EAR HANGING TRIALS FOR THE SCALLOP *PECTEN MAXIMUS*

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Internal Report No.1304

February, 1987

ABSTRACT

This report outlines a series of trials to assess the technique of ear hanging as a method for the cultivation of the scallop *Pecten maximus*.

Various systems were used, including stainless steel wire, nylon 'swiftatchments' and 'securaties' on one and two year old stock. Growth and survival was good in all cases, giving an excellent meat yield in these which have reached a commercial size. Some losses were incurred because of abrasion either on the shell or the tag, but it is thought that these would be reduced with experience and further development.

Ear hanging trials for the scallop *Pecten maximus*

Introduction

'Ear hanging' is the term used for a specific type of cultivation system for the great or king scallop *Pecten maximus*. The method involves the hanging of the scallop onto a line by means of a nylon or wire tag passed through a small hole drilled in the ear of the scallop shell.

This allows the shell to hang unhindered by any type of enclosing net which would reduce the water flow and food supply to the scallop. It is a low cost technique, requiring little capital outlay.

This report gives the results of a series of trials carried out at the Marine Farming Unit, Ardtoe to assess the suitability of the method for commercial scallop farming in the UK.

Materials and Methods

Experimental ear hanging lines were set up in 1984 and 1985 using one and two year old cultivated scallops. These were drilled through the left ear using a bench mounted drill fitted with standard 2mm high speed twist drills.

The hole should not be too close to the edge of the shell and a position around 2mm in is probably best, which would avoid as much damage to the soft tissues as possible (Fig.1).

The following tags were tested (see appendix for suppliers)

1. 1.5mm stainless steel wire.
2. Anchor tags - 40mm nylon 'extra strong' swiftachments.
3. Anchor tags - 60mm " " " "
4. Securatie fasteners

The anchor tag swiftachments are inserted through the drilled hole and the twine by means of a gun fitted with a hollow needle.

Braided twine must be used to prevent the scallop slipping down the lay of the rope. The twine can be prepared with the wire or securatie fasteners in advance of drilling the scallops.

The scallops were attached in pairs, back to back, 10cm. apart or on alternating sides of the twine, to allow sufficient space for growth (Fig.2). The lines were hung from standard scallop cultivation longlines at Loch Cean Traigh and lifted at suitable intervals for counting and measuring, taking note of mortalities and missing shells. Control comparisons were made with scallops grown in lantern nets under normal husbandry conditions.

Results and Discussion

Table 1 gives the growth and survival results for 3 year classes of scallop grown on by the technique of ear hanging. Their growth is shown in Fig.3.

The 1982 stock, which were all on stainless steel wire showed excellent growth and meat yield, significantly greater than the control and shucked out at 19 meats/lb. at $3^1/2$ years, increasing to 12.5 meats/lb. at $4^1/2$ years old.

Losses of scallops were however quite high, ranging between 22% and 27%. Nearly all of these were due to the shell breaking at the drilling point, possibly as a result of wear caused by the wire. A good proportion of these losses may have been avoided by drilling further in from the edge of the shell and could probably be reduced with practice.

Mortality on the line sampled at $3^1/2$ years was 9% increasing to 20% after $4^1/2$ years, lower than would be expected from lantern nets over this period, although no direct comparisons were made during this part of the trial.

The 1985 trial with one year and two year old scallops was carried out using nylon (extra strong) "swiftatchments" anchor tags and securaties which were expected to have a less abrasive effect on the shell and thus reduce losses. However it was found that in some cases the shell was too abrasive for the nylon and losses were incurred by the tags wearing through. The long tags also were found to tangle and wrap around the twine which could also be a problem. The securaties were the most successful with only one loss. Mortality was also lower in these trials when compared to the lantern net control.

Growth once again was greater than in the lantern net control. This faster growth rate by ear hanging is probably a result of the scallops not being enclosed as with lantern nets which reduce the flow of water to the scallops. The attachment of the shells may also reduce the effects of agitation and shell interlocking which may happen in lantern nets with free scallops.

It appears from these results that ear hanging may be a suitable technique for growing scallops in hanging culture which does not require the high capital outlay of lantern nets.

The swiftachment anchor tags cost £7.70 per 5000 and gun £16.75. The securaties are slightly more expensive at £25.95 per 5000. The main expense would be labour for drilling and attaching the shells, but two people should be able to drill around 2000 shells/day.

Scallop shells in hanging culture always become fouled. Shells put out by ear hanging, because they are not handled again, can become very heavily fouled. This should not usually be a problem to the animal, unless the fouling grows over the shell edge, but it does increase the flotation requirement for the longline so care is required to ensure this husbandry aspect is maintained. If the fouling does become too severe it can be easily removed with a knife. This is usually carried out at harvest anyway but does not affect the value of the scallop in terms of processsed meat.

Conclusions

The initial results from the ear hanging trials for *Pecten maximus* have shown the technique to work well using stainless steel wire, nylon tags and securatie fasteners. Losses will occur from each type of attachment, but these may be reduced with careful drilling and handling.

Ear hanging is labour intensive initially, but once the animals are attached, further handling other than routine flotation checks is unnecessary until harvest.

The technique required little capital and is possibly well suited to a small scale or part-time shellfish farming operation.

Appendix 1

Anchor tags and securatie fastners can be obtained from:

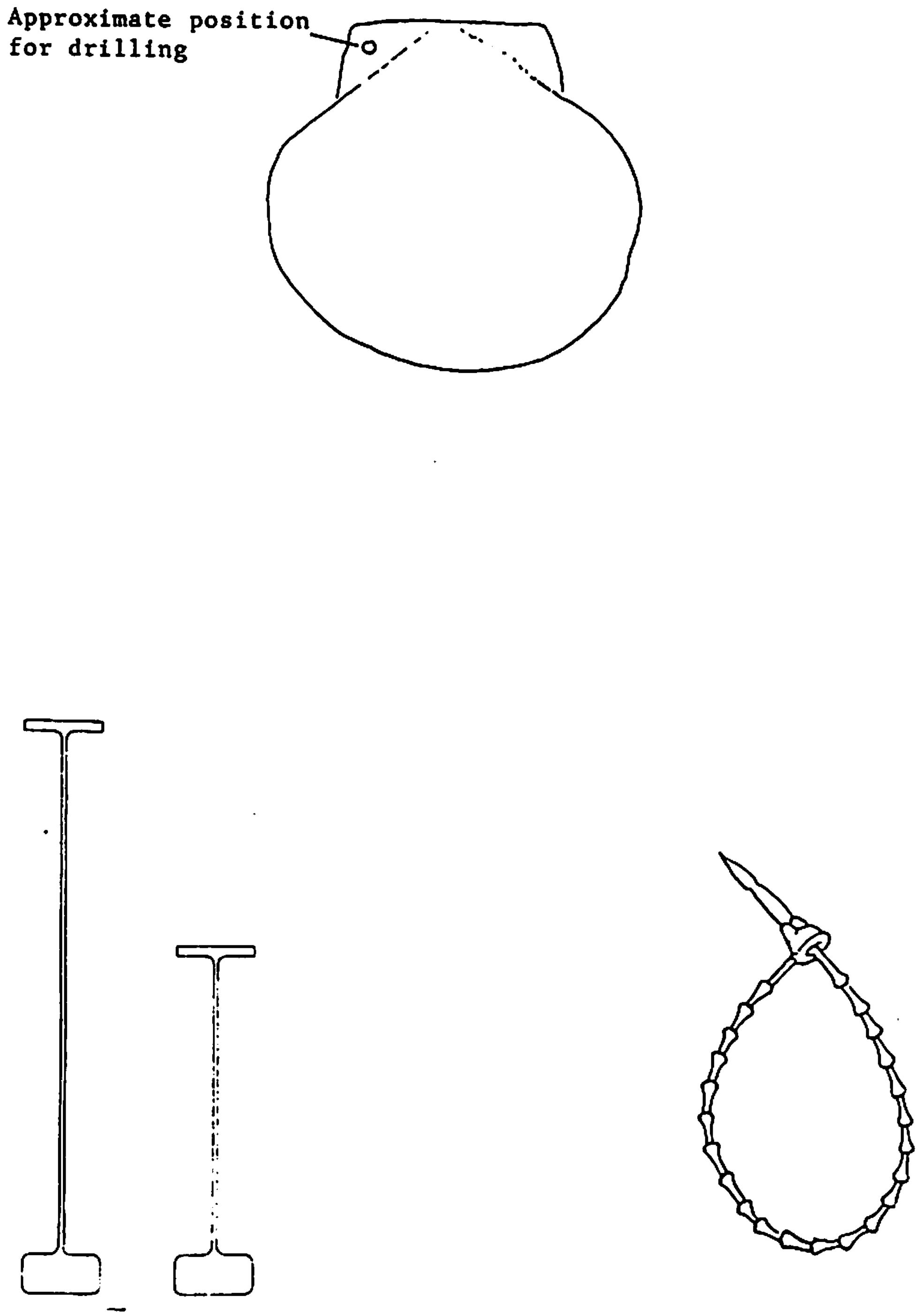
Anchor Tags Co.,
Ashworth House
42 Beddington Lane,
Croydon, Surrey CRO 4TB.

Alex Reid Co. Ltd.,
421 Hillington Road,
Glasgow G52 5BL.

Stock	Sample date	Total sampled	No. dead	%	No. missing	%	Overall survival %	Shell height	Meats/lb
1982	14.10.85	372	45	12	82	22	66	86.66	
St.steel	28. 7.86	88	8	9.1	21	23	69	93.9	19
	12. 1.87	88	18	20.4	24	27	55	99.1	12.5
1983	22.1.87								
65mm ties		26	-		19*	73	27	94.2	
45mm ties		27	5	18.5	1	3	78.5	90.9	
Securaties		26	3	11.5	-	-	88.5	93.6	
Control (lantern)		66	20	30.3	-	-	69.7	86.7	
1984	22.1.87								
65mm ties		46	11	23.9	5	10.8	65.3	66.6	
45mm ties		47	3	6.0	11	23.4	70.6	64.1	
Securaties		50	2	4.0	1	2.0	94.0	69.8	
Control (lantern)		177	47	26.5	-	-	73.5	62.9	

* Larger numbers missing than expected because of line fouled by lifting grapnell during sampling.

Table 1 Growth and survival data for ear hanging trials using the various techniques for 1982, 1983 and 1984 stock



Anchor tag swiftachments

Securatie fastener

Fig.1 Position for drilling shells for ear hanging.
Detail of Anchor tag swiftachments and securatie fastener

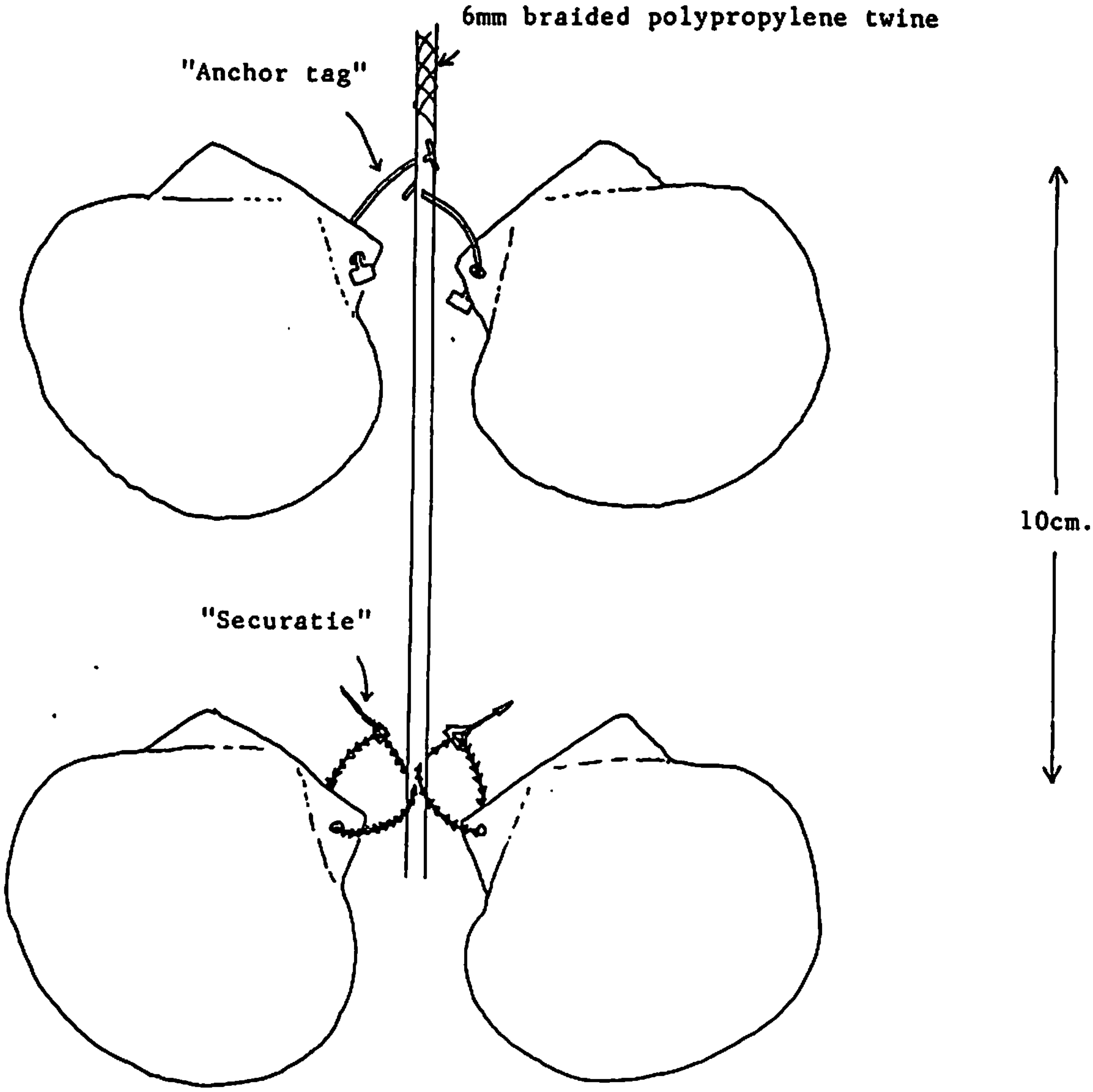
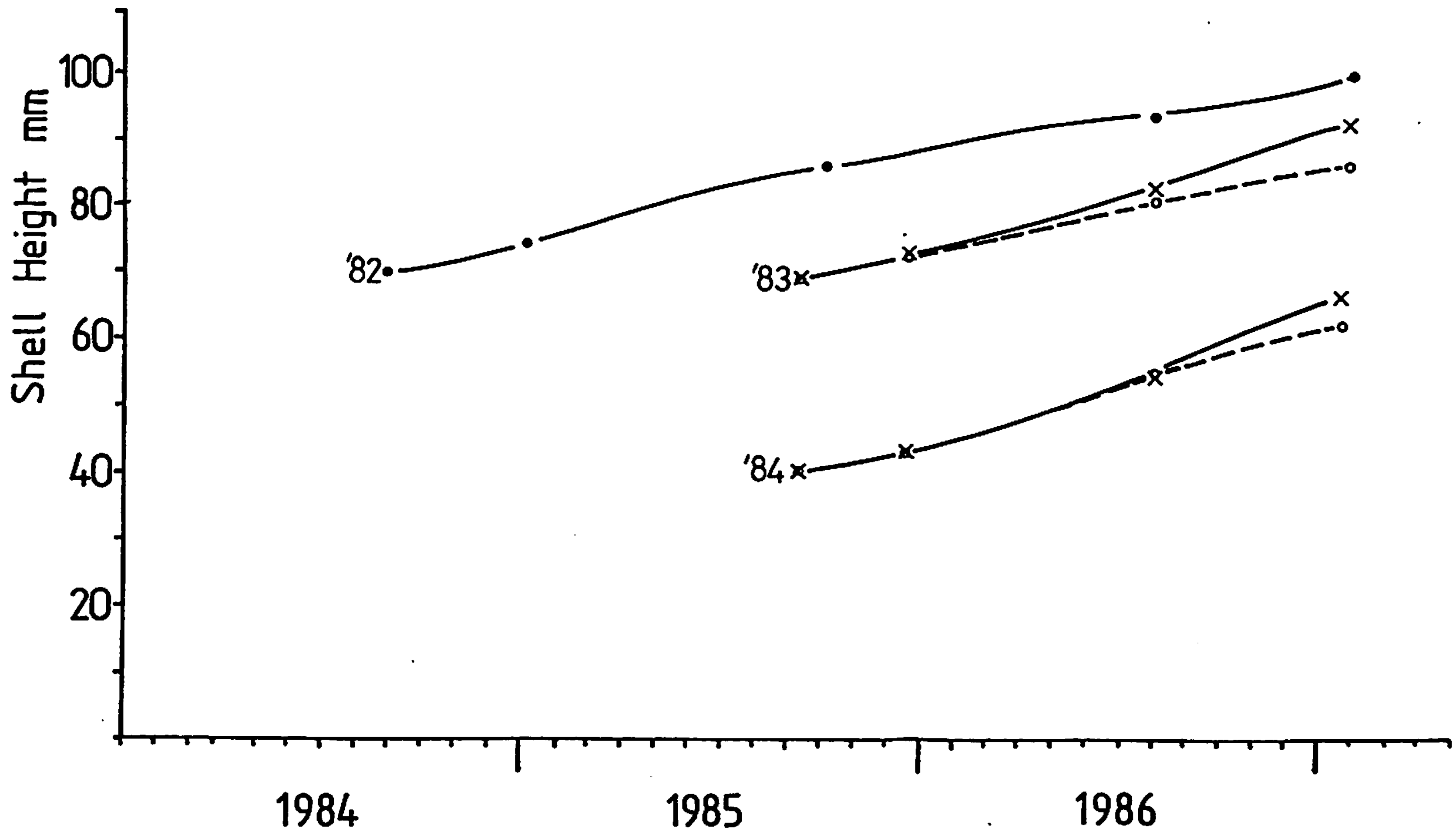


Fig.2 Detail of ear hanging arrangement



<u>Fig.3</u> Growth of the different year classes of scallops cultivated by ear hanging
The dash line indicates the growth of lantern net control scallops

SEA FISH INDUSTRY AUTHORITY

Industrial Development Unit

INVESTIGATION INTO ELECTROMAGNETIC PROBLEMS ON MFV GRADLEY

Internal Report No. 1311

April 1987

K. Hairsine

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INVESTIGATION INTO ELECTROMAGNETIC PROBLEMS ON MFV GRADLEY

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INVESTIGATION INTO ELECTROMAGNETIC PROBLEMS ON MFV GRADLEY

SUMMARY

This report covers an electromagnetic emission survey of the MFV GRADLEY, Hayle, Cornwall.

The electromagnetic interference is generated by some of the microprocessor based equipment in the wheelhouse, which form part of the GRADLEY electronic package. The effect of this interference is to render inoperative several channels of the VHF radio installation.

The main body of the report is a consultancy document prepared by the University of York Electronics Centre, who were employed by the Authority to identify the conducting medium for the interference.

The remainder of the report gives details of the work prior to the consultancy and recommendations on the findings of the survey.

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MFV GRADLEY - INTERFERENCE INVESTIGATION

1. INTRODUCTION

The MFV GRADLEY is a 38 foot potter/gill netter based on a GM38 Cygnus hull and built by H. Baumbach & Sons of Hayle Cornwall. The vessel from the time of commissioning in November 1986 has suffered interference problems which affect the VHF radio installation. As a result of this interference and the unsatisfactory performance of the electronic installation the Authority and the owner Mr. Peter Riley refused to accept the vessel until the problem was resolved.

The nature of the interference is a combination of conducted and airbourne electromagnetic radiation which is rendering inoperative several channels in the marine VHF radio frequency band. The source of the interference is some but not all of the microprocessor based equipment in the wheelhouse.

2. BACKGROUND

2.1 In the period from the refusal of acceptance several unsuccessful attempts were tried to eliminate the interference by both the electronic installer and the boat builder which are reported to have included:-

a) complete re-wire of the vessel;
b) re-siting of the VHF aerials;
c) screening of cable runs;
d) earthing of upper superstructure.

From the onset of the problems with the GRADLEY it has been implied by the electronic equipment manufacturers and installers that the method of distribution of the metal punchings which constitute the ballast of the vessel and differ from the techniques employed by other builders of GRP vessels, were amplifying and re-radiating the interference signals. It is this theory that has had the effect of creating a stalemate between the boat builder and the electrical installer as to where responsibility lies.

In an effort to resolve the situation the Marine Survey group requested IDU assistance in the latter half of December, subsequently an electronic engineer surveyed the electrical and electronic installation. The findings of this survey are to be found in IDU file note 7002, enclosed as Appendix I.

Although criticisms were levelled at the electrical installation, the major conclusion indicated that the inteference was attributable to the auto pilot, and recommended that it should be replaced with a non microprocessor based alternative.

2.2 A visit to discuss the recommendations of the IDU survey and their implement with electronic installers was made by the author in January 1987.

In the period between this visit and the survey, in December, Robertsons', manufacturers of the auto pilot, had installed filters which reduced the conducted interference, however more significantly this reduction in auto pilot interference highlighted interference generated by the RS2000 video plotter, Furuno echo sounder, Loran C, and Navstar navigators which were also blocking several channels of the VHF scanning radio.

A meeting was arranged with the installers and the boat builder to determine what corrective measures were taken to eliminate the interference, and their results, from the time of commissioning to date. From this meeting it was soon apparent that no logical policy had been applied and no documented results were available.

3. COMMENTS

3.1 Discussion with the electrical installer and the boat builder gave conflicting accounts of the measures taken to eliminate the interference. What is known is that the GRADLEY was rewired, the aerials resited, and earth bonding applied in the keel to skeg area, which resulted in little or no effect to the interference.

3.2 It was suggested that the insulated metal punchings were acting as capacitors, which were charging and discharging and thus radiating the interference around the vessel. However the ballast is isolated from any conductive medium thus nullifying any capacitive effect. There was a remote possibility that the punchings were acting as receptors and radiators at the frequency of the interference but this would be a purely passive device which would attenuate rather than amplify the interference.

3.3 Robertsons' admit they have problems with the AP40 auto pilot but see no short term solution, Furuno provided some power line filtering which was of no consequence, as the interference was radiated not conducted. Shipmate, the manufacturers of the RS2000 video plotter declined to become involved in solving the problem.

4. PLANNED INVESTIGATIONS

The uncertainty generated around the ballast and the doubts regarding allocation of responsibility between installer and boat builder dictated that positive action be taken to provide a solution to the GRADLEY problem. Subsequently the following procedure was adopted:

1. The electrical/electronic cabling and screening were connected to manufacturers recommendations.

2. Manufacturers of the offending equipment were informed in writing and verbally of the unacceptable level of interference

generated by their equipment and the consequence on the performance of VHF radio installation.

3. A cabling and equipment layout diagram was produced to identify possible earth loops and interference paths.

4. The employment of an expert in the field of electro magnetic interference to determine the radiating medium of the interference, make recommendations on equipment screening, boat construction and design, also to provide guidance to appropriate rules and standards.

5. CONSULTANCY

On the 12th of February 1987 a contract was placed with the York Electronics Centre, a division of the University of York, to carry out an electromagentic survey on the GRADLEY. Dr. Andrew Marvin of the Electronics Centre who is recognised as one of the leaders in the field of electromagnetic interference, carried out a survey of the GRADLEY on the 20th and 21st of February; he was assisted by his researcher Mr. Steve Goodwin.

The subsequent findings of the survey are contained in Dr. Marvin's report as follows.

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Electronics Centre
UNIVERSITY OF YORK

Heslington York YO1 5DD England Tel: (0904) 430000 ext. 5535/5575 Telex: 57933 (YORKUL)

ELECTROMAGNETIC EMISSION SURVEY OF MFV GRADELEY, HAYLE, CORNWALL

Authors: A C Marvin M Eng, PhD, C Eng, MIEE
S Goodwin BSc

February 1987

CONTENTS

1.0 Introduction

The Centre was approached by Sea Fish Industries and asked to assess the problems currently being encountered on the "Gradeley" fishing vessel concerned with the interference between the VHF radio receiving equipment and the digital electric equipment used for navigation and fish detection. The work was undertaken over two days in February 1987 by York University staff at the constructors premises in Hayle, Cornwall. The following report details our findings, conclusions and recommendations.

2.0 Statement of the Problem

During trials of the GRP hulled fishing vessel "Gradeley" it was observed that the scanning VHF receiver located in the wheelhouse would lock on to a number of channels when no voice signal was present. The signal received was interference from some source external to the receiver. In all cases the same set of channels was affected, but at any one time, the interference may be absent or present on only a subset of the affected channels. The interference causing the receiver to lock on to a channel with no wanted signal present would result in potentially important signals on other channels being missed. It was observed that the interference was associated with operation of the digital navigation and fish detection equipment, and that each instrument interferred with a subset of the affected channels.

3.0 Measurements

The details of the measurements undertaken are recorded in Appendix 1 and the results are shown in Appendix 2. During the two days of measurements on the vessel the interference was observed and a detailed survey of the Electro-Magnetic environment on and around the vessel was performed. The measurements then concentrated on the interference caused by two digital instruments, the RS2000 plotter and the Autopilot.

3.1 RS2000 Plotter

This device is a display of navigational information derived from a number of sources on the vessel for example the Decca and Loran systems. It comprises a VDU and some associated drive electronics housed in a plastic case. The unit is situated on the wheelhouse decking adjacent to the scanning receiver. This unit was capable of interferring with the scanning receiver by direct coupling with the receiver antenna disconnected. The coupling could be altered by the positioning of hands on or around the instrument cases. The plotter was thus found to be a strong source of radiated interference in its own right, the radiation taking place from within the equipment and not requiring external cables for radiation. The interference was present on one of two channels, moving channel after an initial warm-up period. Occasionally no interference would be observed. It is considered that this behaviour is due to the equipment radiating harmonics of its internal clock, one of which falls within the passband of the receiver. The change in affected channel is due to some warm-up drift of the clock in the plotter. The occasional disappearance of the interference is also due to this frequency drift and is due to the signal moving through the guard band between channels.

To prove beyond doubt that the signal was radiated from the plotter itself, the device was disconnected from all external cables and moved out into the deck of the vessel where it was powered by two car batteries. The scanning receiver was moved onto the quay and powered from the mains. The plotter still interferred with the receiver. An alternative plotter was borrowed from the distributor and similar results were obtained.

The receiver specifications state that the minimum input level to the receiver is 0.3 uV (-10dBuV). Figures 1 - 3 in Appendix 2 show the signals presented to the receiver from the two main VHF antennae on the vessel, with the plotter in its operating position. The main VHF antenna is situated on the gantry at the stern of the vessel approximately 6m from the plotter, while the Scanner VHF antenna is situated on the wheelhouse roof approximately 1m from the plotter. It can be seen that the signals received are between 12dB and 24dB above the minimum signal level of the receiver. Note that the alternative plotter interference is on an adjacent channel to that of the original plotter. This is due to the slightly different internal clock frequencies of the two instruments.

3.2 Autopilot

It was observed before our investigation that radiated interference from the autopilot was associated with radiation from the cables connected to it. The manufacturers subsequently supplied a line filter unit that eliminated most of the interference. For the purposes of this investigation, the filter was removed leaving the original high interference levels for us to work with.

Electric and magnetic field probe measurements were made at various positions on the vessel. These all showed energy at frequencies in the receiver passband propagating along the cables connecting with the vessels instrumentation. Field probe measurements were also made around the two ballast blocks in the forward fish room. At the receiver input frequency these blocks which are isolated electrical conductors are approximately one and a half wavelengths long. They are thus resonant and may have an enhancing effect on the fields in the vessel. See figures 4 - 7. The small field probes rod were not calibrated, however their dimensions are such that they are much less efficient than conventional VHF antennae. The fact that the voltages received from the inefficient probes is 10dB - 30dB above that required to quieten the VHF receivers is conclusive evidence of the source of the interference being the radiation from a vessels cable fit. With the cable filter fitted to the autopilot no radiation could be detected around the case of the instrument again indicating that the radiation source is the cables.

Figures 8 and 9 show the input voltage to the receivers from the two VHF antennae due to autopilot interference. Again both signals are 16dB to 20dB above the receiver minimum signal the lower level for the main VHF antenna indicating that it is situated further away from the radiating cables than the scanner VHF antenna.

4.0 Recommendations

The brief survey described above has shown serious short-comings in the design and installation practices where digital electronic instruments are supplied with vessels having non-metallic hulls. No comparison has been made with vessels of other construction, and it may be valuable to survey the interference present on metal hulled vessels of similar size and electronic fit. The levels of interference generated by the instruments in

the "Gradeley" are such that any shielding afforded by a metal hull is likely to be insufficient. A metal hulled vessel would not have a good shielding performance at VHF frequencies because the apertures in the shield i.e. doors, windows and hatches, are comparable in size to the wavelengths of the receiver input frequency.
It appears that no cable layout standards exist for vessels of this type. Neither is the earthing or grounding well defined. There appeared to be some confusion amongst personnel present as to the grounding connections between the various instruments, the engine, the grounding connections to the water, and the sacrificial anode anti-corrosion system. We would suggest that a cable and earthing methodology be established with the aim of reducing future interference problems. This should include details of cable types for power, instrumentation, and communications systems, a cable position strategy for the three cable functions, and an earthing strategy for the three functions. It should be recognised that some development effort will be required here which must include inputs from vessel constructors and instrument installers.

For the above to be effective, conducted and radiated emission standards must be established for the instrumentation used on the vessels. These standards must apply at the frequencies of all the receivers likely to be fitted to a vessel, as well as at potential spurious response frequencies for the receivers. The test methods used for the equipment evaluation would be based on conventional EMC test types for radiated and conducted interference. The specified emission levels would be defined by assuming a standard interference source to antenna spacing and a standard receiver sensitivity. The emission levels would be set such that the receiver was not quietened by the interference. At frequencies outside the receiver passband relaxed emission levels could be adopted. At these frequencies the threat to the receivers is through the receiver spurious responses (e.g. the image frequency), and through intermodulation of two or more interference signals in the receiver input amplifier or a corroded part of the vessel structure (the "rusty bolt" effect). Again some preliminary development work would be required.

5.0 Conclusion

We have observed and measured the interference to the VHF receivers on the fishing vessel "Gradeley". No simple or short term solution exists for the elimination of the interference on this vessel. The interference is due to a combination of poor equipment design with little or no interference suppression and a lack of guidelines for the installation and cabling of the equipment on the vessel. We recommend the establishment of a set of mandatory standards, for interference, emissions from the equipment, and a related set of installation guidelines suitable for the use of constructors and equipment installers.

APPENDIX 1

Small loop antenna

Use was made of a small loop antenna (approximately 5cm in diameter) for the detection of any magnetic fields radiating from equipment casework and their associated cables.

The loop antenna was fed via super screened cable to a TR4131 Advantest spectrum analyser, and any inductive coupling displayed on a wide (200 MHz) frequency scan.

The signals were identified as being sourced by a particular piece of equipment by turning each piece of equipment on and off in turn. The frequency of these radiated levels was located and the frequency scan and resolution bandwidth reduced to discover the nature of the radiation. Clear discrete carrier levels were identified, which fell in the middle of the VHF (156 - 166 MHz) receiver band.

Equipment casework radiation tests

In order to eliminate cabling as a possible source of conducted radiation, and any coupling effect which the wheelhouse may present, equipment which was suspected of case radiation would need to be removed from the wheelhouse and powered independently. One such piece of equipment was the Shipmate Plotter RS2000, which was causing the scanning receiver to lock on to at least two channels in the VHF band. This blocking effect was seen to drift and change channels during a warm up period for the plotter.

The plotter was removed from the wheelhouse and placed on the deck, well away from any metal objects. It was powered by two 12V batteries.

The VHF scanning receiver was also removed from the wheelhouse and placed on the quay some 15 feet above, where it was powered independently from the mains. A biconical antenna (30 -300 MHz bandwidth) with a matched balun was connected to the front end of the receiver. The VHF rig was now totally independent of the vessel.

On powering up the plotter with all other equipment off, the VHF scanning receiver was observed to lock up on the same channels as when all the equipment was located in the wheelhouse.

Radiation was also observed from the front casing of the paper plotter. A simple test to prove this was the main mechanism for radiation, was to power it up from inside the wheelhouse with the front face pointing up and observe the VHF scanning receiver on the quay. As with the RS2000, the receiver locked on to the appropriate channel. However, when the front face of the paper plotter was turned face down, the strength of the signal clearly reduced audibly on the receiver's speaker, and unless the antenna was held directly over the edge of the quay, the channel lock was lost.

Hence case radiation had been identified which was independent of the vessel.

Cable radiation

Where the equipment had an earthed metal case the radiation was cut down to a minimum, however the autopilot (without filter box) which had such a casework still caused problems with the locking out of channels 74 and 80.

The cabling from the back face was clearly conducting the oscillations down the cable. Current oscillation was being induced onto the outside of the braid which was consequently radiating very effectively. This radiation was observed both with the small loop antenna and 10cm electric dipole made from 1/8" brass, on the spectrum analyser. The radiation was observed at all points along the cable.

Inside the fish room the autopilot cabling ran in a loom with other cables, all were consequently found to be conducting radiation throughout the vessel. The ballast in the fish room, as might be expected for an isolated block of metal, supported a strong field around it.

The particular carrier which blocked channel 74 was observed on the analyser. Plots of this were taken for the 10cm electric dipole inside the ballast and against parts of the cabling loom. These are shown in figures 4 - 7.

Blocking carrier level at inputs to receivers

The inputs to both VHF selective and scanning receivers from antennae on the wheelhouse roof and gantry respectively, were monitored on the spectrum analyser. The plotter was powered up, and the signal level of the carrier at channel 74 was observed. The results are plotted in figures 1 - 3, and clearly indicate levels far in excess of the receiver's sensitivity of 0.3uv for 20dB's of quieting. A similar test was made with the Autopilot and the results are shown in figures 8 and 9.

The ballast was later removed in an attempt to identify a possible enhancement of conducted radiation, but the results remain the same, and are shown for the blocking carrier at channel 80 in figure 10.

APPENDIX 2

List of Figures

MINIMUM SIGNAL LEVEL OF RECEIVERS (MSL) = 0.316mV = -10dB

Ratio of Interference to MSL = 3.98:1 (12dB)

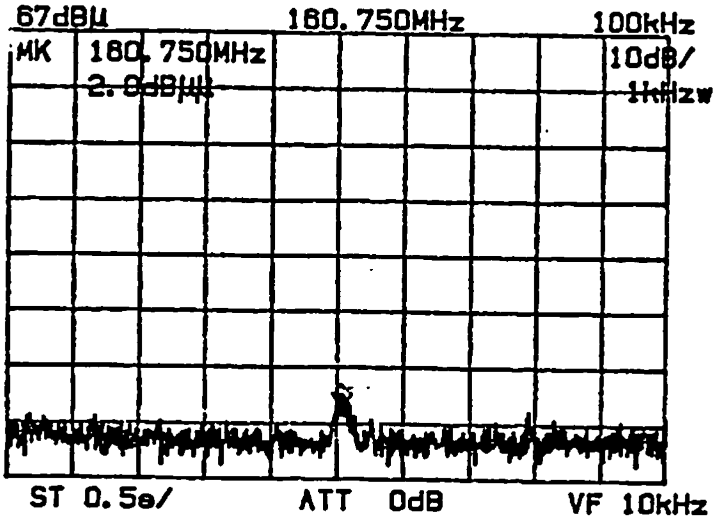

Figure 1

6.3:1 (16dB)

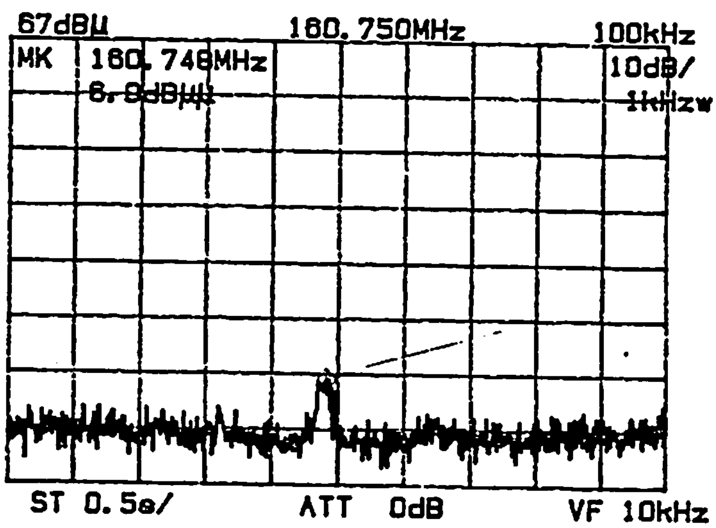

Figure 2

15.8:1 (24dB)

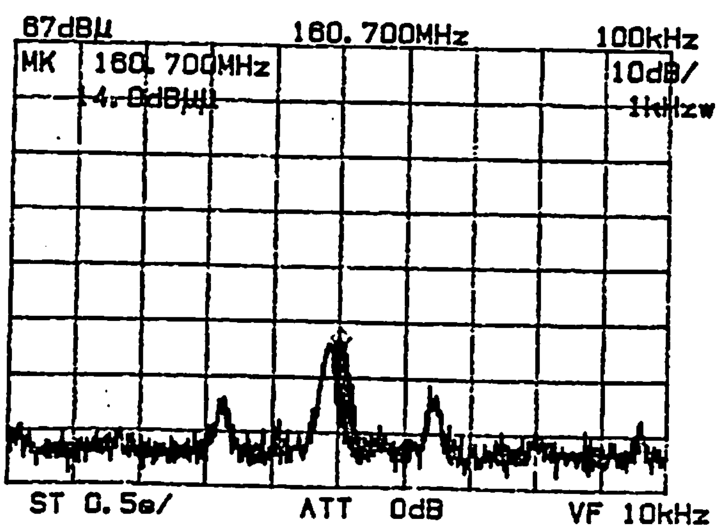

Figure 3

5.4:1 (14.8dB)

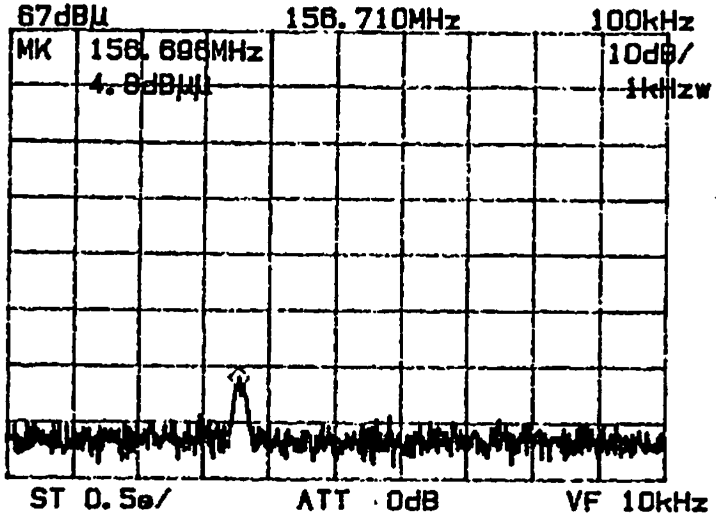

Figure 4

7.4:1 (17.4dB)

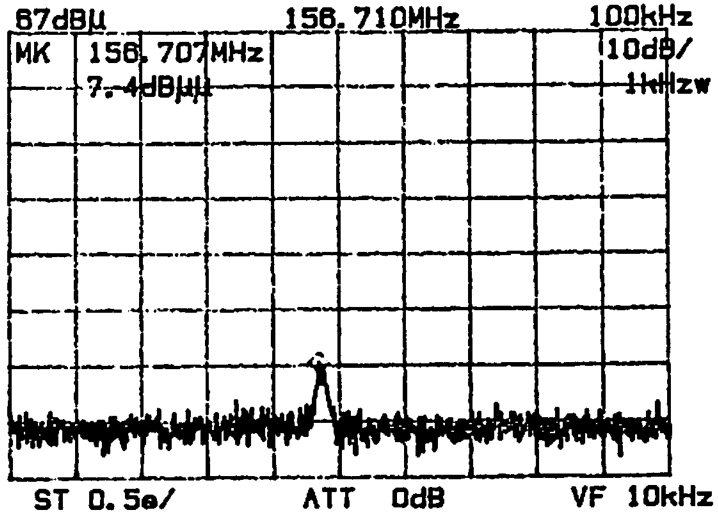

Figure 5

6.4:1 (16.2dB)

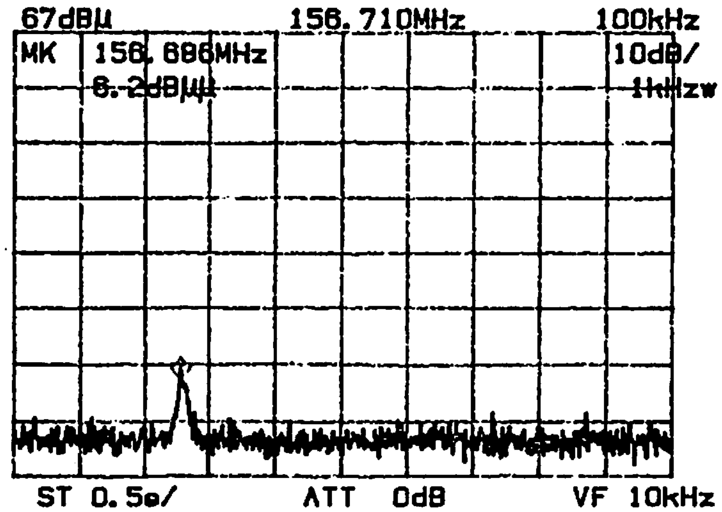

Figure 6

6:1 (15.6dB)

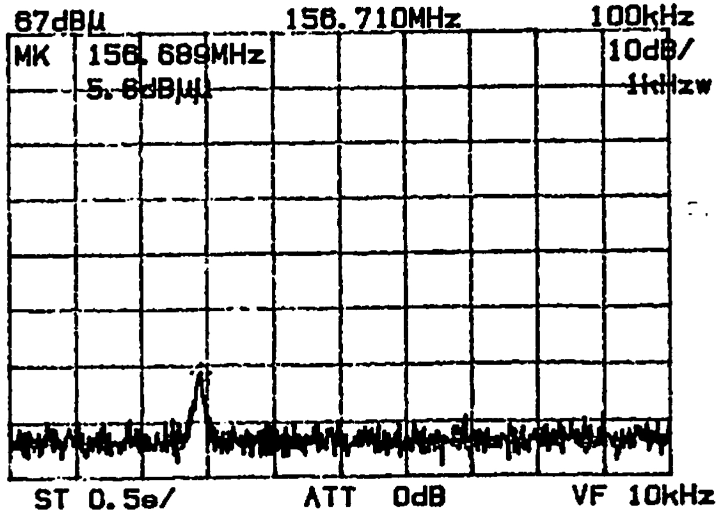

Figure 7

10:1 (20dB)

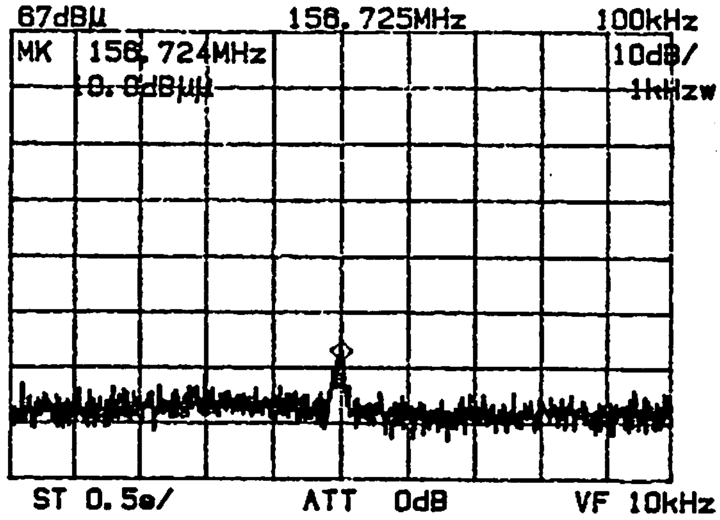

Figure 8

6.7:1 (16.6dB)

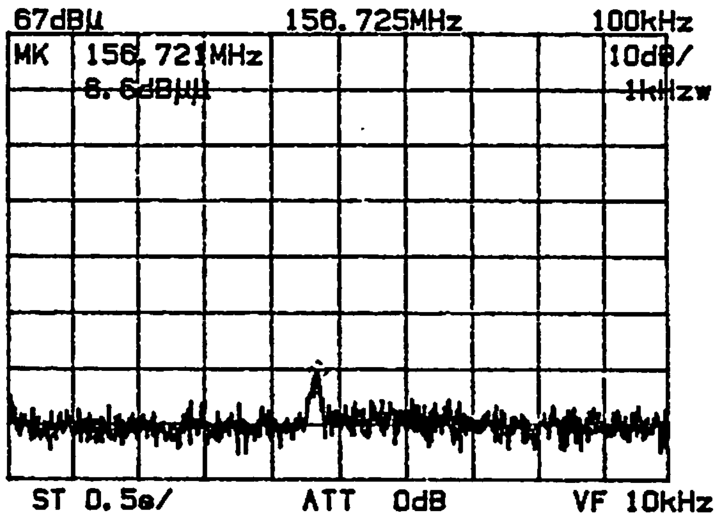

Figure 9

6.1:1 (15.8dB)

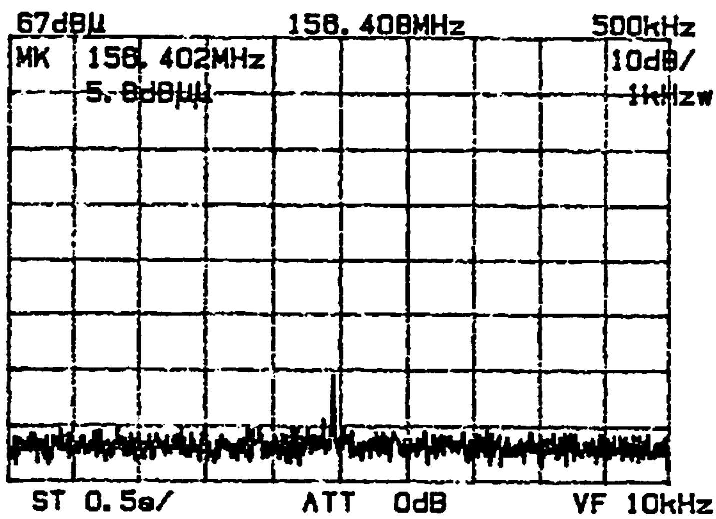

Figure 10

6. SUMMARY OF TESTS AND RESULTS

To determine the conducting medium and the sources of the radiation, a survey of the electromagnetic environemnt on and around the vessel was carried out.

The survey identified a combination of airbourne and cable radiated interference from some, but not all of the microprocessor based electronic equipment within the wheelhouse. The electronic equipment which had no effect on the radio installation are as follows:

a) Furuno FR-802 Radar
b) Furuno FCV-200/201 Colour echo sounder
c) Wesmar SS265 Colour sonar
d) JVC RGB monitor

It is significant that all of the above equipment is packaged in metal housings with its inherent shielding properties, whereas the following equipment, all of which caused a malfunction of the radio installation were, with the exception of the auto-pilot, housed in non-conductive plastic housings.

i) Shipmate RS2000 video plotter
ii) Furuno FE600 Echo sounder
iii) Furuno LC90 Loran C navigator
iv) Navstar 601D Navigator
v) Robertson's AP40 auto pilot

The remainder of the survey concentrated on the AP40 auto pilot as the only source of cable radiated interference, and the RS2000 video plotter, the major contributor to the radiated interference.

TESTS

R.S.2000. A series of tests were carried out on the vessel's RS2000, also to eliminate the possibility of the GRADLEY having a rogue plotter, an alternative RS2000, supplied by the local distributor was also subjected to similar tests.

1. **RS2000 off.**

   Scanning VHF operating normally in scan mode, with antenna disconnected.

   RS2000 on.

   Scanning VHF locked out on channel 63.

2. **RS2000 off.**

   Spectrum analyser connected to scanning VHF antenna downlead. No interference detected on analyser.

   RS2000 on.

   Interference signal present on analyser, signal level of interference approximately six times greater than the minimum signal level (MSL) of the receiver.

3. As for test 2, with analyser connected to main VHF antenna down lead. Signal level four times greater than receiver MSL.

The following test involved removing the RS2000 and scanning VHF receiver from their respective locations on the vessel, and powering them from separate sources independent of the vessel.

The purpose of the exercise was to prove conclusively that the RS2000 was itself radiating the interference signal indepdendent of location and cabling within the vessel.

4. RS2000 on the deck of the vessel, power source 2x12 volts batteries connected in series. No other external connections.

   Scanning VHF receiver on the Quay side approximately 15 feet above the RS2000. Power source 24 volts d.c. derived from a portable d.c. supply powered from the shore mains supply.

   RS2000 on.

   Scanner locked out on channel 63.

The same test was repeated for the alternative RS2000 with similar results.

5. **Auto pilot off.**

Spectrum analyser connected to the scanning VHF antenna downlead. No interference signal detected.

Auto pilot on.

Interference signal present on analyser ten times greater than receiver MSL.

6. Repeat of test 5 with analyser connected to main VHF antenna downlead. Signal level seven times greater than MSL.

All autopilot tests were carried out with line filtering removed.

7. For this test magnetic and electric field probes were connected to the analyser and measurements taken at several locations around the vessel, as follows.

Location	**Interference Signal Level**	**Ratio of interference to MSL = Interference / MSL**
Port Ballast	1.737 Micro Volts	5.5:1
Stbd Ballast	2.344 "	7.4:1
Stbd Cable Loom	2.04 "	6.4:1
Bilge Alarm Cable Loom	1.9 "	6.0:1

7. SUBSEQUENT ACTION

The results of the survey highlighted the port and starboard wing ballast as possible sources for the enhancement of the interference, this is based on the length of the ballast being 1.5 wavelengths and therefore resonant at frequencies in marine VHF band.

Attempts to change the length of the ballast and thus the resonant frequency were unsuccessful. At this point it was decided to remove the wing ballast. Further measurements were made with the ballast removed but no change in the interference amplitude was observed.

The removal of the ballast proved conclusively that without adequate internal shielding of equipment electromagnetic compatibility of the GRADLEY could not be achieved.

Subsequently the owner of the vessel, satisfied that no short term solution to the problem was possible, accepted the vessel and the electronic equipment with the proviso that an improved auto pilot would be fitted at a later date.

8. DISCUSSION

The consultancy report identifies the problem on the GRADLEY and indicates that there is no short term solution for this vessel, which is of little consolation to the owner. However it does provide the data for the Authority to identify areas for improvement and set the standards to achieve an electromagnetically compatable fishing vessel.

The recommendations highlight the short comings of the electronic equipment design and installaton, it also makes reference to the requirement for an input from boat builders, and the introduction of conducted and radiated emission standards, to which electronic equipment would comply.

The report does not make reference to what is considered to be the major consequence of the interference, the vessels safety.

The VHF radio installation is the vessels only means of communication for transmission and reception in an emergency. The unstable nature of the interference suggests the interference may block the standard ship shore communication and information channels, which provide initial contact in an emergency and provide hazard warnings e.g. gales. It is also possible for the interference to upset the magnetic compatibility of compass systems, all of which leave the vessel vulnerable and obviate the necessity to ensure there are no similar recurrences of the problem.

9. CONCLUSIONS

1. The problems associated with equipment design, cabling, screening and earthing techniques, must be resolved by consultation with the respective sectors of the industry.

2. It is considered that the relaxing of emission levels at frequencies outside the receiver passband as the report suggested would not only cause confusion in administering the standards but may cause problems which have an adverse effect to vessel safety.

3. The theory that the distribution of the ballast was the cause of interference was discounted by its removal. However, the Baumbach yard apart, there are few reports of similar interference from other fishing vessels, yet the survey indicates that the interference is of sufficient magnitude to block the VHF radio regardless of construction material, which suggests that skippers are not reporting the problem, or (a possibility not mentioned in the consultant's report) the electronic fit of the GRADLEY is too extensive for the size of the vessel.

4. To achieve electromagnetic compatibility requires a set of rules and standards which meet the criteria of the survey report and the physical restraints of the vessel. The present GRP rules are restrictive not easily administered and do not address the requirements for vessels which rarely exceed 14m registered length.

8. RECOMMENDATIONS

1. A seminar to include representatives of manufacturers, constructors and installers, the Authority and their consultants. The agenda to include:

a. review of current standards;
b. determine emission standard;
c. construction techniques;

d. cable installation requirements;

e. screening and bonding techniques;

f. review of earthing techniques on non metallic hulls.

The subsequent standards to be applicable throughout the frequency spectrum.

2. To determine the extent of the problem a survey on a cross section of GRP, wood and metal vessels should be initiated. The survey to address the ratio of interference to equipment volume, physical restraints and construction material of the vessel.

3. It is considered that the GRP rules be sub-divided to include a section which address vessel's up to 15 metres registered length.

Each section to include the recommendations on cabling and earthing contained in the consultancy report.

APPENDIX I

W. SIDDLE'S PRECIS OF R. HORTON'S FILE NOTE, ETC.
RADIO INTERFERENCE M.F.V. GRADLEY

IDU 7002

23.12.86

1. **THE PROBLEM**

Three new G.R.P. sister vessels have been built, of these two have Robertsons AP40 auto-pilots which cause interference on the V.H.F. radio and cause its scanner to lock onto this interference on three of the channels. The third vessel has a Wagner auto-pilot and has no problems.

2. **DIAGNOSIS**

2.1 Extensive rewiring and screening by the electronic contractor has not solved the problem. This screening and its earthing are subject to criticism.

2.2 If the AP40 is switched off the interference is eliminated.

2.3 There is a suggestion that there is a lesser, spurious, scanning fault with the V.H.F. radio but the auto-pilot interference is a problem aside from this.

2.4 All the electronic equipment power cables are clear of interference therefore it is assumed to be air-borne.

2.5 The auto-pilot and radio have been separately powered from batteries and the interference problem is still there.

2.6 The interference was said to disappear when the vessel touched bottom and it was suspected that an earthpath was made between rudder, skeg and keel bar. A connecting strap was fitted between these items to ensure continuity, the result was that the interference became intermittent and could not be tracked down.

2.7 It has been suggested that the ballast of metal stampings may be a factor whether or not they are connected to the keel bar by fixing bolts.

2.8 Robertsons have made unsuccessful attempts at solving the problem and by screening of the auto-pilot.

2.9 Robertsons appear aware that this equipment produces interference and are introducing "filtered" units. Some filtering by them was partially successful on one of the vessels, but unsuccessful on the one in question (Gradley).

2.10 Robertsons auto-pilots have been fitted to other vessels and did not suffer this problem.

2.11 It is said that an alternative auto-pilot was tried on the vessel (Gradley) and that there was no interference problem.

2.12 It has been suggested that the quayside at which the vessel(s) berth may have some influence on the interference.

3. CONCLUSIONS

3.1 The overriding finding is that when the AP40 auto-pilot is switched off then the interference problem disappears. Hence the interference is generated or propagated within this unit.

3.2 In support of 3.1 another make of auto-pilot was fitted and the problem disappeared.

3.3 The survey of screening and earthing arrangements on this vessel(s) show inadequate attention to continuity and earth connections which although may not be the source of the problem, are bad practice which inhibit tracing such problems.

3.4 There is some earth loop problem on the vessel. Rudder/skeg/keel bar continuity is a factor the effect of which has not been resolved.

3.5 There is the possibility of other associated factors such as static, close proximity of electronic equipment and cabling and earthing of metal appendages which act as aerials.

3.6 Rotation of machinery and shafting is not the problem, it still exists on shutdown.

FILE NOTE

IDU 7002

23 December 1986

AN INVESTIGATION INTO THE RADIO INTERFERENCE ON-BOARD MFV GRADLEY

by R. Horton I.D.U

The observations, tests and recommendations described in this statement are the result of an investigation on-board MFV GBRADLEY, a 38' GRP vessel, 27.11.86 to 2.12.86. A more detailed technical report will follow in due course.

1. Observations and Information

1.1 The source of the radio interference on this vessel was seen, on a number of occasions, to be undoubtedly the Robertson AP40 Auto-pilot. Only on two occasions, the first at sea and the second in port did the system (VHF's) behave normally.

1.2 Similar interference was observed on the sister vessel MFV Trelawney. This could be removed by switching off the Robertson AP40 Auto-pilot.

1.2.1 Since this visit Robertson engineers have recently installed a system of filters to various component parts of the AP40 on both MFV Trelawney and also on MFV Gradley.

1.2.2 Whilst the interference has been minimised on MFV Trelawney, the problems remain on MFV Gradley.

1.2.3 The VHF scanner has been found to be inconsistent in its operation, even in conditions when the interference is completely removed.

1.3 Three vessels of identical structural fabrication have been produced by Baumbach's of HAYLE in the last 18 months:- (in chronological order)

(a) CELTIC MOR
(b) TRELAWNEY
(c) GRADLEY

Vessels (b) and (c) have had Robertson AP40 fitted by the same electronics company, Sea-Com of Falmouth and both suffer radio interference from the Auto-pilot. Vessel (a) employs a Wagner auto-pilot, and does not suffer from radio interference.

1.4 Some weeks previous to this investigation an auto-pilot manufactured by Wagner was intalled on the Gradley and no radio interference was found to be present.

1.5 Earthing of cable screens entering the Robertson AP40 distribution unit was not done in accordance with their installation instruction manual. (It was reported by SeaCom that during the past six weeks many combinations of methods of connection of these screens had been tried, and that the current position produced the best results).

1.6 The electrical/electronic system had been re-wired from its original state of 3 core p.v.c. to butyl 2 core screened, most of the screened cable serving to supply the electronic equipment. The screens of these cables meet at a common star point inside the electronic services distribution box, and from this insulated bus-bar no connection was made to any other point on the vessel. (No screen earth).

1.7 (Arbitary point)
Single pole switching at distribution unit-common neutral.

1.8 V.H.F. scanner supply cable found to be inadequately screened, i.e. cut short.

2. __Tests__

2.1 The supply lines of the below listed items of electronic equipment were monitored using a high resolution oscilloscope.

(i) Both V.H.F. sets
(ii) AP40 auto-pilot
(iii) RS2000 plotter
(iv) Radar
(v) Colour Video Sounder
(vi) Paper Sounder.

2.1.1 Radio interference, of any detectable limits on the ranges employed in using the oscilloscope, was not detected. These measurements were made in the following three combinations

(a) Positive to negative supply
(b) Positive to earth potential
(c) Negative to earth potential.

2.1.2 Furthermore items (i) and (ii) were supplied from separate (independent) power sources with no change in the prevailing interference condition.

2.2 A galvanic corrosion test was made in a number of positions around the vessel, utilising the Calomel half-cell - the results were concluded to be satisfactory.

3 Conclusions

3.1 The tests prove that the nature of this radio intereference is by radiation in air-space and not through conduction supply cables. This conclusion is made subject to the limits of accuracy of the oscilloscope employed - (A.C. range 2mv/div).

3.2 The radio interference source is the AP40 auto-pilot, not only on MFV Gradley, but also on her sister vessel MFV Trelawney.

3.3 The installation observed on-board MFV Gradley; from the view of not adhering to technical codes of practice both generally and through those laid down by manufacturers of specific equipment, AP40 auto-pilot specifically, was found to be not only poor but incorrect. Reference here must also be drawn to the quality of the General Services and Electronic equipments distribution system. On a vessel only recently built, which contains several tens of thousands of pounds of sophisticated electronic equipment, the installation of single pole overload switches in the electrical distribution system does reflect a poor standard of professional integrity by the installers of the system as a whole.

4 Recommendations

(Robertsons of Norway are currently attempting to attenuate the level of interference on-board MFV Gradley).

4.1 Unless the problem of the interference affecting both VHF sets is not resolved then the AP40 auto-pilot should be removed from the vessel, and a suitable alternative should replace it.

4.2 Some suspicion must also lie on the operation of the VHF scanner (ICM 55). It is felt that this unit should also be replaced by a suitable alternative.

4.3 The installation of these alternatives be overseen by Authority staff ensuring that a reasonable standard is maintained.