The Sea Fish Industry Authority

Seafish Technology

Deepwater Fishing Along The North Atlantic Slope

Fishing Trials Onboard MFV "MARANATHA III"

March 1995

Authors: B Greenwood
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Seafish Report No. SR449

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Summary

This report describes the trials carried out by the Sea Fish Industry Authority (SFIA) onboard MFV "MARANATHA III". Primarily an engineering trial to determine winch and propulsion engine power demands, at depths of up to 1000 metres, the opportunity was also taken to gather information on fishing gear performance and post harvest care of the deep water species of the North Atlantic Slope.

1. Introduction

Deep Water species of the North Atlantic slope, presently exploited by French and Spanish vessels, could become an important food and biochemical resource in the next century. If UK vessels are to obtain a market share within this fishery a track record must be established.

In order to exploit the fishery safely there comes a requirement to obtain the necessary knowledge and experience of the relevant technologies involved in fishing this sometimes dangerous terrain.

As part of this requirement, the recently built 27m MFV" MARANATHA III" was partially funded by the Sea Fish Industry Authority to conduct fishing trials on the edge of the Continental Shelf. The vessel owners had already expressed an interest in this area and as such were seen as logical partners.

The primary objective was to conduct an engineering trial to determine the power demands on both winches and propulsion engine. These demands were observed between depths of 200 metres and the maximum depth allowable with the available warp (approx. 1000M). The observations would providing comparative data of towing loads to determine the effects of increased warp weight at different warp length/depth ratios.

The monitoring of other data such as vessels horizontal and vertical accelerations and pitch and roll was also measured at the request of MARINTEK, the Norwegian Marine Technology Institute with whom the Technical Services department of Seafish are co-operating. This and other data from the trials, will then be incorporated into a computer model being developed which is to predict the "Influence of vessel motion on efficiency and energy costs in fishing".

Secondary to this objective was the need for more information on the most appropriate type of fishing gear to be used. As little information exists at present on the most suitable doors, ground rigs and trawls for this fishery. The majority of this data presently coming from sources in New Zealand.

Finally, there was a need to obtain deep water fish samples of known handling history and controlled icing for laboratory assessment over their storage life on ice. Additionally to obtain knowledge of how these unfamiliar fish handle in comparison to typical white fish.

To cover these requirements a Gear Technologist and Fish Technologist were present on the trials.

2. The Purpose

To gather information and compile Technical Information Sheets and reports, to be disseminated to the fishing industry giving advice on all aspects of the Deep Water Fisheries of the North Atlantic slope.

3. The Vessel

"MARANATHA III" Owners : Pitcairn Fishing Company Limited,
Builder/Designer : Macduff Shipyards

Specification

Length of : 27.47m OA Breadth : 8.55m Depth : 3.62m

MATERIALS
Hull : Steel
Shelterdeck : Steel full-length
Wheelhouse : Aluminium

ENGINEROOM
Main Engine : MAN B&W Alpha 6L23/30A, 980hp @ 825rpm
Gearbox : Alpha 44KV9, 4.35:1 reduction
Propeller : Alpha 4-bladed CP, 2500mm diameter
Nozzle : Alpha PTO : Hytek Bowthruster : Boss 105hp
Auxilliaries : 2 x Volvo TMD102A & 146kW Generators
Bilge pumps : Desmi Filters : Alfa Laval and CJC

CAPACITIES
Fuel : 17,000 gallons in 8 tanks Freshwater : 12.3 tonnes in double-bottom tanks
Ballast : 20 tonnes in bulbous bow

DECK MACHINERY
Trawl Winch : 2 x Rapp TWS5030, 20 tonnes
Anchor winch : Fishing Hydraulics
Net drum : 3 x Fishing Hydraulics, 16 tonne
Capstan : Rapp Hydema Syd
Deck cranes : Atlas AK450 with Rapp wide sheave power block, Atlas with Pullmaster M12 cargo winch.
Autotrawl : Rapp Multracom PTS3000

FISHROOM
Capacity : 200 cu m, 1400 boxes
Insulation : Injected polyurethane foam
Chilling Seacool plate evaporators

WHEELHOUSE

Fish finding :	Atlas 783 & JRC JFV120 colour sounder, Scanmar 604 net monitoring system, MCG3100 Autotrawl monitor
Navigation :	Decca Mk53 & CVP3500, Raystar 920 GPS, MLR LRX22P Loran C, MLR TR300 plotter, Microplot Computer, Raytheon R73 radar & R40X radar, Navitron 9209 autopilot, JRC JLN-203 Doppler log
Communications :	INMARSAT C terminal, Skanti TRP7200 SSB radio with Telex, Raytheon RAY152E SSB radio, Sailor RT144C VHF & RT2048 VHF, Icom ICM12 hand VHF, Sailor R501 Watchkeeper, Citizen 1200 Telex, Woodson Talkback, Motorola phone.

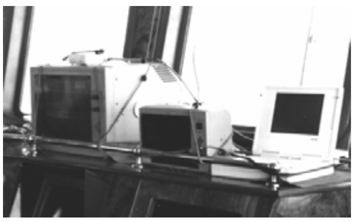
Vessel Layout

The vessel is shelter decked, with the wheelhouse situated slightly forward of mid-ships above the galley area. Aft of the wheel house, on the shelter deck top, are the split winches, main net drum and towing gantry/power block. Below this, on the working deck, are two further net drums which shoot the trawl gear from hatches on the transom. The shelter deck, forward of the wheel house, accomodates the discharge hatch/crane and catch hopper on the starboard side. The fish handling deck and hold, respectively, are below the forward shelter deck.

4. Instrumentation

To facilitate the data requirements of both Seafish and Marintek a large number of parameters were monitored, either visually or through the Data Acquisition Systems.
A table of the parameters measured and sensors used is given below:

Table 1 - Trials Instrumentation

Parameter	Instrumentation	Monitoring System
Propeller Shaft Torque	Strain gauge/FM Telemetry	Orion 3530D/PC
Propeller Shaft Speed	Magnetic Pick Off	Orion 3530D/PC
Propeller Shaft Horsepower	Calculated	Orion 3530D/PC
Engine Speed	Calculated	Orion 3530D/PC
Vessel Pitch	Inclinometer/Gyro	Orion 3530D/PC
Vessel Roll	Inclinometer/Gyro	Orion 3530D/PC
Vertical Acceleration	Accelerometer	Orion 3530D/PC
Horizontal Acceleration	Accelerometer	Orion 3530D/PC
		
Otterboard Tensions	U/W Tension Sensor	Scanmar RU400/PC (SFIA)
Water Temp. at trawl	U/W Temp. Sensor	Scanmar RU400/PC (SFIA)
		
Water Depth at trawl	U/W Depth Sensor	Scanmar RU400/PC (SFIA)
Trawl Speed	U/W Trawl Speed Sensor	Scanmar RU400/PC (SFIA)

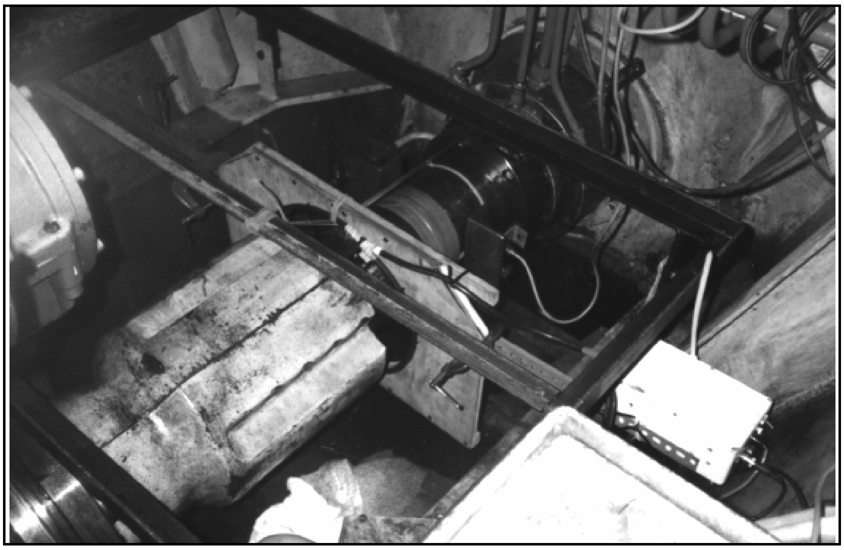
Parameter	Instrumentation	Monitoring System
Otterboard Spread	U/W Distance Sensor	Scanmar CGM (Scantron)
Wing End Spread	U/W Distance Sensor	Scanmar CGM (Scantron)
Headline Height	U/W Height Sensor	Scanmar CGM (Scantron)
Net Parameters	U/W Trawleye	Scanmar CGM (Scantron)
Catch	U/W Catch Sensor	Scanmar (Vessel Equip.)
Engine Fuel Flow	-	Visual
Winch Tensions	Rapp Hydema System	Visual
Warp Length Out	Rapp Hydema System	Visual
Door Angle of Attack	-	Visual
Vessel Position	Gps/Decca	Visual
Depth	Atlas Fishfinder	Visual
Warp Declination	Inclinometers	Visual/Orion
Weather Conditions	-	Visual

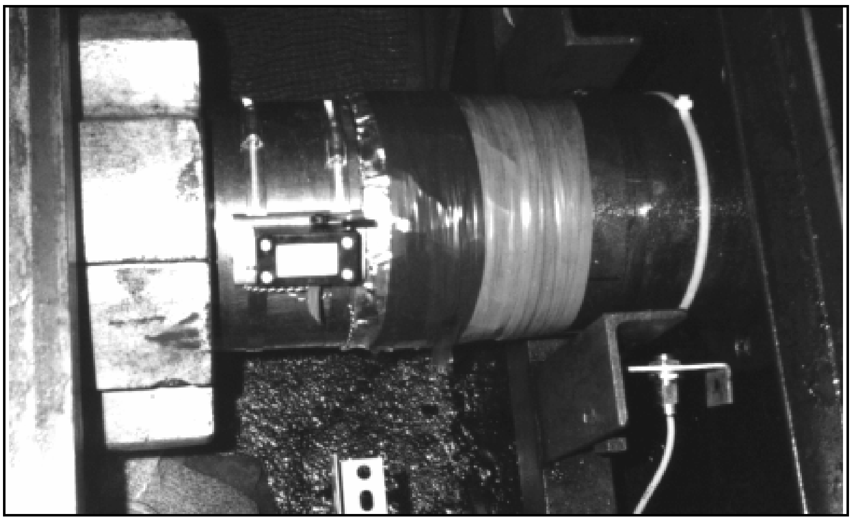
5. Installation

5.1 Monday 9th - Tuesday 10th May

As the strain gauges were still intact on the propeller shaft, from previous trials conducted during the vessels Sea Acceptance Trials, it was estimated that two members of Technical Services staff would need approximately one full day to install all other equipment. However, due to delays loading new doors, nets and running out new warps, access to the shaft to check the gauge installation and fit the F.M. Telemetry equipment was inhibited until 9pm. This task was therefore not completed until 8am the following day.

Whilst awaiting access all cables from the engine room and other sensors around the vessel, where run to the bridge were the Data Acquisition systems were in place.





6. Data Capture

A brief explanation of data capture is given below.

Data acquisition was accomplished by three means:- with a Solatron Orion Data Acquisition System, a Scanmar Net Monitoring System and by taking visual readings from the bridge instrumentation.

Orion 3530D Data Acquisition System
This system monitored analogue and digital data from the following sensors :-

Propeller Shaft torque measuring system, propeller shaft speed pick-off, a midships mounted gyro giving vessel pitch up and down and starboard and port roll, accelerometers mounted above the port towing point provided measurements of horizontal and vertical acceleration.

Using formulas input into the logger calculations of shaft horsepower and engine speed were computed. With a sample rate of 40 channels/second and dependant on run lengths, averages, maximums and minimums were calculated, saved to disk and printed out.

Scanmar RU400 Data Acquisition System
This system saved to disk all underwater measurements from the following sensors, 2 x otterboard tensions, net speed, otterboard spread, temperature, depth and headline height. Not all of the sensors were in use for every tow. An independent system employed by the vessel was also used to monitor these readings. It should be noted that only at one depth were port and starboard door tensions taken simultaneously due to the loss of one sensor when the otterboards came together when the net snagged on an underwater obstruction. To acquire a full set of data at all depths the remaining sensor had to be swapped over at the end of each tow, effectively doubling the time requirement. Due to this there was no time left to gather tension data behind the doors.

Visual Readings
The majority of these spot readings where taken from the bridge instrumentation, this included fuel flow, vessel position, course, speed, depth, pitch setting, winch tensions and warp deployed.

Also visually noted was wind and sea state.

The vessel operated a self tensioning winch system and it was therefore not possible to fix the declinometers onto the warps, therefore manual readings were taken for each run. These readings were validated at regular intervals by manually holding the declinometers onto the warps whilst reading the output off the Orion Data Acquisition System.

Capture Periods

It was decided that in order to limit the amount of data captured during 4/5 hour tows, a pre-defined time sampling system was needed. The example shown explains the procedures.

Table 2 - Example of a 5 Hour Tow timing period

Time			
00.00	Start	Run 1	20 x 1 minute runs - Orion & Scanmar averaging readings (different sampling rates) over 1 minute. During the middle of this 20 min period, a spot reading of all parameters, including bridge readings, is taken and logged.
00.20	End	Run 1	
00.21	Start	Run 2	15 minute averaging - Rather than having 1 minute outputs an output averaging over 15 minutes would suffice. Again, during the middle of this run spot readings where taken.
02.19	End	Run 2	
02.20	Start	Run 3	20 x 1 minute runs - As previously stated.
02.40	End	Run 3	
02.41	Start	Run 4	15 minute averaging - As previously stated.
04.39	End	Run 4	
04.40	Start	Run 5	20 x 1 minute runs.
05.00	End	Run 5	

7. The Sea Trials

The trials team consisted of an Electronics Engineer, Gear Technologist and Fish Technologist from Seafish, a Marine Biologist from SOAFD assessing and monitoring the different species caught, and an engineer from Scantron who had brought along the Scanmar Trawleye System at the request of the vessel owners.

Tuesday 10th May
The vessel sailed from Lochinver at approximately 0830. The aquisition of a new design of otterboards necessitated the testing of them to determine the correct rigging in known local waters. This also allowed the new warps to be stretched. Whilst this was in progress the data loggers were being run and programming alterations made. The whole of the day was taken up trying to determine correct lengths of fore/aft chain straps and door angles of attack. The gear was eventually shot at 20:00 hours and towed for 4.5 hours before coming fast. The vessel then steamed for 25 miles to get to a depth to start data recording.

Wednesday 11th May
Fishing at a depth of 650 metres with the underwater (u/w) tension sensors mounted on the port and starboard otterboards with data being recorded. The starboard sensor gave erratic transmissions therefore it was repositioned along the forward chain strap for tow 2. Adjustments to the footrope and backstraps were also made.

Thursday 12th May
After towing at a depth of 830 metres for approximately 5 hours the net snagged on an underwater obstruction, this caused the doors to close in on each other and become entangled. As the net came free and the doors tried to open up one of the u/w tension sensor transmitter pods was lost and damage sustained to the cables and cell protection brackets. The trawl and doors (still crossed) were eventually recovered. After a major effort disengaging the doors the trawl was shot again, minus the u/w equipment which was under repair. After 2 hours the headline height dropped to 0.8 metres, when hauled it was found that a number of the new 1500 metre floats had imploded. Once replaced the gear was shot again. Upon recovery 4 hours later wingend damage had been sustained and again floats had imploded. It was decided against using these new floats as there appeared to be a manufacturing fault with them. This was proven to be correct when floats of a much lesser depth rating were used and no further problems were encountered.

Friday 13th May
It was decided that the u/w tension sensor transmitter pod would be safer and be more reliable mounted on the inside of the door rather than along the warp as previously used. The gear was shot at 1000 metres. The maximum depth recorded was 1038 metres and at this depth there was very little warp left on the drum.

Saturday 14th May
Data was recorded at a depth of 400 metres with the tension sensor on the starboard side. Shaft horsepower gradually increased as the weather worsened to a force 8.

Sunday 15th May
Although data was collected throughout the day, none was used in the final analysis as both tows were curtailed due to the fishing gear coming fast and a loss of acoustic signals. Upon retrieval of the gear the lead connecting the transmit sensor to the load cell had caught between two chains and the plug at the cell was severed.

Monday 16th May
The tension sensor cable was repaired and the gear was shot in 400m of water with the sensor transmit pod on the port door, to tie in with readings taken earlier, at this depth, on the starboard door. For the second tow data was gathered at 1000m depth.

Tuesday 17th May
Data was gathered at a depth of 830m.

Wednesday 18th May
Data was gathered at a depth of 200m.

Thursday 19th May
The vessel landed in Lochinver. All instrumentation was withdrawn apart from a cable run from the wheelhouse to the engine room which was left in case of future trials. A freezer van and Seafish staff were in port to take off samples of Deep water species for laboratory trials.

8. Trials Analysis

8.1 Engineering Trials

8.1.1 The Results

The data gathered was taken and placed into a spreadsheet format where averaging took place. The total averages, maximums and minimums arrived at are explained below.

Figure 6 The table on figure 6 provides a final averaged figure for the specified parameter at each depth. Winch tension, door tension and warp weight are total values ie. port & starboard.

This data is then transferred to a graph for ease of examination.

It should be noted that all final values are from 10 hours of data, apart from at 650m when both door tension sensors were operable and are therefore for a period of 5 hours.

It is also important to understand that there could be a time difference of days between the two 5 hour tows at one depth, and therefore, different weather conditions, ie. at 400m on day 5 there was a wind reaching force 7/8; on day 7, when the second 400m tow was completed, the wind was only force 3/4.

Figure 7 This information shows all the parameters which were input into the Orion Data Acquisition System. Each depth is showing the final averages and the maximums and minimums were appropriate. Again it should be noted that the majority of these results are from 10 hours of towing and data capture.

The graph is only relative to the 'averaged' parameters.

Figure 8 This shows in tabular and graphical format the individual tows, comparing depth against winch tensions. Other data has been included to assist in the explanation of the results (ie. weather, ship speed etc).

Again it should be noted that these parameters are only spot readings (1 reading within each run),however, they were closely monitored throughout the runs and are seen to be a good gauge of an average figure.

Also, the warp to depth ratios were not pre-defined, only the results of when the vessel was seen to be fishing safely and correctly.

Figure 9 This gives the averaged readings taken by the underwater tension sensors over all depths during differing sampling periods. This information is then carried on to figure 6.

8.1.2 Observations

The primary objective of the trial was to observe the effects on engine and winch power demands whilst towing at different depths. Therefore, the observations made from the results are fundamentally concerned with this objective.

Dependant upon the water depth, the skipper varied the warp to depth ratio and engine power in the following way :-

i) Ratio of warp/depth decreases from 2.5 : 1 to 1.7 : 1 as water depth increased from 200m to 1000m.

ii) Engine power demand was the same at 200m and 650m depth but increased slightly for 830m and 1000m. Extra power was used at 400m depth for one tow due to bad weather.

Due to the changes in water depth, warp/depth ratio and towing power the following observations are made for the performance parameters shown in Figure 6 :-

1. The net speed and ship speed both reduced as depth increased.

2. Warp declination increased from 28 degrees at 200 metres to 30 degrees at 1000 metres depth (ie. very little change).

3. The tension at the doors reduced with increased depth.

4. Winch tension increased with increased depth.

8.1.3 Discussion

As more warp was let out from the vessel to cope with the increased depth, the winch tension increased slightly and ship and net speed reduce slightly.

The slight increase in winch tension, together with very little variation in warp declination meant that the total gear drag (warp, doors and net) also increased slightly, which is a logical expectation.

The increase in drag explains the slight reduction in ship and net speed despite the small increase in vessel power (SHP) in deeper water.

The reduction in speed in deeper water leads to reduced drag of the doors and net which is confirmed by the reduction in tensions measured at the doors.

The simulations presented by Marintek in their report on vessel efficiency using a computer model give results which are very comparable to the data gathered on this trial and, although the vessel speed in their simulation is held constant (3 knots), the warp tension difference between 200m and 1000m are both approximately 1 tonne.

It must be remembered that the “MARANATHA III” has been specifically designed to fish in deep water. The winches are capable of holding 3200 metres of 24mm diameter warp and have a pull of 20 tonnes. Fishing in considerable depths is therefore an exploitable option, however, many other vessels may find that they are restricted from deeper water by the capacity of the winches on their vessels.

From this trial on the “MARANATHA III” the measured warp loads have been found to be relatively modest. At 200 metres, the load on each winch was around four tonnes and at 1000 metres, the maximum load was only five tonnes; a 25% increase. Such modest loads are well within the capabilities of the winches fitted on many vessels and hence, winch load is not a bar to the fishery. However, winch drum capacity is likely to be a factor which will prove an obstacle on some vessels.

2000 metres would appear to be the required drum capacity to be able to fish at a depth of 1000 metres. The “MARANATHA III” fished successfully at this depth using 1800 - 1900 metres of warp at each side, a warp length/depth ratio of only 1.8 to 1.9 : 1. On vessels where the winch drum cannot carry the necessary length of wire, one possible option is to consider using a smaller wire, thereby carrying an increased length on the same sized drum. The smaller diameter wire must be of adequate strength.

Considering the listed wire sizes and strengths below :

Wire Size mm	Min. Breaking loads for wire construction types (tonnes)		
	6 x 19	6 x 26	6 x 26 DYFORM
16	13.6	14	14.7
18	17.2	17.1	18.6
20	21.2	21.1	22.9
22	25.6	25.5	26.9
24	30.5	30.4	32.9

It can be seen that even a wire as small as 16mm diameter could be sufficient to handle the loads recorded on the trial. Obviously, it is necessary to have a large margin of extra strength in order to be able to cope with snags and general wear and tear. Even so, a wire of 20mm diameter should be adequate for the task and still give a working safety factor of 4 : 1. Indeed an 18mm wire could well be considered suitable.

It should be remembered that when changing the wire size, the winch guiding on gear should also be considered, as it may be necessary to change the drive ratio to the helix shaft, on those winches with automatic guiding on gear.

Although the winch loads are only modest, the winch needs to have sufficient power and speed to be able to achieve a reasonable hauling rate. When fishing depths down to 200 metres, the typical vessel will only be shooting around half of the warp off the winch drum and hence the winch is operating in approximately a mid drum range. As such, the winch will achieve a good proportion of its maximum pull and have a reasonably fast hauling rate. Working in deep water will require the full capacity of the winch drum to be used. This will necessitate increasing the layers of wire coils on the drum to the maximum permitted by the drum flanges and nearly all of the warp will have to be shot, working almost down to the drum core. Hence, the winch will be operating at the extremes of its range. When the drum is full, the pull will be low, but the hauling speed will be high. Conversely, when the drum is empty, the winch pull will be high, but the hauling speed will be very slow. With 2000 metres of wire to retrieve, it may prove to be quite time consuming.

The winches on the “MARANATHA III” have been sized to operate in a deep water fishery and thus they are not required to function at the extremes of their range. On other vessels, the winch performance may prove to be slow and the options of installing a larger hydraulic pump or a two speed motor on the winch drive system may have to be considered. The winch manufactures will be able to advise on such considerations and indeed, they should be consulted for advice before making any changes; including the size and quantity of warp on the winch drums, in view of possible increased 'bursting' pressures on the drum flanges.

If it is decided that new winches are justified, in order to have the capability of pursuing deep water fishing, then perhaps it is worthwhile to consider the concept of 'traction' winches with 'take-up' reels. This is an old idea, but one which has recently been revived by at least one winch manufacturer.

In essence, each traction winch consists of two powered drums which the warp is multi-layed around. A 'take-up' reel tensions the warp around the drums and retrieves it as the drums haul the warp in. It is very similar to a seine net winch with a rope reel, apart from having two hauling heads per side as opposed to one.

The advantages of this concept are as follows:

- Constant hauling speed (Unlike the conventional winch where the speed and pull vary as the level of wire on the drum changes).
- Constant pull.

- The take-up reels can be installed in virtually any location on the vessel, thereby saving space on deck and enabling the weight of the warp to be positioned low down in the vessel.
- The traction units are compact and can be located in the most effective position.
- Longer warp life as the wire is not crushed by high loads on a winch drum.

8.2 Post Harvest Care

8.2.1 Purpose

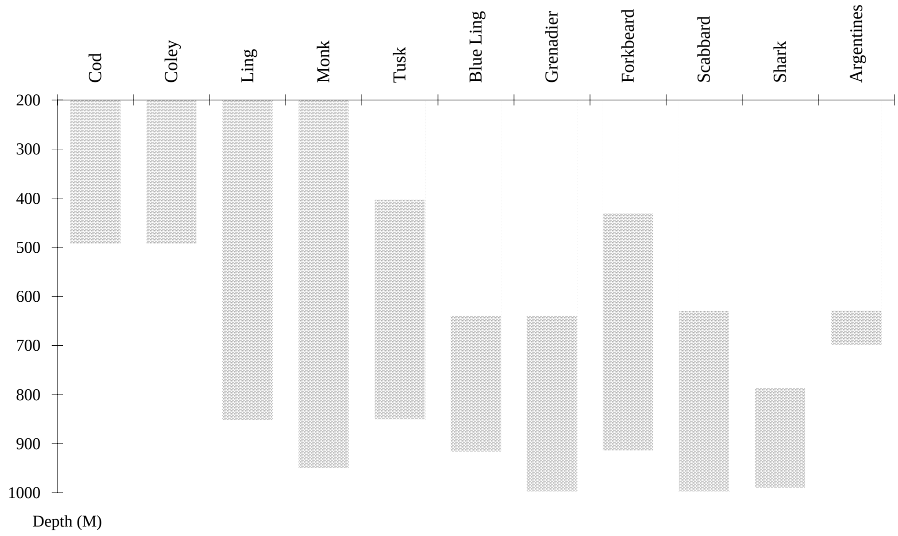
The principal objective of Fish Technology was to obtain deep water fish samples of known handling history and controlled icing for assessment in the laboratory of their storage on ice. Thereby, to provide comparisons with previous results obtained from fish landed from commercial trips. Additionally the aim was to obtain knowledge of how these unfamiliar fish handle in comparison to typical white fish.

8.2.2 Fishing Conditions and Pattern

The weather conditions were good to moderate with winds up to F7 and warmest ambient temperatures of about 20°C. Bottom sea water temperatures were about 7-8°C at the greater depths (data from fishing gear monitoring instrumentation). Sea surface temperatures were about 10-11°C.

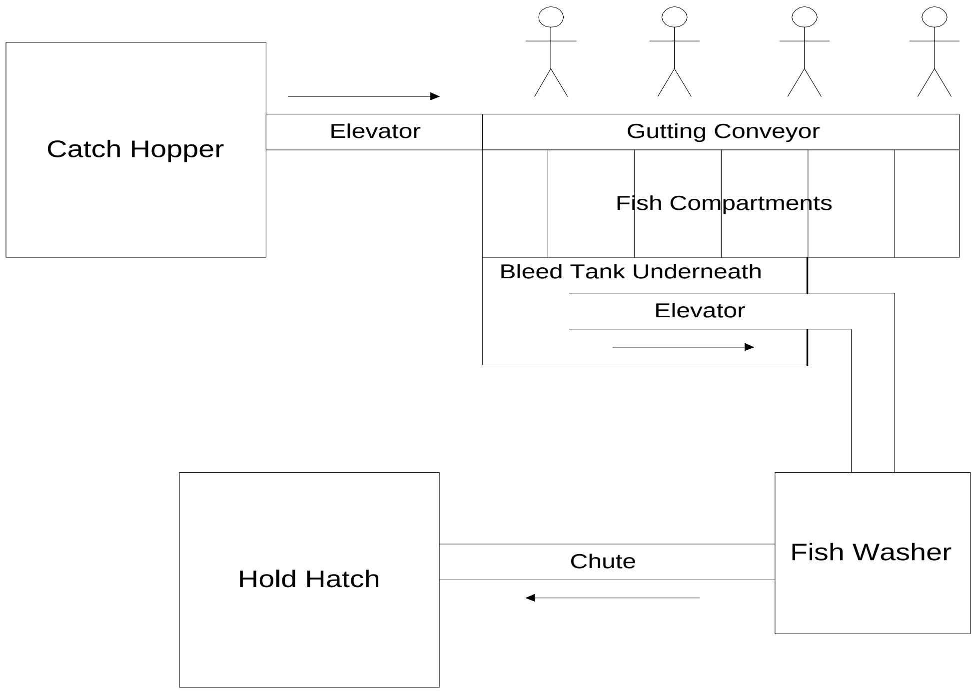
The depths fished were between 200 and 1000 metres, although most fishing was deeper than 400 metres and on mainly muddy (soft to medium firm) ground. Tows were normally 5-6 hours duration.

Figure 10 shows the depth ranges of the main species caught and kept for commercial sale. Below 800 metres the deep water types predominated. Rabbit fish, cardinal and moro appeared in small numbers. Orange roughy was not caught. The deepest tows yielded considerable proportions of the smooth head - a species which is not saleable because of its poor texture (See Section 8.2.4).


Cod
Coley
Ling
Monk
Tusk
Blue Ling
Grenadier
Forkbeard
Scabbard
Shark
Argentines
200
300
400
500
600
700
800
900
1000
Depth (M)

8.2.3 Fish Handling Characteristics.

The vessel has a fairly typical, partially mechanised, fish handling system shown schematically in Figure 11. A hopper is set into the forward shelter deck with a short elevator feed to hand gutting stations along the conveyor. The gutted fish were either directly fed into the bleeding tank or held separately in elevated compartments (to enable separate handling of species and/or grades). An elevator from the bleed tank feeds the batch fish washer. The washed fish is transferred by chute and vertical pipe into the fish room. The catch was either stowed in 660 litre containers or boxed and well iced.



Hauls with a predominance of deep water species tended to jam at the mouth of the elevator from the hopper. This was despite a water feed to the hopper. The sharks - up to about 1.5 metres long - had to be pulled directly out of the hopper via a side entrance. The jamming at the mouth of the elevator was relieved by pulling the blocking fish by hook onto the gutting conveyor. Periodically a crew member trod the fish down towards the mouth of the elevator.

Because of the difficulties experienced in handling grenadier and scabbard fish, including their gutting, they were taken off the gutting conveyor, placed into boxes and handled separately. Otherwise the blue ling, fork beard and tusk were handled as is usual for white fish.

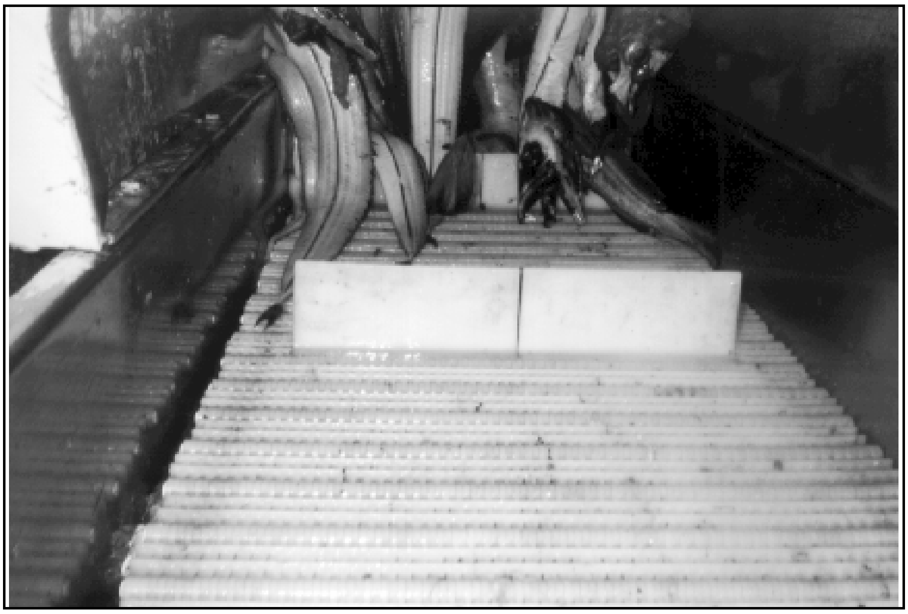


Table 3 overleaf summarises the main handling characteristics of the main commercial deep water species caught.

Species	Condition out of Cod end	Hazards to Handler	Mechanical Handling Characteristics	Gutting and Washing	Transfer a
Scabbard	Dead, most of outer black skin scrubbed off. No softening of flesh or body. Little or no feed in guts	Needle sharp teeth capable of cutting through gloves to flesh. Brittle dorsal fin rays can cause pricking.	They possibly contributed to jamming in the hopper. However only caught in small quantities. Slight tendency for tails to foul in gaps such as sides of conveyors	Awkward to gut conventionally because of long narrow gut cavity. Gut inversion into the mouth was quite common.	In practice to remain handling. scabbard straight in
Grenadier	Dead, most of rough scales scrubbed off body. Some fish showing spot bruising but with little softening of flesh. Some fish in roe. Little or no feed in guts	Slight	They appeared to contribute to the jamming in the hopper. The fish tended to stick in the chutes because of their leathery scales and long intertwining tails.	Somewhat awkward to cut guts out from back of head. Otherwise opening the belly was straight-forward. Gut inversion into the mouth was quite common. Appeared to wash well in the fish washer.	Apart from stick in the washer to fish handl tailed, the in 70L box
Blue Ling	Dead, skin slightly chafed but no softening to flesh.	None	Similar to typical round fish.	Similar to typical roundfish, some gut inversion.	Medium a too big for
Sharks.	Mostly live with little or no signs of codend damage.	Some species have dorsal spines like spur dogs. The jaws are powerful but not heavily toothed.	Their size and roughness of skin strongly contributed to jamming in the bottom of the hopper. Generally too large for whitefish conveyors etc.	Flat surface needed to lay fish on to gut. Belly opening and gut removal appeared to be straight forward. The sharks were too large for the washer and required hose washing to gut cavity and body.	Required degree of fish mostly the side h hopper. Fi 70L boxes
Fork beard and Moro	Dead. Most scales removed with some softening of the flesh immediately below skin.	None	As typical white fish.	Similar to typical white fish.	Similar to

8.2.4 Sensory changes during storage on ice

The following fish were subjected to sensory assessment during iced storage: Black scabbard, roundnose grenadier, blue ling, mora moro, argentine, cardinal, Portuguese shark, leafscale shark and rabbit fish.

Raw assessment of the whole fish and cooked assessment of fillets was undertaken over a storage period of 28 days after capture by people trained in sensory assessment of fish. The Torry scoring schemes for cod and other species were used as a guide. Apart from the sharks and rabbit fish the raw appearance and odour of the gills were found to be good indicators of freshness, as is usual for white fish. The condition of the eyes was also a reasonable indicator although there was more catch damage to the eyes than is usual in shallower water fishing.

Catch damage appeared to be generally superficial although some spot bruising to grenadier fillets and underskin softening of the flesh of forkbeards and moro was apparent. The eating qualities of roundnose grenadier, mora moro, forkbeard and blue ling were considered acceptable and suitable for substitution in recipes or products which currently utilize white fish. The blue ling was very similar to white ling. The scabbard has a fatty layer under the skin and has a delicate texture and interesting halibut and chicken-like flavours. The argentine and cardinal fish had flavours and textures combining both oily and white fish characteristics. The sharks and rabbit fish had bitter flavours from the start of iced storage. The smoothhead had flavours that were characteristic of white fish but was unacceptable because of its very sloppy texture. A summary of the main flavour changes during iced storage is shown in Figure 17.

Figure 17 - Cooked flavour changes for various species during iced storage

All species, except the sharks and rabbit fish followed the familiar 'fresh to off' pattern of flavour changes during storage on ice. The spoilage patterns of roundnose grenadier, mora moro, forkbeard and blue ling follow those of cod and similar white fish but with longer storage lives. The argentine and cardinal fish had similar flavour changes and spoilage characteristics to pelagic fatty fish. Black scabbard followed the white fish pattern but with some fatty fish characteristics on extended storage.

A few scabbard and grenadier were left ungutted for comparison. Although these were only limited trials, it appears that these fish may keep well on ice without being gutted. Generally there was little or no feed in the guts and this may be a factor. Some of the scabbard caught in the trials were subject to worms in the gut flap and these became apparent after landing and smoking. They would have been removed if filleted and trimmed but the fish were smoked whole and headless.

An overall feature of the deep water species was that they remained of merchantable quality (i.e. to a point before off flavours develop) for considerably longer than would be expected of the usual round white fish species, (Fig 17).

8.2.5 Fillet Yields

The deep water fish were filleted by experienced filleters to determine characteristics and yields. A summary of the yields obtained is given in Table 4. The yield from roundnose grenadier is lower than that obtained from cod (which is typically 43% of trimmed skinless fillet from head on, gutted cod). In addition, the scales are easily lost which could cause a possible product contamination problem, particularly in the production of laminated blocks. The black scabbard had a similar yield to cod but was more time consuming to fillet. The black belly lining of the scabbard is diffult to remove and can stain the fillet.

Table 4 - Hand filleting yields for grenadier, scabbard and blue ling

Species	Description	% Yields		
		Untrimmed Fillets	Trimmed Fillets	Skinned & Trimmed Fillets
Roundnose Grenadier *(Coryphhaenoides rupestris)*	Ex frozen head on, gutted and tailed	44.2	38.5	32.7
Black Scabbard *(Aphanopus carbo)*	Ex frozen head on, gutted	53.3	46.7	-
Blue Ling *(Molva dyptergia)*	Ex-frozen, head on and gutted	58.3	56.5	49.5

Machine processing trials by Baader have shown that the grenadier can be successfully processed on a Baader 212 (the Alaskan pollock filleting machine), though filleting the black scabbard was unsuccessful on both the Baader 197 and the Baader 212. Despite some difficulties in hand skinning, a correctly set skinning machine can give good results for scabbard and grenadier.

8.2.6 Discussion

The degree of catch damage to the deep water species was less than might have been expected. However, such damage may well vary with the quantity of the catch and towing depth/time.

These species can be more difficult to handle than most fish. Although typical mechanised fish handling systems may be readily modifiable to prevent the jamming and flow difficulties experienced, sharks would need different arrangements if caught in quantity.

Forkbeard, moro, blue ling and tusk handled similarly to typical whitefish whereas adjustments to normal gutting techniques are needed for species such as grenadier and scabbard. Landing ungutted might be a possible option for some species. Whether to head and/or tail would need to be decided against practicalities and market preferences. Some care will be needed by fishermen when handling certain deep water species to avoid injuring themselves.

Ling, scabbard and sharks are generally too long for 70L boxes.

The long storage lives of black scabbard, roundnose grenadier, mora moro, forkbeard and blue ling may provide a commercial advantage. There is a clear advantage over typical whitefish as they remained of merchantable quality for considerably longer than would be expected of the usual round white fish species. This should help with their marketing with more shelf life being passed onto the buyer thus opening up wider markets for these fish.

There appears to be a number of deep water species that can possibly be substituted in products for other traditional white fish species. The scabbard has a more delicate and interesting halibut and chicken-like flavour and whether fresh or hot smoked (Arbroath smokie style) it clearly is potentially more valuable.

All the deep water fish can be hand filleted but slightly different techniques are required for black scabbard and grenadier because of the differences in anatomy from the usual white fish. The yields from roundnose grenadier are lower than those obtained for cod, and the loose scales of the grenadier may result in product contamination. The black scabbard had similar yields to cod but the black belly lining of the scabbard is difficult to remove and makes filleting more time consuming. Machine processing of grenadier may be feasible.

8.3 Gear Assessment

The Gear Technology department sent one Gear Technologist to assist in taking various measurements and to glean as much information about the doors, ground rig and trawl being used for the exercise as possible.

8.3.1 The Fishing Gear and its Setup

The trawl used was constructed by the boat owners to their own specification (Fig.18) and was commonly used to fish for monk and consequently had too low a headline height to catch deep water species as effeciently as could be possible.

Morgére Super V doors were used in conjunction with a two bridle rig giving a distance of 90 fathoms between doors and wing ends. Sixty 8in and fourteen 11in deep water floats were used. The floats were guaranteed to depths of 1500m but failed frequently at depths of 800m to 1000m resulting in loss of headline height and increased door spread. Fig.19 gives the details of the trawl rig.

The Morgére doors were new to the vessel and consequently the first two or three days were used to set them up to fish at their optimum performance. However, due to time limitations this was never fully achieved. From advice given by other vessels the Morgére doors were set up using four backstrops. It was thought, that using the doors with two backstrops may have increased the doors efficiency, but again due to time this was never attempted.

8.3.2 Full Catch Details

Fig.20 gives haul-by-haul details with the various problems encountered throughout the trip.

8.3.3 Discussion

The most significant factor when fishing at these depths is the time taken to settle the gear onto the bottom (sometimes up to 30 minutes before the gear is properly settled). The paying out speed of the warp and vessel speed were also found to be critical and on occasion the operation was temporarily stopped to allow the gear to take up a more satisfactory geometry before completing shooting operations.

9. Conclusions

9.1 This practical engineering trial has shown that a vessel trawling in depths down to 1000 metres does not necessarily require a large increase in engine power. The observed increase in power from trawling in 200 metres of water, compared to that at 1000 metres of water was 100hp, an increase of approximately 15%.

It must be appreciated, however, that adverse weather conditions will require additional power and this must be taken into account.

9.2 Winch loads increased only slightly as a result of the effects of fishing in greater depths of water. Therefore, winch powers need not be significantly higher than that used when fishing in normal depths of 200 metres or so. However, the time taken to haul in the trawl may cause some skippers to wish to increase their winch power to accommodate a faster hauling rate.

9.3 The warp/depth ratio chosen is limited by the warp carried on the winches; but in practise, the necessary decrease in ratio eg. from 2.5 : 1 down to 1.7 : 1, as the depth increased, does result in a virtually constant angle of warp declination. Achieving this optimum declination, of approximately 30 degrees, minimises the increase in drag when fishing in deeper water.

9.4 The warp loads measured on the trials, showed only an increase of one tonne over normal depth fishing, it can, therefore, be concluded that the existing warps, carried by most vessels, will be quite adequate for deep water fishing.

9.5 The ability of a vessel to pursue deep water fishing is limited by:

1. Available engine power
2. Winch drum capacity
3. Vessel size

However, vessel power does not have to be large, a 15 % margin over that required to fish in 200 metres will be acceptable.

Winch capacity is perhaps the factor which will limit the ability of most vessels to fish down to 1000 metres and it may be that the use of a smaller diameter warp, of improved quality will have adequate strength, which will enable an existing winch to carry the necessary warp length.

An option, which can be considered, is to replace conventional winches with 'traction units' and storage reels. These traction units comprise twin powered drums which the wire is multi-layed around. These give high powered constant speed hauling with the wire being retrieved from the traction unit by a storage reel. The storage reel can be located virtually anywhere on the vessel, taking into account the limitations of the run of the wire.

Finally, it must always be appreciated that, although a vessel may have the winch capacity and the available horsepower to pursue deep water fishing, the vessel itself must be of a size and soundness of construction to be able to withstand the weather and tidal conditions which can prevail in this sea area.

9.6 Some modifications to the handling machinery and techniques would be necessary to handle deep water fish.

9.7 Deep water fish can be hand filleted but slightly different techniques are required for black scabbard and grenadier because of the differences in anatomy from usual white fish. Grenadier can be machine filleted.

9.8 Many deep water fish have good eating qualities and could be substituted for typical white fish in a range of products and some could be marketed in their own right.

9.9 Deepwater fish remained of merchantable quality for considerably longer than would be expected of the usual round white fish species.

10. Recommendations

10.1 The MARANATHA III trials have shown that trawling in the deep water fisheries does not demand large increases in power demands for either engine or winches. However, it must be appreciated that these conclusions are drawn from the results from one vessel fishing under the guidance of one skipper. A different vessel using different gears, trawling speeds and warp/depth ratios could give different results, to what degree any changes would effect power demands is not known. It would therefore be a useful exercise for data correlation purposes to conduct further trials onboard other vessels targeting deep water fisheries.

10.2 An in-depth assessment of more practical types of fishing gear is needed; evaluations of more flexible trawls giving a greater headline lift and also sustaining less damage, of semi-pelagic type trawls in conjunction with deep water doors, allowing the skipper an element of control over unknown grounds, the use of kites rather than floats to give extra headline lift, comparisons of different otterboards and rigging configurations, all areas for further consideration to allow vessels to achieve maximum performance from currently available gear.

11. References

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3. SCANROPE Fibre and Steel wire rope specification catalogue.

4. Development of guidelines for the packaging of chilled fish under modified atmosphere by J W Denton and A Mills. Seafish Internal Report No. 1399. 1990.

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Appendix I

Overall Orion Results - 200 metres

Appendix II

Overall Orion Results - 400 metres

Appendix III

Overall Orion Results - 650 metres

Appendix IV

Overall Orion Results - 830 metres

Appendix V

Overall Orion Results - 1000 metres

Appendix VI

Overall Scanmar Results - 200 - 1000 metres