Not to be quoted without reference to the author

International Council for the
Exploration of the Sea

CM 1980/B:16
Fish Capture Committee

CODE OF PRACTICE FOR THE CONDUCT OF FISHING GEAR EXPERIMENTS

by

D N MacLennan

DAFS
Marine Laboratory
Aberdeen
Scotland
UK

Summary

The "Code of Practice" describes recommended procedures for fishing gear experiments. It is intended as a guide for newcomers to the field and to encourage uniform standards which will facilitate comparison of experimental results obtained by different workers. The second draft was produced after discussion in the 1980 meeting of the gear engineering working group. It is intended that the code should be published as an ICES Cooperative Report.

Résumé

Le "Code de la Pratique" décrit des méthodes recommandées pour les épreuves sur l'attirail de pêche. Il est destiné à être un guide pour les nouveaux venus à ce sujet et à encourager des normes uniformes qui vont faciliter la comparaison des résultats expérimentaux obtenus par divers investigateurs. Le deuxième brouillon a été produit après des délibérations à la réunion de 1980 du comitésur la mécanique de l'attirail de pêche. On se propose de faire paraître le code comme un Rapport Coopératif du CIEM.

Background

This document has been prepared as a result of discussions in the Data Collection and Fishing Gear Engineering Working Groups. The first draft was prepared following a meeting of experts in Aberdeen in February 1980 (C. Res. 1979/2:14). This was presented at the Fishing Gear Engineering Working Group meeting at Reykjavik, May 1980. Comments made in the discussion of the first draft and in subsequent correspondence have led to the present document.

It has been suggested that the "code of practice" should have a different title to reflect the type of experiments covered and the fact that the document is advisory, not mandatory. An alternative title would be "Guide to experimental procedure in fishing gear research and development". The original title has been retained for the meantime, to avoid confusion.

The intention is that the final version of this document should be published as an ICES Cooperative Report.

Contents

1 INTRODUCTION

This report has been prepared by members of the ICES Data Collection and Gear Engineering Working Groups. There have been many contributors in the discussion and writing of the report which has evolved over several years. The principal meetings which have led to the present document, all convened under the auspices of ICES, were the data collection working groups at Hamburg (April 1977) and at Gothenburg (May 1979), and the first draft was produced by an expert group which met at Aberdeen in February 1980. The participants at these meetings are listed in Table 1.

The aim has been to describe the recommended procedures applied in those countries with experience of fishing gear research, as a guide for newcomers to the field, for those with a fishing rather than a scientific background who may wish to experiment with gear, and as an aid for the planning of fisheries projects in the developing countries.

The scope of this report is restricted to studies of engineering aspects of fishing gear design and performance. By this is meant the performance of the gear as a whole. Thus basic investigations of component properties such as the strength of twines are not covered. Design features of vessels and their equipment are only included in so far as they may influence the gear used or gear performance. It is recognised, of course, that fish behaviour as well as gear engineering has an important bearing on the level of fish catches, but, again, fish behaviour observations are only relevant here to the extent that they can indicate the merits or demerits of particular gear designs, when taken in conjunction with physical measurements or observations. Fish selectivity experiments are excluded.

This report is about experiments on full-scale or model gears, or on component parts of gears such as netting panels but excluding twine properties, where some physical measurements or observations are used to investigate engineering aspects of gear performance.

A previous report (ICES 1977) has dealt with comparative fishing experiments. It has not been necessary therefore for this document to cover the type of experiment where the overall performance of a gear is estimated from fish catch data alone.

There are many problems in the design and execution of fishing gear experiments which make it difficult to produce satisfactory and repeatable results. Mostly these problems have to do with the severe and variable environment in which fishing gear works, and the carefully controlled conditions under which experiments can be done in a laboratory are far removed from the circumstances that prevail on a fishing vessel at sea. Nevertheless, the important point is that fishing gear technologists should be aware of the limitations of available techniques so that significance of their results can be readily understood. It is considered that the recommendations set out here if carefully followed should help to achieve this aim.

The term 'fishing gear experiment' covers an extremely wide range of activities, not only because there are many different types of gear - trawls, seines, set nets and lines to mention only four - but also because the sophistication of gear work varies so much. On the one hand, there is the simple test which aims to establish that some standard gear is a satisfactory fishing tool in a particular application, although such basic work can produce valuable results notwithstanding its simplicity. At the other extreme, there is the advanced research into gear performance which requires large investment in complex instrumentation and computing equipment. Nevertheless, the same principles can be applied to all work of an investigatory nature, the first principle being that the work should be planned and executed in a logical manner.

2 OBJECTIVES OF FISHING GEAR EXPERIMENTS

It is essential from the very start of a programme to have a clear idea about the objectives of the work to be done. The objectives must be selected bearing in mind what facilities are available, vessels and instrumentation for example, and their limitations. It is no use hoping to measure small differences between two gears if the available instrumentation is too inaccurate, when the only result will be failure. It is unwise to be too ambitious.

There is an extensive literature on how objectives should be selected and achieved through the effective management of projects, see for example Drucker 1964 and Mali 1972. The technique of "management by objectives" is of course largely concerned with industrial production, but the principles are applicable in research or indeed in any activity which involves the coordination of people and facilities in working towards a common goal.

The purpose of fishing gear research is to improve the economics of fishing and working conditions such as the safety of fishing operations. The economic return from a fishery, in so far as it is determined by the gear depends on:-

1 the quantity, quality and composition of fish catches

2 the cost of gear

3 the running cost of vessels and labour.

Any fishing gear experiment will be directed towards improvements in one or more of the above criteria. The objectives are explicit statements about what is to be achieved. They should be prepared at an early stage and communicated to all concerned so that there can be no misunderstanding about what is required as the work proceeds.

It is necessary to distinguish between the detailed <u>objectives</u> for a particular experiment and the broader policy <u>aims</u> for the parent project of which one experiment is only a part. The aims applying to fishing gear research and development will generally include one or more of the following:-

A to reduce operating costs

B to exploit underutilised resources

C to increase the catch per unit effort

D to improve the management of fisheries

E to improve the safety of fishing operations

F to overcome problems due to man's other activities in the sea.

On the other hand, the objectives for an experiment should provide a more detailed description of what is required, notwithstanding the contribution of the experiment to one of the above aims, for example:-

(a) to compare the spreads achieved by door types A and B when fished with the same net and sweeps.

(b) to observe the operation of a bottom set gill net, particularly the dependence of inclination angle on tidal flow and floatation.

(c) to determine whether gear C can be worked effectively by vessel type X on fishing ground F.

(d) to investigate the effect of floatation and rigging changes on the mouth opening area of trawl D.

A further distinction can be made between <u>fundamental</u> and <u>applied</u> objectives. The former are concerned with fundamental research which aims to understand the factors governing the performance of gear, providing essential information which can subsequently be applied in commercial gear development. For example, the study of net drag and how it relates to mesh and twine sizes is fundamental work which does not of iteself result in new commercial gears. However, new principles and methods of calculation resulting from such work may be applied in the design and development of better gears for fishermen to use. On the other hand, any project which aims to produce an improved gear for an existing fishery, or to introduce an existing gear into a new fishery, has applied objectives.

3 PREPARATORY WORK

3.1 Design of experiments

A number of tasks must be done before experimental work can begin. First, some thought should be given to the design of the experiment in order to fulfill the objectives. In the case of simpler experiments, this requires no more than a logical approach and a knowledge of technique limitations. However, when precise data near the limit of measurement accuracy are required, it is necessary to consider a statistical design which will indicate the number and arrangement of tests for adequate precision. Advice on this matter will be found in Anderson and McLean, 1974.

3.2 Programmes

A programme for the experiments should be prepared. Sometimes it will be possible to make a complete plan. In the case of flume tank experiments for example, it is not difficult to anticipate the time required for a series of measurements. However, there will often be an element of uncertainty, in particular the uncertain weather at sea, which makes it difficult to forecast how the work will progress. Nevertheless it is important to start work with a definite programme in mind which can if necessary be modified as the work proceeds. This programme should be communicated preferably in writing to all personnel engaged on the experiment.

Some Institutes require a standard form of programme to be issued for the work on research and commercial fishing vessels. A hypothetical programme in the form used by the Marine Laboratory, Aberdeen, is shown in Appendix A. It is recommended that a brief programme along these lines should be issued prior to all work involving vessels, since the cooperation of skipper and crew is essential for success and they may not be familiar with scientific aspects of the work. Of course, it may still be appropriate to prepare a second more detailed work programme for the benefit of scientific personnel.

The programme should include plans for the calibration of instruments (see section 6). It may be convenient to do some of the calibration work before the beginning of the experiment itself.

3.3 Logistics

A list of the gear, instrumentation, spares and other items required for the experiment should be prepared to facilitate the equipment being in the right place at the right time. It is most inconvenient to discover after the ship has sailed that some important item has been left behind.

Essential background information must be collected unless it is already to hand, for example tidal data for a proposed working area, details of the vessel and gear handling arrangements.

Drawings should be prepared of the gear to be tested and any special apparatus. It is particularly important that the skipper who has to work the gear should be provided with drawings of the gear and rigging. To be easily understood by the recipient, these drawings should be prepared according to local practice which will not necessarily be in the same form as gear illustrations prepared for a report (see section 7).

Tabulation sheets should be produced in sufficient quantity for the number of tests. These are forms on wchih data and observations are recorded in the course of the experiment. The design of tabulation sheets and some examples are discussed in section 5.

4 EXPERIMENTAL TECHNIQUES

4.1 Model tests

The purpose of experimenting with a model rather than with a full-scale gear is to obtain results more quickly and/or at lower cost. The model is constructed in such a way that the mechanical performance of the full-scale gear is imitated so that, from measurements on the model and a knowledge of the scaling laws, the performance of the real gear can be predicted.

In general, however, any practical model will not faithfully reproduce all the mechanical features of the real gear. For example, the scale factor for buoyancy forces may not be the same as that for friction forces. Thus it is important that measurements on models should only be used to predict those aspects of full-scale gear performance for which the scaling laws are well understood. Further information about scaling problems will be found in Dickson (1961) and Fridman (1973).

A simple method of visualising the working shape of a net is to construct a three-dimensional model from paper cut-outs representing the netting panels. Each panel is drawn on paper at a scale proportional to the horizontal and longitudinal stretched netting lengths, then the cut-outs are joined together as indicated by the net plan. Such a model cannot be used for precise measurements, but it can be a useful tool in thinking about different net designs and the planning of experiments.

Working models of complete gears or parts of gears may be tested in a wind tunnel, in a water flume or towed in a water tank. Indeed, large scale models may be operated from a small boat in open water. Errors in extrapolating from model results to the full-scale increase as the scale is reduced. Thus models should be constructed at the largest practical scale having regard to the available test facilities.

The relative motion of water and gear can be simulated by using a model in water or in air. In either case, it is necessary to consider the scaling of linear dimensions such as mesh size or otterboard length and the scaling of velocity in order to obtain the correct scaling of the forces acting on the model and the full-scale version.

It is difficult but not impossible to construct a model whose linear dimensions are all scaled by exactly the same factor say S. In the case of components such as otterboards, exact geometric scaling is simply a matter of careful engineering. In the case of nets, however, the sheet netting available from manufacturers will probably not have the exact twine diameter and/or mesh size required for the model scale. The normal practice is net modelling is to ensure that the twine area and the total surface area of each panel are scaled correctly. The following procedure may be adopted. Suppose that the scale of the complete model is to be S but that the nearest available model twine size is t_m for a full-scale twine size t. The actual scale of the model twine is therefore $S_t = (t_m/t)$ which will not equal S. To obtain the correct model dimensions for each panel, mesh size is also scaled by the factor S_t but the numbers of meshes along and across the panel are scaled by the factor (S/S_t). Experience has shown that the overall geometry of such a model can be a good representation of the full-scale net, but it must be accepted that features such as small areas of slackness in the netting, covering only a few meshes, may be quite different in the model.

The principal forces acting upon a gear are (1) static forces such as weight and buoyancy, (2) dynamic forces, notably the pressure drag or lift which is associated with the acceleration of fluid around a solid object and (3) friction forces. The latter include viscous forces in the fluid flowing across solid surfaces and, in the case of gears moving over the seabed, ground friction also.

The fluid velocity applied to the model is chosen to give the correct scaling factor for the most important forces. However, it is not possible to scale correctly and simultaneously all three types of forces. The ratio of dynamic to fluid friction forces is determined by the Reynolds Number :-

$$R = V\,l\,/\,\nu$$

While the ratio of dynamic to static forces (Froude Number) is determined by:-

$$F = V / \sqrt{(g\ l)}$$

Here V is the fluid velocity, l is a characteristic dimension of the body in question, ν is the kinematic viscosity and g is the acceleration due to gravity. Thus if R is the same for both model and full-scale, the dynamic and friction forces will be scaled correctly. And if F is the same, the dynamic and static forces will be scaled correctly, but there is no model velocity at which R and F are both the same as the full-scale values. Scaling by Reynolds Number requires the velocity in the model tests to be higher than at full-scale. Scaling by Froude Number requires the velocity to be lower.

Of course, certain forces may not be relevant to a particular model test or it may be known that some forces are negligible so that they will scale correctly over a wide velocity range. The choice of whether the Reynolds or the Froude Numbers should be made the same between model and full-scale will depend upon which forces are significant in a particular experiment.

For example, measurements of drag and lift forces on model otterboards should be done at the correct Reynolds Number. The dynamic and friction forces determine drag and lift at a given attitude, while the otterboard weight (a static force) is not relevant. Thus the Froude number is not important in this application. There is however, only a narrow range of Reynolds Numbers from 6×10^5 to 6×10^6 in which the force coefficients are independent of Reynolds Number. Tests should always be undertaken within this range.

On the other hand, experiments with nets are normally done at the correct Froude Number. In this case, the static forces such as buoyancy cannot be ignored, and their ratio to the fluid dynamic forces will clearly influence the shape taken up by a model net. It is generally assumed that the friction forces will not detract from the model performance provided the Reynolds Numbers (based on twine diameter) of both the model and full-scale nets are within the range 1,000 to 200,000. Within this range, the drag coefficients of spheres and circular cylinders are independent of the Reynolds Number.

Models of complete trawls are also usually tested at the correct Froude Number in order to reproduce the correct net shape. However, the force coefficients of common otterboard types are independent of the Reynolds Number (based on the board length) only within a narrow range, between $R = 6 \times 10^5$ and $R = 6 \times 10^6$ (Walderhaug and Akre, 1963). Froude Number scaling is likely to result in the Reynolds Number of the model otterboards being below this range, and the otterboard forces will not be correctly scaled.

4.2 Full-scale tests

Experiments with full-scale gears are done on research ships or commercial fishing vessels. In either case, a suitable size of gear and rigging arrangements must be selected to match the power and facilities of the vessel in question. Of course it is recognised that some experiments may have the objective to compare different sizes of gear, but too great a mis-match between gear and vessel, or between gear components (eg doors and net), will not give satisfactory results. The gear should be designed having regard to significant features of the vessel, for example a stern trawler normally requires a different pennant arrangement and codend dimensions compared with a side trawler.

With the exception of work on certain research vessels, it is essential that the net construction should conform to the mesh size regulations for the relevant area and type of fishery. If there are special reasons for conducting an experiment on a commercial vessel with a net that would be illegal in commercial fishing, a permit for the work must first be obtained from the appropriate authorities.

The choice of whether full-scale tests should be done on research or commercial vessels may depend on what ships are available, or on financial considerations, but when the experimental programme is the main criterion the following points are relevant:-

1 Research vessels have facilities not normally available on fishing vessels, eg laboratories and advanced instrumentation.

2 Commercial vessels are designed for fishing and for no other role. Their crews have specialised knowledge of at least one commercial fishery.

Experiments with full-scale gear are essential at some stage in the development of any new gear for commercial fishing. Model tests alone are not enough, although they can play a vital part in the earlier stages of development.

4.3 Instrumentation for full-scale tests

While some measurements can only be made with equipment taken onboard for the purpose, the standard navigational and other instruments commonly found on fishing vessels can be put to good use by the experimenter. Most vessels have a vertical echosounder to detect fish and to measure the water depth. More advanced acoustic equipment such as searchlight sonar or a netsonde may be available which can provide geometric data (eg net depth).

Navigational aids such as Decca, Loran, Omega or perhaps a satellite navigator may be available. The ships speed relative to the ground can be determined from periodic position fixes, although the accuracy of this calculation may be poor due to random error in each fix. In shallow water, a Doppler speed log can provide very accurate ground speed measurements.

The ships speed relative to the water may be measured by other types of installed log, propellor or electromagnetic. The latter type is the more accurate since propellors are liable to fouling which can cause large errors.

Over the past two decades many instruments have been developed with which a wide range of gear parameters can be measured - loads in wires, distances on the gear, attitude angles of doors and so forth. Some of this equipment can be purchased from manufacturers, mainly items with an application in commercial fishing such as netsondes, but the more specialised instruments developed by research institutes are often not marketed because the potential sales are insufficient to justify commercial production. However, most institutes are willing to make arrangements for small production runs, although the cost for small quantities can be rather high. It should also be emphasised that the assistance of experienced technicians is essential when using advanced instrumentation.

4.4 Tide corrections

In the case of gears towed in the sea, whatever speed measurements are obtained from shipboard instruments, there is a difficulty in that the measured speed may not be the same as the gear speed relative to water at the gear depth, due to the tide or other water currents. In some areas the tide may be known to be negligible, but otherwise the measured speeds must be corrected. This can be done using the reciprocal tow method which works as follows. The vessel tows first in one direction, preferably a direction with or against the tide. While maintaining this fixed heading, measurements are made under the various test conditions eg different engine power settings. The vessel then turns through 180° and tows on the reciprocal course when the measurements are repeated. Thus for each test condition, measurements have been obtained while towing both with and against the tide. It is then possible to calculate the tide as described in section 6.

It is recommended that the reciprocal tow method should be used in all towed gear experiments where precise speed measurements are important, unless (a) the speed of the gear relative to the water is measured directly, (b) accurate tide information is available from other sources, or (c) it is known that the tide is negligible.

5 DATA ACQUISITION AND MANAGEMENT

5.1 Clarification of data

This section is concerned with the information collected during an experiment. The information will consist of numerical data for the most part, but it also includes written records such as notes about gear damage, indeed any kind of fact that constitutes an experimental result.

It is important to record all relevant information at the time of the experiment. Memories fade quickly, and it may be too late to fill in gaps at a later time.

Data can be classified into three groups as described below:-

1 Information about how, where and when the experiment was conducted. A log should be maintained in which the following information is recorded:-

- date and time (start, end and intermediate times as required)
- ship name and haul or test reference number. This is often abbreviated to a single letter (ship reference), two digits (year), and a third digit (haul reference). Thus T79/6 means haul 6 on TRIDENS in 1979. ALL records should be labelled with the same reference code.
- where the experiment was conducted
- environmental data eg ships' course, wind speed and direction, sea state
- list of instruments used, including for each an identification number, where it was used, start and stop times, remarks on how it functioned
- any observations that may affect the validity of the experiment eg gear damage

- details of the gear used, particuarly changes made since the previous test or haul.

- anything else the log book keeper can think of. In this instance, it is better to write too much than too little.

This log is often called the 'rig book'. An example is shown in Appendix B.

2 Data recorded from instruments. Some instruments produce permanent records, the echo-sounder being the most common example, while others display ephemeral information on dials. The latter must be written down at the time using tabulation sheets as discussed below. Permanent records need not be read immediately, but it is of the utmost importance that all records should anotated with correct times. This is essential to allow different records to be correlated during the subsequent analysis.

3 Data in the form of notes. These might include:-

- the polish on door keels, chains or bridles, indicating contact with the ground

- gear damage

- details of the catch

- signs of fish being meshed in the net which might indicate that the meshes were not completely open.

This information will be recorded in the rig book or in tabulation sheets.

A tabulation sheet is simply a form containing a number of headings and spaces in which information is recorded. The use of such forms makes it easier to ensure that important items are not forgotten. Some examples are shown in Appendix C.

All experiments will produce data in group (1) which constitute the essential record of what was done. The quantity of group (2) and group (3) data will depend on the type and complexity of the experiment. The larger the quantity of data, the greater is the need to organise an effective system of data management. It is essential to record sufficient information to show without ambiguity what the data are and how they are cross-referenced.

Most of the emphasis in this section is on experiments at sea where data management problems are perhaps more severe, but of course the same principles apply to all experiments.

5.2 General guidelines

All data must be indexed (usually by times such as the beginning and end of actual measurements) in order to relate different measurements to one another. Instrument traces must be identified by indelible marking. Where several people are engaged in recording different measurements, they must synchronise watches or note the time from the same clock.

Instruments may fail to work during an experiment. If the instrument is a remote self recording device such as a tension meter on the gear, a failture may not be discovered until the end of the test. It is therefore adviseable to produce redundant information for key parameters. For example, tension meters can be used simultaneously at the upper and lower ends of a warp, and if one of these should fail some information on warp loads will still be available. In this way there is less chance that information from instruments that did work will be wasted owing to the failure of others.

Measurements can be taken at one instant in time (spot readings) or as an average over a period of time. It is necessary to think carefully about the kind of measurements that will be most useful. Even spot readings from a dial are in effect averaged over a short period of time since the instrument will not respond to very rapid fluctuations. Thus the real question to be considered is: over what period of time should measurements be averaged to eliminate variations that are irrelevant to the experiment in question? Unwanted variation of data can arise first because there are real changes in the parameter being measured and secondly due to random errors introduced by the instrument or measurement. In fishing gear experiments, it is usually the former source of variation which causes the greater problem, and some experience is necessary to judge the best way of taking measurements.

Consider trawling experiments as an example. These are often done by changing the engine power in steps, at each step keeping the engine power and course the same for a period of time normally between 10 and 20 minutes. The problem is to decide what measurements are appropriate to these steady state conditions. The gear parameters will change rapidly at the beginning of each period and they will tend towards the required steady values. In practice, however, towing conditions are never precisely steady. The wind and tide may change and, in bottom trawling, variable forces arise from the uneven nature of the ground. Assuming that these variations are not themselves the subject of study they must be averaged out. This is done by selecting a time interval (usually 5 minutes or so) at the end of each 'steady state' period, and all measurements are taken as averages over this time interval. It is of course essential that the same interval for averaging is applied to all data.

When calibrations are applied to measured data, it is good practice to record both the primary information (eg number of divisions on a chart) and the calibrated value. This will make it easier to apply a revised calibration should that subsequently be found necessary.

The zero reading of some instruments is liable to change. If this is possible, zero readings should be taken at least at the beginning and end of a haul. Readings should be taken relative to the most appropriate zero. If a large zero change is noted, perhaps caused by mechanical shock, the instrument must be recalibrated (see section 6.2).

5.3 Quality of data

Some data are more useful than others, and it is a waste of time recording completely useless data. They merely divert attention from more important matters. If it becomes obvious that an instrument is giving misleading information, ignore it.

The quality of data is influenced by the care taken in recording as well as the performance of instruments. Some general remarks can be made about data derived from different types of instrument:-

- visual recordings (eg from a dial): it is vital that the correct reading should be logged at the time, mistakes cannot be rectified afterwards. The quality of such data will be poor if the random variation is a significant proportion of the average. Dial readings of towing loads are generally not useful unless the instrument has been designed to integrate readings over a reasonable period of time.

- permanent records on the ship (eg paper charts): these include for example warp tension and echo-sounder records. Instruments on the gear transmitting information to recorders on the ship by means of cables or acoustic links are particularly useful. They provide the experimenter with information as to whether the gear is working correctly so that remedial action can be taken if necessary. On the other hand, it has to be considered whether attaching long cables to a gear will alter the performance compared to what it would have been in the absence of such attachments.

- remote recording instruments (eg tension meters on the gear): this type of instrument requires no connecting cables on the gear, but an important disadvantage is the time delay between the recording and the results being received onboard the ship. Thus a malfunction of the instrument will only be discovered after the experiment. It is generally true that instruments attached to the gear are liable to more failures than those on board the ship, due to the severe environment in which the former have to work. On the other hand, some parameters can be measured only by attaching instruments to the gear.

Sometimes there is ambiguity in instrument recordings and unless this can be resolved with reasonable confidence the data will not be useful. For example, an echo-sounder recording may show two traces one of which is the desired measurement and the other arises from a spurious reflection. It may be possible by comparison with other results to select the correct trace. If not, the recording should be ignored.

When data are recorded on tabulation sheets but there is some doubt about reliability, it is good practice to indicate this by adding a question mark or some other symbol.

5.4 Storage of data

The primary data, instrument traces and so on, relating to one test should be collected together in the same folder as soon as possible, and certainly no later than the end of the day's work. Data scattered around several locations can all too easily disappear. Tabulation sheets of trace readings and calculations can later be added to this collection.

After the analysis work has been completed, the primary data (including calibration details) and the final results from analysis should be stored in a safe place. It is not essential to keep the results of intermediate working since they can if necessary be regenerated from the primary data.

Some institutes have adopted standard procedures for the storage of data. These schemes are normally based on standard forms on which the data are recorded. Then these forms are themselves stored, or alternatively they are used to store the data in a computer file. These computer-based 'data banks' greatly facilitate the handling of data. They enable calibration corrections to be done quickly and of course computers are essential for many of the complicated calculations done in modern analysis procedures.

6 DATA ANALYSIS

6.1 General

The primary data have to be studied and various calculations performed in order to arrive at the final results of the experiment. This work comprises the analysis. It begins with the conversion of instrument readings into the required units (calibration). Then parameters not measured directly may be calculated. The measured and calculated data must be presented in a suitable form and interpreted. For example, graphs and tables can be prepared, and statistical tests can be used to indicate the significance of differences between one set of data and another (a data set might comprise all the measurements on one gear, for example).

While full analysis of the data may take a long time, simple checks should be made during the experiment or shortly thereafter, to detect peculiarities which may indicate that something is wrong. For example, the headline height reading from a netsonde can be compared with the expected value or that from a previous haul. If the headline height is unexpectedly low, the net or sweep wires may be foul. The cause should be investigated at once, to avoid wasting time collecting invalid data.

6.2 Calibration of instruments

Data from instruments which produce an analogue reading need to be converted to the units in which the measurement is required. In the case of a tension meter for example, the output is read as divisions on a paper trace and this must be converted to the load in tonnes. The analogue reading produced by an instrument under a given load is likely to change due to damage, old age or overhaul.

A calibration is a careful test to determine the levels of analogue reading produced by a series of precisely known outputs (parameter values). These precise inputs are measured by a special standard instrument of high accuracy used only for calibrations. The calibration procedure should be decided by the expected performance of the instrument or measurement technique, particularly the accuracy and constancy of readings at a given input.

The underwater tension meters currently used on fishing gear have been found to require the most thorough calibration. The following remarks refer mainly to these instruments by way of example. It is essential that the instruments are calibrated regularly using a standard procedure. The series of loads should cover the full range of the instrument and should include an equal number of points when the load is increasing and decreasing. As far as possible the calibration should be performed under the conditions in which the instrument will operate as its performance may change with temperature and pressure and, in the case of acoustic instruments, with salinity also.

The most convenient method of presenting a calibration is on a graph (Figure 1). A quadratic or linear regression, depending on the expected linearity of the instrument, should be calculated and the regression line plotted on the graph. This line is subsequently used in reading off load values against the number of divisions. An explanation of regression calculations will be found in any statistical text book, for example Weatherburn (1961).

Before using the calibration graph, it is advisable to check that none of the following features are present, as otherwise the calibration is suspect.

i) outlying points - usually due to human error

ii) excessive non-linearity. At the full-scale reading the quadratic terms (Ax^2) should not be greater than 15% of the load. Here x is the number of divisions and ($Ax^2 + Bx + C$) is the quadratic regression curve - see Figure 6.2.

iii) large hysteresis when the points for increasing load do not coincide with those for decreasing load.

iv) a residual R less than 0.996 which indicates that the scatter of points is not acceptable.

v) inconsistency with previous calibrations. If at the full-scale or half full-scale reading the two calibrations give values which differ by more than 4% then the reason for the change should be sought. If there is no apparent reason, the calibration should be repeated.

The calibration shown in Figure 6.2 is less than satisfactory. It exhibits all the features (ii), (iii) and (iv).

The details of each calibration performed on an instrument should be recorded in a catalogue to allow easy comparison between calibrations and to check the long term performance of the instrument.

Calibration should normally be done at least before and after a series of experiments. If successive calibrations are found to be significantly different, care must be taken to identify when the change occurred and the appropriate calibration used on each occasion the instrument is used.

If the cause of a change (like a shock load on an instrument) cannot be found, and therefore the two calibrations must be regarded as equally valid, the calibration nearest in time to each set of measurements should be used rather than the average of both calibrations.

6.3 Derivation of parameters which are not measured

One of the most important measurements in any fishing gear experiment is the relative speed between the gear and the surrounding water.

This is particularly true in trawl gear experiments when it is often more convenient to measure ship speed relative to water rather than gear speed, the parameter which determines gear performance. There may be a large difference between ship and gear speed relative to water because of the presence of tides or currents. However, the reciprocal tow method described in Section 4.4 can provide the data required to calculate the correct gear speed.

The reciprocal tow method is based on the observation that the dominant variation of some commonly measured parameters correlates well with the speed relative to water. Such parameters are wire tensions at the net or otterboards, headline height and, for pelagic gears, otterboard and net depth. A graph of one of these parameters against measured ship speed will show a separation of the results for the first and second tow directions. If there is an approximately constant tide or current then a best fit pair of parallel lines can be drawn through the data for the two tow directions. Half the distance between these two lines, measured in the direction of the speed axis, gives the magnitude of the tide or current (Figure 2).

The assumption that the tide or current is constant may be invalid since a haul can take up to three hours to complete. More complex calculations assuming sinusoidal variations in tide strength may be made.

Some features of a gear may be estimated by simple methods which do not require sophisticated instrumentation and computers. A description of such techniques and methods of calculation will be found in FAO 1980.

If sufficient data are available for a given experiment, more complex calculations may be done to determine the major performance parameters of the fishing gear. The book by Fridman (1973) contains a comprehensive description of the theoretical basis for fishing gear calculations.

Figure 3 tabulates a selection of parameters describing the performance of trawl gear and Danish seines and gives the measurements required to calculate them. It is assumed that information on the dimensions and weight of the gear components is available. Other assumptions may be necessary, for instance the values of wire hydrodynamic coefficients and the effect of ground contact.

The precise calculation of many parameters is only possible on a digital computer. The equations are too complicated for manual calculation unless severe approximations are introduced. When computer facilities are available, it is normally convenient to store data on magnetic tape or another medium accessible by the computer, perhaps in a data bank as described in Section 5.4. It then becomes possible to run different calculation programs and to prepare tables and graphs (if a graph plotter is part of the computer system) with great speed. An example of the comprehensive output which can be produced is shown in Figure 4.

It is important to remember that computer output is not infallible. Mistakes can arise, largely it is true from faults in programming or typing errors. Small errors in results can go unnoticed if there is too much reliance on automatic computing without adequate safeguards. It is good practice to verify a sample of the results, perhaps by performing a particular calculation whose result is known. Another recommended procedure is to include sum checks with data accessed by a computer. These are sums of columns or rows of data and a simple program can check that the sums agree with the data received. This procedure will detect almost all typing errors.

7 PREPARATION OF REPORTS

The purpose of producing a report is to inform others of the work done and the results achieved. Thus it is essential while writing a report to bear in mind who will read it. The report may be intended for scientists, for practical fishermen, or indeed for some other group with different interests and background knowledge. The style of the report and the information to be included should be based on the type of presentation likely to be most acceptable to the intended readership.

A good starting point is to list section headings, together with brief notes outlining the contents of each section. In this way the complete framework of the report can be constructed as a first step which will show how each section relates to the whole, and the writing of each part is made much easier. It is generally convenient to prepare figures and tables before writing the text.

It is most desirable that a standard form of presentation should be used in reporting the results of fishing gear experiments, so that workers can communicate their results in a manner that will be easily understood by others. Of course, the form of presentation will sometimes be governed by the rules of publishers and editors, particularly in the case of papers for publication in scientific and technical journals, but such rules are intended to ensure uniform standards and comprehensible reporting. Indeed, useful advice on this matter can be found in the written guidance for authors which many journals provide on request.

The rules applying to good quality scientific papers are perhaps more rigorous than those applying to other kinds of publication, but it certainly does no harm and it is recommended that authors should strive to maintain the highest standards in all their reporting. Sound advice on the art of scientific writing will be found in Porter (1961) and in a useful booklet produced by the Royal Society (1974).

It is recommended that the SI system of units should be used in the presentation of data and experimental results. Where there are strong reasons for using other units, a common example being the measurement of speed in knots (SI unit - ms^{-1}), the units must be clearly stated and the SI equivalent should also be quoted. Thus a speed measurement might be written as 3 knots (1.54 ms^{-1}).

A particular difficulty may confront the author who has to produce a report not in his mother tongue. Care must be exercised in translation, particularly of technical terms, and some useful references are included in the bibliography.

The report must include a description of the gear, vessels and other facilities used in the experiment. It is not necessary that every minor detail should be included explicitly, but sufficient information should be provided so that the reader can find out, from other sources if necessary, exactly how the work was done and what was used. References can be given to prior publications containing additional information which need not then be repeated.

The <u>vessel</u> description must include the name, vessel type and main specifications such as engine power. When much additional detail is to be included, this can be presented conveniently in an Appendix to the main report. Figures may be used to illustrate the deck layout, ancillary equipment and gear handling methods. It is recommended that all vessel descriptions should accord with an internationally recognised procedure, such as that adapted by the FAO, EUROSTAT or ICNAF.

The <u>gear</u> description must include an engineering drawing containing all the information required for construction and rigging (unless this is precluded for reasons of confidentiality). It is recommended that the drawing rules adopted for the FAO fishing gear catalogues (FAO, 1972 and 1975) should be used. These have been summarised in Appendix IV. Should there be reasons for using other drawing rules and symbols, they must be defined and the equivalent FAO symbols quoted.

The gear description prepared for the report should not be confused with the working drawings mentioned in Section 3. The latter should conform with local practice to promote good communication with fishermen and gear manufacturers.

The following scheme is recommended as a logical sequence of headings which cover the essential items of a report on fishing gear experiments.

1 Title of the report, names and affiliations of authors.

2 Abstract or summary. This item is most important since it is the only part of the report that some people will read. It will consist of a brief concise statement of the work done and the results achieved.

3 Equipment. A description of the gear, vessels, instrumentation and other test facilities should be provided. The gear tested should be illustrated in accordance with the rules described in Appendix D of this report.

4 Experimental techniques. This section will describe how, where and when the tests were carried out, including notes on limitations presented by the environment (eg weather, availability of fish) and by the instrumentation or other facilities.

5 Results. This section is the heart of the report. The results may be presented as tabulated data or as graphs. Alternatively, if the numerical results are few, they may be incorporated in the text. When computed results as opposed to directly measured data are presented, a description of the analysis methods should be provided.

6 Conclusions. This section should begin with a brief statement of the conclusions reached as a result of the experiments. It is useful to state the limitations of and the confidence in the results obtained, leading to a discussion of the need for further work to be done. Longer term aims such as the application of the work in commercial fishing should also be covered.

7 References. Whenever previous work or publications are mentioned in the report, a reference to the source should be made and a list of all such references collected in this section. One of the standard methods for describing references must be used, as described in R. Soc., 1974.

8 REFERENCES

Anderson, V. L. and McLean, R. A.	1974	Design of experiments. Marcel Dekker, New York.
Bridger, J., Foster, J. J., Margetts, A. R. and Strange, E. S.	1980 in press	Glossary of fishing gear terms. Fishing News (Books) Ltd.
Collocott, T. C. and Dobson, A. B.	1974	Chambers dictionary of science and technology. W & R Chambers, London.
Dickson, W.	1961	Trawl performance - a study relating models to commercial trawls. Marine Research No 1, 1961.
Drucker, P. F.	1964	Managing for results. Heinemann, London.
FAO	1972	FAO catalogue of fishing gear designs. FAO, Rome.
FAO	1974	Otterboard design and performance. FAO, Rome.
FAO	1975	FAO catalogue of small scale fishing gear. FAO, Rome.
Fridman, A. L.	1972	Theory and design of commercial fishing gear. IPST, Jerusalem.
Gabriel, O. and Schumacher, W.	1977	Windkanaluntersuchungen zur Verbesserung der hydrodynamischen Eigenschaften pelagischer Scherkörper. (wind tunnel tests on the hydrodynamic characteristics of pelagic otterboards). Fischerei - Forschung, 15 (1) 1977 pp 59-76.
Gabriel, O.	1974	Ergebrisse von Windkanaluntersuchungen an Grundscherkörpermodellen. (study of wind tunnel tests on ground otterboard models). Fischerei - Forschung, 12 (2) 1974.
ICES	1977	Report of the working group on standardisation of scientific methods for comparing the catching performance of different fishing gear. ICES Coop. Res. Rep. No 66, May 1977.
ISTPM	1978	Technologie de la peche - manuel d'initiation et d'instruction (fishing technology - introduction and instruction manual). ISTPM, Nantes.

Kaye, G. W. C. and Laby, T. H.	1973	Tables of physical and chemical constants (14th ed.), pp 3-14, Longman, London.
Klust, G.	1973	Netting materials for fishing gear. FAO fishing manual. Fishing News (Books) Ltd.
Layton, C. W. I.	1978	Dictionary of nautical words and terms (2nd ed.). Brown and Ferguson, Glasgow.
MacLennan, D. N.	1979	Hydrodynamic characteristics of trawl warps. Scot. Fish. Res. Rep., No 16, 1979.
Mali, P.	1972	Managing by objectives. Wiley, New York.
Porter, J. R.	1961	Style manual for biological journals. Amer. Inst. Biol. Sciences, Washington DC.
R. Soc.	1974	General notes on the preparation of scientific papers (3rd ed.). The Royal Society, London, August, 1974.
Strange, E. S.	1978	A guide to the preparation of net drawings. Scot. Fish. Inf. pamphlet No 2, 1978.
Walderhaug, H. A. and Åkre, A.	1963	Model tests with three bottom trawl otterboards. Norwegian Fishing and Maritime News, No 1, 1963.

<u>International standards published by the ISO, Geneva</u>

ISO	1973a	Fishing nets - designation of netting yarns in the tex system. Standard No 858.
ISO	1973b	Fishing nets - description and designation of knotted netting. Standard No 1530.
ISO	1973c	Fishing nets - hanging of netting - basic terms and definitions. Standard No 1531.
ISO	1973d	Fishing nets - cutting knotted netting to shape ("tapering"). Standard No 1532.

ISO 1973e Fishing nets - determination of breaking load and knot breaking load of netting yarns. Standard No 1805.

ISO 1973f Fishing nets - determination of mesh breaking load of netting. Standard No 1806.

ISO 1974 Fishing nets - netting - basic terms and definitions. Standard No 1107.

ISO 1976a Fishing nets - mounting and joining of netting - terms and illustrations. Standard No 3660.

ISO 1976b Fishing nets - determination of elongation of netting yarns. Standard No 3790.

In press

FAO 1980a Calculations for fishing gear design. FAO Rome.

FAO 1980b Fisherman's pocket handbook. FAO Rome.

TABLE 1

Participants at the principal ICES meetings concerned with the production of this report

HAMBURG, 1977

Convenor	J J Foster	UK
Rapporteur	H von Seydlitz	FRG
	J Carrothers	Canada
	D MacLennan	UK
	B van Marlen	Netherlands
	C Nedelec	FAO
	J Prado	France

GOTHENBURG, 1979

Convenor	D MacLennan	UK
Rapporteur	B van Marlen	Netherlands
	J Brabant	France
	H B Becker	Netherlands
	J Carrothers	Canada
	A L Fridman	USSR
	C Nedelec	FAO
	J Prado	France
	H von Seydlitz	FRG

ABERDEEN, 1980

Convenor	D MacLennan	UK
Rapporteur	-	-
	R Ferro	UK
	G V Goosev	USSR
	B van Marlen	Netherlands
	C Nedelec	FAO
	E M Postnikov	USSR
	J Prado	France
	H von Seydlitz	FRG

APPENDIX A

The following is a hypothetical example of the standard form of programme used by the Marine Laboratory, Aberdeen, for experiments on research vessels.

In Confidence

Cruise 6/80

FRV EXPLORER

PROGRAMME

3-21 June 1980

Personnel

I Newton (in charge)
B Smith
C Jones
D Baird (14-22 June only)

Objectives

1 To measure the towing loads and geometry of three high opening trawls - BT 500, BT 501 and BT 502.

2 To observe the gears using underwater television equipment, particularly to detect areas of slackness or excessive strain in the netting.

Procedure

Gear and equipment will be loaded at Aberdeen on 2 June. On departing from port, the ship's log will be calibrated by making several runs over the measured mile in Aberdeen Bay.

The instrumentation work will be done mainly during the first half of the cruise, on selected tows East of the Shetland Islands. The tests will include deep water fishing North of Shetland. On all instrumented hauls, the gear will be towed for about one hour on a straight course, then for another hour on the reciprocal course to allow tide corrections to be made.

EXPLORER will berth at Lerwick on 13 June when Mr Baird will join the ship. Thereafter, trawling will be done on tows near the Orkneys, in the shallower water depths required for television observations.

B B Parrish

9 May 1980

APPENDIX B

THE RIG BOOK

The following two pages contain an extract from a log (rig book) describing one haul with bottom trawl gear. The extract includes essential background information about the test - where it took place, what was used and how the test was done.

This type of rig book is the standard form of presentation used by the Marine Laboratory, Aberdeen.

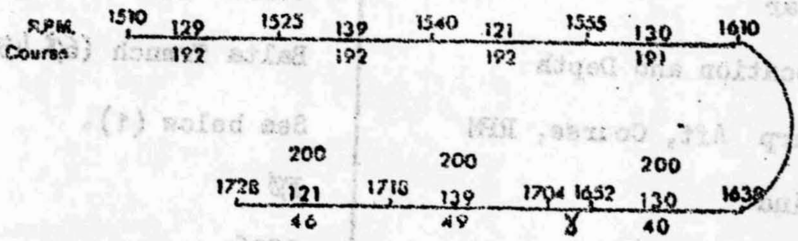
Haul Number	S79/67
Date	11.6.79
Objectives	To determine the engineering performance of the 1400HP White Sea Trawl with 11' flat trawl boards.
Gear	1400HP White Sea Trawl.
Location and Depth	Balta Trench (60 45N 000 40W) 93-103 metres.
Warp Aft, Course, RPM	See below (1).
Wind	F0
In Block	1506
Knock Out	1731
Wire circumference/diameter	warp 3.25" circumference, upper sweep 2.25" circumference, lower sweep 3.25" circumference, warp 26mm diameter, upper sweep 18mm diameter, lower sweep 26mm diameter
Rig	See below (2).
Board reference number	F25 and F26
Groundrope	See below (3).
Headline	140ft, with 100 8" deep sea floats in fives.
Computer Instrumentation	Time, DECCA position, latitude and longitude, depth, Doppler ground speed, RPM, ship's speed.

Self Recording Instruments

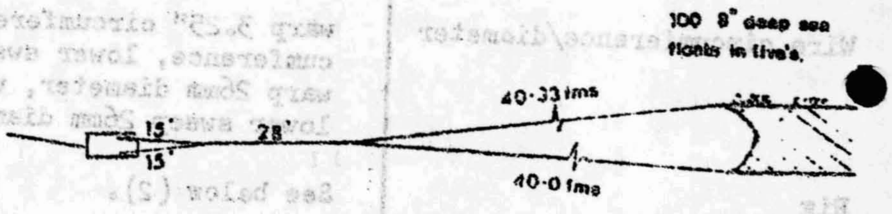
Instrument	Position	On	Off	Comments
Tension Meter	T1S			
Tension Meter	T1P			
LC28	T5S	1434.5	1820	Data logger
LC20	T5P	1434.5	1822	"
LC32	T6S	1444	1816	
LC31	T6P	1444	1816	
Spread Meter	1fm up sweep from W-E	1448	1744	
Spread Meter	25fm up warp from board	1500	1737	
Spread Meter	Headline Centre	1441	1758	Measuring headline height
Speed Log	Headline Centre	1441	1758	
Cableless Simrad	Headline Centre			Headline height
Heel, pitch, depth meter	Port door			No Depth
Heel, pitch, depth meter	Stbd door			Instrument failed

Catch	Nil
Damage	Nil
Comments	Outer warp blocks used (31 foot apart).

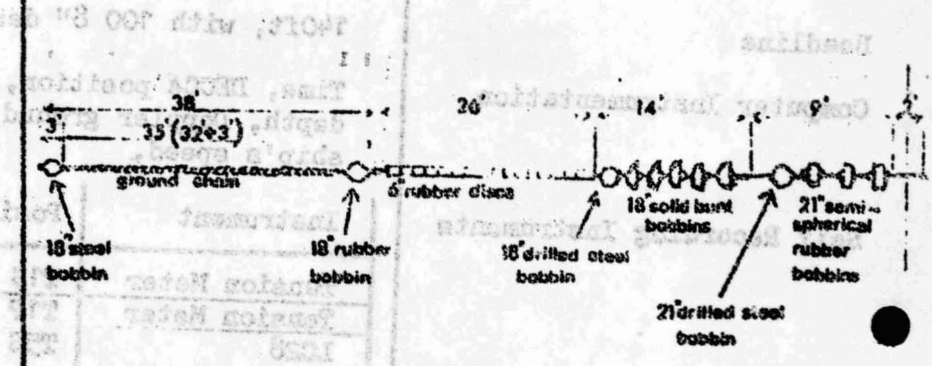
1.



2.



3.



APPENDIX C

Tabulation sheets

Tabulation sheets are forms in which data are recorded during an experiment or in the course of the subsequent analysis.

Some examples are given in the following pages. The 'form' reference in each sheet has been included to relate to the notes below, otherwise the sheets are as used in fishing gear experiments.

Form A

Used for trawling work (mainly pelagic) by RIVO, IJmuiden, Includes information from a multi-netsonde system and shipboard tension meters.

Form B

Used for trawling work by the Marine Laboratory, Aberdeen. Includes information from self recording instruments on the gear.

Form C

Used in purse seining by ISTPM, Lorient. Includes records of visual observation of the net shape at different stages.

Form D

The above examples are for recording data during an experiment. This form is used later for the purpose of storing data on the Marine Laboratory data banks. Sum checks are included for the detection of errors.

FORM A (1 page)

DATE	GEAR TYPE	SHIP	WIND	COURSE
HAUL NR.	SCALE	POSITION	SEASTATE	

clock nr.	time in	stbd warpl. (tonne)	port warpl. (tonne)	h/l depth (m)	h/l height (m)	w/e spread (m)	w/e height (m)	hor. netopng (m)	sect. spread (m)	sect. height (m)	door spread (m)	door depth (m)	shaft hpower (hp)	speed of ship (knots)	warp length (m)	bridle extn. (m)	bridle weights (kgf)	time out

INSTRUMENTS	UPPER BRIDLES	DOORS; TYPE
	LOWER BRIDLES	AREA (SQM)
	BACKSTROPS	FLOATS
	WARP ATTACHMENT	KITES

FORM B (1 page)

VESSEL ....

HAUL NO. ....

DATE ....

TRAWL TYPE ....

TRAWL BOARDS ....

AREA ....

WARP AFT ....

COURSE TOWED ....

WIND DIRECTION ....

WIND FORCE ....

Block No.								
Time								
Revs								
Speed (Crude Log)								
" (Tide corrected)								
T_1F (Tons)								
T_1A (Tons)								
T_2F (Tons)								
T_2A (Tons)								
T_3F (Tons)								
T_3A (Tons)								
T_5F (Tons)								
T_5A (Tons)								
T_6F (Tons)								
T_6A (Tons)								
Water Depth (Fm)								
Headline Height (Ft) - Memo								
Headline Height (Ft) - "								
Net Spread (Ft)								
Board Spread (Ft)								
Divergence Meter (Ft/Fm)								
Divergence (Ft)								
Declination (Degrees)								

Gear Rigging and/or Remarks

FORM C [illegible]e)

coup	jour	date	mois	bateau	n st

Observations

- heure ....
- reperage du poisson (position/surface) ....
- position du bateau (bateaux aux environs)...................
- meteo (vent: force, direction) ....
- thermocline ....
- houle ....
- courants ....
- couleux de l'eau et transparence ....
- vitesse de filage, evaluation d'une meyrune ....
- longueur remorque filee ....
- croquis forme du filet a la surface, evolution

- pression d'huile treuil ....
- tonnage peche, nature du poisson ....
....
....
....

CHRONOLOGIE

AV n BK skiff a l'eua - temps 0

......

......

......

AR filage triangle AR - debut filage remorque ......

fin de filage remorque ......

debut du boursage ......

arrives des anneaux ......

debut du hissage au power block ......

debut du salabardage ......

fin du salabardage ......

filet sur le pont ......

fin des operations ......

FORM D (5-pages)

CODING FORM FOR GEAR TRIALS DATA BANK

CONSTANT DATA RECORD

Haul number (eg. E77/14)	S79/67
Number of blocks (max. 20)	7
Type of trawling	DEMERSAL TRAWLING
Net reference number	18/1
Board reference number	F25
Sweep system	TWIN SWEEPS WITH Y-BACKSTRAPS
Rig reference number	2
Comments & further information (last character of string should be \ (backslash) to indicate end of comments)	RECIPROCAL COURSE TOWED FLOTATION:- 100 EIGHT INCH DEEP SEA FLOATS \

	DEG	MIN	N or S	DEG	MIN	E or W
at & long at start of haul	60	45	N	000	40	W
at & long at end of haul	60	46	N	000	39	W
ind speed (knots)	0					
ind direction (degrees from north)	-1					

If data unavailable for any channel then enter -1, in first two spaces, for that channel

CODING FORM FOR GEAR TRIALS DATA BANK

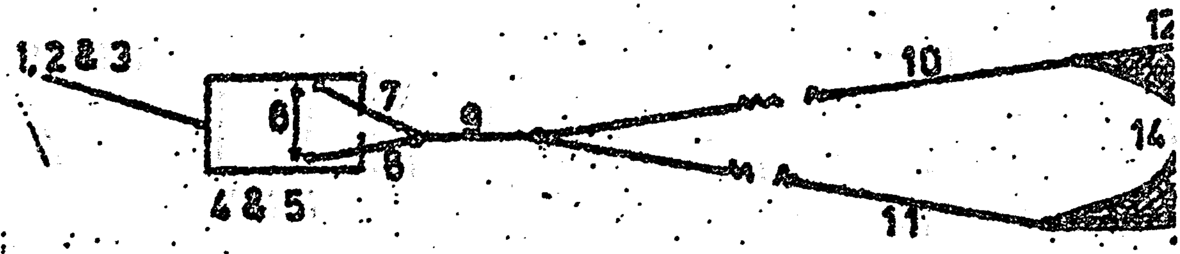
page 2
(Haul no. 579/67)

RIG DATA

2. DEMERSAL TWIN SWEEP RIG

Enter 999 if a particular parameter was not included in the rig u
Enter -1 if a parameter was present but its value was not recorde

1. Distance between warp upper ends (ft)	31
2. Warp circumference (ins)	3.25
3. Warp weight in water (lbs/ft)	1.85
4. Board weight IN WATER (lbs)	658
5. Board area (sq.ft)	58
6. Distance between backstrop fixings (ft)	-1
7. Length of upper backstrop (ft)	15
8. Length of lower backstrop (ft)	15
9. Length of stem of Y-backstrop (ft)	28
10. Length of upper sweep (fm)	40.33
11. Length of lower sweep (fm)	40
12. Headline length (ft)	140
13. Groundrope length (ft)	100
14. Sideline length (ft)	39



Notes

1. Block numbers should be separated by a comma (eg 3, 4, 6, 7, 8 etc)

2. Start times of blocks should be integers separated by commas (eg 0845, 1220, 1510 etc)

3. Tension measurements are as follows:

T0	Warp tension measured on deck
T1	Warp tension at top of warp
T2	Warp tension at bottom of warp
T3	Tension in upper backstrop
T3 lower	Tension in lower backstrop
T4	Tension in cable immediately forward of danleno bobbin or spreading wire junction
T5	Tension in upper sweep or spreading wire at its aft end
T5 upper	Tension in upper bridle at headline
T5 lower	Tension in lower bridle at headline
T6	Tension in lower sweep or spreading wire at its aft end
T6 upper	Tension in upper bridle at footrope
T6 lower	Tension in lower bridle at footrope

4. Codes:-

0	No data - leave remainder of row blank
1	Acceptable data averaged from continuously recording instruments
2	Acceptable data averaged from visual readings (eg from a dial)
3	Data from divers measurements
4	Corrected or calculated data
5	Suspect data
6	Uncalibrated data or non standard units

5. If some, but not all, values of a parameter are available enter = for those values which are missing

page 3
(Haul no. 579/67)

CODING FORM FOR GEAR TRIALS DATA BANK

DATA VARIED DURING HAUL

	CODE*														
1. Block number		1	2	3	4	5	6	7							
2. Start time of block		1510	1525	1540	1555	1638	1704	1718							
3. Propeller RPM	2	129	139	121	130	130	139	121							
4. Propeller pitch (ins)	0														
5. Propeller shaft thrust (tons)	0														
6. Shaft horse power	0														
7. Ship speed relative to water (knots)	4	3·01	3·44	2·50	2·89	3·76	3·95	3·28							
8. Tide corrected ship speed	0														
9. Course (degrees from north)	2	192	192	192	191	40	49	46							
0. Warp aft (fm)	2	200	200	200	200	200	200	200							
1. TOS (tons)	0														
2. TOP (tons)	0														
3. T1S (tons)	1	3·87	4·45	3·23	3·8	3·65	4·0	3·05							
4. T1P (tons)	1	3·2	3·45	2·8	2·96	3·55	3·5	2·7							
5. T2S (tons)	0														
6. T2P (tons)	0														
7. T3S (tons)	0														
8. T3P (tons)	0														
T3S lower (tons)	0														
T3P lower (tons)	0														
T4S (tons)	0														
T4P (tons)	0														
T5S (tons)	1	1·165	1·425	1·0	1·3	1·15	1·2	0·85							
T5P (tons)	1	0·925	1·0	0·635	0·865	0·785	0·89	0·65							
T5S upper (tons)	0														
T5P upper (tons)	0														
T5S lower (tons)	0														
T5P lower (tons)	0														

* SEE NOTES ON REVERSE OF FORM

CODING FORM FOR GEAR TRIALS DATA BANK

page 4
(haul no. 579/67)

Continued from page 3

	CODE														
29. T6S (tons)	1	1.67	1.98	1.37	1.67	1.51	1.74	1.26							
30. T6P (tons)	5	1.10	1.21	0.83	0.97	1.21	1.33	1.02							
31. T6S upper (tons)	0														
32. T6P upper (tons)	0														
33. T6S lower (tons)	0														
34. T6P lower (tons)	0														
35. Divergence (ft/fm)	0														
36. Declination stbd. (deg)	0														
37. Declination port (deg)	0														
38. Warp roll angle (deg; 0=ang=360)	0														
39. Warp or board spread (ft)	1	170	166	166	148	175	168	175							
40. Dist. from board to spreadmeter (fm)	2	25	25	25	25	25	25	25							
41. Net spread (ft)	1	79	80	82	75	82	80	78							
42. Dist. from wingend to spreadmeter (fm)	2	1	1	1	1	1	1	1							
43. Water depth at ship (fm)	1	53.59	52.49	53.59	53.59	52.49	55.23	56.32							
44. Warp or board depth stbd. (fm)	0														
5. Dist. from board to depthmeter (fm)	0														
6. Warp or board depth port (fm)	0														
7. Dist. from board to depthmeter (fm)	0														
8. Headline depth (fm)	0														
9. Headline height (ft)	1	19.3	18.2	20.7	21.3	18.2	19.03	21.0							
0. Height of footrope above seabed (fm)	0														
1. Wingend height (ft)	0														
2. Dist. wingend to mano. head (ft)	0														
3. Warp or board angle (deg; 0=ang=360)	0														
Board attack angle (deg; 0=ang=360)	0														
Board heel angle (deg; 0=ang=360)	1	13	6.8	13.7	5.4	5.2	2.5	9.2							
Board tilt angle (deg; 0=ang=360)	1	1.1	-0.9	1.8	-1.75	-1.8	-1.7	0							
Net speed (knots)	1	3.725	4.0	3.2	3.725	3.375	3.475	2.7							

CO G FORM FOR GEAR TRIALS DATA BANK

(Haul no. 579/67)

SUMCHECK DATA

For each of the 57 parameters on pages 3 and 4 add up all the numbers in each row (inc. code no.) and record the total on this form

Row number	Sum	Row number	Sum	Row number	Sum
1	28	20	0	39	1169
2	11190	21	0	40	177
3	911	22	0	41	557
4	0	23	9.09	42	9
5	0	24	6.75	43	378.3
6	0	25	0	44	0
7	26.83	26	0	45	0
8	0	27	0	46	0
9	904	28	0	47	0
10	1402	29	12.2	48	0
11	0	30	12.67	49	138.73
12	0	31	0	50	0
13	27.05	32	0	51	0
14	23.15	33	0	52	0
15	0	34	0	53	0
16	0	35	0	54	0
17	0	36	0	55	55.8
18	0	37	0	56	- 2.25
19	0	38	0	57	25.2

Now add together the 57 row sums and record the total sum 17060.52

Punch down the three 'Sum' columns - each entry on a new line

APPENDIX D

Gear drawing rules as adopted by the FAO

So far as is possible, the main design drawings are prepared to scale. The scale is indicated by unit length equivalent in the metric system. Of course, the one scale cannot refer to netting and framing lines at the same time, and the following basic rules, in accordance with the mode of presentation in the FAO Gear Catalogures, are recommended.

- Surrounding nets (purse seines, lamparas, etc): the length of the net is drawn according to the length of the floatline, and its depth according to that of the stretched netting.

- Trawls: the width of netting panels or sections is drawn according to half the width of the stretched netting, and the depth or length according to that of the stretched netting.

- Gillnets, tangle nets: the drawn length is proportional to the length of the floatline. When the net has side lines, the depth is drawn according to their length, and in the absence of side lines according to the stretched netting.

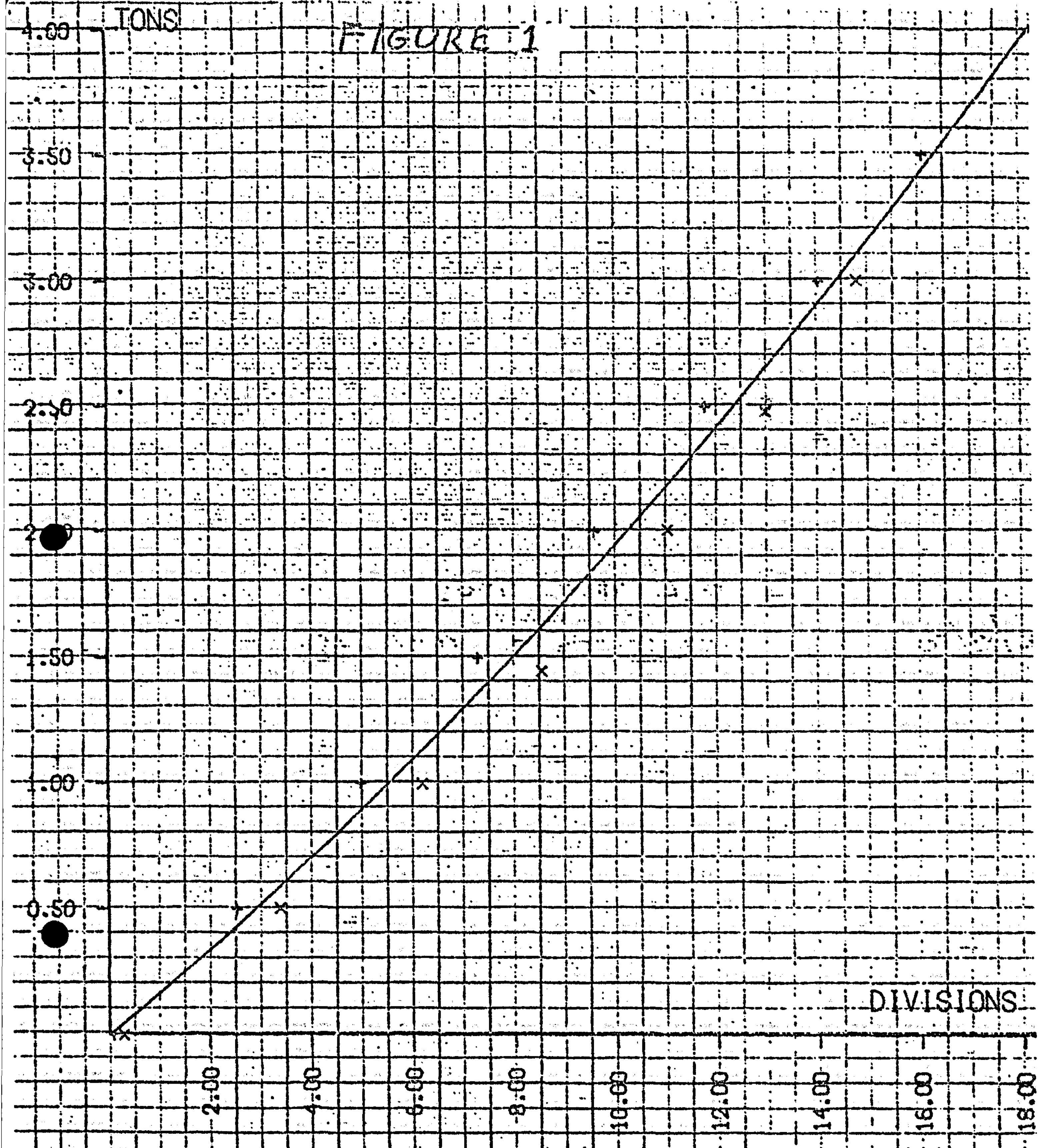
- Other gears (dredges, pots, lines, etc): in view of the great variety in construction, a standard presentation would be impractical. Schematic or perspective sketches, complemented by detail drawings as required, should be given with dimensions and scales where applicable.

The specification of netting should be given in accordance with the international standards set by the ISO (International Standardisation Organisation). Thus the yarn size is in the tex system (R tex), the mesh size is the stretched length of a mesh, the cutting rates are defined by symbols (N, T, B, AB), and the size of the netting by the number of meshes in both the N (normal) and T (tranverse) directions, or by the stretched netting length in the case of the N-direction. The ropes are specified by their material, diameter, length and when necessary, by their construction. The hanging ratio (E) is the ratio of rope length to the stretched netting length hung on the rope. E is expressed as a decimal fraction.

The materials used in gear construction are indicated by abbreviations based on terms in common international use, such as PA (polyamide), PE (polyethylene) and PP (polypropylene).

To complement a gear design drawing, sketches of the complete rig must also be prepared together with detailed drawings of important components such as otterboards.

FIGURE 1

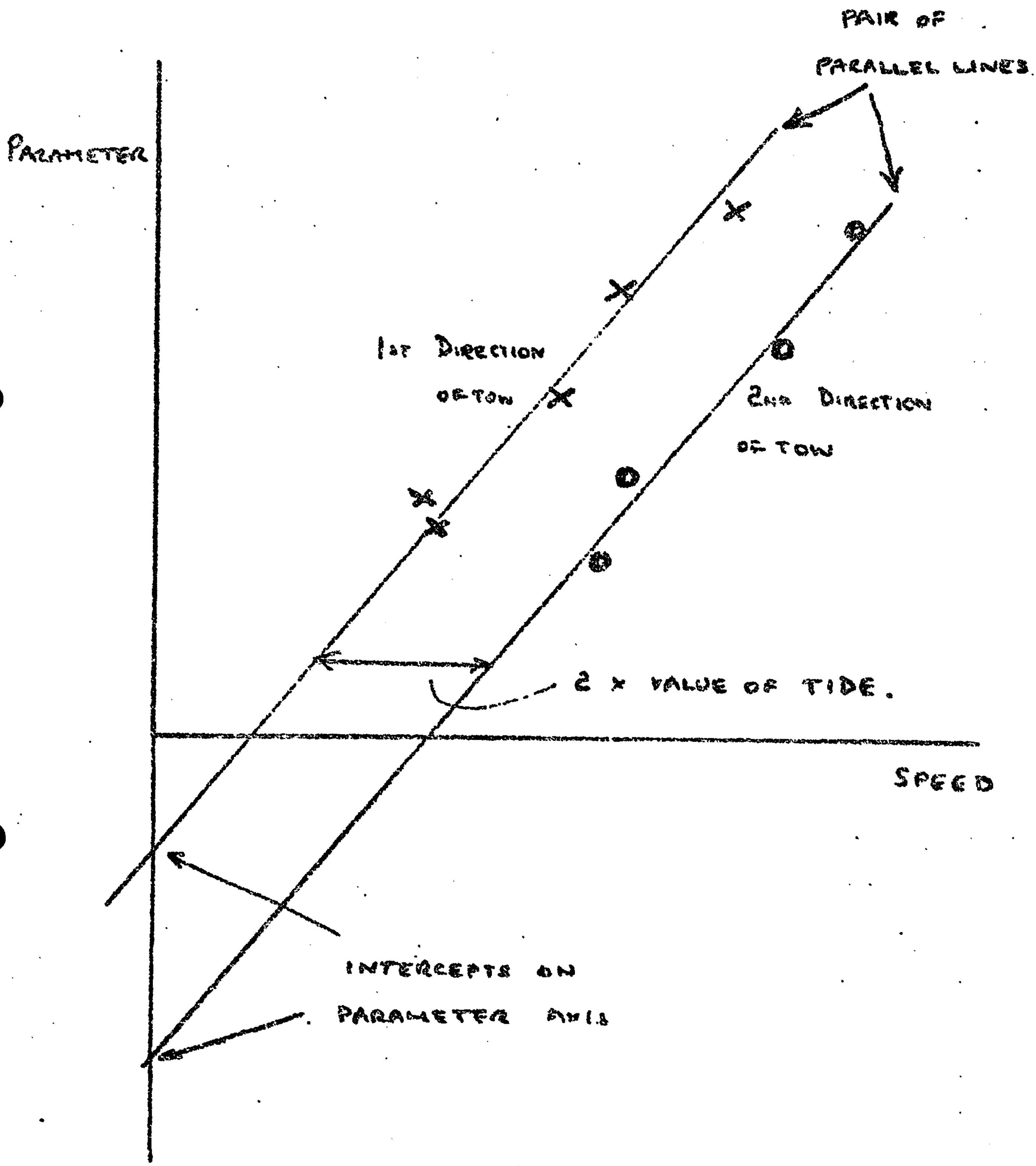


5.5 TON L.C. 32 (CONVENTIONAL)

COLD CAL. (7 DEG. C) - 2/10/79

A= 0.00313
B= 0.1640
C= 0.0
ZERO ERROR= 0.2747
R= 0.9940

FIGURE 2


PAIR OF
PARALLEL LINES
PARAMETER
1ST DIRECTION
OF TOW
2ND DIRECTION
OF TOW
2 × VALUE OF TIDE.
SPEED
INTERCEPTS ON
PARAMETER AXIS

DATA REQUIRED:	FOR THE CALCULATION OF:
(1) <u>TRAWL GEAR</u>	
WARP DIVERGENCE OR DOOR SPREAD AND WARP TENSION AT SHIP OR DOOR AND DOOR DEPTH OR WARP DECLINATION AND TOWING SPEED	GEAR DRAG, GEAR TOWING POWER, WARP SHAPE, DOOR POSITION OR WARP LIFT FORCE
DOOR SPREAD AND NET SPREAD	BRIDLE ATTACK ANGLE
DOOR DEPTH AND WINGEND DEPTH AND HEADLINE HEIGHT*	BRIDLE INCLINATION ANGLE
BRIDLE TENSIONS AND ANGLES	NET DRAG AND SPREADING FORCE
WARP TENSIONS AND ANGLES AT THE DOOR	DOOR DRAG AND SPREADING FORCE
(2) <u>DANISH SEINE NET</u>	
TOWING SPEED AND ROPE SPEED AND ROPE TENSION AT SHIP OR NET AND NET SPREAD OR ROPE DIVERGENCE AND ROPE DECLINATION AT SHIP	ROPE SHAPE, GEAR DRAG, GEAR TOWING POWER, NET POSITION; SWEPT AREA, NET DRAG OR NET SPREADING FORCE

* INSUFFICIENT FOR RIGS WITH A LOWER BRIDLE WEIGHT FORWARD OF THE WINGEND. IN THAT CASE A TENSION MEASUREMENT, FORE OR AFT OF THE WEIGHT, IS REQUIRED IN ADDITION.

FIGURE 3 DATA REQUIRED TO CALCULATE CERTAIN FEATURES OF TRAWL GEARS AND SEINE NETS

```
HAUL NUMBER  :   S79.67                                                                                    RUN ON  25-SEP-79

                                                          GEOMETRY

BLOCK   SHIP    WARP          WARP ANGLES             WATER      DOOR      WINGEND    BRIDLE    HEADLINE
 NO.    SPEED   LENGTH    DIV     DEC(S)   DEC(P)     DEPTH     SPREAD     SPREAD     ANGLE      HEIGHT
        (KN)    (FM)     (DEG)    (DEG)    (DEG)      (FM)       (FT)       (FT)      (DEG)       (FT)
  1     3.49     200     6.99     21.67    22.65      53.6      192.7       81.4      11.3        19.3
  2     3.94     200     6.74     20.41    21.55      52.5      188.2       82.3      10.7        18.2
  3     3.01     200     6.84     23.12    24.29      53.6      188.1       84.2      10.5        20.7
  4     3.41     200     5.86     21.85    23.25      53.6      167.1       76.3       9.1        21.3
  5     3.20     200     7.37     22.00    22.17      52.5      197.8       84.4      11.3        18.2
  6     3.37     200     8.99     21.99    22.71      55.2      190.0       82.3      10.9        19.0
  7     2.68     200     7.41     24.52    25.42      56.3      198.5       80.5      12.6        21.0

                                                          FORCES

                         STBD     PORT               STBD      PORT     DOOR SPREAD                   SWEEP SPREAD
BLOCK   SHIP             WARP     WARP     GEAR      DOOR      DOOR        FORCES           NET          FORCES
 NO.    SPEED    RPM     LOAD     LOAD     DRAG      DRAG      DRAG     STBD     PORT      DRAG      STBD     PORT
        (KN)            (TONS)   (TONS)   (TONS)    (TONS)    (TONS)   (TONS)   (TONS)    (TONS)    (TONS)   (TONS)
  1     3.49     129     3.87     3.20     6.54      0.68      0.83     0.82     0.62      4.76      0.55     0.40
  2     3.94     139     4.45     3.45     7.37      0.67      0.88     0.94     0.65      5.51      0.63     0.41
  3     3.01     121     3.23     2.80     5.52      0.52      0.99     0.85     0.45      3.77      0.43     0.27
  4     3.41     130     3.90     2.93     6.23      0.46      0.76     0.69     0.48      4.74      0.47     0.29
  5     3.20     130     3.65     3.55     6.66      0.65      1.21     0.79     0.65      4.56      0.53     0.40
  6     3.37     139     4.00     3.50     6.92      0.69      0.91     0.83     0.66      5.06      0.56     0.42
  7     2.68     121     3.05     2.70     5.20      0.60      0.69     0.65     0.53      3.69      0.44     0.35

                    DOOR ANGLES (DEG)

BLOCK    SPEED            HEEL             PITCH            ATTACK
 NO.     (KN)       STBD     PORT     STBD     PORT     STBD     PORT
  1      3.49       0.0      13.0     0.0       1.1     0.0      0.0
  2      3.94       0.0       5.8     0.0      -0.2     0.0      0.0
  3      3.01       0.0      13.7     0.0       1.8     0.0      0.0
  4      3.41       0.0       5.4     0.0      -1.8     0.0      0.0
  5      3.20       0.0       5.2     0.0      -1.8     0.0      0.0
  6      3.37       0.0       2.5     0.0      -1.7     0.0      0.0
  7      2.68       0.0       9.2     0.0       0.0     0.0      0.0
```

FIGURE 4