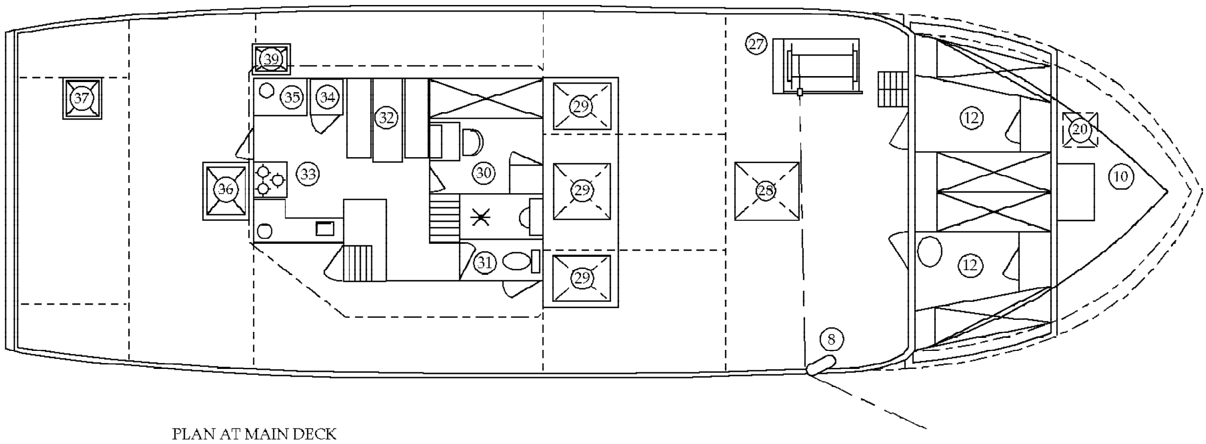
Main particulars

Length over all	21.00	m
Length water line	19.90	m
Beam (max) moulded	6.50	m
Depth (moulded)	3.60	m
Draft at D.W.L.	3.00	m
Hold capacity	30.00	m^3
CSW tank capacity	39.00	m^3
Fuel oil	22,500	l
Fresh water	5,500	l
Main engine	300	hp

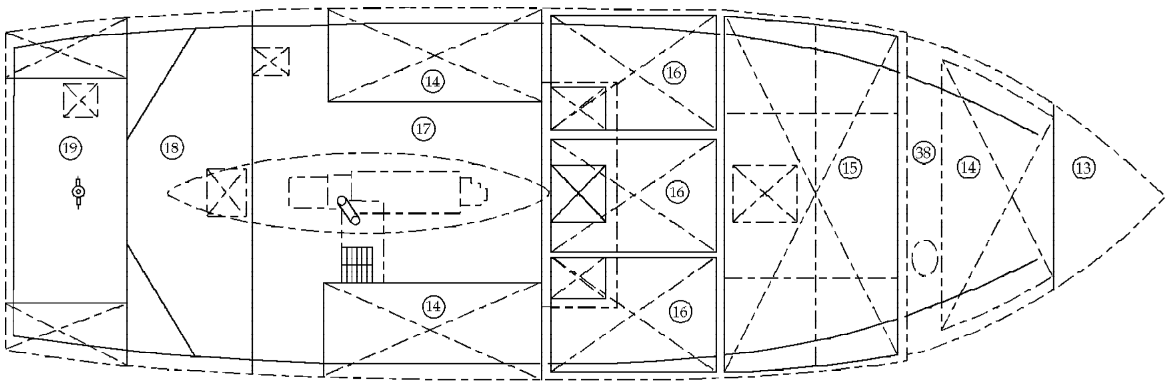
21.00 m steel fishing boat		
GENERAL ARRANGEMENT II		
Scale: as shown	Boat no.	Drwg no.
Drawn: GB	SB2	1 & 2
Rome, 1983		



SECTION 'A' (looking aft)



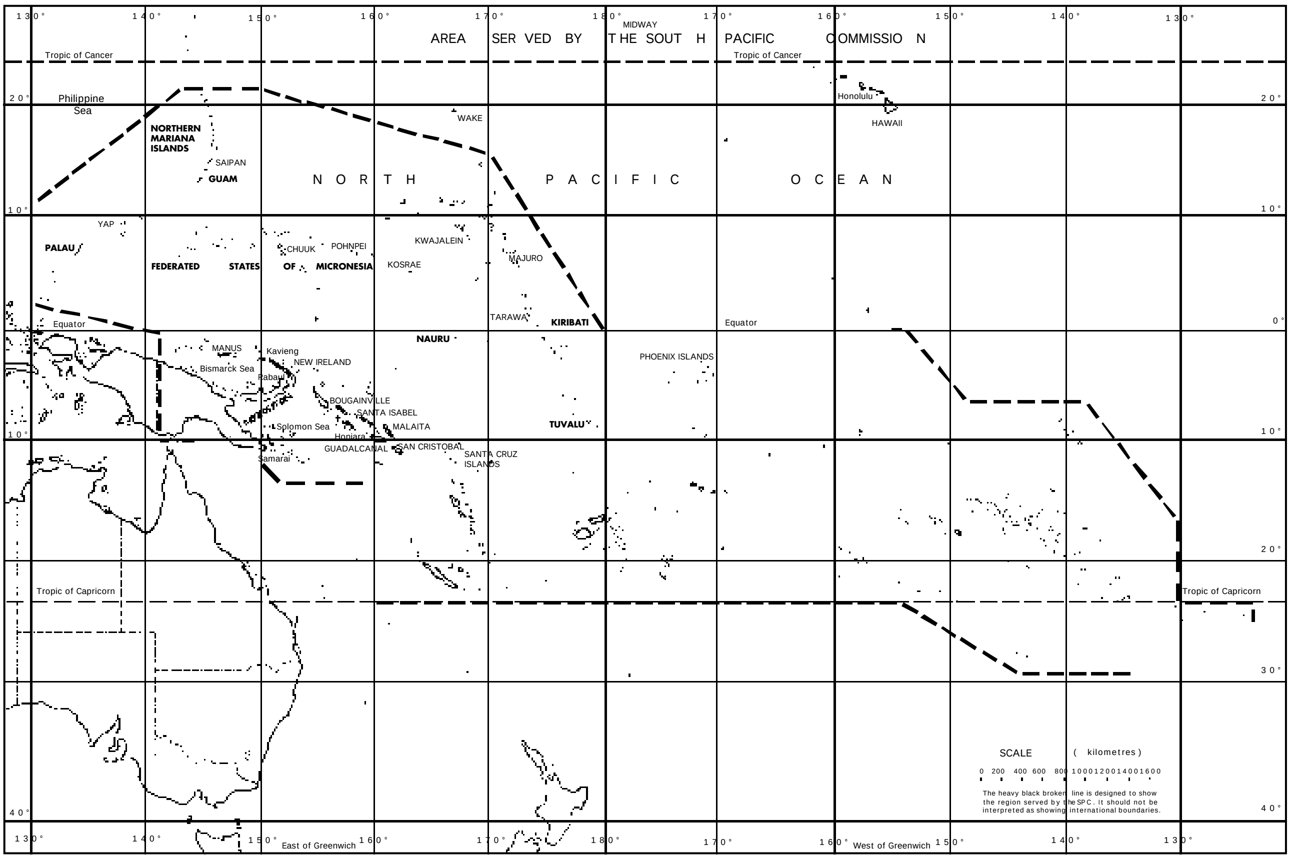
PLAN AT MAIN DECK



PLAN BELOW MAIN DECK

0 1.00 5.00 m

1. Fishing lights
2. Navigation lights
3. 6.50 m boom, 1000kg SWL
4. Search light
5. 4.25 m boom
6. Anchor roller
7. Windlass
8. Mainline davit
9. Mainline block
10. Fore peak stowage
11. Anchor chain stowage
12. Accomodation (8 berths)
13. Salt water ballast
14. Fuel oil tanks
15. Fish hold, 30 m^3
16. 3 C.S.W. tanks, 13 m^3 each
17. Engine room
18. Gear stowage
19. Steering gear and fresh water tanks
20. Access to fore peak
21. Wheelhouse
22. Concrete ballast
23. Chart table
24. Deck store
25. Inflatable liferaft, 10 man
26. Supply vents to engine room
27. Line hauler
28. Hatch to insulated hold
29. Hatches to C.S.W. tanks
30. 2 berth cabin
31. W.C. and shower
32. Galley
33. Mess table and seating
34. Refrigerator
35. Locker
36. Hatch to gear store
37. Hatch to steering gear
38. Sonar space
39. Emergency exit from engine room


AREA SERVED BY THE SOUTH PACIFIC COMMISSION
NORTH PACIFIC OCEAN
Tropic of Cancer
Philippine Sea
NORTHERN MARIANA ISLANDS
SAIPAN
GUAM
WAKE
MIDWAY
Honolulu
HAWAII
YAP
PALAU
FEDERATED STATES OF MICRONESIA
CHUUK
POHNPEI
KOSRAE
KWAJALEIN
MAJURO
TARAWA
KIRIBATI
NAURU
Equator
MANUS
Bismarck Sea
Kavieng
NEW IRELAND
Rabaul
BOUGAINVILLE
SANTA ISABEL
MALAITA
Solomon Sea
Honiara
GUADALCANAL
SAN CRISTOBAL
Samarai
SANTA CRUZ ISLANDS
TUVALU
PHOENIX ISLANDS
Tropic of Capricorn
East of Greenwich
West of Greenwich
SCALE (kilometres)
0 200 400 600 800 1000 1200 1400 1600
The heavy black broken line is designed to show the region served by the SPC. It should not be interpreted as showing international boundaries.