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International Council for the
Exploration of the Sea

C.M. 1994/B:9
Fish Capture Committee

REPORT FROM

ICES WORKSHOP ON HYDROACOUSTIC INSTRUMENTATION

3 - 5 MAY 1994.

HELD AT THE

BRITISH ANTARCTIC SURVEY

CAMBRIDGE

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IN CAMBRIDGE, UK 3 - 5 MAY 1994.

INTRODUCTION AND TERMS OF REFERENCE

The background for the workshop was a suggestion from the Danish representatives during the ICES FAST Working Group Meeting in Göteborg in 1993. The idea was accepted by the Working Group and set forward as a recommendation from the Fish Capture Committee during ICES Statutory Meeting in Dublin September 1993. According to C.Res.1993/2:13, "**A Workshop on Hydroacoustic Instrumentation will be held in Cambridge, England, UK from 3-5 May 1994 under the chairmanship of Mr H.P. Knudsen (Norway) to discuss and collate information on:**

a) **selection on towing cables and fairing;**
b) **methods for towed body deployment;**
c) **underwater and inboard electrical and mechanical connections;**
d) **towed bodies;**
e) **practical aspects of calibration of towed bodies and hull mounted systems.**"

Since most of the participants are field-working, technically skilled personnel, with interests beyond hydroacoustic instrumentation, some additional topics, such as CTD calibration, were included.

The following participated in the Workshop:

Afanasyev	British Antarctic Survey, Cambridge
Ivan Ahlquist	Norwegian Institute of Fisheries and Aquaculture, Tromsø
Dave M. Blake	British Antarctic Survey, Cambridge
D.G.Bone	British Antarctic Survey, Cambridge
S. Bremner	British Antarctic Survey, Cambridge
Phil Copland	SOAFD Marine Laboratory, Aberdeen
Thyge Dyrnesli	Danish Institute for Fisheries and Marine Research, Hirtshals
Inigo Everson	British Antarctic Survey, Cambridge
Paul G. Fernandes	Fisheries Research Centre, Dublin, Ireland
Catherine Goss	British Antarctic Survey, Cambridge
Lars F. Hansen	MacArtney A/S, Denmark
Grahame Hughes	British Antarctic Survey, Cambridge
Doug Huntington	MacArtney, UK
Jón Jónsson	Marine Research Institute, Reykjavik, Iceland
Rudy Kloser	CSIRO Division of Fisheries, Tasmania, Australia
Hans P. Knudsen	Institute of Marine Research, Bergen, Norway
Anne Lebourges	ORSTOM, France

Bo Lundgren	Danish Institute for Fisheries and Marine Research, Hirtshals
Kyrre Lydersen	Norwegian College of Fishery Science, University of Tromsø
Gary Mason	Northwest Atlantic Fisheries Centre, Canada
Rolf L. Nielsen	SIMRAD Subsea, Norway
Tommy Nielsen	Danish Institute for Fisheries and Marine Research, Hirtshals
D.B. Pye	Hydrocable Systems, Aberdeen, Scotland
Pall Reynisson	Marine Research Institute, Reykjavik, Iceland
Brian Riches	MAFF, Lowestoft, UK
Ingvald Svellingen	Institute of Marine Research, Bergen, Norway
Mogens Sørensen	Danish Institute for Fisheries and Marine Research, Hirtshals
A. Tait	British Antarctic Survey, Cambridge
Trewor Ward	Scanmar A/S, Norway
Paul Woodroffe	British Antarctic Survey, Cambridge
Val Torpey	British Antarctic Survey, Cambridge was local contact and secretary for the Workshop.

TUESDAY 3 MAY

OPENING SESSION

The chairman H.P. Knudsen, IMR Bergen, opened the meeting by explaining the background for the workshop and the expectations of it. There was a presentation round where the participants gave some details of their backgrounds and their main tasks. Most people were involved in jobs related to the maintenance of research vessels, but there were also a couple of representatives of firms supplying instruments and utilities to the vessels

D.M. Blake welcomed the participants on behalf of BAS, gave some logistic information and a short, but informative overview of the activities of BAS.

MAIN SESSION

Chairman for the day: Dave Blake
Rapporteur: Bo Lundgren

Computer network systems, data transfer modules, and practical installations

T. Nielsen, DIFMAR, Hirtshals commenced by describing how some data transfer and preprocessing problems on the R/V "Dana" have been solved by using signal conditioning modules that convert analog data into RS232 data streams. These can then be directly fed into the main computer of the vessel.

During the discussion afterwards it became clear that most participants had struggled with similar problems. On the British vessels (run by BAS or MAFF) and on the Australian vessel the solution had been to use similar modules converting sensor signals to the RS485 standard, which has the advantage over the RS232 that many modules can be combined and addressed on the same busline. The standard also allows longer distances and higher signalling speeds.

G. Hughes, BAS Cambridge, gave an overview of three levels in the BAS strategy of converting and transferring data on the BAS ships. Level A is conversion of sensor data to a common format, level B combining and buffering data in groups, and level C is final storage of data and supplying the users with processed data.

I. Svellingen, IMR Bergen, remarked about NMEA being used as a common format between navigational instruments.

The discussion also showed that the use of Local Area Networks (LANs) is increasing rapidly, mostly by Ethernet types, but also with ATM (Asynchronous Transfer Method?).

Cabling on board and underwater

Th. Dyrnesli, DIFMAR, Hirtshals described some of the problems encountered in adapting the cabling on board R/V "Dana" to changes in instrumentation. He showed how many of the cables which were previously dedicated to specific installations had been reorganized into star-configurations and connected to patchboards (connector arrays) at strategic locations. This arrangement has made it much easier to modify the data-paths between instrumentation groups.

Problems of cable-changing are well-known, especially with respect to safety regulations when passing the cables through walls between watertight sections of a vessel. Several interesting solutions were presented during the discussion, including removable cable-glanding systems

I. Svellingen, IMR continued the discussions on the RS485 bus by describing the system about to be established for new Norwegian vessels. It is based on connecting all points of interest for data transfer by high-quality unshielded twisted pair (UTP) cables to a central 100-way patchboard. The cables allow transmission speeds of up to 100 Mbits/s. The system will run two parallel local networks, one PC-network and one Ethernet type, and can also be connected to the onboard digital telephone switchboard (DPABX), making it possible also to transfer data to or from the vessel via mobile telephone or the INMARSAT service. This cable is run into all scientific spaces as well as into individual cabins.

A. Lebourges, ORSTOM Paris, showed block diagrams of a network system installed on new French research vessels, for example the new catamaran vessel, R/V "l'Europe", of IFREMER. This system combines transfer of both data and digitized video signals over an Ethernet system.

I. Ahlquist, NIFA in Troms¢, mentioned that they had installed relatively wide steel tubes between strategic points that made it easy to install new cables when needed.

P. Reynisson, MRI Reykjavik, indicated that the problems with cabling changes was less pronounced for them, because they had relatively constant instrument setups.

P. Copland, Marine Lab. Aberdeen, mentioned that as they had to use different ships from time to time they therefore had to bring their own cabling along with the instrumentation.

The advantages (e.g. high bandwidth, noise immunity, small weight) of including fibre optics in parts of the networks were discussed, and D. Huntingdon, McArtney UK, asked for reasons why the use of fibre optics, was fairly limited. Some people answered that the copper connections are often already there, weight is not a strong concern, so it is used only when speed and/or noise immunity requirements are high. The rapporteur's own experience is also that until recently the price of the conversion electronics and the mechanical difficulties in connecting the fibres has played a role. There is also the general inertia in becoming acquainted with new techniques.

Bo Lundgren, DIFMAR Hirtshals, explained that one of the expectations that the Danish group had for the workshop, was that some kind of recommendations could be established regarding an international standard for interconnections on research vessels that could make it easy to bring and hook up instrumentation on vessels from any country. The feeling among those groups (British and

Norwegian), who have the most experience in designing ship systems, were that because the development is very fast in this field, it would not be possible to make lasting standards, but one had to try to choose the best available technique at the time of purchase and then be prepared to update when necessary.

Cables for towed bodies, terminations, and fairings

M. Sørensen, DIFMAR Hirtshals, reported that the main features of the towed body system used on R/V "Dana" are its ability to work at small deployment depths and its ability to pull sideways away from the vessel because of its adjustable depressor and self-balancing weight distribution. The cable (four screened twisted pairs and four single conductors with two-layer steel armour) and the required load termination that have been used until now are relatively heavy and disturb the balance of the towed body. A lighter but somewhat thicker cable with a Kevlar central strength member has been realized and will be tried this summer. Pictures of the cable termination and of the new crane on the foredeck of DANA, from which the towed body is deployed, were also shown.

The discussion afterwards gave several good tips on how to terminate Kevlar cables and what precautions one should take.

D.B. Pye, Hydrocable Systems Aberdeen, outlined the two most used termination methods, one where the Kevlar member is put through a hole in a stainless steel block and then spread out evenly around a conically shaped surface inside the block. A conical piece of steel is placed inside the block to fix the Kevlar fibres in place and the assembly is potted with polyurethane. The other method is to put the strength member through a hole in a box, then through a retaining washer and finally tie a knot on it inside the box. After that the box is filled with a potting compound.

P. Copland, ML Aberdeen, and L. Hansen, McArtney DK, demonstrated an example of a cone type termination and added the warning that although kevlar is very strong, it can also be brittle if it is handled incorrectly. A fibre breaks easily if its surface has been scratched.

The differences between Kevlar cables with a central strength member and those with a braid of Kevlar around the conductors were discussed. The main advantage with the latter is, that under light load conditions the braid offers some mechanical protection. On the other hand, at high loads the cable will seem more elastic because the braid will compress the inner parts and possibly destroy them.

Phil Copland described the difficulties involved in using a number of different vessels for acoustic surveys and the ML policy of using adaptable towing systems. He discussed in some detail their experience of faired towing cables and their solution of placing steel tow wire and signal cable inside a ribbed hose to eliminate vibration which was thought to be causing conductor breakage.

R. Kloser, CSIRO Hobart, wondered if the if the use of the hose might decrease the steepness of the wire angle and thereby reduce the vibrations.

Towed bodies, deployment and calibrations

Phil Copland, Marine Laboratory Aberdeen, described the acoustic towed body used in Aberdeen. It consists of a stainless steel open frame capable of carrying a 38 kHz split-beam, and 120- and 200-kHz single-beam transducers at the same time. The towed body is deployed alongside the survey vessel on a fixed tow length at an operating depth of 5 metres. It has two aerofoil wing sections to give a depressive force and two counterweights for balance. The vertical rear fins can be altered to counter any roll tendency and the tow point moved for pitch adjustment. The unit is passive in that these adjustments are not carried out during towing but only on deck.

On-board instrumentation suggests that the towed body is stable at speeds varying from 4 to 11 knots without adjustment. The pitch angle changes steadily from two-degrees nose up to two-degrees nose down over this speed range. The heel over this range is stable.

There were several questions regarding possible problems of noise generation because of the open sharp-edged construction, but P. Copland had not noticed any problems with noise caused by the special shape.

R. Kloser, CSIRO Hobart, described their system which was used for surveying fish at depths of 600 - 1100 m. The pressure-compensated split-beam transducer was mounted in a bomb-shaped, heavy (600 kg) towed body, The deployment arrangement was mobile, consisting of a winch and a small A-frame. The winch with 3000 m of cable had a constant tension regulator (Hägglund) in order to reduce the influence of ship movements on the stability of the towed body.

WEDNESDAY 4. MAY

Chairman for the day: Paul Woodroffe
Rapporteur: Paul Woodroffe

Fibre Optic Slip Rings

Thyge Dyrnesli raised the subject of optical slip rings and asked if any delegate had experience of their use. Doug Huntington showed engineering drawings of multiple fibre sliprings designed by Focal Technologies Inc and explained how they work. Lars Hansen explained the differences between multi-mode and single-mode fibre optic systems. It was stated that the slip rings had a typical loss of 3.5 dB in actual applications and that an LED signal source could be used for cable lengths typically found in Marine applications.

Hans Knudsen described an actual application of the fibre optic technology. In a towed body system with sensors for depth, tilt and roll in addition to the acoustic transducers, there were problems with interference. This meant that in spite of the different sensors using separate and individually shielded conductors, they could not be operated at the same time without disturbance. A new concept with the echo sounder transceiver mounted in the underwater unit was described. The acoustic data and data from the movement sensors are sent as telegrams in an optical fibre on a time-share base.

Presentation of the ROTV system

Doug Huntington gave a presentation describing the FOCUS remotely operated towed vehicle. The FOCUS vehicle is controlled and communicates data by means of a fibre optic cable. His presentation described the modular nature of the design, and illustrated applications to which the equipment has been put. These applications are mostly related to oil-industry operations but with some mention of fisheries work, including net avoidance and net performance, the ROTV being used as a platform for video equipment in this application. Other applications include an acoustic pipeline survey, laser line scan survey and sub-bottom profiling. These applications often achieved results that would have previously required an ROV at increased cost to the user.

In the discussion, the issue was raised of the field reliability of fibre optic systems and whether it is necessary to build excess fibres into a cable. It was stated, in reply, that operational experience had shown optical fibres to be at least as reliable as copper conductors but that extra fibres could be built into certain types of cable at minimal extra cost and that this could be desirable from the point of view of expanding the capabilities of a system. Hans Knudsen agreed that the fibres are generally very strong.

Casting Materials and forms

Mogens Sørensen opened a discussion on the materials and techniques for producing joints and terminations on underwater cables. Dave Pye gave an extensive reply to Mogens' opening questions, describing, in some detail, the advantages and disadvantages of various moulding techniques. These fall into two broad categories - hot and cold processes. He was also able to give some practical tips regarding hot-set moulding. Doug Bone (BAS) offered to make his hot-splice mould available for inspection by participants at the meeting. Hans Knudsen demonstrated, with the use of diagrams, the technique used for producing a conducting cable termination using polyester. Bo Lundgren suggested that a questionnaire be circulated, asking people to provide details of commercial materials used in this application.

CTD calibration

Tommy Nielsen described the techniques used for laboratory calibration of the CTD used on board R/V "Dana". Having had problems with in-situ calibration techniques, a system was devised using four 250-litre seawater tanks in a lab environment. He went on to describe the procedure used and demonstrated the improvement in results resulting from the change to laboratory calibration, and the use of a better salinometer (a Guildline portasal).

A discussion then ensued regarding CTD calibration and operation philosophy at the different institutes represented at the meeting, and concluded with a discussion of corrosion problems encountered on Rosette systems.

Practical solutions for echo sounder calibration

Bo Lundgren described an automatic test-equipment-based system for measuring the impedance of split-beam transducers. He displayed results illustrating the change in characteristic impedance over time and results demonstrating the pitfalls of attempting this kind of measurement in a shallow harbour. Using the results from a PC-based storage scope system, which was connected to a permanently installed current transformer, he was able to demonstrate the effect of a bubble layer on the transmit pulse of the EK500.

Hans Knudsen described a remote-control positioning system for a calibration sphere, drawing attention to the fact that an existing radio-controlled, battery powered system was no longer adequate since the arrival of automatic beam pattern measurement, this requiring a great deal of sphere movement. He also illustrated the stability of echo sounder calibration on three Norwegian vessels since 1989.

TAPF

Ingvald Svellingen described a system developed for testing the operation of split-beam echo sounders. The Time-Amplitude-Phase-and-Frequency device can provide signals of varying relative phase in order to simulate a target in any of the four beam segments of an EK500 or similar split-beam sounder. This allows the TS compensation to be tested. A single phase, variable amplitude signal can be used to test the Sv function of the integrator in an EK500. The unit is triggered from the external trigger output of the sounder, and altering the delay will simulate a target at various ranges, enabling the TVG function to be checked.

Proposal to establish international guidelines for equipment maintenance intervals

A lively discussion debated the validity of stating a minimum value for calibration intervals, with particular regard to echo sounder calibration. David Blake felt that the main requirement should be to meet the demands of the "customer" but agreed that if ICES was regarded as one experiment (such as WOCE) then it would probably be correct to publish a minimum standard to which ICES members should adhere. The view from the Bergen representatives was that an absolute minimum should be 3 calibrations per annum (for equipment in continuous use). The consensus was that echo sounders should preferably be calibrated at the beginning and end of every vital acoustic survey and that principal scientist organising cruises should be made aware that time must be allowed for this activity in their cruise program. The group therefore made the following recommendation:

> ***All hydroacoustic instrumentation should be calibrated immediately prior to and following all acoustic surveys. Where possible such calibration should be carried out in the survey area. Additionally where equipment is in constant use calibrations should be carried out not less frequently than once every three months.***

THURSDAY 5. MAY

Chairman for the day: Grahame Hughes
Rapporteur: Rudy Kloser

Standardised protocol for wireless acoustic links

T. Nielsen, DIFMAR, started discussions by asking, "Is it possible to establish a standard for connections to an acoustic link interface?". With this as the starting point of the session, T.Ward from Scanmar gave a presentation on "Hydroacoustic telemetry for monitoring and control of underwater systems".

T. Ward started his presentation by describing the problems associated with acoustic telemetry such as fading and multipath interference. Systems in the past were application-specific, with limited processing power for complex multi-frequency telemetry systems.

Advances in technology have improved systems using high-speed digital signal processing. The Scanmar hydroacoustic communication system is now application-programmable and can be quickly modified. Several applications were presented from a trawl-eye monitoring system equivalent to slow scan video to military applications controlling ROVs.

Discussions started with the need to know how much data can be sent up acoustic links. In T. Ward's experience using a hamming code for error correction and sending at 600 baud, the throughput is 300 baud working on 8 bit block lengths. He stressed the need for compacting data prior to sending on the acoustic link. For an acoustic link system a clever modem is required and currently there are four on the market. T. Ward stressed the need for good back-up support when using acoustic-link communications systems. Comments on hydrophone requirements and difficulties that are experienced in temperature fronts were discussed. T. Ward indicated that today's receivers can pick up signals 9 dB below the noise level, and he has often found good results in temperature-front zones. Further comments were made on underwater systems that had high-volume data storage units with a low-speed acoustic link to the surface to check for data quality. On the question of connections to acoustic- link instruments T. Ward indicated that most of the common protocols such as RS232, RS442 and current loop were standard.

Deep sea acoustic surveys

P. Fernanders, FRC Ireland, started the session by listing countries that were performing deep-sea acoustic work. They were Australia, Canada, Norway and companies involved such as Simrad and Biosonics. He then asked the representatives of the countries to discuss the technical aspects of their systems.

R. Kloser, CSIRO Australia, discussed the cost of deep-water towed systems (500-1000m) and the maintenance required to keep them operational. Analogue systems were much harder to keep up and more expensive in the long run than a digital system. In certain circumstances, a well designed hull-mounted system can be just as good as a towed system if in-situ target strength data is not required.

P. Reynisson, MRI Iceland, commented that they can achieve good results, detecting single red-fish down to 400 m with a hull-mounted system.

G. Mason, DFO Canada, commented on the results using good hard-casing fairing. Shorter cable lengths can be achieve for deeper depths at faster towing speeds. His experience was obtaining a towed body depth of 300 m with just 400 m of faired wire out at 10 knots.

H. Knudsen, IMR Norway, showed an echogram of a Russian submarine on the bottom at 1650-1700m using hull-mounted acoustics, further demonstrating that good results can be achieved with hull-mounted systems.

Instrumentation for bad-weather operation

H. Knudsen presented a paper on "Fisheries research instruments for bad weather operation". He started by outlining the problems experienced with hull-mounted acoustic systems in bad weather, specifically vessel movement and more importantly aeration under the transducer. To solve this problem he discussed the advantages of towed-body systems and the experience at his institute over the last 20 years in using them. The disadvantage of using towed bodies are that they restrict the operation of the vessel and require trained personnel to launch, retrieve and maintain them. Also, in bad weather the launch and retrieval of heavy towed bodies can be dangerous.

A solution to the launch and retrieval problem was developed by deployment of the towed body through the centre of the ship independent of personnel. Several problems were encountered in this method that were not satisfactorily addressed. A better solution was found by placing acoustic transducers on centre-boards and lowering these in bad weather. Hans described several vessels that have been fitted with these centre-boards. Good results have been experienced from all of them.

The placement of centre-boards varied from 1/5 to 1/3 along the vessel and they are lowered 3-4 m below the keel. A question on the optimal centre-board depth was posed; good results have been experienced with just 1 m depth, but this would depend on the weather and sea state. Hans was asked his preference for centre-boards or towed bodies. He indicated that the centre-board is the best for overcoming the practical problems of towed bodies and does not restrict vessel movement. For very deep water work and in-situ target strength measurements, towed bodies were required.

Discussion, adoption of recommended methods. Summary, preparation of reports

A list was distributed on contacts for hydroacoustic instrumentation and this was extended to all people interested in instrumentation electronics by general agreement. The lists were to be returned to Val Torpey from BAS.

It was discussed that H. Knudsen would compile the report from the meeting and that the rapporteurs would comment as well as other interested people. An appendix to the report should contain the names of people working in the field and materials in use.

Discussion of the resolution on the calibration of equipment for acoustic surveys: It was felt that this should be expanded to cover general electronic instrumentation used in the calibration procedure. This instrumentation should be kept in calibration by a national standard according to the manufacturer's specifications. The accuracy of acoustic calibrations to the level of ±0.1 to ±0.5 dB was then discussed. H. Knudsen responded by saying that if they noticed a change ≥0.5 dB in the calibration then some form of action would be taken.

Digitisation at the transducer, to eliminate long cable runs was discussed. R. Nielsen, Simrad, responded that each installation is different and that the cable runs should be as short as practicable. This extended to discussions on cable runs on vessels, in general separating power from signals. The experience in Denmark is that use of cable trays, of the same type as used in hospitals for separating high-power and low-power signals, gives good results.

R. Nielsen discussed the topic of painting ceramic transducers to protect them. The general opinion was that transducers should not be painted. Rolf contended that painting of transducer faces was now strongly recommended and that he would provide more information for the report.

Discussions were held on recommending to the Fish Capture Committee that these meetings be held annually or biannually. H. Knudsen suggested that a report be first compiled and submitted to FAST, for possible future direction.

The forum was then open to discussion of topics not covered over the last few days.

B. Richards, Lowestoft England, discussed problems they are experiencing with synchronisation of echo sounders. There was general agreement that this was a problem at several institutes. Simrad has developed a solution, but it is very expensive.