Evaluation of Technical Conservation Measures in UK *Nephrops* Fisheries – New Trawl Designs

Seafish Report No: SR532

Author: Ken Arkley

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ABSTRACT

The work covered in this report is part of a three-year project aimed at reducing roundfish bycatches in UK Nephrops fisheries.

This final phase examines a technical measure aimed at avoiding the capture of the unwanted bycatch rather than the post capture release approach previously used in other TCMs. It involves the development of new prawn trawl designs in conjunction with commercial gear manufacturers, modelling and Flume Tank testing of scale models, followed by engineering performance trials at full scale with subsequent sea trials planned to evaluate the new designs under commercial fishing conditions.

CONTENTS

1 INTRODUCTION

In 1997/98 Seafish started a programme of work to investigate ways of improving whitefish selectivity through the more effective use of technical conservation measures.

Interest focussed on UK *Nephrops* fisheries, some of which are generally recognised as having significant discard problems. The resulting report entitled *A Review of Technical Conservation Measures in UK Nephrops Fisheries* (Seafish Report No. SR508) identified some technical options for further investigation.

The second stage of the programme was designed to examine the most promising of these options. The first to be investigated was the separator trawl. In 1998/99, gear engineering and commercial fishing trials were conducted using separator trawls on a range of vessels operating in the Irish Sea *Nephrops* fishery. This work is described in Seafish Report No. SR522, *Evaluation of by-catch reduction devices in UK Nephrops fisheries – The use of separator trawls in the Irish Sea.*

The latest exercise conducted under this programme has concentrated on a slightly different approach to the preceding work on by-catch reduction devices. Up to this stage, effort has been directed at developing ways and means of reducing discarding by releasing the unwanted by-catch after it has been caught. This has often raised questions about the ultimate survival of escapees. This latest work places the emphasis on avoiding the capture of unwanted by-catch in the first place, thus precluding the question of survival.

The aim of the project was to design a trawl with attributes that reduced the potential for catching certain finfish species, whilst at the same time maintaining *Nephrops* catching performance. In other words, making the gear design more species-specific.

The gear is aimed at those *Nephrops* fisheries in which the by-catch of species such as haddock and whiting is of no commercial value and is even seen as a nuisance factor.

The task of introducing new net designs, especially ones originating from the R&D sector as opposed to from commercial gear manufacturers, is always a difficult one. For this reason, this project was conducted in direct collaboration with established trawl designers/manufacturers. The credibility gained from this partnership would hopefully increase the prospects of commercial uptake of any successful designs resulting from this work.

The project relied heavily on trawl design work coupled with modelling and testing at the Authority's Flume Tank in Hull.

2 AIMS AND OBJECTIVES

As with all the work within this programme, the overall aim is to reduce the level of discarding and wastage. A significant part of the discarded catch from the *Nephrops* fishery is made up of non-target species. Some of this by-catch is unavoidable. However, there are some species of finfish which, because of their behaviour, could be avoided.

The technical measures developed to date all rely on releasing the unwanted elements of the catch once they have entered the net. The objective of this exercise was to determine ways of changing the design, construction and rigging of the *Nephrops* trawl so as to exclude the unwanted roundfish by-catch prior to it entering the net. This would have to be achieved in a commercially acceptable manner without any detrimental effect on the *Nephrops* catching capability of the gear.

To achieve this overall objective a number of aims were set as criteria for judging the outcome:

- To demonstrate, at model and full scale that the design features of traditional *Nephrops* trawls could be modified to avoid capture of certain by-catch species.
- To show that this could be achieved relatively simply and at low cost.
- To compare the dynamic characteristics and geometry of the modified designs with those of a standard net under a range of commercial fishing conditions.
- To compare the handling performance of the new designs with that of an unmodified net of similar dimensions.
- To compare the catching performance of the new designs with that of an unmodified net of comparable dimensions for both target (*Nephrops*) and by-catch species.
- To identify and quantify any commercial benefits of this technology, the most likely being a reduction in catch sorting time and an improvement in catch quality and hence value. There may even be savings in fuel consumption as a result of reductions in overall net drag.

In the process of redesigning the trawl to avoid roundfish capture, the aim was to at least maintain, if not improve, the *Nephrops* catching capabilities of the new designs. In this way, any short-term losses attributable to the loss of roundfish by-catch may be offset by improved *Nephrops* catches. If successful, the positive benefits would then be used to encourage commercial acceptance and uptake of the new designs.

3 MATERIALS AND METHODS

3.1 Approach

One of the most important elements of this project was the involvement of commercial fishing gear manufacturers in the trawl design process. It had been agreed in the early planning stages of this project, that any new trawl designs that emerged from this work would stand a much greater chance of commercial acceptability if they had the endorsement of reputable gear manufacturers.

With this in mind, two prominent Scottish gear designers/manufacturers were selected to collaborate on the project. J&W Stuart Ltd from Eyemouth and Scotnet UK Ltd from Fraserburgh both volunteered the benefit of their knowledge and services. Both companies have a wealth of experience in the design and manufacture of *Nephrops* trawls both in the UK and abroad.

Discussions were held with the gear manufacturers and Seafish gear technologists to establish the basic design criteria required for the new trawl designs. It was accepted that the final designs would have to satisfy a balance between trying to achieve optimum selectivity and commercial acceptability.

Once the design criteria had been established, it was a case of where possible, applying them to existing, traditional *Nephrops* trawl designs. The intention was to stay as close to the traditional basic design as the new design criteria would allow. The main areas of attention were:

- Headline height
- Wing length
- Removal of cover (square panel)
- Mesh size in the upper panels of the net, particularly the forepart.

Each gear manufacturer was asked to modify one of their established trawl designs to incorporate the design criteria as agreed through earlier consultations.

These designs were then scaled and built as models by Seafish gear technologists at the Flume Tank.

Following a series of tank tests and subsequent alterations, two promising designs, one from each manufacturer, were selected for building at full scale.

These full-scale trawls were then subjected to engineering performance trials in which all the relevant gear parameters were measured and compared to those of a standard *Nephrops* trawl of similar size. The measurements obtained from this exercise were compared to those obtained from the their respective scale models in the Flume Tank. This provided some limited model/full-scale correlation for the new designs.

The final stage of the evaluation process would be to test the new trawl designs under commercial fishing conditions. Comparative fishing trials would be required to assess the new trawl design's ability to catch *Nephrops* and to avoid the capture of certain round, finfish by-catch species such as haddock and whiting.

A more comprehensive model/full-scale correlation would be performed on completion of the full-scale sea trials. The intention would be to construct updated models of the final versions of the new designs. These would incorporate any changes resulting from the commercial usage of the new nets.

3.2 Net designs

The main aim of the exercise was to redesign the conventional prawn trawl, removing all the design features that result in the capture of round fish by-catch species such as haddock and whiting, without adversely affecting the prawn catching efficiency of the net.

Each manufacturer designed three versions of each net. Each version differed only in the overall length of the wings. Short, medium and long winged versions, in which each varied by approximately 5-6m were designed and built at model scale.

The bodies of both manufacturers' net designs were essentially the same. The principal differences were in the wing designs and the lengths of the crown or bosom sections.

Figure 1a: Scotnet design

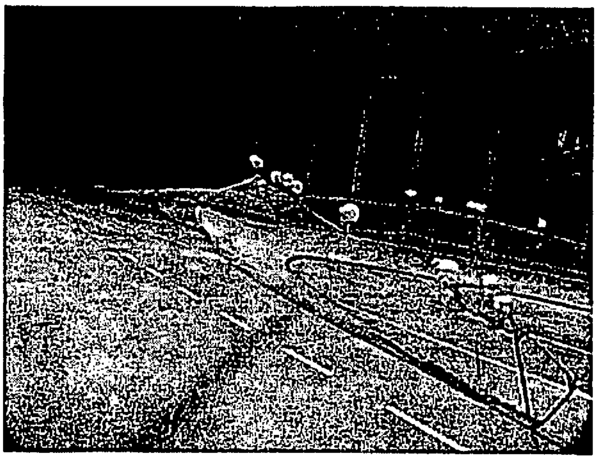


Figure 1b: Stuart Nets' design

In both manufacturers' designs the relative headline and footrope lengths were the same - approximately 28m (91ft) and 30m (100ft) for the Scotnet and Stuart Nets designs respectively. The bosom length in the Scotnet design (Figure 1a) was 3m (10ft) compared to 1.8m (6ft) in the Stuart net. (Figure 1b).

Mesh sizes in both designs were based on the legal minimum mesh size (MMS) for *Nephrops* i.e. 70mm. This mesh size was used for the construction of all the lower netting panels.

The upper panels in the forepart of the body of both designs were made in 200mm (nominal 8-inch) mesh. This is the largest mesh size that is currently readily available (Figure 2a).

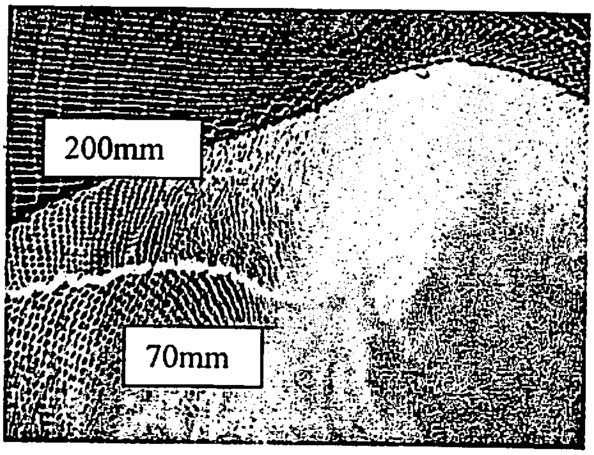


Figure 2a Showing variations in mesh size between top and bottom panels

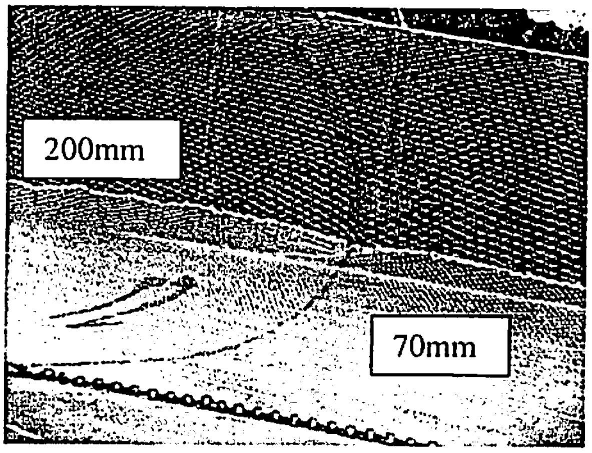


Figure 2b Showing variations in mesh size between top and bottom wings

The Stuart design had this same mesh size in the top wings. The wings in this design were rigged in the conventional manner with the meshes cut and set on the bar (Figure 2b).

The Scotnet design incorporated a single wing arrangement made in 115mm mesh attached to 70mm mesh in the lower shoulder and 200mm mesh in the upper shoulder sections (Figure 3). In this arrangement the meshes were cut and set on a sideknot on the fishing line and on a sideknot 6 bar cut on the headline. The result of this was that the meshes were more closed along the length of the wing but retained the scope for opening to maintain good ground contact. This is a less conventional way of rigging prawn trawls but has certain merits in this application.

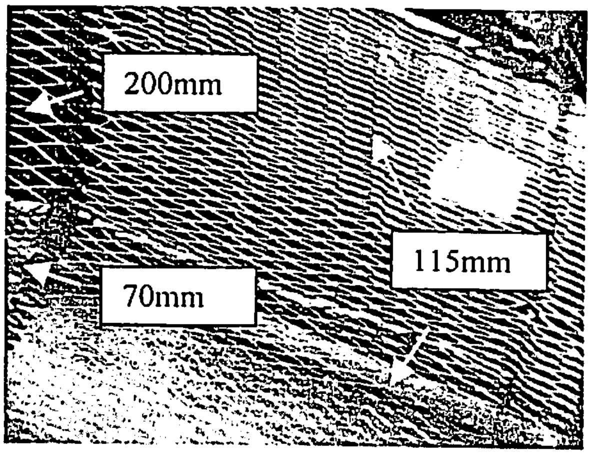


Figure 3 Showing single wing arrangement on Scotnet design

The wing-end arrangements on the two designs also differed. The Stuart net was rigged with a 609mm (24 ins) 'triangle' onto a straight-gabled wing-end (Figure 4a). This was in contrast to the Scotnet design, which had 'V' wings (Figure 4b).

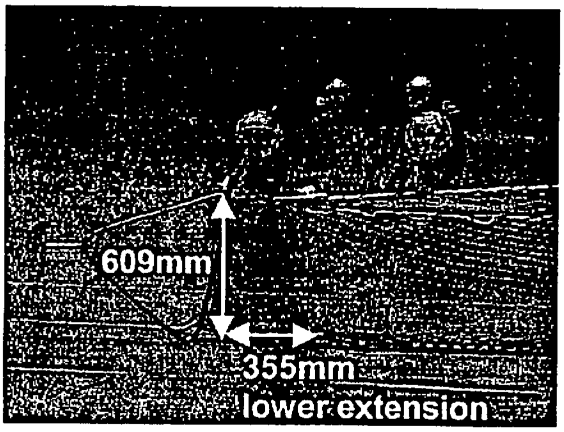


Figure 4a Stuart Nets wing-end

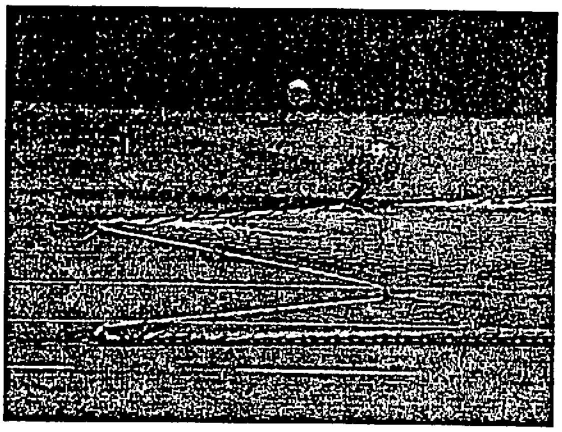


Figure 4b Scotnet wing-end arrangement

3.3 Flume tank tests

The net designs were modelled at a scale of 1:7 and tested in the Seafish Flume Tank over a range of conditions. Following these tests the models were refined prior to full-scale manufacture of the most promising designs.

During the Tank tests, preliminary observations were made of all three wing-lengths for each design. Following these tests, the decision was made to concentrate attention on the short wing versions. Since the main objective was to avoid round fish capture; it was felt that a limited herding effect would be more easily achieved with the shorter wing arrangements.

Initial tests were based on a predetermined spread, which produced the required footrope shape. The wing-end spreads achieved were equivalent to 35-40% of the headline length.

Warp:depth ratios were fixed at 3:1 and the main gear parameters were measured over a range of towing speeds equivalent to full scale speeds of between 1 and 1.75m/sec (2 and 3½ knots). The parameters measured included: headline height, wing-end spread and net drag.

The different wing-end designs used in the two nets required the use of different sweep/bridle arrangements. The overall lengths were kept constant, but the configurations were slightly different.

The Scotnet design with the 'V' wing was rigged with 9.1m (5 fathoms) split bridles, connected to 27.4m (15 fathoms) single sweeps by a 1.8m (1 fathom) length of chain. The Stuart net was rigged with 0.6m (24ins) 'triangles' at the wing-ends and connected to 27.4m (15 fathoms) of single sweep. A further 9.1m (5 fathoms) section of sweepline connected by a similar 1.8m (1 fathom) chain section made up the arrangement.

The pre-set spread, in combination with the sweep/bridle set-up produced bridle angles in the region of between 8° and 10°.

3.6 Instrumented performance trials

The aim of this exercise was to measure all the main gear parameters for correlation with the results obtained at model scale and to establish the best rigging arrangements to enable the new trawl designs to be fished, and evaluated under commercial conditions.

The parameters that were measured included:

Door spread	SCANMAR – Acoustic net monitoring system
Wing-end spread	
Headline height	
Trawl speed	
Bridle angle	Calculated
Warp tension	Load cells

The results have been summarised in Table 3 and presented in graphical format in Appendices I and II.

4 RESULTS

4.1 Flume tank tests

The initial observations of both net designs revealed one or two design faults. Both nets showed excessive strain lines emanating from the headline quarters. These strain lines followed the line of a bar. The simplest cure for this problem was to remove the area of netting bounded by the strain lines. This had the positive effect of increasing the open area above the fishing line and creating a much larger potential escape area for round fish swimming in the mouth of the net (Figure 5).

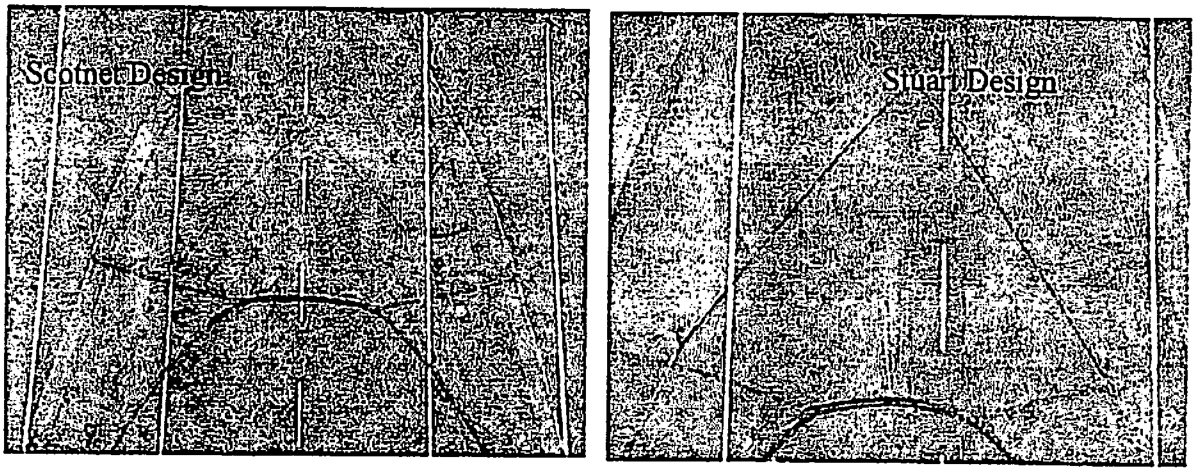


Figure 5 Showing area of netting cut away from the top panel to create greater potential escape area

It was noticeable from these tests that the large meshes in the top panels were wide open compared to those of the lower sheets (Figure 6).

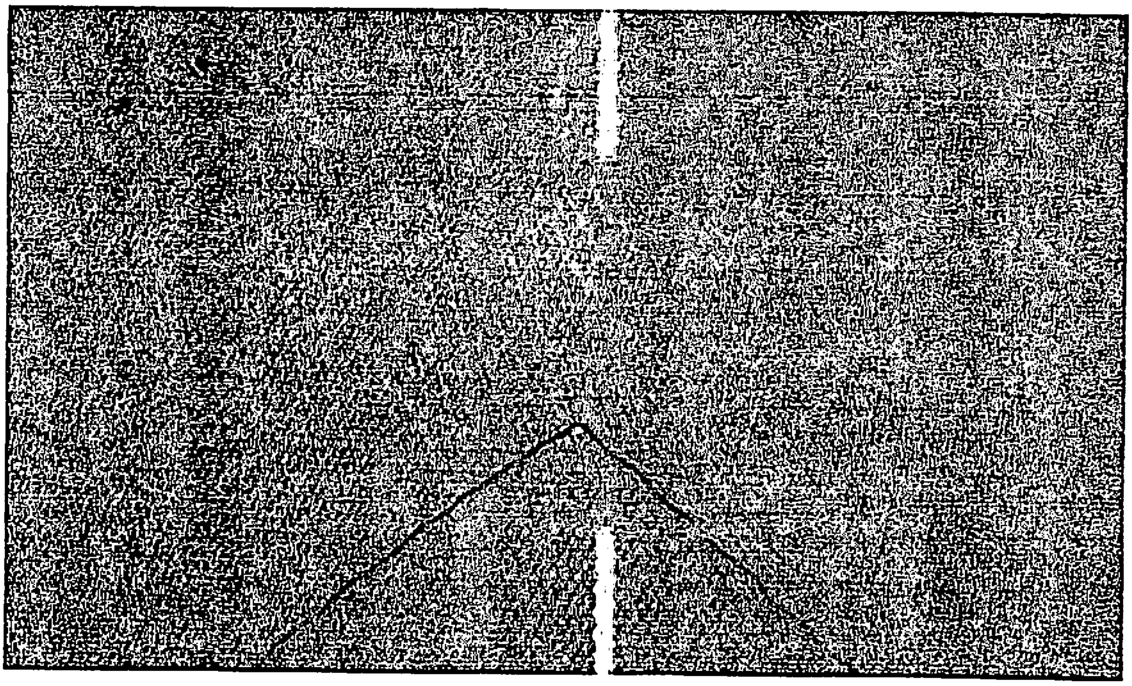


Figure 6 Showing wide open meshes in the top sheets of netting

This had the effect of shortening up the meshes in the top panels relative to the lower ones (Figure 7).

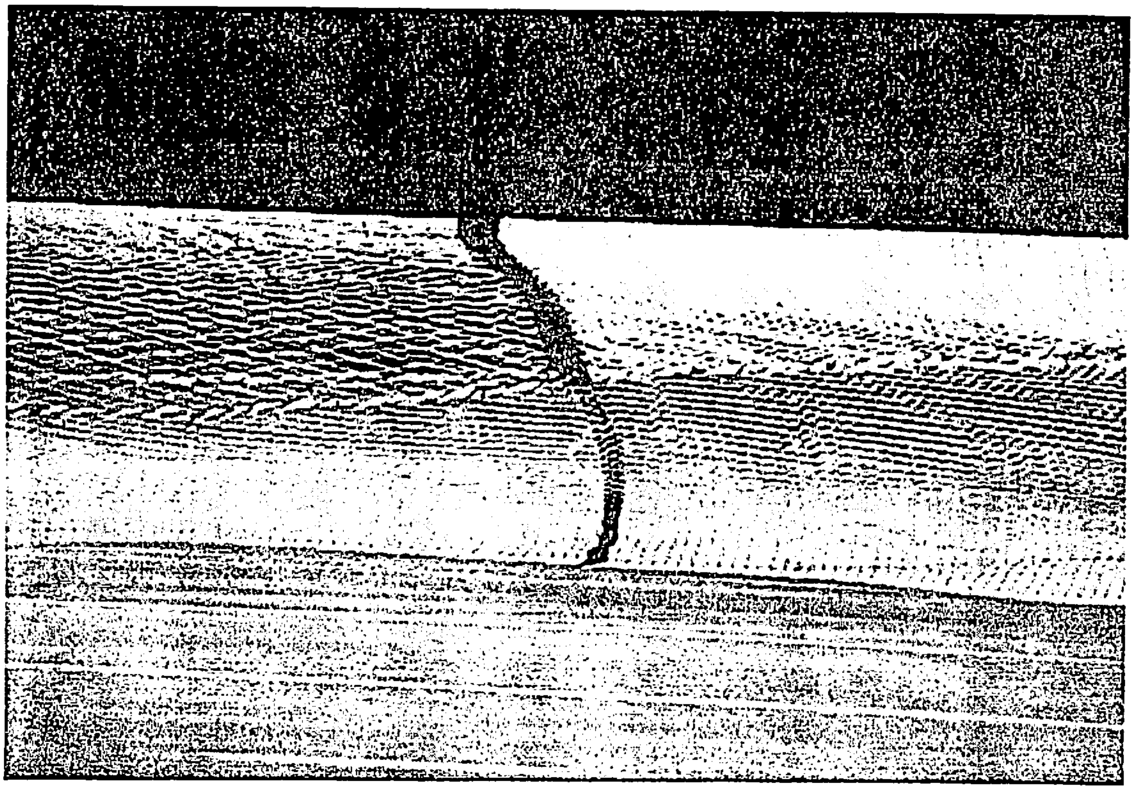


Figure 7 Showing tension created in the top panels as a result of the more open meshes

This contributed to the 'rippling' effect noticed in the belly section of the Scotnet trawl (Figure 8).

Figure 8 Showing 'rippling' effect created by differences in mesh opening between top and bottom panels

These open meshes, in conjunction with the increased open area above the fishing line produced as a result of the cutaway 'V' section at the back of the headline, created a much more open escape area for round fish rising in the mouth of the trawl (Figure 9).

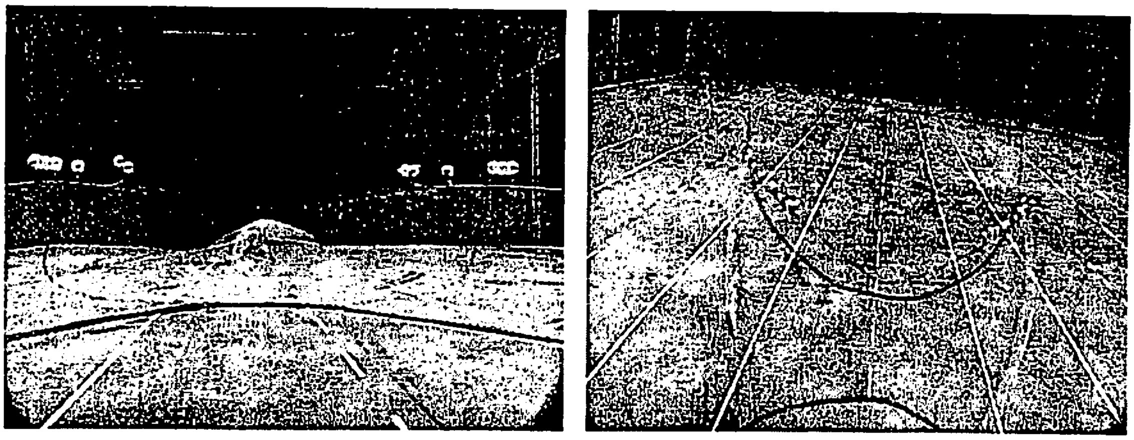


Figure 9 Showing open area in the mouth of the net

Following the tests using pre-set spreads; similar exercises were performed but this time with trawl doors included in the set-up. Based on experience and indications of drags from the preliminary trials, standard 'V' doors were selected for these rigs. The size chosen was equivalent to 1.7m (5.5ft) at full scale. Tests were conducted at speeds equivalent to 2.5 knots.

The Scotnet design achieved wing-end spreads of 9.75m (32ft) for a door spread of between 20.7 and 21.3m (68 and 70ft). Bridle angles were measured at 11°. The port and starboard loads averaged out at 286kg.

The same tests performed on the Stuart net produced the same door spread of 20.7m to 21.3m (68 to 70ft)) with a smaller wing-end spread of 8.5m (28ft). Loads averaged out at 317kg. The bridle angles were similar to those for the Scotnet trawl.

The Stuart net did not achieve the same wing-end spread for the same measured door spread when compared with the Scotnet design. It was noted that the 'triangle' arrangement on the wing-end of the Stuart net was lifting the sweep off the bottom for a considerable part of its length (approximately 14m).

Replacing the 'triangle' rig with 9.1m (5 fathoms) split bridles put the sweep line in better contact with the bottom. Wing-end spread increased, but only slightly, up to 9.1m (30ft). Some 'rippling' reappeared in the lower wing netting at about mid length. This was considered as an alternative rig for this net. The 9.1m (5 fathoms) split bridles were separated from the 27.4m (15 fathoms) single sweep by 1.8m (1 fathom) of chain to help maintain ground contact.

It was felt that the differences in wing-end spreads between the two net designs was more likely to be attributable to the differences in the wing designs and mesh size/twine diameter combinations.

The model scale gear parameters obtained in the Flume Tank tests are summarised in Tables 1 and 2 for the Stuart Nets design and the Scotnet design respectively.

Table 1

Flume tank tests – Stuart Net Design
(1:7 scale)

NET	Stuart – Short-wing version
Warp:Depth Ratio	3:1
Trawl Doors	Fixed spread – approx. 21.3m(70 ft)
Sweeps/Bridles	38.4m total – 27.4m singles + 9.1m splits +1.8m chain
Floatation	Equivalent to 16×200mm floats. Includes 1 on each triangle.
Comments: Triangles on wing-ends with floatation attached.	
Approx. 35cm extension required in lower wing-end.	
Spreads based on 35-40% of h/line length.	
Strain lines from h/line quarters running down on a bar.	
1.8m. chain between 9.1 and 27.4m sweep sections.	

Speed (knts)	**2.0**	**2.25**	**2.5**	**2.75**	**3.0**	**3.5**
Load Port (kg)	199		233	295	322	326
Load Stbd (kg)	158		206	261	285	353
Door Spread	≅ 21.3m (70ft)		21.3m	21.3m	21.3m	21.3m
Wing-end Spread	10.7m (35ft)		10.93m (35.87ft)	10.86m (35.64ft)	10.85m (35.6ft)	10.85m (35.6ft)
H/line Height	1.68m (5.5ft)		1.52m (5.0ft)	1.22m (4.0ft)	1.19m (3.9ft)	1.1m (3.6ft)

Comments: Door spread readings are actually sweep spread at end of sweep since no doors were used for these trials (fixed door spread).
Floatation increased from original setting to equivalent of 16×200mm floats to lift slack netting in lower wings clear of the bottom. At 2.5k all netting in wings clear of bottom. Some minor 'rippling' effect at about mid wing length.
Chain footrope equivalent to about 12mm mid-link chain at full scale.
Top sheet just taking strain – 1st joining round just pulling forward in top sheet. Triangles stood upright with the addition of float.
Towing speed increases do not significantly alter gear geometry.
Triangular shaped section of netting removed from panel at the back of the h/line, bounded by the strain lines coming from the quarters. Possibility of leaving small crown (30–60mm) at the apex of this cutaway to even out any points of strain that may result.

Table 2

Flume Tank Tests – Scotnet Design
(1:7 scale)

NET	Scotnet – Short wing version
Warp:depth Ratio	3:1
Trawl Doors	Fixed spread – approx. 21.3m(70 ft)
Sweeps/Bridles	38.4m total – 9.1m splits + 27.4m singles
Floatation	Equivalent of 9×8 inch floats

Comments: No extension in this rig.
1st joining round pulled forward in top sheet causing some 'rippling' in lower belly sheets.
Wings and shoulders well clear of bottom and standing up well.

Speed (knts)	**2.0**	**2.25**	**2.5**	**2.75**	**3.0**	**3.5**
Load Port (kg)	161		233	243	267	333
Load Stbd (kg)	151		216	247	270	333
Door Spread	21.3m (70ft)		21.3m	21.3m	21.3m	21.3m
Wing-end Spread	11.3m (37.0ft)		11.2m (36.75ft)	11.2m (36.75ft)	10.9m (35.72ft)	11.03m (36.2ft)
H/line Height	1.71m (4.5ft)		1.1m (3.6ft)	1.04m (3.4ft)	0.99m (3.25ft)	0.99m (3.25ft)

Comments: At 2.5k headline height lower than Stuart net.
Film taken at 2.5k.
Triangular shaped section of netting removed from back of h/line-corresponding to the area bounded by the strain lines developing away from the quarters. This produces much greater potential escape area for round fish.

4.2 Instrumented performance trials

4.2.1 Trials narrative

The instrumented gear trials took place in October 1999, onboard MFV *Coquet Herald*. The vessel was based in the Scottish West Coast port of Ullapool.

Operations commenced on Monday 4th October with Seafish personnel preparing the vessel's own gear for measurement. SCANMAR gear-mounted acoustic monitoring equipment was fitted to the vessel and gear.

Despite a very poor weather forecast, conditions did allow the vessel to get to sea for the first stage of the exercise. The gear was shot on fine ground in approximately 91m (50 fathoms) of water just outside of Ullapool.

The gear was towed for approximately 2.5 hours, in which time a series of average gear parameters were recorded. The tow resulted in between 6 and 8 baskets of 'bulk'. This consisted mainly of small fish and prawns. The skipper and crew confirmed this as being a fairly typical catch for that ground and that duration of tow. Unfortunately, no other vessels were in the immediate vicinity to allow any other catch comparisons to be made.

On the second day of the trials, the first of the new designs was measured. This was the design from Stuart Nets. The net was first rigged with 27.4m (15 fathoms) of single sweep between the net and the doors.

As the wing tips of this net were low, it was decided to mount the SCANMAR wing-end sensors at a point approximately 3m away from the wing-ends. This ensured that the sensors could produce reliable readings of the net spread without too much interference from the seabed. This resulted in two readings for wing-end spread being recorded, Scanmar and actual.

The first three-hour tow produced six baskets of bulk, approximately half of which consisted of prawns of mixed size. The rest was made up of bottom debris and fish.

The weight of fish was made up with two medium ling, three relatively large monkfish and some small haddock. Although the prawn catch compared well to that of a similar vessel operating in the area, the skipper commented that under the prevailing circumstances, he would have expected to have seen more round fish from a tow on that particular ground.

The Scanmar instrumentation indicated a consistent headline height of over 2.0m. This was greater than expected or desired.

Operations on the second day were concluded after the second tow was invalidated due to the gear becoming 'mudded-up' before any meaningful measurements were recorded.

The trials continued on day three with the Scotnet trawl. This net had the ground gear rigged in three, 9m (30ft) rubber leg sections. The two wing sections consisted of 50mm rubber discs on 16mm wire. The centre (bosom) section was made up of 150mm discs at 300mm spacing in the bunt area and 200mm spacing around the centre. Originally the net was rigged with 12 x 200mm floats on the headline.

The net design resulting from the Flume Tank trials incorporated a 'fish-tail' wing-end arrangement. However, the net manufacturer supplied the test net with an alternative refinement designed to restrict headline height. This consisted of a 'curtain-rail' type rig. The wingline was made from 11mm-longlink chain with the net hung on codend rings threaded onto the chains, 100mm rubber discs were used to separate the codend rings.

This gear was rigged to tow with 27.4m (15 fathoms) of 22mm combination sweeps with 1.8m (1 fathom) of 13mm short-link chain separating them from 27.4m (5 fathoms) combination split bridles, (16mm top legs and 18mm bottom legs).

On this third day the weather had improved sufficiently to allow the vessel to steam further offshore to operate amongst other vessels. The opportunity for longer, straighter tows allowed a better evaluation of net performance and the chance for comparisons of catching performance with other similar vessels.

A number of problems were encountered during this exercise. Initially the gear settled well indicating a door spread of 40m and a wing-end spread of 14.5m. This was comparable with the measurements obtained for the Stuart net, allowing for the extra 11.0m (6 fathoms) of bridle. However, when the engine speed was reduced to commence the instrumentation run, these spreads reduced to 30m and 12m respectively. The engine speed had to be increased to between 1450 and 1500 rpm to restore the original spreads. It was suspected that the net and/or the sweeps were 'digging in' to the soft ground.

When the net was hauled, the net end of the single sweep, the lower bridles, and approximately 6m of the wings on both sides of the net were covered in mud. The wing-line and around the headline toe also showed signs of 'mudding-up'. Although the sweeps, bridles, wing-ends and wings were in good contact with the bottom, the bosom sections showed little sign of having been on the bottom at all. Despite this, the three-hour tow produced three or four baskets of prawns in the cod end.

In an attempt to improve the bosom contact, the lower bridles were extended with 300mm of 16mm chain each side. The doors were also altered to try and reduce the overall spread of the gear.

The gear was towed for 2 hours maintaining a straight course to give the net as much chance as possible to show some evidence of ground contact. On hauling there was still no visible signs on the gear to indicate that the centre of the ground gear had been on the seabed. However, there were significant numbers of prawns and bottom fish in the cod end.

As the net was being hauled, a number of strain lines were evident. It could be seen that the strain on the netting was travelling down the line of a mesh bar from the headline toe to a point on the footrope approximately 3.5m from the lower wing-end. This first section of ground gear was quite slack, but beyond this point it was still as tight as before. It appeared that any benefit gained by the slacking back of the lower bridles was being lost due to the cut and hanging of the netting in the wings.

During the following days' trials further attempts were made to improve the performance of the Scotnet design, i.e. improve the net's ground contact. The wing-end arrangement was altered from the curtain rail style to a simple 'V-wing' configuration as per the original model design. The netting was cut on a bar from the top and bottom wing tips. This resulted in a wing-line length of about 1.8m top and bottom. It was hoped that this would allow the extension in the lower bridle to have more effect on the net.

As well as leaving in the lower bridle extension (300mm), 2x200mm floats were removed from each wing-end. This left a total of eight on the net. A 3.5m length of chain was added to the centre section of the bosom of the footrope to give it additional weight.

The vessel once again steamed to grounds further afield in an attempt to operate amongst other vessels in order to obtain some comparisons of performance.

On the initial tow the engine speed was increased to spread the trawl. This gave better gear parameter readings than at the lower end of the engine speed range. An excessive headline height of 2.4m was measured during the first part of the tow. This settled down to a more acceptable 1.8m. It was suspected that the netting was initially snagged in the region of the headline transducer causing anomalous readings. During the instrumentation runs the gear performed poorly at low speeds, particularly when towing against a freshening SSW wind. Once the towing speed was increased, the gear parameters improved. The tow was cut short when the trawl 'came fast' on the seabed.

The trawl was changed for the Stuart net for the next day of trials. The net was shot using the same length of bridles as used with the Scotnet trawl on the previous day, i.e. 27.4m single sweeps plus 1.8m chain plus 9m split bridles.

On the first tow there was too much warp out for the depth of water, considering the weight of bridles and the soft muddy seabed. As soon as the depth decreased, the gear 'came fast'. The gear was hauled and shot away again. The vessel performed two runs, one run towing east, then turning back west before hauling alongside another vessel, the *Brighter Morn*. The *Brighter Morn*, which is a similar sized boat, had towed the same grounds for four hours to catch 7-8 baskets of mixed prawns and fish. In comparison, the charter vessel produced about 3-4 baskets of prawns and a few small fish for only two hour's towing. The net showed plenty of signs of having been in good contact with the seabed, with mud, weed and starfish etc. throughout the lower part of the wings and belly sections.

Throughout the course of the week's trials the Scanmar readings were indicating that the wing-end spread was approximately 60% of the footrope length. This was greater than required. The towing point of the doors was altered to try to decrease the spread slightly. This was not very successful. Although some reduction in door spread was achieved, the Scanmar readings were much more variable, particularly at low engine speeds. It was not until engine speeds were above 1400 rpm that acceptable readings were achieved. It appeared that the doors were unstable at lower speeds when rigged on this setting. The average door spread was reduced by several metres but this made no noticeable difference to the catch on the short tows.

On the final day of trials, a last attempt was made to improve the ground contact of the Scotnet design. Two additional lengths of chain were wrapped around the ground gear. These were put across the bosom and two metres out along each bunt. The centre section of the net was now excessively heavy for this size of gear. At each end of the chains, approximately 300mm were left hanging. These were used as indicators of bottom contact. The floatation was also reduced to three, 200mm floats down each wing, plus one either side of the Scanmar sensor in the centre of the headline.

Shortly after shooting the trawl 'came fast'. The gear was hauled without sustaining any damage. The net was shot again and towed for three hours without incident. Similar gear parameters to those achieved on previous tows earlier in the week were recorded. The problem of light bottom contact still remained. Despite this there was still a good haul of prawns for the short tow.

At this stage it was accepted that this net would require closer attention in order to establish a solution to the problem of bottom contact. No further tests were carried out at this stage. The gear parameter measurements obtained during the instrumented gear trials are summarised in Table 3, with more detailed information contained in Appendix II.

Table 3

Average daily results

Day/ Date	Net	Bridles		Floats	Door spread	Wingend spread		Headline height	Bridle angle	Warp load
		single	double			Scanmar	actual			
Mon 4th	Scotnet disc net	-	27.4m		27m	10m	10m	2.2m	18°	1.4 T
Tue 5th	Stuart	27.4m	0	15 x 200mm	35m	14.5m	18.1m	2.2m	19.6°	1.35 T
Wed 6th	Scotnet	27.4m	9.1m	12 x 200mm	42m	15m	18.75m	1.8m	20°	1.38 T
Thur 7th	Scotnet	27.4m	9.1m	12 x 200mm	42m	15m	18.75m	1.8m	20°	1.38 T
Fri 8th	Stuart	36.6m	0	8 x 200 mm	42m	16.5m	20.6m	Nil	18.75°	1.4 T
	Stuart	36.6m	0	8 x 200 mm	Ave 37m	14m	17.5m	1.8m	16.8°	
Sat 9th	Scotnet	27.4m	9.1m	8 x 200 mm	44m	16m	20m	1.8m	18.75°	1.36 T

Note: Scanmar wing-end spreads are readings taken 3m from wing-end.

Shortly after returning from these trials, the Scotnet design was examined by Seafish gear technologists in conjunction with the net's designer. Some minor modifications were agreed and carried out in preparation for further instrumented trials. This involved resetting the lower wing netting onto the fishing lines.

5 DISCUSSION

The modelling and Flume Tank tests demonstrated that the design features of traditional *Nephrops* trawls could be modified relatively easily to remove those design features that contribute to the gear's roundfish catching capabilities. The potential herding area of the overall gear was reduced by a combination of reduction in sweep lengths, wing lengths, headline height and removal of cover netting. This was all achieved relatively simply with uncomplicated design and rigging changes.

Similarly, the engineering trials with full-scale versions of the modified gear established that the required gear parameters could also be achieved.

The instrumentation trials highlighted differences in the spreads achievable with these new modified designs. The Tank tests were predominantly conducted using fixed door spreads based on expected footrope spreads of 30-40% of headline length. The full-scale trial however, produced wing-end spreads considerably in excess of what was initially expected. This was mainly due to an oversight on the part of those involved at the design stage.

Traditional net designs are based on the fact that the headline is shorter than the footrope. This effectively constrains the spread of the wings of the trawl. With these new designs the headlines and footropes were initially of equal length. Cutting back the top panels increased the headline lengths relative to the footrope even further. The cutaway arrangement increased the headline lengths by 3m (10ft) for the Scotnet design and by 4.6m (15ft) for the Stuart Nets design. The overall result of these changes was to allow the trawl to spread much wider than traditional designs. It is therefore unrealistic to rely too heavily on the model/full-scale comparisons of spread. More realistic correlations will be sought following the completion of the commercial evaluations and the construction of new models of the final designs.

Since the headline height of the net is influenced by the spread, then there is the additional benefit that the increased spread is helping to constrain the headline height. This was one of the new design criteria.

It was also demonstrated that the modifications could be achieved at low cost. Essentially, most of the changes have resulted in the reduction in the amount of materials used in the construction of these gear designs compared to traditional nets of a similar size. The indications are that there are also potential benefits to be gained from the reduction in gear drag in the form of reduced fuel costs. However, insufficient data are available at this stage to confirm this.

Most of the questions appertaining to the performance of these trawl designs, in respect to their acceptance as an effective means of reducing discards, can only be answered after commercial evaluations. Similarly, the identification and quantification of commercial benefits of the technology can only be ascertained on completion of sea trials under representative conditions. Benefits such as reduced catch sorting times and improvements in catch quality have been demonstrated as being achievable with other technical conservation measures that separate catch from by-catch and therefore it is reasonable to assume that similar benefits can be achieved here.

In this respect, the results from the first stages of this work are limited and incomplete. It is not therefore possible to draw many definitive conclusions at this stage.

Unfortunately, insufficient time was available to complete the evaluation process during this round of trials. Due to the problems encountered with the Scotnet design, only one of the two prototype trawls was at the stage where it was ready to undergo evaluation under commercial fishing conditions.

A combination of poor fishing and weather conditions during the time allocated to conduct the commercial fishing trials meant that this project could not be completed during the 1999/2000-work programme.

It is expected that the remaining trials will take place at appropriate times during the year 2000/01. Commercial fishing trials will be based on two *Nephrops* fisheries, one on the NE coast of England and the other on the West Coast of Scotland.

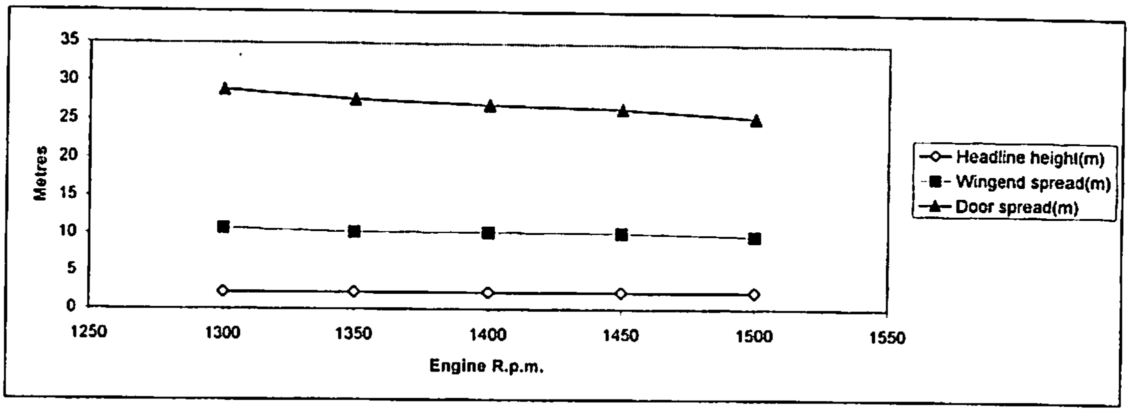
6 FURTHER WORK

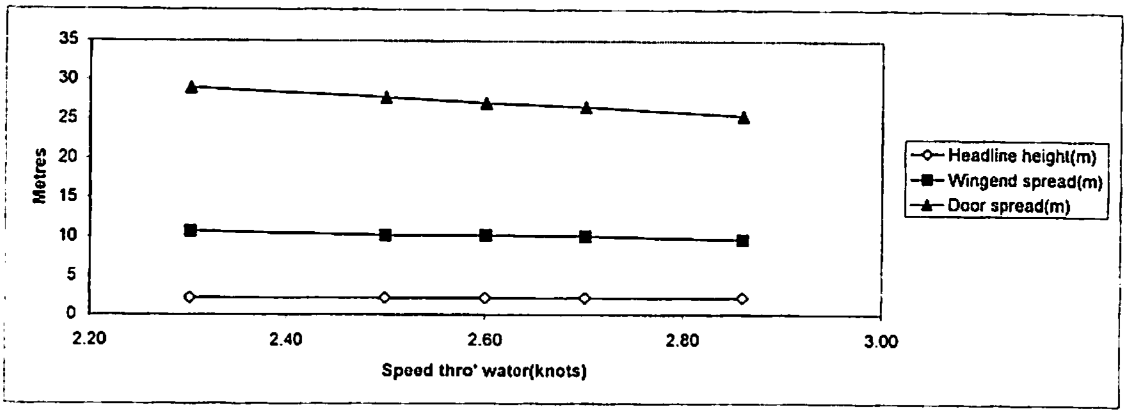
As indicated above, a further series of trials is scheduled to evaluate these two nets under commercial fishing conditions.

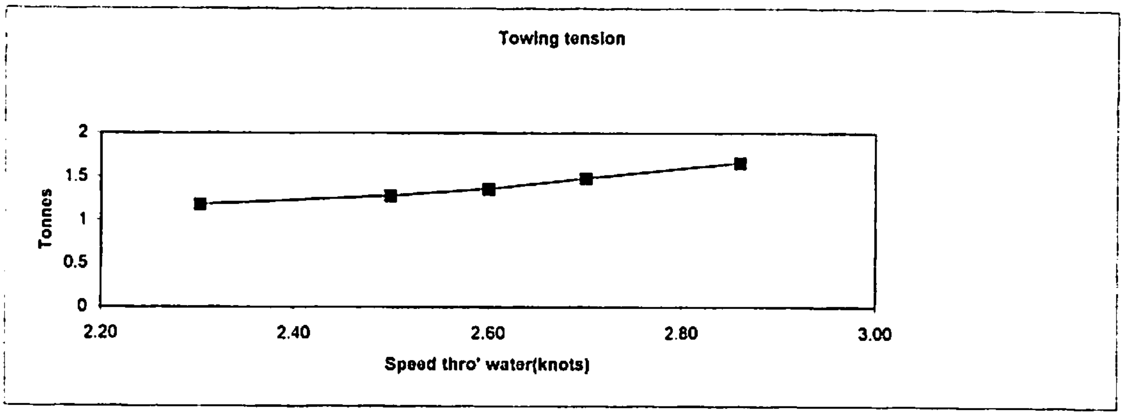
APPENDIX I

Gear parameters for standard net onboard *MFV Coquet Herald* (LH 94)

APPENDIX I GEAR PARAMETERS FOR STANDARD NET ONBOARD M.F.V. COQUET HERALD LH 94







Summary Table

Speed thro' water(kts)	ENGINE R .P.M.	Headline height(m)	Wingend spread(m)	Door spread(m)	Towing tension(tonnes)
2.30	1300	2.2	10.7	28.9	1.18
2.50	1350	2.2	10.2	27.7	1.28
2.60	1400	2.2	10.2	27	1.36
2.70	1450	2.2	10.1	26.5	1.48
2.86	1500	2.2	9.7	25.4	1.66

APPENDIX II

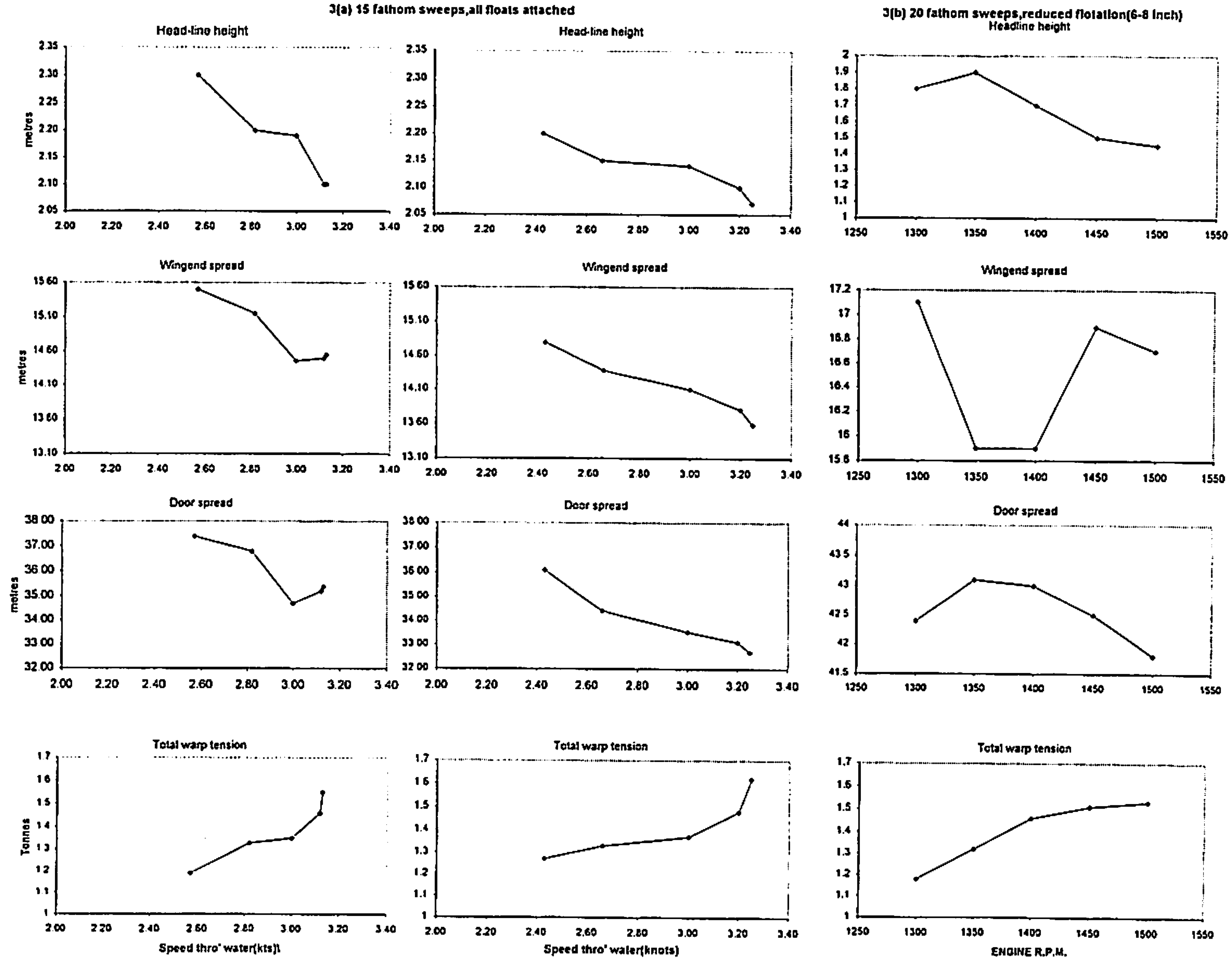
Gear parameters for Stuart Nets – prototype new prawn trawl design – *MFV Coquet Herald* (LH 94)

Appendix II(a): 15 fathom sweeps, all floats attached

Appendix II(b): 20 fathom sweeps, reduced flotation (6-8 inch floats)

APPENDIX II

GEAR PARAMETERS FOR STUART NETS-PROTOTYPE NEW PRAWN TRAWL DESIGN. M.F.V. COQUET HERALD LH94



Ullapool October 1999(RSH/MM)