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Fishing Technology Committee

REPORT OF THE WORKING GROUP ON RESEARCH AND ENGINEERING ASPECTS OF FISHING GEAR, VESSELS AND EQUIPMENT

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(a) the Working Group on Research on Engineering Aspects of Fishing Gear, Vessels and equipment, convened by Mr. E.J. de Boer, should meet to discuss technical aspects of fishing gear, fishing vessels and fishing methods.

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AGENDA

1. Progress reports

2. Presentation of papers and verbal contributions

   2.1 Calculation of rope trawls.

   2.2 Construction and tests of a rope trawl.

   2.3 Rope trawl development.

   2.4 Rope trawl experiments with commercial trawlers on herring.

   2.5 The rope wing bottom trawl and the Polish rope wing midwater trawl (verbal).

   2.6 An acoustic tracking technique for gear geometry measurements.

   2.7 Development of a pelagic trawl in France (verbal).

   2.8 The calculation of towing warp loads in the event of a gear fastener.

   2.9 Automated gear handling of purse seine.

2.10 Investigations into the strain of netting yarn after repeated loading and after application of stress in different magnitude.

2.11 The development and testing of a flatfish grader.

2.12 Underwater observation techniques - Performance of trawl gear on rough ground (verbal).

2.13 New fishing vessel hull forms.

2.14 The application of electrical fences (verbal).

2.15 Investigations on Antarctic krill with advanced echosounding and gear techniques.

Progress reports - agenda item 1.

Objective of the progress reports is to inform the participants about recently started and planned activities by member countries in the fields of gear technology, equipment and vessel development.

BELGIUM

- In the field of electrical fishing further experiments were carried out with a compact pulse generator. This pulse generator was designed, constructed and tested with fixed frequencies, peak voltage pulse length on several fish species. Experiments at sea have been conducted with shrimps and sole.
- During investigations on semi-pelagic gears netsonde and sonar were used in order to obtain data on the position and behaviour of both the net and the fish, the position of wrecks and the condition of the seabed.
- An inquiry among fleet owners and fishermen made it possible to estimate the hindrance caused by offshore oil- and gas exploitation at sea.
  On traditional fishing grounds fishermen consider pipe laying operations to be the main interfering activity.
- On request of industry various types of yarns and webbing were tested for yarn strength, knot strength, mesh strength; mesh size, etc.
- A work-time study on the automatic feeding system for the rotary shrimp sorting and seeving machine has been started.
- A compact, battery powered, underwater pulse generator is under development.
- Experiments with set gillnets for cod.
- Further investigations on netting materials.
- Compilation of a "List of Wrecks" for the North- and the Irish Sea.

CANADA

- Development and research projects of concern to the Fishing Technology Committee are conducted by many divergent agencies in Canada. The federal government sponsors "national" projects as well as "regional" projects of particular interest to the Newfoundland, Maritimes, Quebec and Pacific Regions respectively.

The provincial governments with marine fisheries also sponsor projects, often with financial assistance from the federal government. Also, some of the universities are showing increasing interest, particularly with the advent of jurisdiction over the fisheries to 200 miles offshore. Voluntary co-ordination of the programs executed by these various agencies in eastern Canada is achieved through the Canadian Atlantic Fisheries Technological Advisory Committee (CAFTAC).

- With this diversity of interests and thrusts it is difficult, and probably not desirable, for this submission to detail all the projects. Instead, the following is a summary with apologies to those whose pet projects have been omitted.
- Improvement of shrimp trawling has been tackled on three fronts, with emphasis on minimizing the by-catch of juvenile redfish. The national projects, in co-operation with New Brunswick, include a midwater trawl for night fishing to complement the traditional bottom trawl. Also, a variable-depth sonar for improved resolution in shrimp detection has been developed and the beam trawl developed in the Pacific is to be tried in the Gulf of St. Lawrence. In Quebec and Newfoundland, various types of separator trawl have been tried.
- Other national projects include further development and promotion of mechanized longlining, trials of stern drum seining on larger vessels, a rope-wing bottom trawl for cleaner catches, and a trawl-net instrument package primarily for mensuration of mid-water trawls but also adaptable to bottom trawls.
- In Newfoundland, much of the effort goes to adapting techniques already developed elsewhere in an effort to improve the viability of inshore fisheries of local economic importance. Such projects include Irish lobster-pot hauler, purse-seining for capelin inshore and offshore, gill-netting lumpfish for roe, updating seine-net techniques, pair bottom trawling, vessel stability converting from longlining to seining, and conversion of a Pacific coast 65-ft vessel for Newfoundland conditions. Two innovations include handling and unloading catch from the hold in netting bags and mesh-size experiments with cod traps to minimize the catch of undersize fish. Also, the effectiveness of crab and lobster traps as a function of design and soak time have been studied.
- In the Maritime Region, fishing trials for sand launce were conducted, effects of hole size and material on selectivity of lobster traps were studied, and a modified scallop rake has been designed in an effort to reduce damage to lobster grounds. Two experimental onboard washers for scallop meats are being tried.
- In addition to the shrimp trawl trials, Quebec has conducted trials with the Western and Yankee 41 trawls including a modification for cleaner catches. Trawl models have been studied in the Boulogne Tank. Trawl instrumentation has included a warp tension meter and an improved battery for the Furuno net sounder.

- In the Pacific Region, promotion of stern ramp trawling on smaller vessels continues, an improved tub washer for fish using hydraulic principles and an onboard jet and air-lift unloading system are being developed, the upright-oval cambered doors are being refined, and warp tension meters are being designed.
- In addition to the above projects which are addressed specifically to the commercial fisheries, government groups are conducting research to improve fishery resource inventory techniques and to provide other technical advice related to fishing methodology for management of the fishery resource, particularly under extended jurisdiction. Techniques for acoustic surveys are subjected to co-ordinated studies in three laboratories: development of hardware and data analysis techniques at the Marine Ecology Laboratory in Dartmouth, groundfish echo strength studies at St. Andrews, and pelagic fish techniques in St. John's. The traditional trawl engineering studies have been specifically directed toward a critical examination of trawl survey methods. It is hoped that interest in fishing gear standards can be maintained.
- Polyethylene and nylon nettings are used almost exclusively in mid-water and bottom trawls in Atlantic Canada, with the latter predominating in cod-ends.

FRANCE

- Further experiments with large meshed (16 metre stretched meshes) two-boat midwater trawls onboard of 20 metre commercial vessels. These vessels fish during night in waters on the Atlantic Coast with a depth of 40-80 metres. This very large gear is towed with a speed of 4-4.5 knots. These vessels land large catches and new species are caught.
- With the objective to increase both the fishing efficiency and the selectivity, and to reduce damage to the scallops by the fishing gear a new type of scallop dredge is under development.
- Research into the influence of mounting, rigging and length of tuna purse-seines on the sinking speed is furthered. The full-scale measurements will be supplemented by observations of model research.
- Research into the biting behaviour of albacore (Thunnus Germo) during trolling operations. As bait coloured artificial lures were used. Black lures gave the best result.
- In order to check old selectivity figures a new series of selectivity experiments is started.

FEDERAL REPUBLIC OF GERMANY

- In 1977 research was concentrated on rope trawls. In this gear the webbing in the front part is replaced by an arrangement of parallel running ropes. In order to find out the best type of rope, experiments were carried out with different types. The experience with twisted ropes were unfavourable because they tended to twist together the tips of the netting. Braided ropes with a core of polyamide and a sheath of mixed monofilament and multifilament fibres with a high abrasion resistance gave the best results.

During fishing experiments with the FRV "W. Herwig" in the Irminger Sea a rope trawl was very efficient in concentrating and catching widely dispersed redfish.
In close connection with net manufacturers a rope trawl with 634 meshes (800 mm stretched) in circumference and ropes exceeding 100 m in length (selvedge) was constructed. This trawl is at the moment used by commercial trawlers.
In addition rope trawl experiments were conducted with small trawlers. A comparison between a rope trawl and conventional one proved that the latter needed 20% more power in order to achieve the same towing speed; moreover the mouth area of the rope trawl was 60 to 100% larger.
In midwater trawling conducted by a pair of small trawlers a rope trawl proved very successful when fishing in a scattered layer for herring. During model tests (scale 1:4) conducted in the central part of the Baltic Sea emphasis was also paid to rope trawls. As expected the results were very favourable in respect to towing resistance and opening-area and the gear was as easily manoeuverable as a conventional midwater trawl.

- Model tests with otter boards, especially with spherical and symmetric ones (in the latter portside- and starboard doors are exchangeable) gave promising results, but have to be continued.
- Theoretical investigations into the dynamic loading of trawls were extended to shooting and hauling operations. Especially the vertical movement of the gear during shooting is of great importance in aimed trawling. Measurements of movements of a trawler caused by the motion of the sea were continued in co-operation with the Institut for Ship Design, University of Trondheim.
- Investigations in order to replace the heavy and thus destructive flatfish beam trawl by a light electrified gear were continued. The electrified gear caught larger quantities and besides it was possible to influence the length composition of the fishes caught by changing the voltage and the duration of the electrical pulses.
- For measuring gear geometry a new ultrasonic "multi netsounder" was contructed as a part of a data acquisition system. It is equipped with six channels. Time sharing allows to measure with each channel two distances at the same time and to display them on a graph recorder.
- In October 1977 a second expedition into Antarctic waters was started in order to locate and catch krill on a semicommercial scale. Especially developed high frequency vertical and horizontal echo-sounders proved successful for finding and observing krill schools. Modified midwater trawls with a lining of fine netting proved very suitable for catching krill in commercial quantities.
- All midwater trawls and more than 90% of the bottom trawls manufactered in the Federal Republic are made of polyamide. In 1977 some revival in the use of polypropylene yarns in the form of mixed yarns (PP, PA) of higher R-tex values for application in cod-ends could be observed.
- Research on elasticity changes of netting yarns after repeated loading revealed the magnitude of the imposed load to be the most important factor for an elasticity decrease whereas the number of repetitions of the same load showed relatively few influence.

- The co-operation with national and international bodies concerned with net materials and standardisation of testing methods was maintained.
- In 1977 for the first time reliable results were obtained on the selectivity of saithe, which is now the most important species in the German deep sea fishery. For a cod-end made from polyamide (mesh opening 151 mm) a selection factor of 3.5 to 3.9 (depending on the amount of catch) was obtained.
- Investigations into the relation between water temperature and the distribution of fish were continued. In 1977 observations on saithe were conducted by means of a combined thermo-netsounder.
- Observations by means of different types of echo sounding equipment when fishing with rope trawls revealed that the ropes herded redfish efficiently into the path of the trawl. However, blue whiting showed no noticeable reaction.

ICELAND

- The experiments with selective prawn trawls were continued.
- Selectivity experiments with both a Danish seine and a bottom trawl have been carried out; the results were compared.
- Diving observations on the behaviour of plaice and dab in relation to Danish seine were started and will be continued in 1978.
- A few measurements on the dimensions of the mouth area of a bottom trawl rigged with different types of doors and different angle of attack.
- Ten national standards on netting technology, which are in agreement with the ISO-standards, were edited in 1977.

NETHERLANDS

- The geometry of rigging and netopening of several rope trawls were studied during a cruise of the FRV "Tridens" in which also staff and instruments of the Marine Laboratory -Aberdeen participated. One of the tested rope trawls had a meshed upper panel intended to decrease the large difference in depth position between otterdoors and headline which so far has been observed. An other attempt to improve this difference in depth position was the rigging of strings of floats along the headline of a rope trawl.
- Prolonged comparative fishing trials with an electrified beam trawl were carried out onboard a commercial trawler. The fishing area was along the Dutch coast and in the German Bight. The main species caught was sole (Solea solea). In both technical performance and in catch rates improvements in relation to the results of the past years were observed.
- The prototype of the flatfish grader was tested on a commercial beam trawler. The first tests with the grader were very successful, especially in relation to the improved working conditions. The sorting work, which to this very moment doesn't meet ergonomic criteria, will now be done by the grader. In March and April 1978 the tests will be continued.

The aspects of the influence on both the quality of the landings and the survival chances of the discards will be studied. These tests will partly be carried out in combination with fishing experiments on flatfish species with an electrified beam trawl.

- Further investigations on collecting mussels from the seabed by hydraulic transport with an improved mouth piece on the suction pipe of the pump installation had good results. The application of this gear for clearing the musselbeds has been successful. Experiments showed that loading and unloading of the vessels by hydraulic transport with both mussels and musselseed is possible.
- A study to design the optimum (beam)trawler for the Dutch conditions has been started. Economical criteria and a parameter study are at the moment the most important items.
- Experimental fishing trials with the objective to introduce, after adaptation to the specific characteristics of Dutch trawlers, a pair trawl for round fish species originating from Denmark (Danish pair trawl) into the Dutch fishing industry.
- Preparation of experimental fishing for cod with gill nets on wrecks.
- Preparation of an expedition with three commercial stern trawlers to look into the possibilities of blue whiting fishing.

<u>NORWAY</u>

- For information, the research and development in the fields of fish behaviour, fishing gear and vessels is carried out by respectively the Institute of Marine Research (Bergen), and Departments of the Institute of Fishery Technology Research in Bergen (gears) en Trondheim (vessels).
- Research into the effects of gear characteristics (e.g. hookshape, etc) on the hooking rate was continued.
- Experiments with the automated longline system using traditional lines showed very good results in the Barents Sea. A similar system for smaller vessels is under development.
- In order to further mechanize the handling of gill nets a new type of floatline with inbraided floats has been developed. Experiments are conducted with a simpler way of mounting and different hanging ratio's.
- During experiments with large meshed gill nets (220 mm stretched) for cod the catch increased with 30% in weight in comparison with gill nets having the minimum mesh size in accordance with the regulations.
- Selectivity experiments were carried out with mono- and multi-filament gill nets.
- The development work on sorting panels in prawn trawls continued.
- In the Barents Sea experimental midwater trawling for prawns (Pandalus Borealis) proved rather successful.

- In preparation for an expedition to fish for blue whiting in July 1978 a study of specific blue whiting gears was made. Recent experience when fishing with a 425 x 160 cm midwater trawl showed that the blue whiting is herded in the front part of the net.
- Introduction of pair trawling for round fish species in the North Sea.
- Experiments with the objective to compare the efficiency of several types of trawl doors.
- A further development of a mechanized gear handling system for inshore and coastal vessels.
- A purse-seine with hexagonal meshes was designed, constructed and tested onboard a coastal vessel. This new type of purse-seine proved to be less effected by tides and currents and a high sinking speed was observed.
- The system for testing models of vessels in open waters has been further developed.
- Experiments to close off small fjords by means of electrical fences have been conducted.
- Research into improved methods of recapturing of stored live fish was aimed at the influence of sound and light level on the feeding behaviour. In addition experiments with lift nets and modified traps were conducted.
- The development of a fish tracking programme was continued.

POLAND

- Modeltests on scale 1 : 3 with three types of trawls were carried out.
- The hydrodynamic performance of oval Matrasov-type doors, three types of round doors and Süberkrüb doors was studied.
- Underwater dynamometers and a towed vehicle for gear observations by divers were developed.
- During the second Polish Antarctic expedition the activities directed to catch krill showed good results when applying small meshed lining in a midwater trawl.
- The influence of dimensions and shape of the cod end on the selectivity was investigated when fishing for haddock and cod in the North and Baltic Sea.
- The development of a new type of webbing for cod ends was reported. The meshes of this webbing are square and constructed of polyamid tape having slots in which the "bar" of the tape perpendicular to it fits. This webbing is at the moment constructed with a meshsize (stretched) of 70 to 110 mm. For small trawlers the dimensions of the tape are 0.1 by 0.7 cm; for the distant water trawlers working on rough grounds tape of 0.35 by 2.0 cm is necessary.

SWEDEN

For information, the research and development in the fields of fishing vessels and gears in Sweden is carried out by the Division of Ship Hydromechanics, Chalmers University of Technology, Göteborg.

- Research into the influence of a fixed propeller nozzle on the environmental, technical and economical performance of a side trawler when steaming and during pair trawling was carried out. When trawling in particular gear parameters, speed, revolutions of the propeller and fuel consumption were measured.

Also the noise generated by the propeller in different parts of the hull and in the water were recorded before and after the nozzle was fitted.
Fitted with a nozzle and trawling at a speed of 4.5 - 5.0 knots a saving in fuel consumption in the order of 20-25% in comparison with the unducted c.p. propeller was observed. After fitting the bollard pull increased considerably at the same fuel consumption. The influence of the nozzle on the fuel consumption when steaming was insignificant. The noise level did not change significant after the nozzle was fitted.

- Comparative fishing experiments were carried out with a conventional Swedish bottom trawl using flat rectangular doors and a Danish bottom trawl rigged with V-type doors.
- The development of a multi-purpose trawl which could be used both as midwater and bottom trawl without changing the attachment point of the warps to the doors was started. In order to select the most suitable doors for this type of gear divers observed the behaviour of flat rectangular and round cambered doors from a towed vehicle. In addition the water flow through the net was measured. The observations by the divers indicated that the round doors were more stable than the flat ones.

U.S.A.

- Experiments are carried out to re-introduce the beam trawl gear for catching flatfish species.
- For catching squid experiments with a two-boat midwater trawl were carried out.
- In order to facilitate the handling of large meshed bottom trawls onboard small trawlers on the East Coast a netdrum was introduced.
- Attention was paid to the further development of lobster gear. Among others, a study on lost ("ghost") pots was made. The application of escape hatches and decomposable materials was tested.
- For improvement of shell fish harvesting a blade depth indicator and a tilt meter for the dredge has been developed.
- In the near future mesh selectivity studies for trawls are planned.
- Research capacity is also directed into the handling and processing of squid.

UNITED KINGDOM (SCOTLAND)

- The Marine Laboratory 4 panel trawls have continued to become more popular with United Kingdom fishermen. These trawls are now available in a number of sizes to suit vessels in the range 100-2000 HP. Further developments now in progress include a higher opening (7-8 metre) version to improve the prospects of catching fish that distance from the seabed. The 4 panel design of net also shows good promise as a demersal pair trawl and experiments in two-boat fishing have been carried out recently.

- The direct observation of gear has produced much information on the behaviour of gear as well as of fish, and in particular the action of otterboards has been observed while towing over ground where there are many stones and boulders. The object of this work is to compare the performance of different kinds of otterboard as regards their suitability for use on rough ground. Since fish can react to turbulence it is important to ensure in the development of new gears that the otterboard turbulence trail is correctly positioned to reinforce the herding action of the bridles. Observers are able to detect this turbulence by watching the mud cloud it generates and so check its alignment to the bridles.
- The operation of scallop dredging equipment has been studied. It was found that the towing loads experienced with this type of gear fluctuate to a much greater extent than those of trawls, on account of the tendency for the dredge to stick on the ground from time to time.
- A semi-pelagic trawl has been developed specially for the large catches in deep water that are typical of the blue whiting fishery. This fish is found in dense concentrations and often very close to the seabed, so that it is advantageous to use the "delagic" principle of a pelagic style of gear which can be safely operated with the net in ground contact when required. Fishing trials were carried out on the research vessel "G.A. Reay" during the 1978 blue whiting season. The semi-pelagic trawl did as well as and in some cases better than gears on commercial vessels working in the same area, West of the Hebrides, although the fish tended to be in midwater so that the particular capability of the blue whiting trawl for fishing on or close to the seabed was not tested on this occasion.
- The mark II Charlie boards have now been tested at sea. These devices incorporate a spinning rotor extending the full length of the board which is used to control the horizontal position and opening of the gear. Although the use of electric motors on the boards does require warps with electrical conductors which are rather more expensive than ordinary warps, it was shown that this kind of equipment can be operated reliably under fishing conditions. The power consumption of a rotor at 300 rpm was about 4 kw. Typically, a board could be moved 18 m sideways between the zero and 300 rpm conditions.
- Staff from the Marine Laboratory and the White Fish Authority participated in a cruise of the Dutch research vessel "Tridens" concerned with the development of rope trawls. The background to this project is described in the progress report from Holland.
- The dynamic behaviour of a small pelagic trawl has been studied by tracking the gear as turning manoeuvres are performed over an acoustic range. A total of four pingers attached to the otterboards and at each wing end were tracked simultaneously so that the horizontal assymetry of the gear could be measured as a turn was executed. Work has continued on the development of a three dimensional computer model of the trawl gear to predict aspects of performance that are difficult to measure directly and to reduce the requirement for expensive tests at sea.

- Commercial trials of an electrified beam trawl for flatfish are due to take place soon, and recently a prototype equipment has been tested which aims to solve the more difficult problem of applying electrical fishing techniques in otter trawling.
- Experiments with artificial baits for long lines have not yet produced a product superior to natural baits such as mussel and chopped squid, although much has been learned about the physical and chemical properties of baits which determine their effectiveness. The mechanics of hook and line systems have been studied mainly by theoretical calculations of the force applied to a hook as fish attempt to escape.
- The Marine Laboratory has been closely associated with an international project to find out what happens when beam and otter trawls are towed over exposed pipelines in the sea. Full scale experiments as well as model tests have produced many useful results concerning the forces generated in gear/pipeline collisions.

UNITED KINGDOM (White Fish Authority)

New and under utilised species Blue Whiting - Baader 121 Filletting machine.

- The machine under development was loaned to the W.F.A. and was installed in the I.D.U. Laboratory for three weeks during February 1978.
  Extensive trials were carried out on thawed, frozen at sea fish. Adjustments to the machine took place. This machine has been fully developed and the Baader Co. intend to build three production units.
  Skinless, flap-off single fillets were produced from 90% of the post spawning fish (caught in May 1977). A few badly distorted or damaged fish were not processed.
  Large pre-spawning fish were found to be unusable, generally due to careless packing of freezer units.
  A production machine is to be installed in May 1978 for further trials at Stornoway.

Production of Surimi

- In co-operation with a Japanese Company a production line for Surimi and Kamobotzo, Japanese products, has been in operation in Stornoway for one month. Fresh, iced at sea, blue whiting not older than four days on ice has been successfully processed. Trials are continuing on sea frozen fish.

Squid

- Trials using Japanese electrical jigging machines and fish attraction lights during October 1977 off the Devon coast were unsuccessful. It was not found possible to concentrate squid in any quantity. However fishermen hand lining for mackerel have reported occasional concentrations of squid on the bottom in the Channel. It is planned to modify mackerel gurdies to take simple squid drums so that fishermen may change their gear at sea if they find these shoals.

Horse mackerel

- A commercial freezer trawler was chartered for a nine day fishing survey of these stocks in the Channel during January.

Despite poor weather, sixty five tonnes were caught mainly during two nights concentrated fishing. The shoals were evident over an area of about 240 square miles but the main concentration was off Start Point, Devon.
The best fishing was with the pelagic trawl during the night. There is also a demersal fishery during daylight. Bad weather evidently dispersed the shoals.

Gear development

- Electrically assisted fishing
  A second series of trials using the American Ocean Harvester equipment was carried out in December 1977 on a 30 metre, 350 HP trawler off Suffolk. Beam trawls, each four metres in length were fished, both trawls fitted with electrical arrays but only one with power supplied. The "powered" beam consistently outfished the "dead" beam. When fished against the fully chain rigged beam however, catches were only 30% of the fully rigged side. A new pulser unit with a PRF of 6 as against 4 previously used, has been supplied. It is intended to carry out trials with this unit in similar comparative modes as before and also to try Peter Stewart's (Marine Laboratory-Aberdeen) rig during these trials. These are planned for July 1978.

Dual purpose trawls

- I.D.U.-staff participated in the "Tridens" trials of the Dutch rope trawls in 1977. Some model investigations have since taken place at the Flume Tank. The Institut für Fangtechnik (Hamburg) have also carried out trials at the Tank and I.D.U.-staff have evolved a mathematical formula based on these various trials, to define rope lengths. Model trials are continuing.
  It is proposed to design a rope trawl suitable for vessels of about 600 HP for use in next winter's Cornish mackerel fishery.
  Sea trials of the Marine Laboratory "Delagic" trawl on a commercial vessel, fishing blue whiting, are planned to take place shortly.

Long lining

- The autoclip system, the prototype of which was tested last summer on a 20 metre boat, has been modified during the winter and will be tested at sea during the summer of 1978. This is a fully automatic system which attaches snoods to a drum stored longline; baits and finally detaches the snoods when hauling.
  In parallel the W.F.A. have assisted a Cornish fisherman who has designed a storage system for hooks and snoods capable of installation on small boats of 9 to 15 metres length.
  American connectors are manually clipped to the line which is payed out from a drum. Two-man crews will work some 2000 hooks having pre-baited them. Four man crews on the 15 metre boats will bait immediately before shooting. The latter system has been used commercially for a few days now out of Falmouth. A safe and efficient system for small boats has been demonstrated.

Flume Tank models

- Over thirty models of commercially used trawls have now been constructed. Sea trials of full scale versions, fully instrumented, are being carried out on commercial vessels. A few representative types will be measured to compare the results with model data.

F.A.O.

Directory of Fishing Technology Institutions and Services

- In accordance with Council Resolution 1977/3:2, F.A.O. has prepared the Questionnaire which follows the general outline established for a wider scope of other similar directories to be prepared by the Aquatic Sciences and Fisheries Information System (ASFIS). This has taken longer than envisaged but 200 copies have recently been mailed to the General Secretary of ICES for distribution to ICES member countries (A limited number of copies is available for advance information).

Promotion of National Fishing Technology Services/Units

- Consultancies provided to developing fisheries including those mentioned in the last Progress Report have so far resulted in requests for Technical Cooperation Programme (TCP) funded projects in Brazil and Morocco. Plans for the establishment of national fishing technology services have been worked out for Sri Lanka (including draft project document for outside assistence, Uruquay and Senegal (within the framework of the CECAF Fisheries Development Project).
- Similar consultancies in the near future are planned for Indonesia, Burma/Thailand, Philippines, Nigeria/Ghana/ Sierra Leone and the Sahel Zone. For part of these consultancies, outside experts are required.
- Promotion through Regional Bodies and Projects include contribution of papers and participation in meetings of the Committee for Inland Fisheries of Africa (CIFA), the General Fisheries Council for the Mediterranean (GFCM) and the FAO/Norway Workshop on Fishery Resources of the North Arabian Sea organized by the International Indian Ocean Fisheries Survey and Development Programme (IOP).(A limited number of copies of the respective papers were on display).
- In addition to those mentioned in the last Progress Report which are ongoing with the exception of the Nepal Training Scheme, activities have been taken up on the design and construction of simple fishing boats in wood, FRP and ferrocement through projects in Western Samoa, Chad, Guinea, Nigeria and Tonga.
- A world-wide approach to echo-sounder manufacturers regarding the design of low-cost echo-sounders for small-scale fisheries has resulted in the provision by one supplier of proto-type units incorporating a new concept of digitized indication of echo strengths. Initial tests through projects in Sri Lanka and Southwest India have given promising results but will need to be continued to enable conclusive evaluation and recommendation of modifications.

Training courses

- The international training courses in fishing technology jointly sponsored by FAO and the French Government (ACTIM) is in the last phase of preparation and will be implemented in close cooperation with ISTPM in Nantes in June/july. A similar course for English-speaking countries in the Indian Ocean area to be financed by Norway is expected to soon receive the green light. This will probably be held in Cochin, India in 1979. It is still hoped that the Government of France and the Norway Government Cooperative Programme will agree to fund a series of such courses for other areas.
- A workshop or seminar on the development of community fisheries centres in West Africa is under preparation.
- A training course on fishing vessel design (3 months) will be held in Bangkok for participants from the Asian region to instruct on the specific requirements of fishing vessel design and related fishing gear.

F.A.O. Technical Publications

- Work on the series of FAO Fishing Manuals is continuing. Some five titles are in different stages of final preparation and two more, namely, "Monitoring Trawls in Action" and "Squid Fishing with Small Boats" have been contracted with outside authors with delivery date December 1978.
- GFCM Studies and Reviews no.56, Data on Fishing Vessels and Gear in the Mediterranean which was prepared in collaboration with ISTPM has already been mentioned.
- A popular (POP) manual on Small-Scale Pair Trawling is being processed in English, French and Spanish. This type of manual for semiliterate small-scale fishermen will, eventually, be developed into a new series subject to the response received to the first prototype title.
- A technical paper on small-scale bottom trawling prepared in collaboration with ISTPM is practically finished and will soon go for printing.
- The FAO catalogue of Fishing Gear Designs published in 1972 will be reprinted this year and the opportunity will be used to weed out misprints, up-date the Glossary and include a number of new gear designs which have evolved meanwhile.
- A Guide for the Planning, Establishment and Operation of National Fishing Technology Services is in an advanced stage of preparation. It will be initially published only in English for limited distribution to receive comments from selected contacts.
- In the field of fishing boat design and construction, the English version of "Fishing Boat Designs : 3, Small Trawlers" is ready for print. Spanish and French versions are to follow. The following titles are in various stages of preparation: Outline of Naval Architecture for Fisheries Workers; Handbook of Engine Installation and Maintenance for Small Fishing Boats; Handbook of Ferro Cement Construction for Fishing Boats; Fishing Boat Designs : 4 Medium Speed Fishing Boats.

Field Activities

- The development and testing of high-opening bottom trawls for fish-cum-shrimp was started by a TCP Project in Tunis and is to be taken up seriously by other projects in Southwest India and in the Gulf.

- Comparative gillnetting with multifilament and monofilament nets for small pelagic species in Sri Lanka has shown a clear superiority of monofilament giving a catch rate of about three times that of the traditional multifilament nets. Trials with monofilament and monotwist monofilament versus traditional multifilament drift gillnets for large pelagic species in Sri Lanka are still going on to obtain conclusive results. These trials are also to be extended to the Southwest coast of India and the Gulf.
- The comparative testing and demonstration of a limited number of different types of proto-type small-scale fishing boats is being undertaken in Senegal.

Unconventional resources

- The reports of the preparatory phase of the Southern Ocean Fisheries Survey Programme have been published. The three volumes refer to the "Living Resources of the Southern Ocean" (by Inigo Everson), "The Harvesting of Krill" (by G.C. Eddie) and "The Utilization of Krill" (by G.J.Grantham). Copies can be obtained from F.A.O.
- Attempts to start midwater trawling trials for mesopelagic fish, in particular myctophids, have not yet come off the ground in spite of an encouraging response from Norway and the promising results of the Survey of the Arabian Sea conducted by R.V. Dr. Fridjof Nansen (under sub-contract to the Institute of Marine Research, Bergen). It is, however, hoped that at least a modest start could be included in the vessel programme of the Regional Survey and Development Project in the Gulf area (Gulf of Oman and Northwest Arabian Sea) and, eventually, also later of the R.V. Strelliger (off the Southwest coast of India).

PRESENTATION OF PAPERS AND VERBAL CONTRIBUTIONS

2.1 Calculation of rope trawls by K. Lange

2.2 Construction and tests of a rope trawl by W. Dickson

2.3 Rope trawl development by B.van Marlen

2.4 Rope trawl experiments with commercial trawlers on herring by H. von Seydlitz and W. Kelle
(Rapporteur: G. Freytag)

2.5 The rope wing bottom trawl and the Polish rope wing midwater trawl - verbal contribution by W.W. Johnson

2.6 An acoustic tracking technique for gear geometry measurements by R.S.T. Ferro and G.G. Urquhart
(Rapporteur: R.S.T. Ferro)

2.7 Development of a pelagic trawl in France - verbal contribution by J.C. Brabant

2.8 The calculation of towing warp loads in the event of a gear fastener by D.N. MacLennan

2.9 Automated gear handling of a purse-seine by A. Beltestad

2.10 Investigations on Antarctic krill with advanced echo-sounding and gear techniques by G. Freytag, H. Mohr and R. Steinberg
(Rapporteur: G. Freytag)

2.11 The development and testing of a flatfish grader by A. Verbaan

2.12 Underwater observation techniques: Performance of trawl gear on rough grounds - verbal contribution by C.S.Wardle

2.13 New fishing vessel hull forms by A. Endal

2.14 The application of electrical fences - verbal contribution by E. Sølvberg

2.15 Investigations on the strain of netting yarn after repeated loading and after application of stress in different magnitude by E. Dahm

CALCULATION OF RÓPE TRAWLS

by K. Lange

1. Introduction

Since 1973, when rope trawls were first described (1), this type of trawl has become an important gear in commercial trawl fishery (2), (3). Meanwhile first attemps were made to introduce rope trawls into bottom trawling (4), (5).

Compared with conventional trawls, when designing rope trawls special efforts have to be made to get an uniform load distribution in all ropes. In (1) a semi-graphical method was used. The first rope trawls used by the "Institut für Fangtechnik" were designed by means of pure graphical methods with a more or less parabolic shape of the mouthlines. Later on the catenary theory was used to get a suitable shape of the mouthlines (6), (7).

With this theory, there are two main disadvantages:

1) The catenary theory assumes a constant load distributed over the full length of the mouthline (e.g. headline, footrope or side ropes). This leads to a curved shape of that line. In fact the mouthlines of a rope trawl are loaded by the ropes at distinct points; between two load points they are not curved but straight.
2) By the catenary theory only forces parallel to the longitudinal axis of the net can be simulated. This does not correspond to the conical shape of the rope part which is necessary to increase the opening area of the net part.

A method for calculating rope trawls published in 1977 (8) took the distinct point load of the mouthlines into consideration but the ropes are still assumed parallel. An increasing net opening is obtained only by non-parallel wing tip ropes. This disadvantage is avoided in the method presented in this paper.

2. Basic assumptions

Before starting the calculation some assumptions have to be made

1) Each panel is considered separately to reduce the calculation from a 3- to a 2- dimensional problem.
2) The tension T in all ropes is equal.
3) The ropes and the different sections of the mouthlines between the ropes are assumed straight lines.

4) The size of the rope part has to be determined (see figure 1).

Length of the rope part	Y_{WT}
Distance between the wing tips	$2x_{WT}$
Distance between the wing tip ropes of a panel at the webbing part	$2x_N$
Length of the centre rope	Y_C

The calculation is correct if the shape of the net when trawling corresponds to these assumptions. With respect to this condition some explanations of x_{WT} and x_N are necessary. It will always be possible to obtain the initial determined x_{WT}. By adequate trawl doors, bridles and trawl weights the vertical and horizontal distance between the wing tips can be influenced in a wide range. On the other hand there is no possibility to influence x_N when trawling.

x_N is calculated as follows:

$$x_N = m \cdot 2a \cdot u \qquad (1)$$

with m = number of meshes at the fore end of the net work part

2a = mesh size

u = hanging coefficient

Usually u is assumed 0,3. From modeltests in the W.F.A.-flume tank (Hull) we know that this value should be increased up to 0,4 (9).

3. Calculation

At first we need the straight line equation of each rope which is determined by the coordinates of two points of the line.

These are (see figure 1):

$$x_1 = \frac{x_N}{N} \cdot n \; ; \; y_1 = 0 \qquad (2)$$

$$x_2 = \frac{x_{WT}}{N} \cdot n \; ; \; y_2 = y_{WT} \qquad (3)$$

n = rope number = 0,1,2, ... N
0 = centre rope
N = wing tip rope
= total number of ropes

These coordinates inserted in the general equation of a straight line

$$y = A + B \cdot x \qquad (4)$$

leads to a couple of equations from which the factors A and B can be derived:

$$\left.\begin{array}{l} y_1 = A + B \cdot x_1 \\ y_2 = A + B \cdot y_2 \end{array}\right\} \qquad (5)$$

We start the calculation of the equilibrium of forces at the point x = 0; $y = y_C$. For reasons of symmetry in this point the y-component F_y of the tension in the first segment of the mouthline is equal to the half of the tension T in the centre rope (see figure 2):

$$F_y = 1/2\ T \qquad (6)$$

The x-component F_x may be assumed for the first run

$$F_x = 2\ T \qquad (7)$$

From F_x, F_y and the coordinates of the centre point x = 0; $y = y_C$ we obtain the equation of the first segment of the mouthline.

$$y = y_C + F_y/F_x \cdot x$$

By this equation and the equation of the rope nr. 1 the point of intersection can be found. At this point the equilibrium of forces is calculated again which leads to the equation of the second mouthline segment and so on until the point of intersection between mouthline and wing tip rope is obtained.

Usually in the first run the mouthline does not meet the wing tip rope at the assumed point x_{WT}; y_{WT}. In this case F_x has to be changed and the calculation is repeated until the mouthline meets the wing tip rope at x_{WT}; y_{WT} with sufficient accuracy.

To save time the calculation should be done with a computer. Only a simple programme is necessary to solve the problem.

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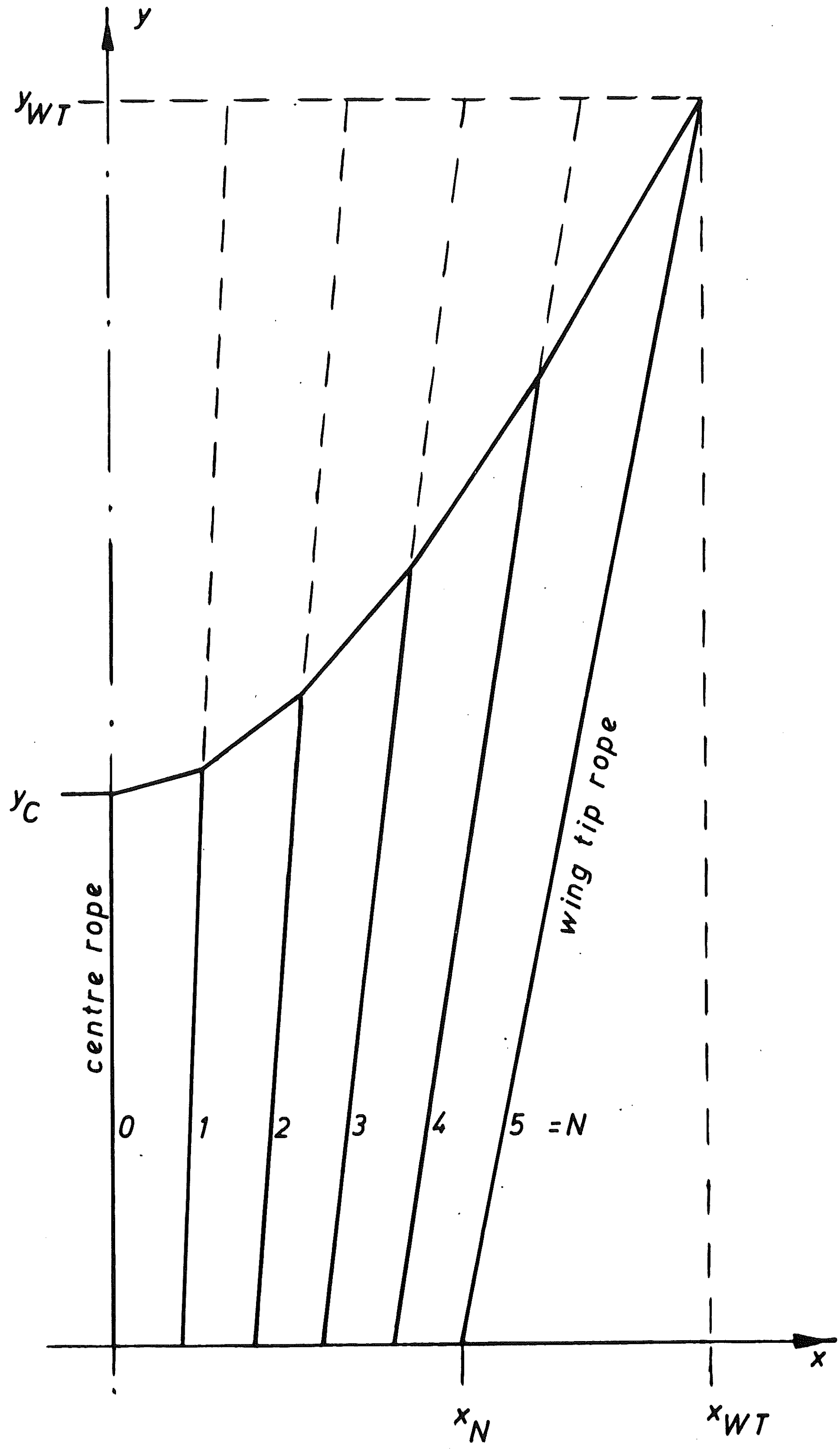


Fig. 1: Geometry of the rope part.

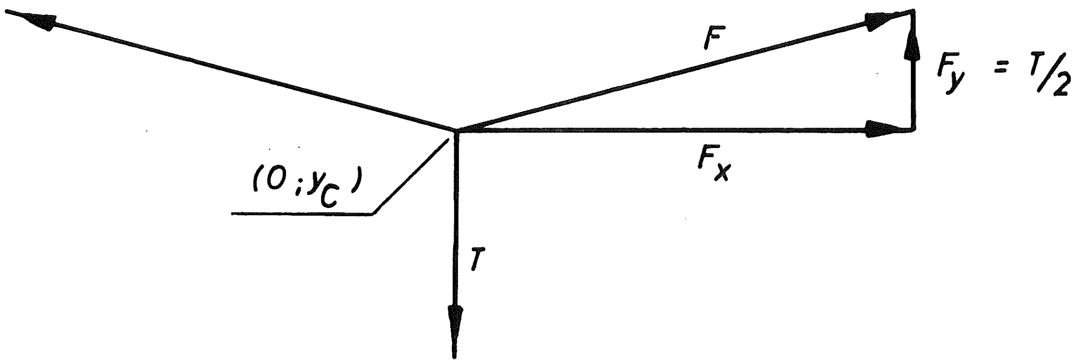


Fig. 2: Equilibrium of forces at the centre point.

CONSTRUCTION AND TESTS OF A ROPE TRAWL

by William Dickson

Following observations made on M/S "Havdrøn" fishing for blue whiting at the Porcupine Bank as early as 1974, it was decided to construct a rope trawl. This was because it appeared to be frequently necessary to fish the trawl with the footrope in close proximity to the bottom. Observations of the gape of the 572* trawl (572* in 560 mm mesh, equivalent to 1600* in 200 mm mesh) showed that the trawl should be designed for 21 m gape and rough measurements suggested designing for some 25 m wing end spread.

After some initial difficulties it was decided to confine the ropes to the bottom of the trawl only and moreover to keep stumpy lower wings in the net so that the ropes would be not too disimilar in length and so to alleviate the problems encountered with rope stretch.

The design steps are as follows:

1) Decide on the number of dropper ropes that will suit attachment to the first netting panel (in this case 19 droppers).
2) Decide on a loading pattern for the dropper ropes. In the absence of better information it was decided that the loading should be treated as uniform, that is the net in the form of a cone would load all ropes equally.
3) Choose a suitable lead in angle for the footrope end, one which will correspond with the required sweep angle and otterboard spread (in this case 14.8°). The headline or footrope lead in angle is greater than the sweep angle, which is also affected by the lead in angle of the winglines.

4) Choose a spacing between ropes that will give the net the required spread e.g. 25 m. From the spread the hanging ratio of the netting in the first panel follows ($\sin \varphi/2 = 0.33$, $\varphi/2 = 19^{\circ}$) and from that the reduction of the mesh length in the lengthways direction ($\cos \varphi/2 = 0.945$) also follows.

5) Construct a table as per Table 1 from which the spacing along the footrope between the ropes and the lengths of the dropper ropes are found. The total length of the foot-rope is also found. In the present case the footrope was to be kept the same length as that of the 572* trawl (58,5 m). In such case (when the footrope has to be a required length) it is necessary the work round the table a second time adjusting rope length (d) spacing between ropes along the footrope (ℓ) and spacing between the ropes proportionally so that all the angles remain the same. The design spread now becomes 26.3 m.

The procedure is similar to the design of a simple suspension bridge, with the difference that the span is much shorter in relation to rope length.

Fig. 1

Table 1.

6) The stumpy lower wings are now re-introduced so that the dropper ropes are shortened and of similar length. In calculating the rope lengths, accounts has to be taken of the forshortening ($\cos \varphi/2 = 0,945$) of the meshes.

Fig. 2

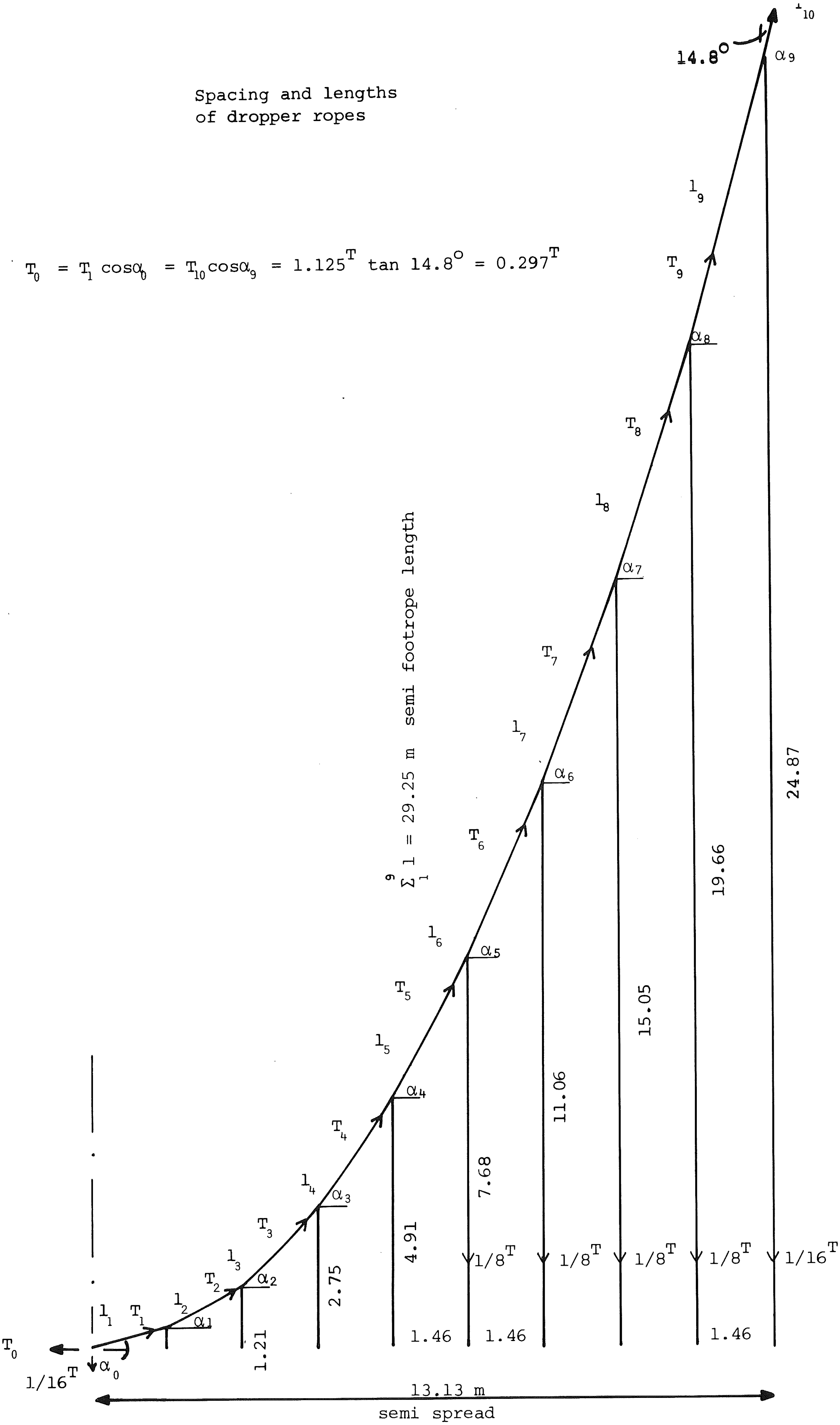

Spacing and lengths
of dropper ropes
T0 = T1 cosα0 = T10cosα9 = 1.125T tan 14.8° = 0.297T
14.8°
Σ l = 29.25 m semi footrope length
1.21
2.75
4.91
7.68
11.06
15.05
19.66
24.87
1/16T
1/8T
1/8T
1/8T
1/8T
1/16T
1.46
1.46
1.46
13.13 m
semi spread

FIG. 1

Length of footrope for 572# trawl = 2 x 29.25 = 58.5 m

$T_0 = T_1 \cos\alpha_0 = T_{10} \cos\alpha_9 = 1.125^T \tan 14.8^\circ = 0.297$

$T_1 \sin\alpha_0 = .0625^T$

hence $\dfrac{T_1 \sin\alpha_0}{T_1 \cos\alpha_0} = \tan\alpha_0 = \dfrac{0.0625}{0.297}$ and $\alpha_0 = 11.88^\circ$ and so the table proceeds

Spacing			α	l	d	loading		
1.46 m	=	$l_1 \cos\alpha_0$	11.88°	1.49	0.30	$T_1 \sin\alpha_0$	=	0.0625 ton
"	=	$l_2 \cos\alpha_1$	32.26°	1.72	0.91 1.21	$T_2 \sin\alpha_1$		.125 0.1875
"	=	$l_3 \cos\alpha_2$	46.46°	2.12	1.54 2.75	$T_3 \sin\alpha_2$		.125 0.3125
"	=	$l_4 \cos\alpha_3$	55.83°	2.60	2.16 4.91	$T_4 \sin\alpha_3$		.125 0.4375
"	=	$l_5 \cos\alpha_4$	62.17°	3.13	2.77 7.68	$T_5 \sin\alpha_4$		.125 0.5625
"	=	$l_6 \cos\alpha_5$	66.64°	3.68	3.38 11.06	$T_6 \sin\alpha_5$		.125 0.6875
"	=	$l_7 \cos\alpha_6$	69.92°	4.24	3.99 15.05	$T_7 \sin\alpha_6$		.125 0.8125
"	=	$l_8 \cos\alpha_7$	72.42°	4.84	4.61 19.66	$T_8 \sin\alpha_7$		.125 0.9375
"	=	$l_9 \cos\alpha_8$	74.38°	5.42	5.23	$T_9 \sin\alpha_8$		.125 1.0625 .0625
13.13 m semi span		α_9	75.21°	29.25	24.87	$T_{10} \sin\alpha_9$		1.125

Design spread is about 26 m

1st netting panel is 152# in 560 mm mesh, leaving 4 meshes for each selvedge hanging ratio is

$\dfrac{13.13}{72^{\#} \times .56} = 0.33 = \sin\dfrac{\varphi}{2}$ giving $\dfrac{\varphi}{2} = 19^\circ$ and $\cos\dfrac{\varphi}{2} = 0.945$

TABLE 1

Modified lower wings, ropes and square fitted into 572# trawl

8# @ 560 mm x 0.945 = 4.23 m (cut out of square)

length of droppers

droppers as per Table 1		length of netting cut out of square and put back into stump wings		final length of droppers
0.00	+	4.23	=	4.23
0.30	+	4.23	=	4.53
1.21	+	4.23	=	5.44
2.75	+	4.23	=	6.98
4.91	+	0	=	4.91
7.68	-	4.23	=	3.45
11.06	-	8.46	=	2.60
15.05	-	12.69	=	2.36
9.66	-	16.92	=	2.74
24.87	-	21.15	=	3.62

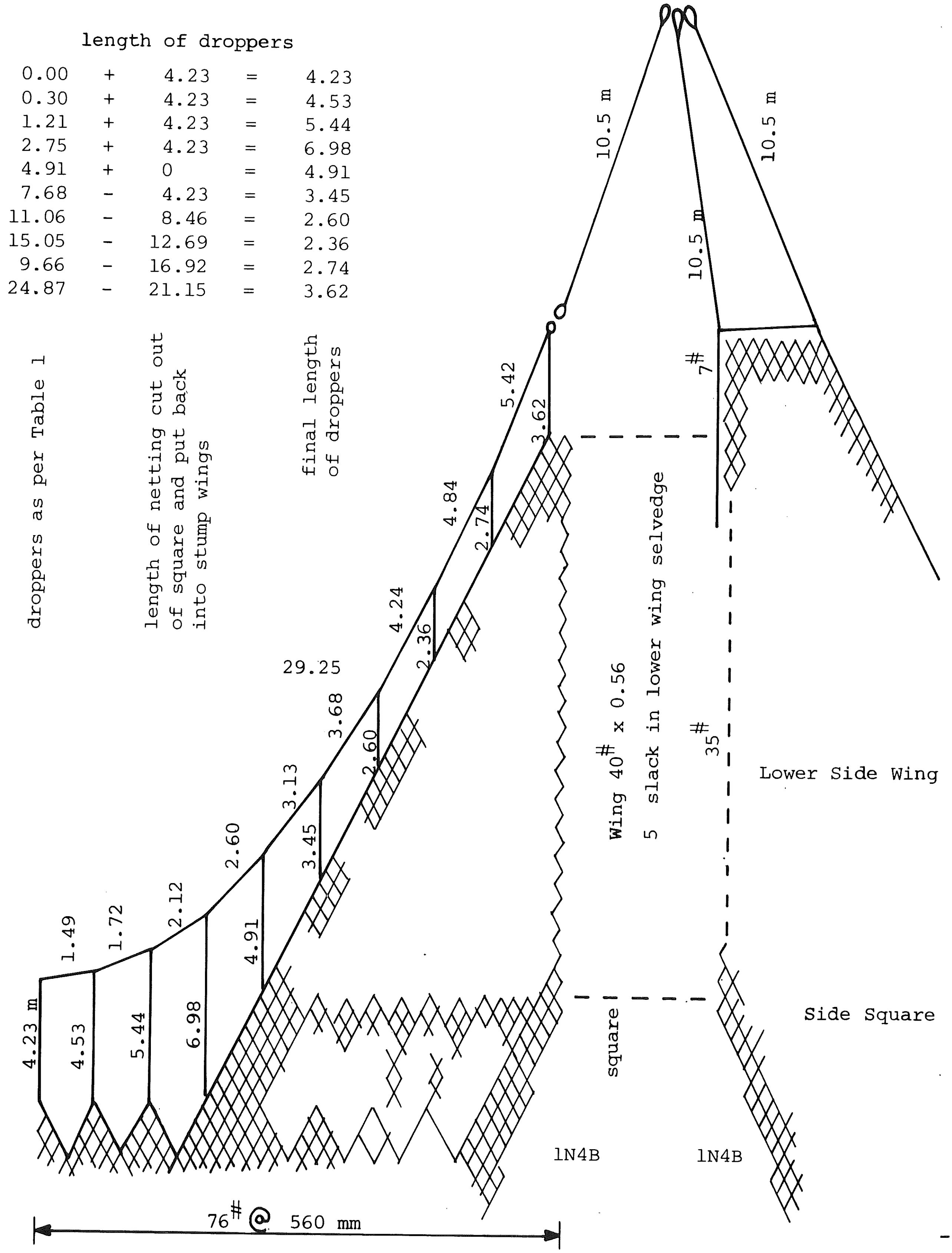


FIG. 2

Fishing operations

The net was used to catch blue whiting and anything else available in the Norway Deeps during the first half of June 77. No heavy concentrations were encountered although the whole of the deep water and slope area was searched from Stavanger as far north as Tampen. Light concentrations of blue whiting were however found near bottom in Udsire Hole, where catches of up to 110 hectolitre were taken. Average catch rates were a modest 2 ton/hour. The rope trawl has not yet been used on heavy bottom concentrations. In mid-water fishing for blue whiting it is now customary to use much bigger nets with large meshes (1000 or 2000 mm) in the wings and square (equivalent size 2640* in 200 mm mesh). There would be more uncertainty about putting such a large net onto the bottom.

In Fig. 3 the trawl is being fished as a midwater trawl would be in these circumstances, close to but yet not touching bottom. Some of the fish are rising off bottom as the net approaches and some of these may be rising above the rope but it would obviously be beneficial to put the footrope on bottom. The footrope appears to be on the bottom in Fig. 4 but actually the centre of it is still some ½ to 1 m off bottom as evidenced by the polishing of only the end links of a short chain hung from the footrope centre. Some of the very uneven grounds trawled over is seen in Fig. 5

The maximum slope of the bottom is about 1:7 which is at the limits of what it is usually considered reasonable to attack with a bobbin rigged ground trawl.

In Fig. 6 there is an indication of where the heavy chain weights touch the bottom with the footrope still 1,6 m off bottom. As the ship slows down the net sinks and the headline height at first increases but when the heavy weights hit bottom the headline height falls quickly. Also to be seen in Fig. 6 are examples of where a fish (or a group of fish at the same range) rise up in the trawl mouth at the same time as gradually falling back through the netsonde beam width. It is thus possible by knowing the trawling speed, the beam width and the time the targets remain in the beam to make an estimate of the fish swimming speed in the trawl mouth as well as its rate and angle of ascent. The following Table 2 gives the details.

Semi beam angle $\theta/2 = 10^{o}$

Beam width at range R = R 2 tan $\theta/2$ = 0,35 R

V_s Towing speed of vessel 2,6 knots or 1,34 m/s.

V_f Swimming speed of fish

Table 2. Horizontal and vertical components of fish swimming speed in trawl mouth

T Time of target in beam	R Mean Range m	W Beam width at mean Range R m	$V_s - V_f$ m/s	V_{fh} horizontal component speed	H vertical distance moved by target in beam m	V_{fh} Vertical component of swimming speed	Angle of ascent of fish	V_f Swimming speed of fish in their direction of motion m/s
18	20	7	0.39	0.95	6	0.33	19°	1.00
13.5	19	6.7	0.50	0.84	4.4	0.33	21°	0.90
9	20	7	0.77	0.56	3.3	0.37	33°	0.67
9	20	7	0.78	0.56	2.7	0.30	28°	0.63
9	20	7	0.78	0.56	2.2	0.24	23°	0.61
7.5	19	6.7	0.89	0.45	2.2	0.29	33°	0.54
9	21	7.4	0.82	0.52	2.7	0.30	30°	0.60
9	14	5	0.56	0.78	2.2	0.24	17°	0.82
12	21	7.4	0.62	0.72	2.7	0.23	18°	0.76
9	20	7	0.78	0.56	2.7	0.30	28°	0.63
18	15	5	0.28	1.06	5.5	0.31	16°	1.10
9	23	7	0.89	0.45	1.6	0.18	22°	0.49
15	19	6.7	0.45	0.89	4.4	0.29	18°	0.94
10.5	10	3.5	0.33	1.01	2.2	0.21	12°	1.03
					mean	0.28	23°	0.77

One cannot be sure where the echoes passed through the beam but the most distinct and long lasting patterns were selected so that presumably they pass through somewhere near the centre of the beamwidth. Neither the net speed nor the beamwidth are accurately known so that the values obtained for horizontal swimming speed (about 2½ body length per sec.) are open to a margin of doubt. The vertical component (rate of ascent V_{fv} should be more reliable at nearly 1 body length per second.

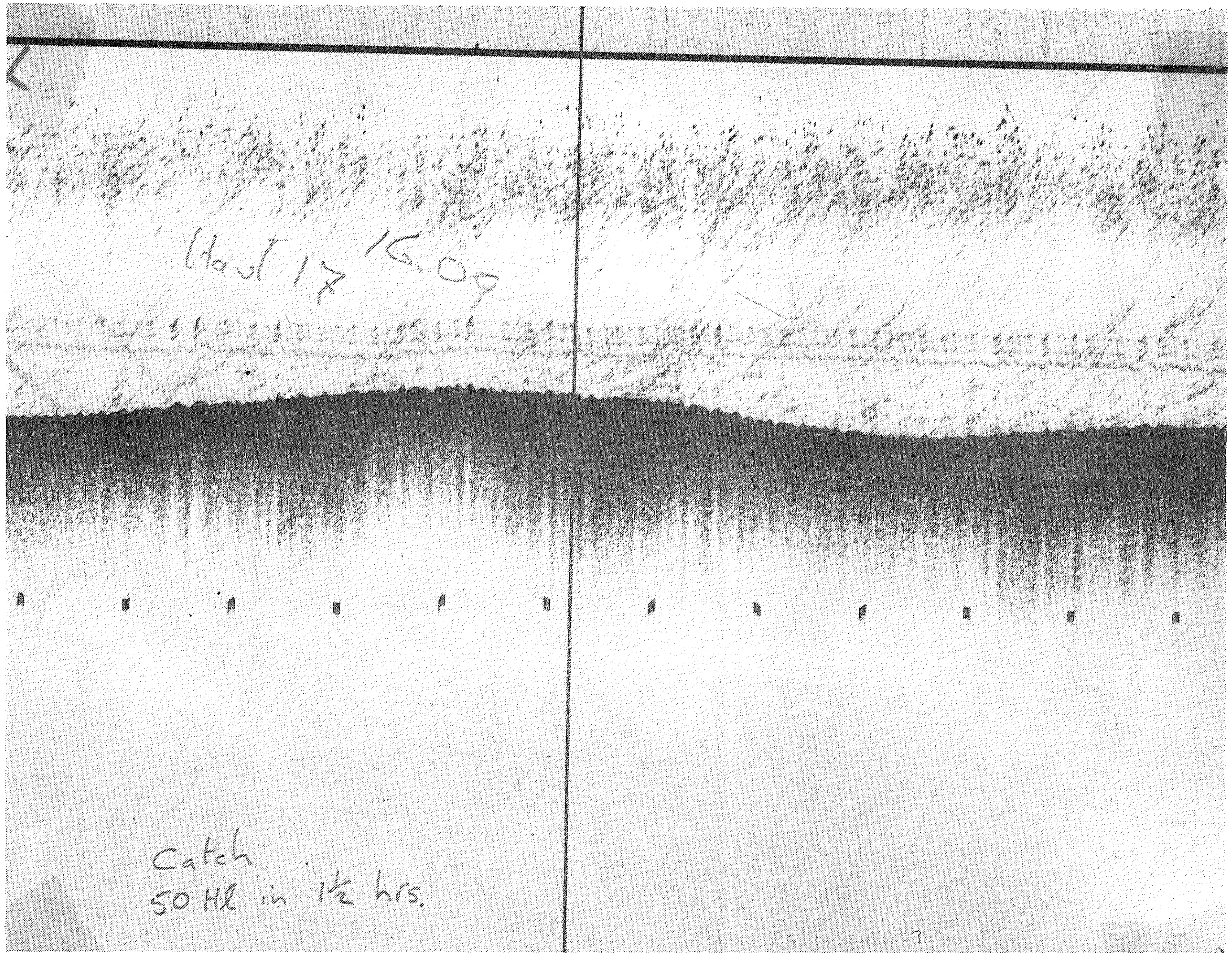


Fig. 3. Fish rising from bottom and footrope.
Skipper not yet confident to put $572^{\#}$ rope trawl onto bottom.

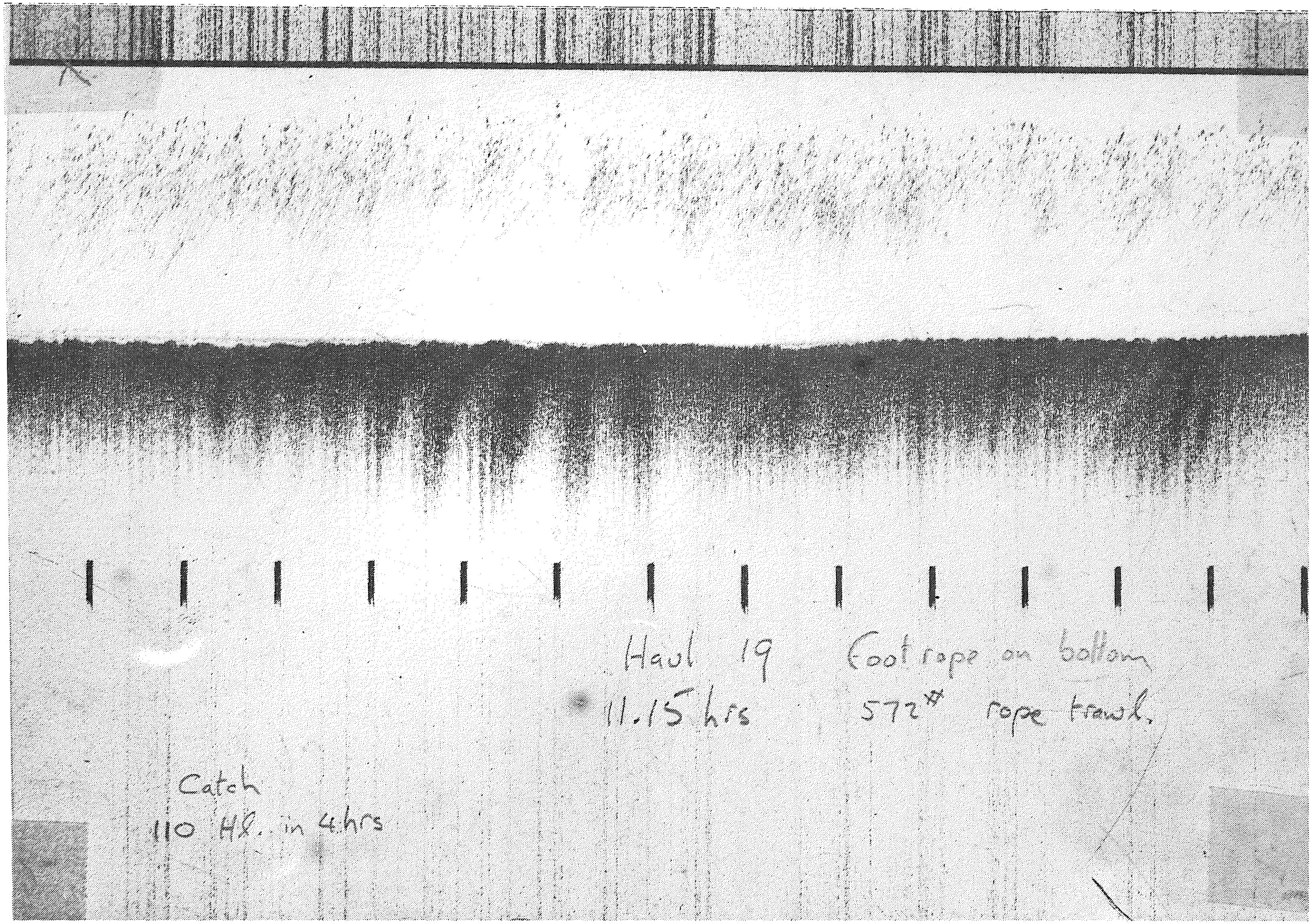


Fig. 4. Fish rising to within 7 m of net roof (beam very narrow there) they do not stop in middle of net. Foot rope appears to be on bottom but is ½ to 1 m above.

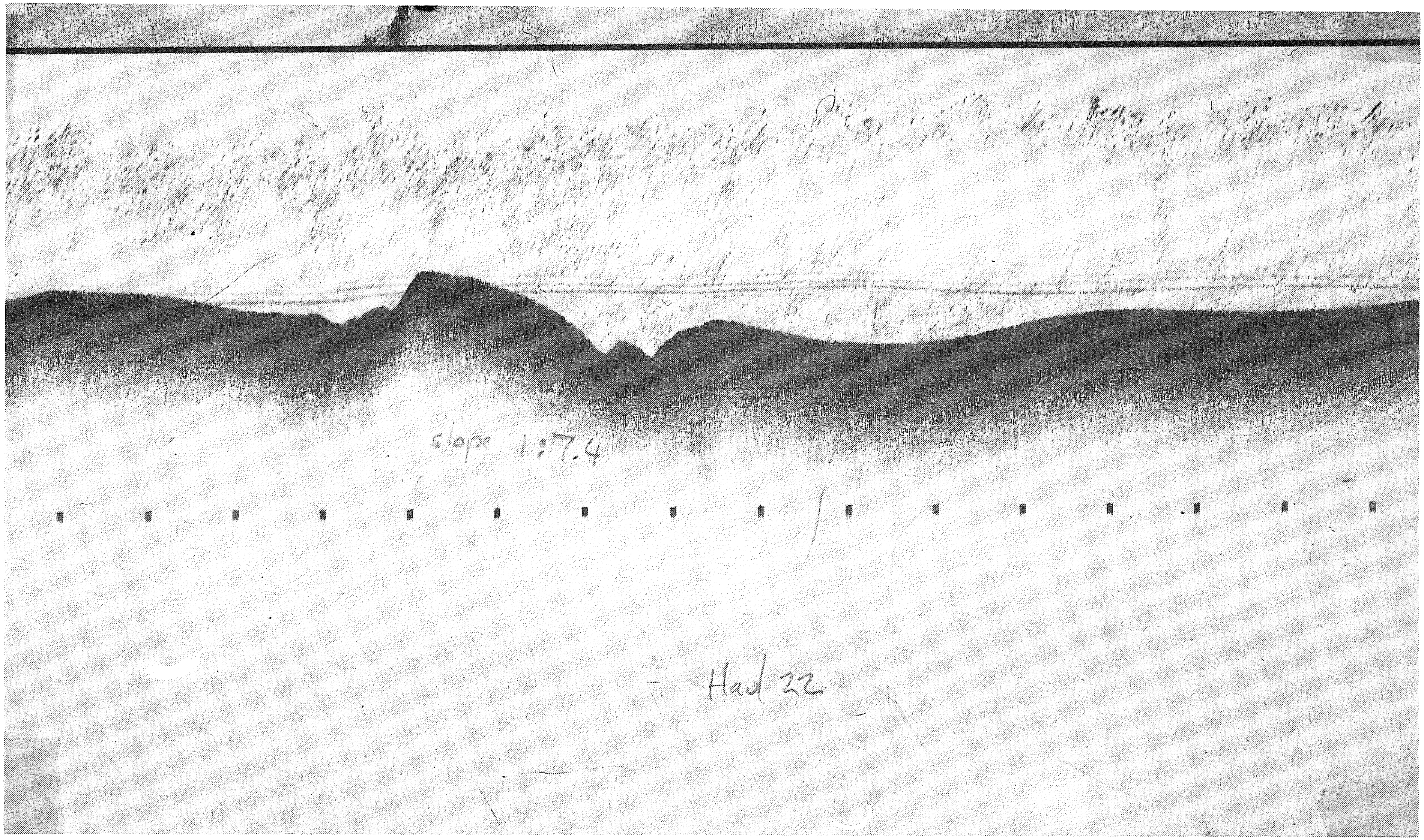


Fig. 5. 572* rope trawl coming across very uneven ground.
No damage. Catch 70 hl. Udsire Hole.

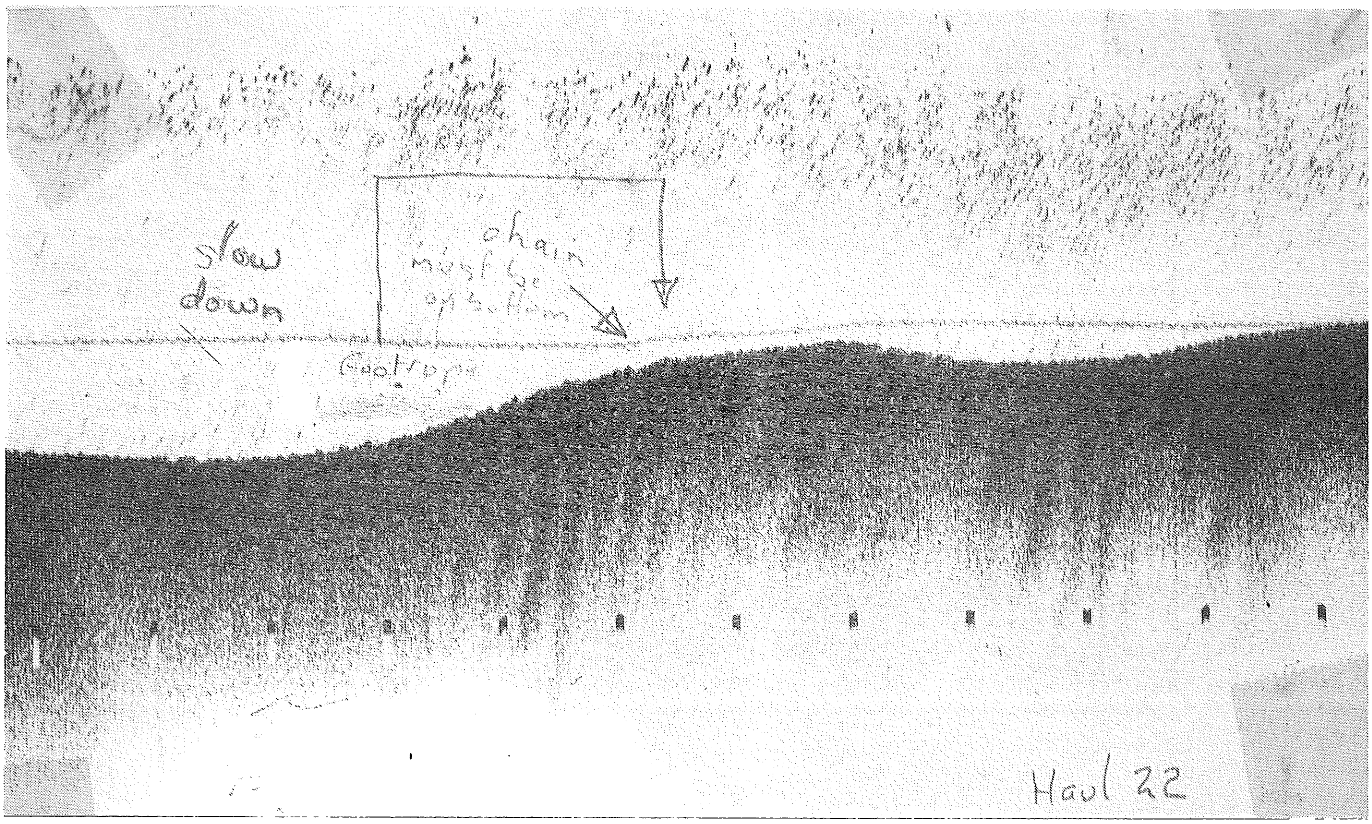


Fig. 6a. When ship slows down gape starts to increase and gear sinks but as heavy chains touch bottom gape decreases again and footrope starts to run parallel to bottom.

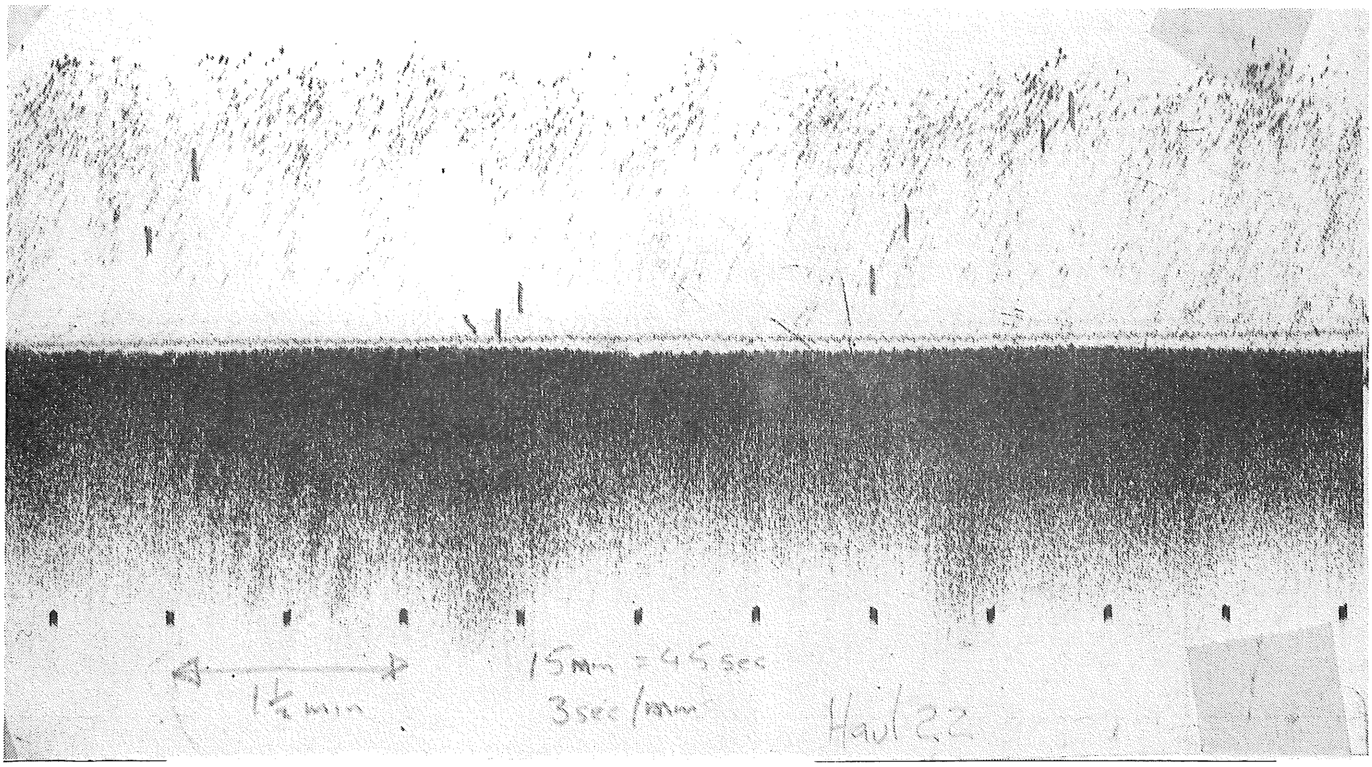


Fig. 6b. Measure off vertical distance and horizontal time over which fish rise and swim forward in the beam. Also measure off mean range.

Operating dimensions

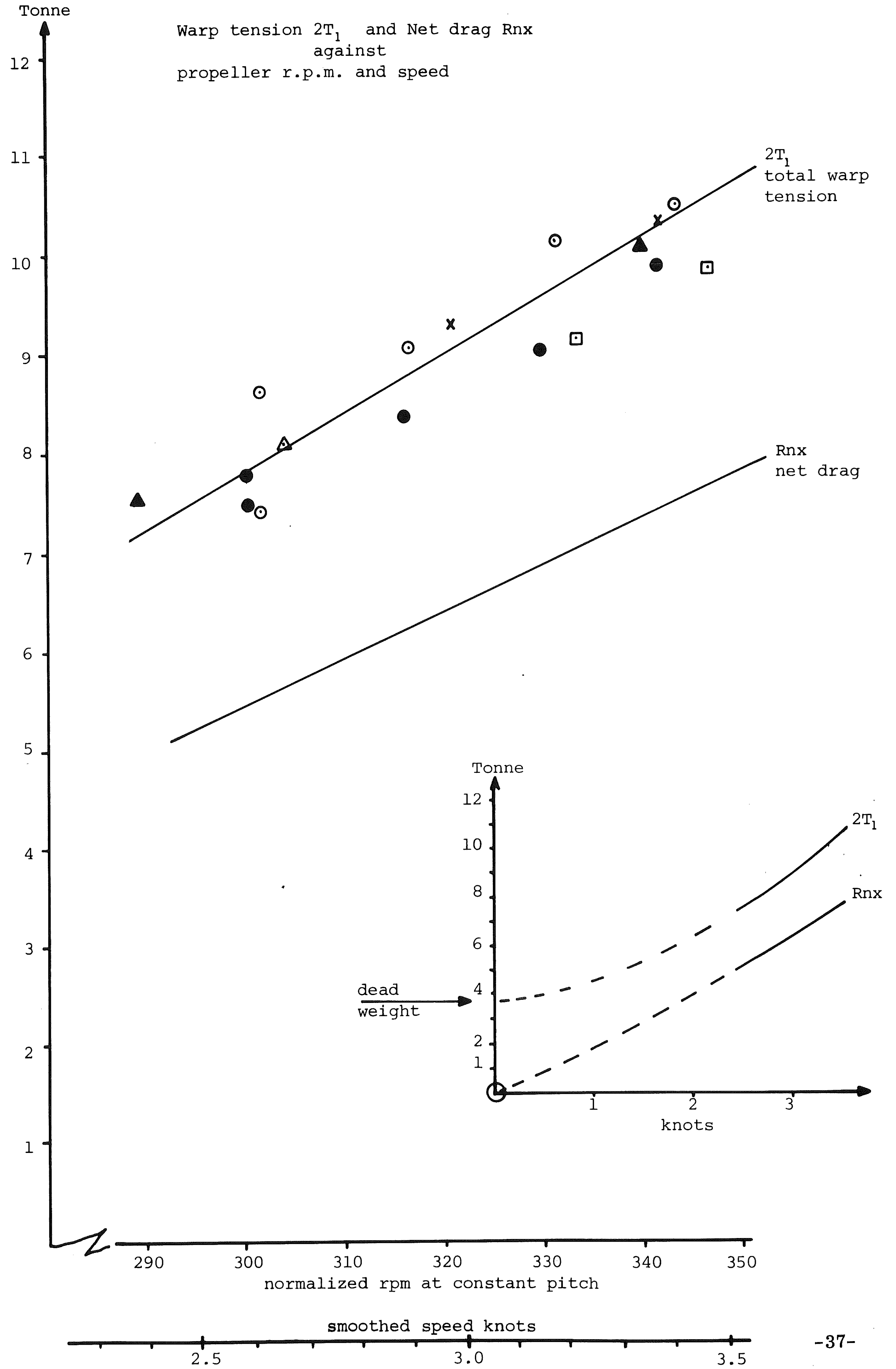
The level of instrumentation available was neither high nor very advanced. In addition to the netsonde giving headline depth and net gape there was also a strain gauge tension meter which was used to record warp tension on the deck first on one warp and then on the other. There were also hand instruments for measuring warp spread at the surface and warp declination.

Because the ship had a V.P. propeller and because the pitch tends to drift it was necessary to arrive at a procedure for normalizing the propeller rpm to a constant pitch. The values warp tension also headline depth and gape are plotted against normalized rpm in Figs. 7 and 8. In order that there may be some indication of how the plots vary with speed also a smoothed speed scale is added to the figures. The smoothed speed scale arrives from a plot of speed readings against normalized rpm at constant pitch.

There is not much indication of departure of warp tension from a linear relationship with speed over the range measured, but it must be there, with the warp tension falling to a limiting value given by the total weight of all the gear in the water (in this case 3,8 ton) at zero speed. The drag of the net alone in the horizontal direction is calculated from the warp tension. The net drag must presumably fall to zero at zero speed. These extrapolations are indicated on the small scale graph of Fig. 7.

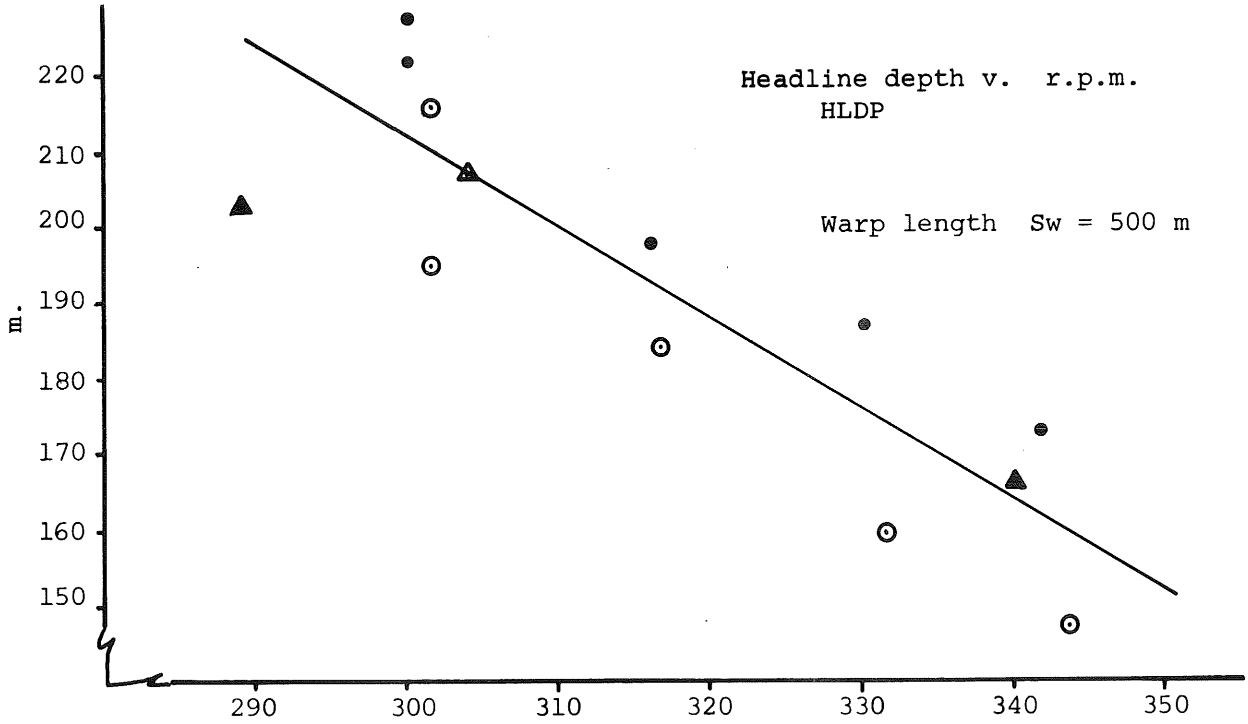
The net is generally below the otterboards by an amount that decreases with increase of speed. Based on weights and drags of all parts aft of the otterboards a calculated plot of depth of headline below the otterboards is given. With the headline depth below the otterboards as estimated and with the gape as measured there is a necessary extra length required in the lower sweep to keep the net in balance i.e. headline vertical lead in angles and tensions equal to groundrope vertical lead in angles and tensions. This necessary extra length S_{10} is calculated to be as in Fig. 8. In fact the net has built into it a foot-rope extension of 4 3/4 m at each end and this would appear to be approximately correct at 3 1/4 knots, somewhat too short at lower speeds and too long at higher speeds. This is of course with the particular rigging assembly used as indicated in Fig 9. Different sweep length, different position and values of the heavy weights affect the lower sweep extension required.

The mean net spread as calculated from otterboard spread would appear to be about 27½ m with an indication that this rises slightly with increase of speed and warp length and falls slightly with reduced speed and warp length. In general the net spread would appear to be in good agreement with the design spread.
A printout of the measured parameters and those calculated from them is given in Table 3.



Tonne
Warp tension $2T_1$ and Net drag Rnx
against
propeller r.p.m. and speed
12
11
10
9
8
7
6
5
4
3
2
1
$2T_1$
total warp
tension
Rnx
net drag
Tonne
12
10
8
6
4
2
1
dead
weight
$2T_1$
Rnx
1
2
3
knots
290
300
310
320
330
340
350
normalized rpm at constant pitch
smoothed speed knots
2.5
3.0
3.5

FIG. 7


Headline depth v. r.p.m.
HLDP
Warp length Sw = 500 m
m.
220
210
200
190
180
170
160
150
290
300
310
320
330
340
350

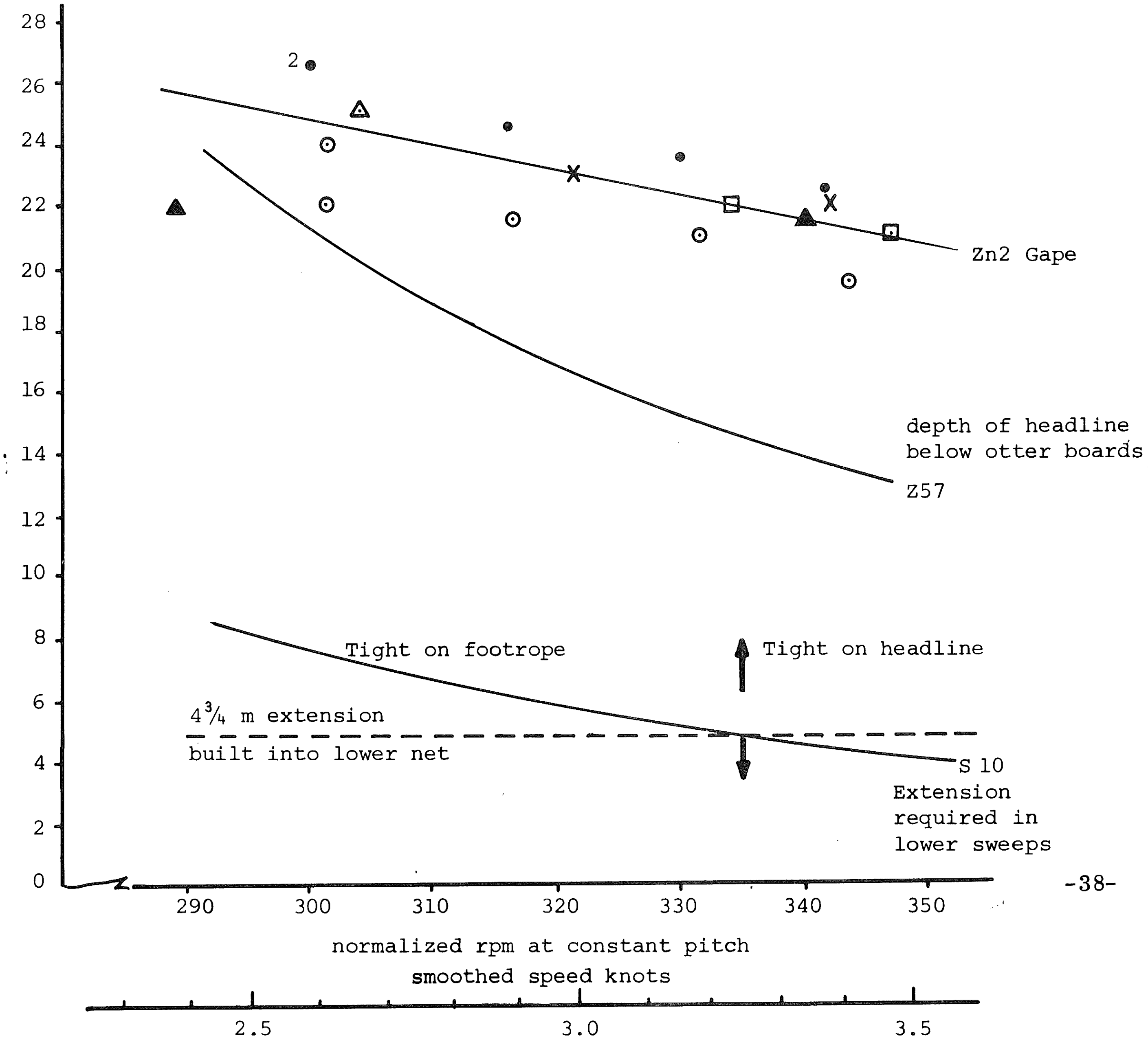
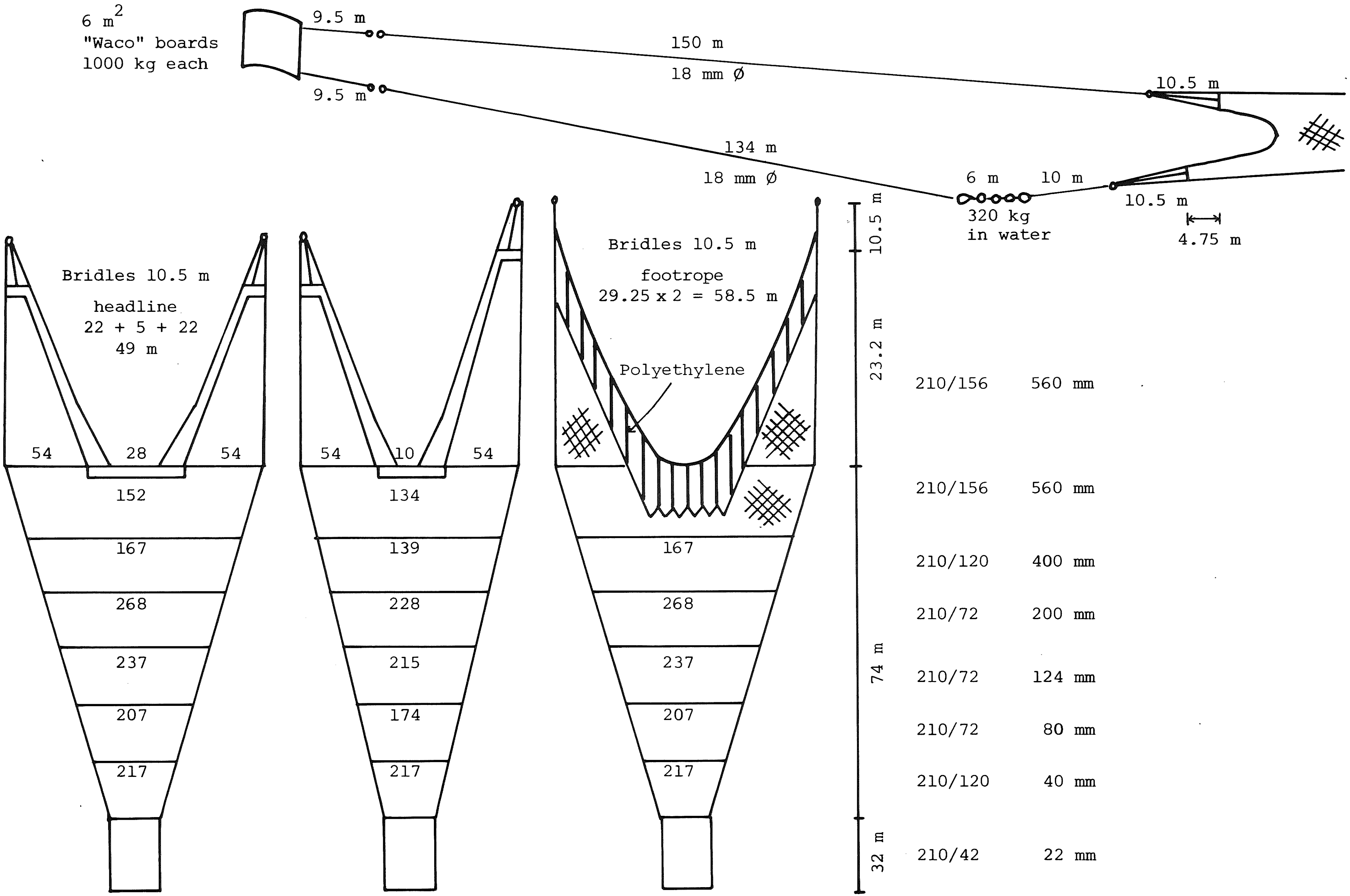

28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
2
Zn2 Gape
depth of headline
below otter boards
Z57
Tight on footrope
Tight on headline
4¾ m extension
built into lower net
S 10
Extension
required in
lower sweeps
290
300
310
320
330
340
350
normalized rpm at constant pitch
smoothed speed knots
2.5
3.0
3.5

FIG. 8



6 m2
"Waco" boards
1000 kg each
9.5 m
9.5 m
150 m
18 mm Ø
134 m
18 mm Ø
10.5 m
6 m
10 m
10.5 m
320 kg
in water
4.75 m
Bridles 10.5 m
headline
22 + 5 + 22
49 m
54
28
54
152
167
268
237
207
217
54
10
54
134
139
228
215
174
217
Bridles 10.5 m
footrope
29.25 x 2 = 58.5 m
Polyethylene
167
268
237
207
217
10.5 m
23.2 m
74 m
32 m
210/156 560 mm
210/156 560 mm
210/120 400 mm
210/72 200 mm
210/72 124 mm
210/72 80 mm
210/120 40 mm
210/42 22 mm

FIG. 9

Table III. PROFILE AND DRAG OF PELAGIC TRAWL

WS	T3/T2	Z01	S57	S58	S810	S1012	W68	W8	W810	WNS	W
1.5	0.805	5	170	146	24	22	292	320	48	100	760

HAL	SW	HLDP	ZN2	Ti	Ei	VS	YB2	YN2	D57	T2	T3	Z12	EW	Z57	E57	S10	E68	RNX
16	500	195	24.0	4320	28.0	3.0	96.0	27.0	11.7	3964	3191	177.1	21.4	17.2	5.8	6.2	17.7	6006
16	500	184	21.5	4530	25.5	3.0	96.0	27.0	11.7	4196	3378	166.5	20.1	16.9	5.7	5.3	16.4	6385
16	500	159	21.0	5060	24.5	3.4	103.0	28.0	12.7	4776	3845	144.7	17.4	13.7	4.6	4.4	14.7	7305
16	500	147	19.5	5250	22.0	3.1	106.0	29.0	13.1	4990	4017	133.0	16.0	13.4	4.5	3.9	13.9	7634
16	500	216	22.0	3710	29.0	2.6	93.0	26.0	11.3	3313	2667	191.0	23.1	24.1	8.2	7.7	20.3	4940
19	500	203	22.0	3770	28.0	2.0	97.0	27.0	11.9	3398	2736	179.0	21.6	23.2	7.8	7.4	19.8	5072
19	500	166	21.5	5040	24.0	3.2	101.0	28.0	12.4	4742	3817	151.8	18.3	13.6	4.6	4.5	14.9	7257
20	550	195	23.0	4650	25.0	2.7	107.0	29.0	13.2	4294	3457	178.9	19.5	15.5	5.2	5.4	16.4	6512
20	550	171	22.0	5170	22.0	2.9	111.0	30.0	13.8	4862	3914	157.6	17.2	12.8	4.3	4.4	14.6	7405
21	450	168	22.0	4560	26.5	3.5	94.0	26.0	11.4	4258	3428	151.1	20.3	16.2	5.5	5.3	16.3	6492
21	450	157	21.0	4920	22.5	3.6	98.0	27.0	12.0	4640	3735	142.0	19.1	14.4	4.9	4.5	15.0	7099
22	500	207	25.0	4050	27.5	2.6	100.0	28.0	12.3	3671	2955	187.1	22.6	19.1	6.5	7.2	19.0	5512
24	500	222	26.5	3880	30.0	2.5	96.0	27.0	11.7	3471	2794	201.0	24.3	20.2	6.8	8.1	20.3	5194
24	500	198	24.5	4190	28.0	2.9	96.0	27.0	11.7	3828	3082	179.2	21.6	18.0	6.1	6.6	18.3	5785
24	500	187	23.5	4510	24.8	3.2	103.0	28.0	12.7	4270	3437	121.0	14.6	15.4	5.2	5.5	16.5	6484
24	500	173	22.5	4940	23.8	3.7	106.0	29.0	13.1	4628	3726	158.7	19.1	13.7	4.6	4.8	15.3	7054
24	500	228	26.5	3740	30.3	2.8	97.0	27.0	11.9	3319	2671	205.3	24.9	21.8	7.4	8.7	21.1	4940

ROPE TRAWL DEVELOPMENT

by B. van Marlen

Summary:

The last few years the Technical Research Department of the Netherlands Institute for Fishery Investigations has conducted a research program into the design of pelagic trawls with ropes instead of large meshes in the front sections of the net. The main objective of this research is to develop a trawl suitable for catching herring close to the bottom over rough grounds. An additional requirement is that the gear should be able to fish in shallow water of about 40 metres depth.

The trials were carried out on board the Fishery Research Vessel "Tridens" in November 1977. This trip was a joint project of the Netherlands Institute for Fishery Investigations, the Marine Laboratory (Aberdeen, Scotland) and the White Fish Authority (Hull, England).

Three configurations of a rope trawl were tested:

- A rope trawl with a meshed upper square.
- A trawl with ropes in all the front panels.
- Last mentioned trawl with flotation on the headline.

For each net the following parameters were varied:

- The speed or horsepower setting: 800-900-1000-1100-1200 HP.
- The length of the warps paid out: 450-550-650 metres.
- The weights at the lower wing tips: 450-600-750 kgf.
- The bridle extension at the lower wing tips: 2.4 and 4.4 metres.

Measurements were taken of:

- Speed relative to water.
- Warp tensions on aft deck, port and starboard.
- Depth of the port door.
- Door spread.
- Headline centre depth.
- Headline height.
- Wing-end spread.
- Horizontal netopening.
- Wing-end height.
- Tension before doors at end of warp (port and starboard).
- Tension at beginning of upper and lower bridles (port and starboard).
- Tension at lower wing-ends (port and starboard).
- Heel angle of port and starboard door.
- Tilt angle of port and starboard door.
- Spread of warps, 3 fms before doors and 50 m from wing-ends.
- Shaft horsepower.

A computer program written by Mr. R.S.T. Ferro of the Marine Laboratory was used to analyse the data. Instrumentation was supplied both by the Dutch Institute and the Marine Laboratory.

In addition to these trials model experiments on scales 1 : 4 and 1 : 25 were conducted respectively in cooperation with the "Institut für Fangtechnik" (Hamburg, Federal Republic of Germany) and the "White Fish Authority" (Flume Tank; Hull, England). Unfortunately these model tests are only partly comparable to the full scale tests discussed in this paper. This is mainly due to the fact, that there has been some changes in the design, such as narrowing of the side panels. The Flume Tank has limitations in testing the gear fully rigged.

Usually the door spread is fixed at an expected value that might not much full scale measurements.
A detailed analysis of the relationship between full scale results and the ones found from model experiments will be discussed in a separate report.

Conclusions

Because of lack of data in some cases and inaccuracies in the speed measurement, the influence of the parameters mentioned on the performance of the trawl is hard to derive.
The major differences of the three configurations were found with the depth measurements. Both the floats and the meshed upper square do lift the gear in comparison with the standard rope trawl. This effect is most significant with the floats on the headline. A penalty however is a substantial increase in drag (up to 20%).
To overcome problems with speed measurements and setting of the gear (the port door seemed to heel incorrectly on many hauls) and to extent the set of data in order to derive more definite conclusions further experiments will still be needed.
A fully detailed report "Rope trawl development", T.O.78-02, is published by and available at the Netherlands Institute for Fishery Investigations, Technical Research Department, P.O. Box 68, IJmuiden, Holland.

ROPE TRAWL EXPERIMENTS WITH COMMERCIAL TRAWLERS ON HERRING

by H.v. Seydlitz and W. Kelle

1. Introduction

The German fishing fleet in the Baltic is specialized in one and two-boat midwater and bottom trawling for cod. Fishing is performed by small vessels of the side-trawler type (cutters) of different size. They operate in the Baltic as well in the southern part of the North Sea. The trawlwinches of these vessels are designed to match the requirements of bottom- and midwater-trawling. For efficient gear handling since several years netdrums are used and different types of netsounder winches are installed.

The small vessels, with a length up to 16 m, fish in relatively shallow waters where cod and herring are found. For instance, they fish from April to June on the shallow banks of the Baltic for herring on or near the bottom. Since 1976 the traditional trawl is often replaced by a high opening two-panel-rope midwater trawl. Herring is caught successfully with this gear by pair trawling near the bottom.

The larger cutters (18 to 24 m length) were fishing exclusively for cod nearly 12 months of the year. But, in 1977 the quota for cod in the Baltic was too small for the German fishing fleet, so they were forced to catch herring as well. The Institut für Fangtechnik demonstrated to the fishermen how to fish herring by pair trawling with two-panel and specially with four-panel rope midwater trawls. These experiments will be further described. They were carried out in October 1977, to show also that in the Baltic herring can be caught in other seasons too.

2. Ships, instruments and materials

The cutters

	(a)	(b)
Length overall (m)	24	22.90
Breath moulded (m)	6.85	5.85
Main engine power (HP)	305	435
Net drum (hydraulic)	low pressure	high pressure
Year of construction	1951	1961
Number of crew (incl.capt)	4	3

Instruments

Vertical echo sounder	30 Kc with digital memory	30 Kc without digital memory
Netsounder frequency	30 Kc	30 Kc
" cable length (m)	500	500
	(multi-netsounder with 2 channels)	
Speed log	Seafarer EM-log	

Gears

A: Four-panel rope trawl; 386 meshes (800 mm stretched); 40 ropes (12 mm PP-braided rope with PES core)

B: Four-panel rope trawl; 228 meshes (800 mm stretched); 34 ropes (12 mm PP-braided rope with PES core)

C: Two-panel rope trawl; 400 meshes (400 mm stretched); 48 ropes (10 mm PA-braided rope)

The rigging of the trawls

	Trawl A	Trawl B	Trawl C
Number of warps per cutter	2	2	2 or 1
Number of legs per wing	2 à 50 m 2 à 25 m	2 à 50 m 2 à 25 m	3 à 50 m
Number of floats (Volume 3.2.1)	100	100	80
Weight at each side in front of the wings	200 kg	200 kg	200 kg
Weight at the groundrope	ca230 kg	ca.230 kg	ca.150 kg

The experiments onboard the commercial cutters were carried out after the nets were already tested in the following way: At first visual impressions were obtained by observation of paper-models (scale 1 : 100), followed by model-tests (scale 1 : 4) in open water with one boat operation and different types of otter boards and at last full scale tests onboard the research vessel "Solea" also with different types of otter boards (gear C).

3. Conditions of the experiments

Between 3 and 23 October 1977, 33 hauls were made in the Baltic under commercial conditions; 23 east of Bornholm and 10 in the Kattegat and near Fehmarn-Island.

Fishing experiments were performed at positions where echo-traces from herring had been observed. The herring shoals were near the bottom during the day and in midwater during the night. The echo sounder with digital memory marked the dispersed traces at nighttime very well (Fig. 1). Catches of up-to 20 baskets per hour were realised with the four-panel rope trawl (gear A).

By means of the small multi-netsounder with 2 channels distance headline-footrope (H) and distance of the two wing tips (B) the net opening was measured and comparison between the different gears was made (Fig. 2).

4. Observations

In two-boat operation the cutters were capable to tow not only the small trawls (B and C) but also the larger one (A) at a speed of 3 to 4.5 knot. The three trawls, however, showed large differences in the net opening (H x B).

For a warp length of 200 m and a speed of 3.8 knot the mean net opening was:

	Gear A	980 m^2
	Gear B	530 m^2
	Gear C	590 m^2

In figures 3 to 5 the distances of the headline to the footrope and between the wing tips, are shown in relation to the speed and the warptension. The regression lines are calculated by the formula $y = a + bx$ using the observed data.

All figures show that the net opening becomes smaller with increasing speed or warp tension.

To show the different resistances of the three nets, the warp tension was compared with the speed for each net. For this regression curve the formula $y = a + bx + cx^2$ was used.

Fig.6 shows the resistance of the different nets. As expected, the small four-panel rope trawl had far less resistance than the larger one. It can be seen that the four-panel rope trawls with large meshes in the front part of the net have a lower resistance compared with the two-panel rope trawl with smaller meshes. The total catch of the three weeks was 57.8 ton herring and 1.8 ton cod.

The experimental programme required the changing of the trawls and a comparison of the catches of the different gears. It was observed that the four-panel rope trawl (type A) with 980 m^2 net opening fished with best results in midwater. The two small rope trawls (type B and C) were previously used by commercial fishermen with satisfactory results on the bottom or near the bottom in shallow waters (till a depth of 25 m).

Conclusion

Herring fishing in the Baltic was demonstrated by pair trawling with different types of midwater rope trawls. On both cutters, also on the smaller ship with 3 crew members, the handling of the rope trawls was made possible by means of the hydraulic netdrums. Small herring shoals during daylight and dispersed herring at night could be observed with the modern echosounding equipment of the cutter (2.1.a.). It was demonstrated that herring can be caught with cutters, equipped with powerful engines, modern echosounding equipment, modern winches and netdrums and fishing gear of low resistance like the high opening rope trawl. After the end of the experiments, in November 1977, the same cutters made two successful trips with the gear described above (A).

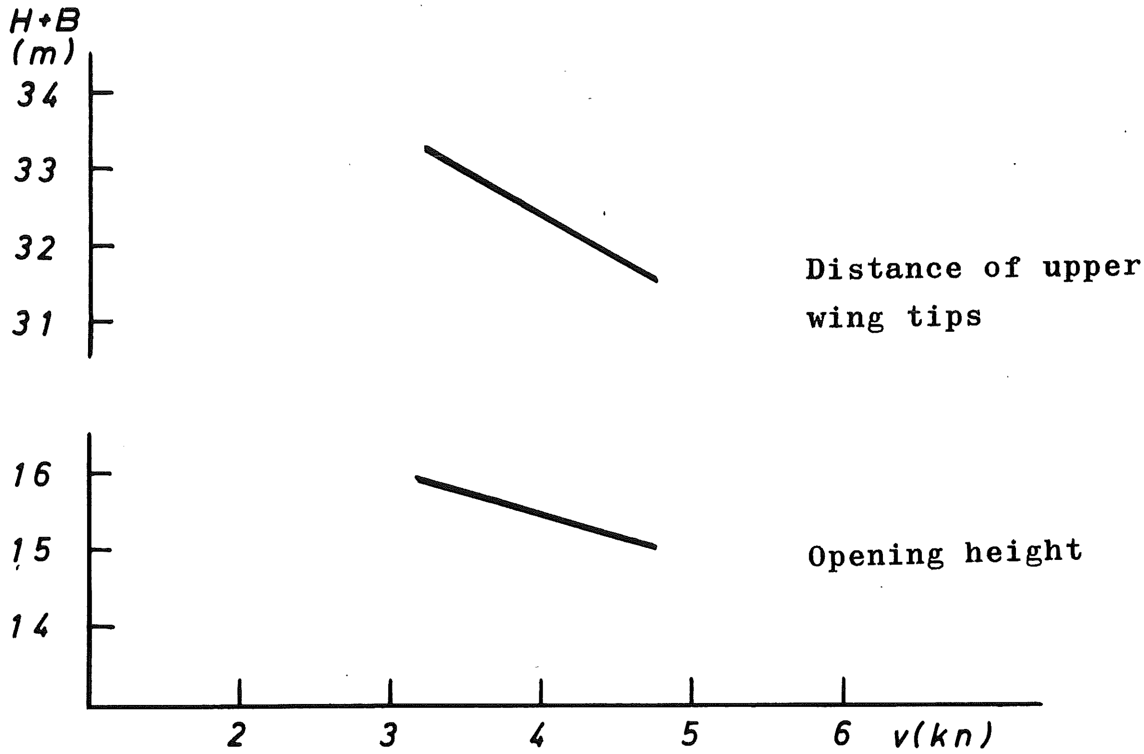


Fig. 4 a : Four-panel rope-trawl (B)
Ships speed / H + B

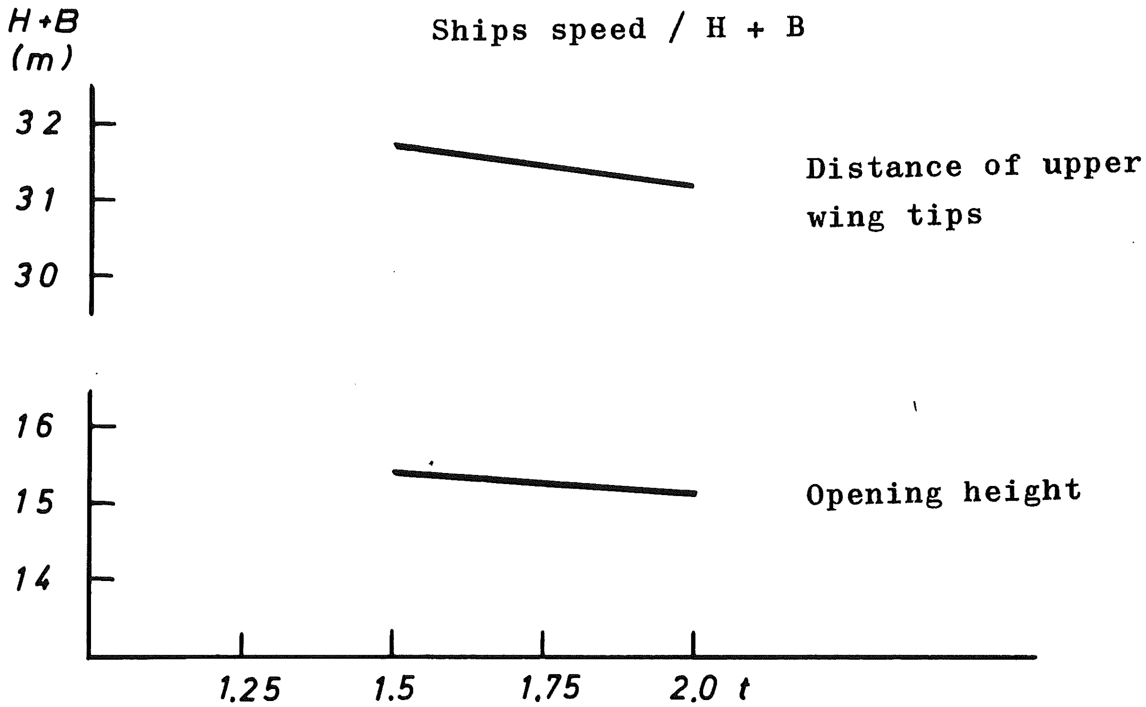


Fig. 4 b : Four-panel rope-trawl (B)
Warp tension / H + B

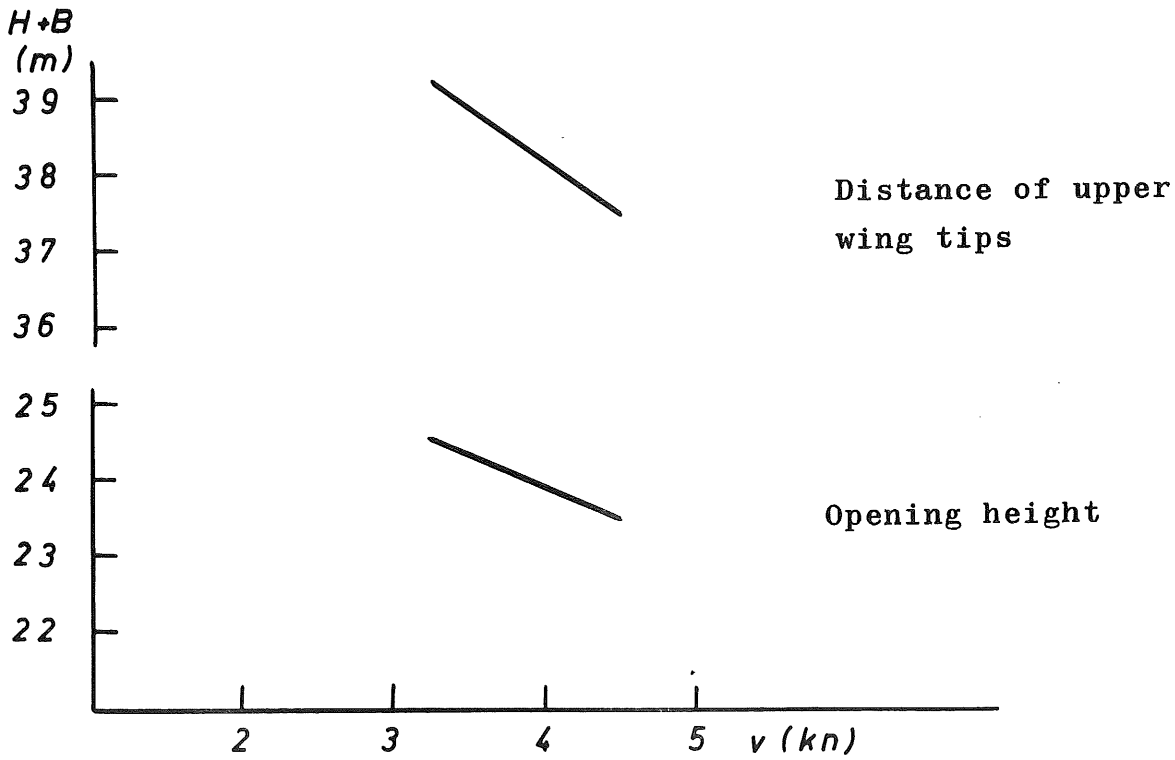


Fig. 3 a : Four-panel rope-trawl (A)
Ships speed / H + B

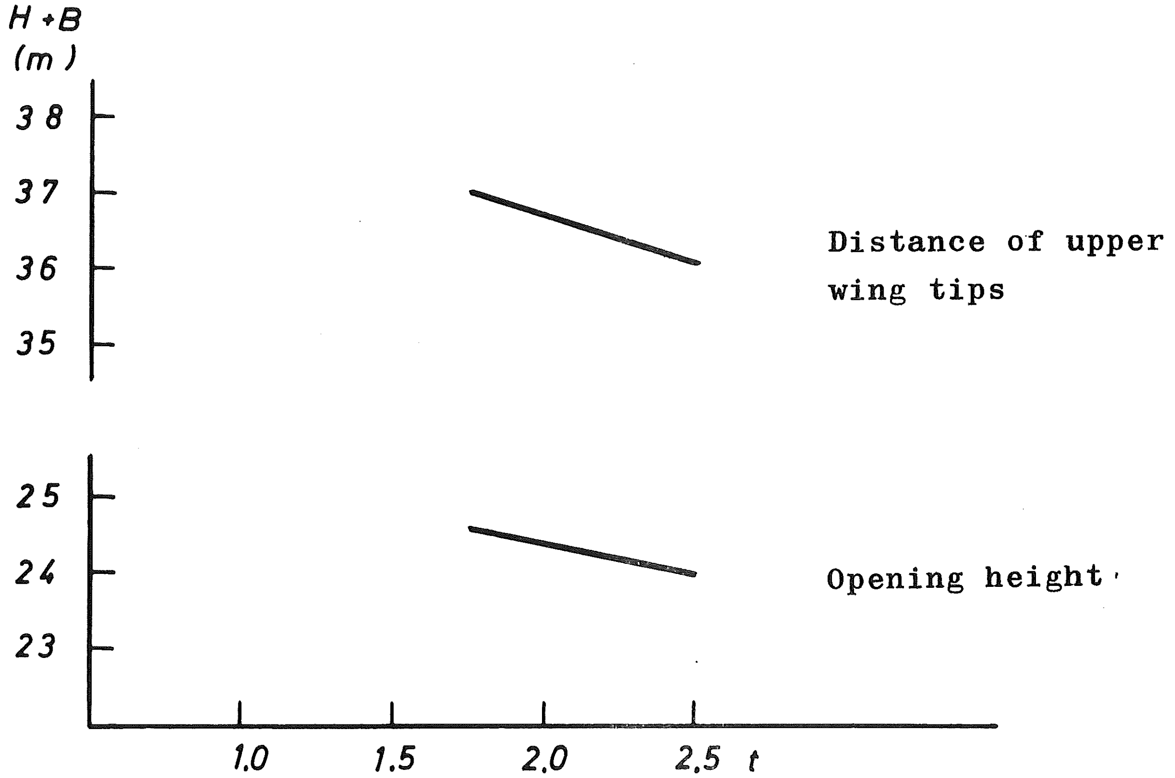


Fig. 3 b : Four-panel rope-trawl (A)
Warp tension / H + B

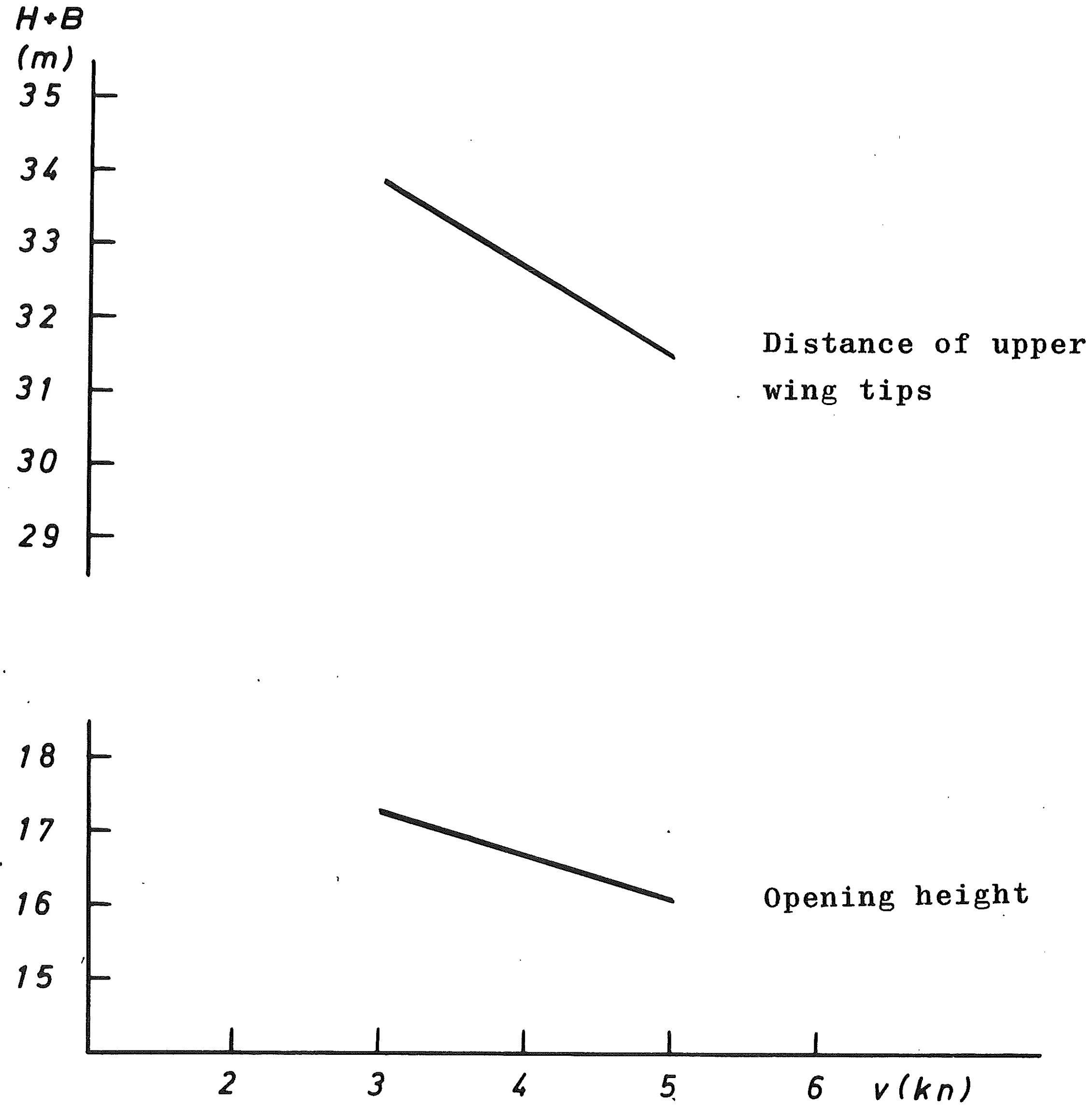


Fig. 5 a : Four-panel rope-trawl (C)
Ships speed / H + B

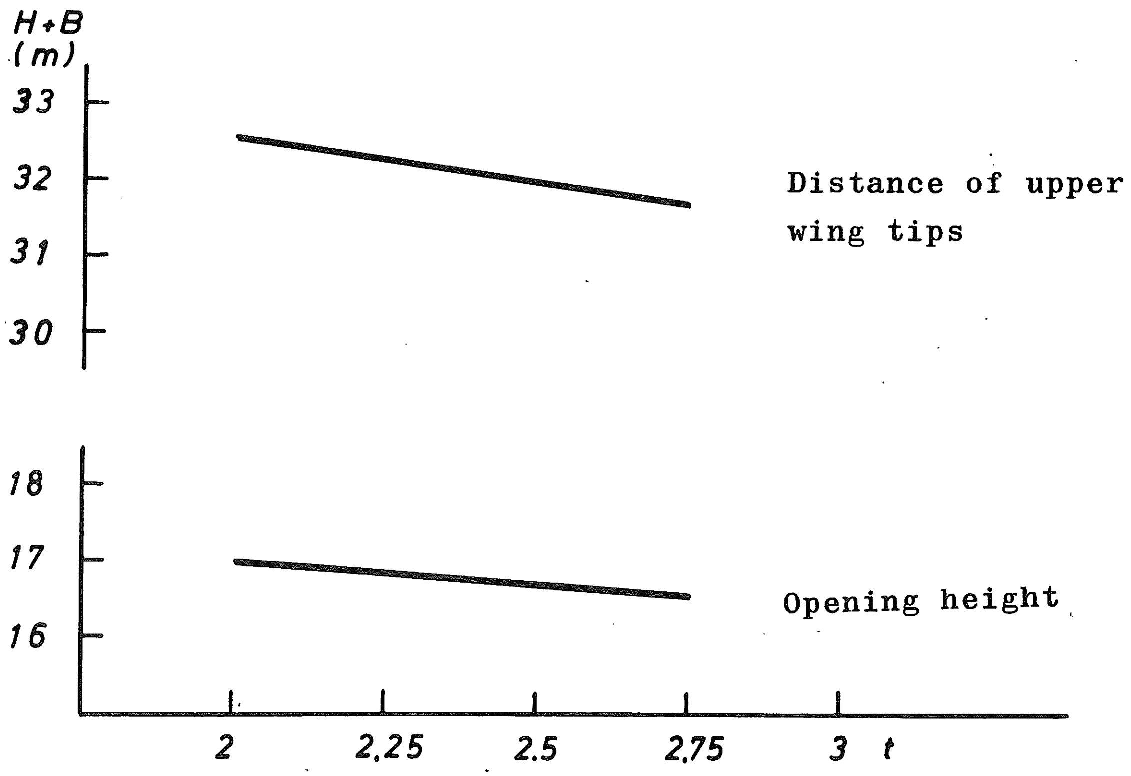


Fig. 5 b : Four-panel rope-trawl (C)
Warp tension / H + B

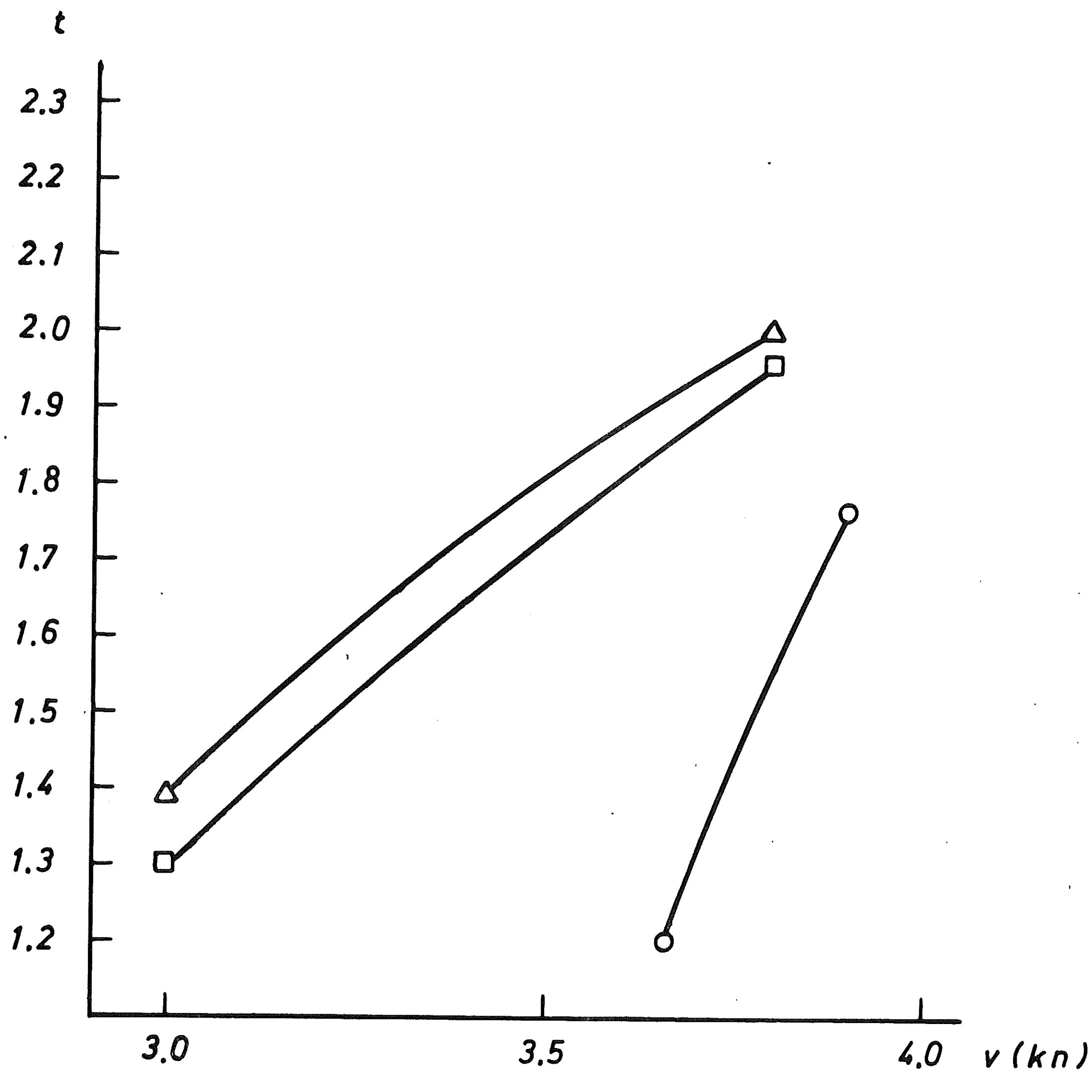


Fig.: 6 Warp tension/speed

△ four-panel rope trawl
386 meshes (800 mm stretched)

○ four-panel rope trawl
228 meshes (800 mm stretched)

□ two- panel rope trawl
400 meshes (400 mm stretched)

THE ROPE WING BOTTOM TRAWL AND THE POLISH ROPE WING MIDWATER TRAWL

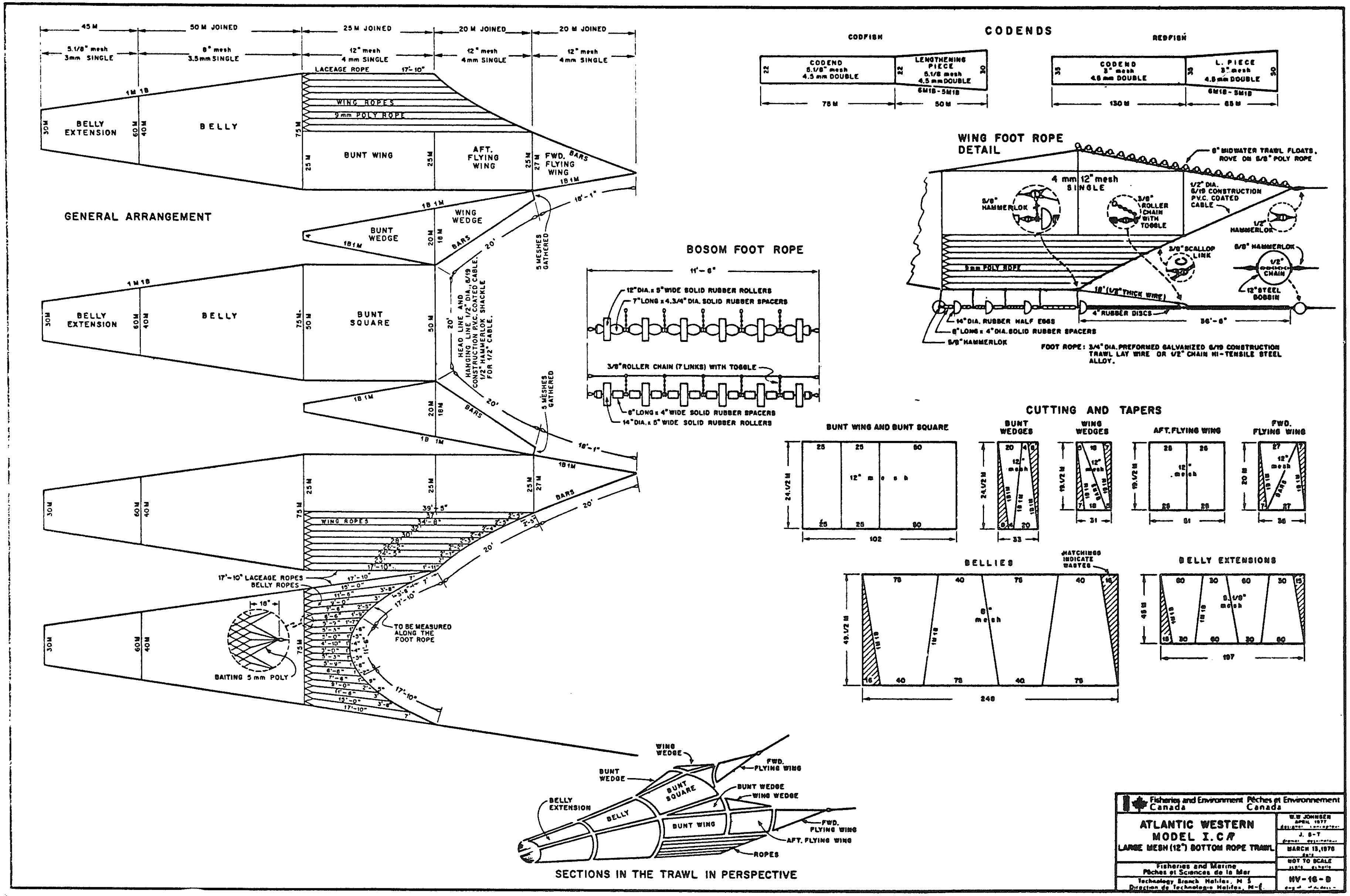
by W.W. Johnson (verbal).

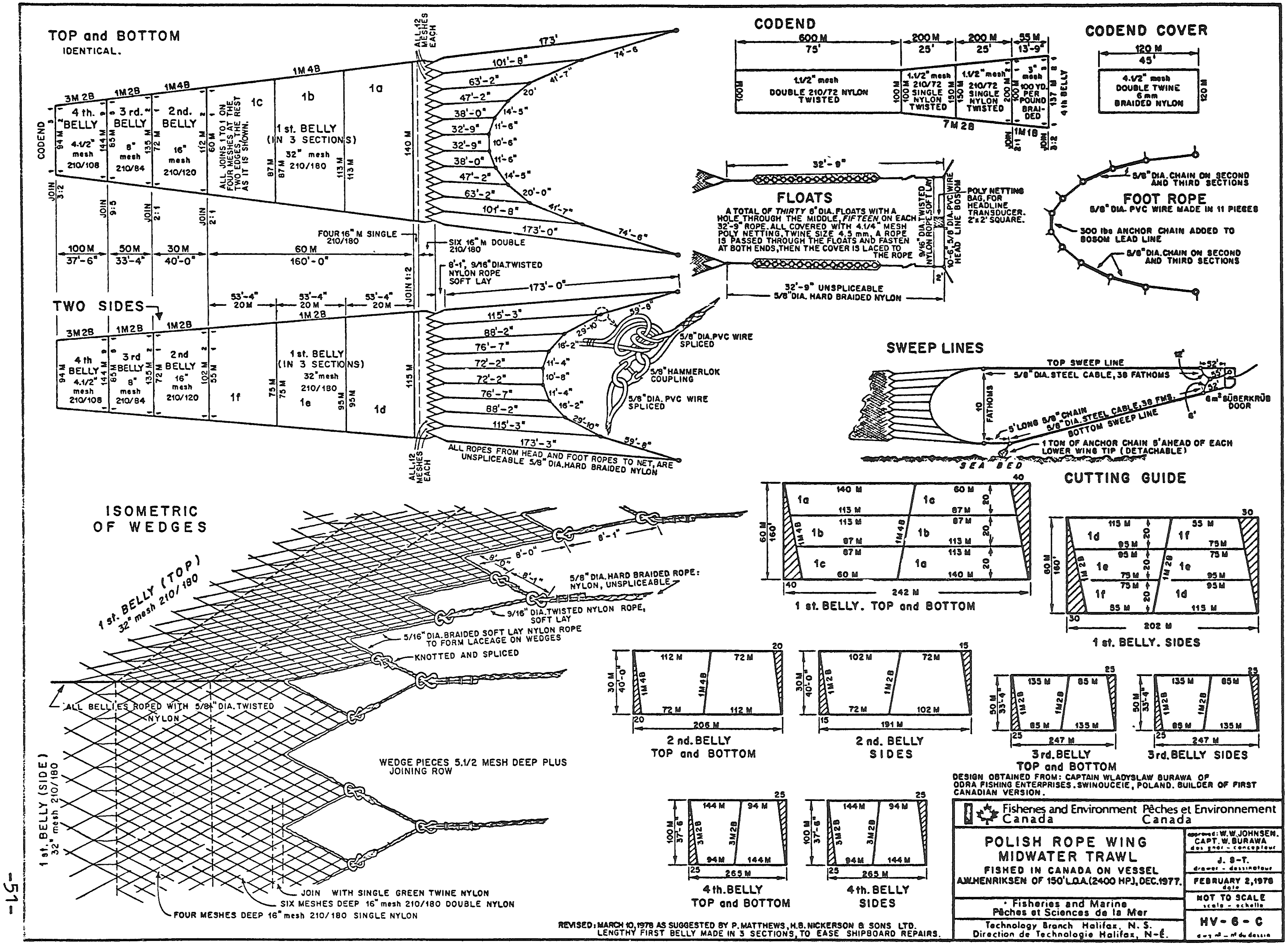
In this verbal contribution the application of ropes in the front part of nets in Canada was illustrated when Mr. Johnson showed the drawings of a rope wing bottom trawl (Atlantic Western Model I CR) and a Polish rope wing midwater trawl.

The rope wing bottom trawl is designed for vessels having a propulsive power of 350-500 hp. Species caught with this type of net are pollack, haddock, halibut and other flatfish species.

The Polish rope wing midwater trawl is used on the east coast by a 2400 hp stern trawler when fishing for mackerel, cod and red fish.

In his explanation of the characteristics of the designs Mr. Johnson stated that the length of the individual ropes was determined from a card board scale model.


GENERAL ARRANGEMENT
BELLY EXTENSION
BELLY
BUNT WING
AFT. FLYING WING
FWD. FLYING WING
BUNT WEDGE
WING WEDGE
BUNT SQUARE
WING ROPES
9 mm POLY ROPE
LACEAGE ROPE
BAITING 5 mm POLY
17'-10" LACEAGE ROPES
BELLY ROPES
TO BE MEASURED ALONG THE FOOT ROPE
5 MESHES GATHERED
HEAD LINE AND HANGING LINE 1/2" DIA., 6/19 CONSTRUCTION P.V.C. COATED CABLE. 1/2" HAMMERLOK SHACKLE FOR 1/2" CABLE.
CODENDS
CODFISH
REDFISH
CODEND
LENGTHENING PIECE
L. PIECE
BOSOM FOOT ROPE
3/8" ROLLER CHAIN (7 LINKS) WITH TOGGLE
WING FOOT ROPE DETAIL
4 mm 12" mesh SINGLE
FOOT ROPE: 3/4" DIA. PREFORMED GALVANIZED 6/19 CONSTRUCTION TRAWL LAY WIRE OR 1/2" CHAIN HI-TENSILE STEEL ALLOY.
CUTTING AND TAPERS
BUNT WING AND BUNT SQUARE
BUNT WEDGES
WING WEDGES
AFT. FLYING WING
FWD. FLYING WING
BELLIES
BELLY EXTENSIONS
HATCHINGS INDICATE WASTES
SECTIONS IN THE TRAWL IN PERSPECTIVE
Fisheries and Environment Canada
Pêches et Environnement Canada
ATLANTIC WESTERN
MODEL I.C
LARGE MESH (12") BOTTOM ROPE TRAWL
Fisheries and Marine
Pêches et Sciences de la Mer
MARCH 13,1976
NOT TO SCALE


TOP and BOTTOM
IDENTICAL.
4th. BELLY
3rd. BELLY
2nd. BELLY
1 st. BELLY (IN 3 SECTIONS)
CODEND
ALL JOINS 1 TO 1 ON FOUR MESHES AT THE TWO EDGES. THE REST AS IT IS SHOWN.
FOUR 16" M SINGLE 210/180
SIX 16" M DOUBLE 210/180
8'-1", 9/16" DIA. TWISTED NYLON ROPE SOFT LAY
TWO SIDES
ALL ROPES FROM HEAD AND FOOT ROPES TO NET, ARE UNSPLICEABLE 5/8" DIA. HARD BRAIDED NYLON
CODEND
DOUBLE 210/72 NYLON TWISTED
CODEND COVER
4.1/2" mesh DOUBLE TWINE 6 mm BRAIDED NYLON
FLOATS
A TOTAL OF THIRTY 8" DIA. FLOATS WITH A HOLE THROUGH THE MIDDLE, FIFTEEN ON EACH 32'-9" ROPE. ALL COVERED WITH 4.1/4" MESH POLY NETTING. TWINE SIZE 4.5 mm. A ROPE IS PASSED THROUGH THE FLOATS AND FASTEN AT BOTH ENDS, THEN THE COVER IS LACED TO THE ROPE
32'-9" UNSPLICEABLE 5/8" DIA. HARD BRAIDED NYLON
POLY NETTING BAG, FOR HEADLINE TRANSDUCER. 2'x2' SQUARE.
FOOT ROPE
5/8" DIA. PVC WIRE MADE IN 11 PIECES
5/8" DIA. CHAIN ON SECOND AND THIRD SECTIONS
300 lbs ANCHOR CHAIN ADDED TO BOSOM LEAD LINE
5/8" DIA. PVC WIRE SPLICED
5/8" HAMMERLOK COUPLING
SWEEP LINES
TOP SWEEP LINE
5/8" DIA. STEEL CABLE, 38 FATHOMS
BOTTOM SWEEP LINE
6m² SÜBERKRÜB DOOR
1 TON OF ANCHOR CHAIN 8' AHEAD OF EACH LOWER WING TIP (DETACHABLE)
SEA BED
CUTTING GUIDE
1 st. BELLY. TOP and BOTTOM
1 st. BELLY. SIDES
2 nd. BELLY TOP and BOTTOM
2 nd. BELLY SIDES
3rd. BELLY TOP and BOTTOM
3rd. BELLY SIDES
4th. BELLY TOP and BOTTOM
4th. BELLY SIDES
ISOMETRIC OF WEDGES
1 st. BELLY (TOP) 32" mesh 210/180
1 st. BELLY (SIDE) 32" mesh 210/180
5/8" DIA. HARD BRAIDED ROPE: NYLON, UNSPLICEABLE
9/16" DIA. TWISTED NYLON ROPE, SOFT LAY
5/16" DIA. BRAIDED SOFT LAY NYLON ROPE TO FORM LACEAGE ON WEDGES
KNOTTED AND SPLICED
ALL BELLIES ROPED WITH 5/8" DIA. TWISTED NYLON
WEDGE PIECES 5.1/2 MESH DEEP PLUS JOINING ROW
JOIN WITH SINGLE GREEN TWINE NYLON
SIX MESHES DEEP 16" mesh 210/180 DOUBLE NYLON
FOUR MESHES DEEP 16" mesh 210/180 SINGLE NYLON
DESIGN OBTAINED FROM: CAPTAIN WLADYSLAW BURAWA OF ODRA FISHING ENTERPRISES. SWINOUJCIE, POLAND. BUILDER OF FIRST CANADIAN VERSION.
REVISED: MARCH 10, 1978 AS SUGGESTED BY P. MATTHEWS, H.B. NICKERSON & SONS LTD. LENGTHY FIRST BELLY MADE IN 3 SECTIONS, TO EASE SHIPBOARD REPAIRS.
Fisheries and Environment Canada / Pêches et Environnement Canada
POLISH ROPE WING MIDWATER TRAWL
FISHED IN CANADA ON VESSEL A.W.HENRIKSEN OF 150' L.O.A. (2400 HP), DEC. 1977.
Fisheries and Marine / Pêches et Sciences de la Mer
Technology Branch Halifax, N. S. / Direction de Technologie Halifax, N-É.
approved: W. W. JOHNSEN. CAPT. W. BURAWA
J. S-T.
FEBRUARY 2, 1978
NOT TO SCALE
HV-6-C

AN ACOUSTIC TRACKING TECHNIQUE FOR GEAR GEOMETRY MEASUREMENTS

by: R.S.T. Ferro and G.G. Urquhart

Introduction

In the past few years there has been a growing interest in the development of computer models to predict the configuration of trawl gear. These models may be used for instance to determine the asymmetry of a gear when the towing ship does not tow in a straight line or when the warps are not the same length. These are practical problems facing the fisherman who requires to know under what circumstances his net will be damaged.

The development of a computer model cannot rely only on a theoretical approach. It is necessary to obtain data from experiments in order to test the theory and even to formulate empirical relationships between parameters for use in the model.

This paper describes some techniques which have been used to track simultaneously the positions of several points on a trawl gear relative to the towing vessel.

Description of tracking system

The underwater tracking system employs an array of hydrophones laid on the sea bed and spaced 200 to 300 m apart. Acoustic pulses from transmitters attached to the fishing gear are picked up by the hydrophones and sent as electric signals along cables to a shore station. The signals are electronically processed and interfaced to a computer which is programmed to interpret them and calculate the positions of the transmitters relative to the hydrophone range. The positions are output on a printer as rectangular co-ordinates. In the past the system has assumed that the hydrophones are coplaner and that the transmitters lie in this plane. However, future trials will be adapted to calculate positions in three dimensions.

a. System operating parameters

The system is designed to operate in the band 70 kHz - 85 kHz. This band was chosen to be above the frequency of greatest noise output from ships, fishing gear and natural sources but low enough to avoid serious attenuation problems. A receiver of 2 kHz bandwidth can be tuned throughout the operating band and has been used successfully with 4 transmitters operating at 72 kHz, 76 kHz, 80 kHz and 84 kHz respectively although closer spacing could easily have been achieved.

Near the centre of the operating frequency band the background sea noise level is approximately -57dB (relative to 1 microbar sound pressure level) at sea state 6. With a receiver bandwidth of 2 kHz the inband noise level is -24dB. For reliable automatic operation allowing for signal fluctuation a signal to noise ratio of about 20dB is required and this means that the signal level at the receiver input must be about -4dB. With transmitters of source level 70dB the allowable propagation loss is therefore 74dB and this corresponds to a theoretical range of approximately 900 m. In practice, there is still considerable ship noise in the operating band and the effective working range is reduced to about 400-500 m.

b. Transmitters

The transmitters used for gear tracking are an adaptation of a standard design of long life pinger made by the MAFF Fisheries Laboratory, Lowestoft. Four modified instruments were made to our specification and the main features are tabulated below. The transmitters were made to produce different pulse lengths as a secondary means of identification but this feature has not proved necessary and it will not be included in future devices.

Table 1. Main characteristics of transmitters for gear tracking

Transmitter no.		1	2	3	4
Frequency	kHz	72	76	80	84
Pulse length	mS	5	10	15	20
Pulse repetition period	S	1.5	1.5	1.5	1.5
Source level	dBre1V//ubar/m	70	70	70	70
Length	mm	180	180	180	180
Diameter	mm	60	60	60	60
Weight in air	gm	500	500	500	500
Batteries		6 volt organic lithium			
Appr.duration months		12	6	4.5	3

c. Hydrophones

The tracking hydrophones are constructed using a stack array of ring transducers arranged to give maximum omnidirectional response in the horizontal plane and minimum response in the vertical plane. This means that the hydrophones are most sensitive looking horizontally through the water and are relatively insensitive to surface noise and to ships moving overhead. The preamplifier which is an integral part of the hydrophone has a low input impedance differential current amplifier input stage coupled by a tuned transformer to the main amplifying and driving stages. The centre frequency is set to mid band (77.5 kHz) with sufficient bandwidth at the 3dB points to cover the operating band. The overall sensitivity of the hydrophone is about -100dB re 1 volt per microbar.

d. Cables

The hydrophones are connected to the shore equipment by individual cables each with a pair of twisted conductors and a conducting screen insulated with polythene, with an overall sheath of polyurethane. The characteristic impedance of the cable is approximately 120 ohms at 75 kHz, the signal attenuation over a 600 m length is about 3dB and the signal to noise is not affected significantly.

e. Main amplifiers

Each hydrophone is connected to a low noise amplifier of variable gain and fixed pass band of approximately 15 kHz to 100 kHz. Most of the amplification of the sonar frequencies takes place in these amplifiers. The amplified signal from each hydrophone together with an identification code is then presented at a row of sockets on the front panel of the receiving equipment.

f. Receiver

The heart of the receiving hardware is a 4 channel AM superheterodyne receiver with a common local oscillator. The operator manually selects the four hydrophones to be connected to the 4 channel receiver by plugging into the main amplifier outputs. All 4 channels are then tuned simultaneously to one transmitter frequency by adjusting the frequency of the local oscillator. This oscillator is voltage controlled so that tuning can be preset and switch selected and automatic frequency control can be applied. Each of the 4 identical channels consists of a mixer stage, and a narrow band mechanical filter and IF strip operating at 455 kHz. The output from the detector stage of the IF strip operates a voltage comparator so that signals exceeding the preset threshold level are converted to logic level. Logic circuitry rejects very short spurious pulses and accepts only those of a preset minimum duration. Retriggering is inhibited for a short interval after each pulse so that the circuit responds only to the leading edge of the direct path pulse. Output pulses from each of the 4 channels corresponding to the acoustic pulses detected by the hydrophones are then generated and fed to the computer.

g. Computer

The computer which is used with this system is a CAI alpha LSI 2. This machine recognises the hydrophones from their identification codes and times the incoming signals to the nearest 0.0001 secs against its own internal clock.
The system operation up to this point can be monitored on a VDU which, under the control of the computer, gives a continuous update of the following information.

(i) real time (hours, minutes, seconds)
(ii) number of hydrophones from which signals are detected (0, 1, 2, 3 or 4)
(iii) identification of first hydrophone to receive a pulse together with a relative arrival time of 0
(iv) identification of second hydrophone to receive a pulse together with its relative arrival time (ms x 10^{-1})
(v) identification of third hydrophone to receive a pulse together with its relative arrival time (ms x 10^{-1})
(vi) identification of fourth hydrophone to receive a pulse together with its relative arrival time (ms x 10^{-1})

The relative arrival time data is then used to compute the position of the transmitters relative to the hydrophone positions which have been previously input and stored in the computer system's floppy disk memory. The result of this computation is then output to a printer which gives real time together with x and y co-ordinates in metres relative to the chosen reference axes.

h. Auxiliary equipment

In addition to the main elements of the system described above the following auxiliary equipment is used.

(i) A 4 channel oscilloscope is used to monitor the system's operation. This is normally connected to the 4 receiver outputs but cab be quickly reconnected to various points in the system for performance monitoring or fault finding.

(ii) A multi-channel tape recorder can be connected to the main amplifier outputs without disturbing the on-line operation of the system. For gear tracking work, it is normal practice to record every test so that the data can be replayed through the system as often as necessary to obtain the best track for each point on the gear.

(iii) The IF signals of the receiver can be connected to a beat frequency oscillator with an audio output for tuning and monitoring.

Errors

The most significant sources of error are acoustic propagation anomalies, variations in sound velocity (c), hydrophone location errors and the limitations of the receiving and processing equipment. These can be regarded as errors which contribute to an overall error in distance measurement Δ (ct). The actual error in a computer position will be a function of all these errors and in addition a position factor which depends on the actual position of the transmitters relative to the hydrophone array. This position factor is in general low for positions inside the area bounded by the hydrophones but increases rapidly as distance from the range is increased. In practice, within the working area used for gear tracking the final error ranges from better than $\pm$ 0.5 m to about $\pm$ 2 m.

Description of trials

The hydrophone range was laid in Loch Torridon in a water depth of approximately 30 m. A 50 horsepower pelagic type trawl was designed to be towed at 1.5 to 3 knots at warp lengths of up to 50 m. Transmitters were attached to the two upper wing-ends and the two Süberkrüb otterboards. The gear was towed into the hydrophone range on a straight course so that the configuration in the steady state could be obtained. A manoeuvre was then executed and the vessel returned to a straight course before the gear passed outside the range. Typical tracks of a transmitter and the vessel are shown in figure 1 together with the locations of the four hydrophones at which the signals were received. The hydrophone system gave position fixes at a maximum rate of one every 1.5 seconds whereas the vessel's range and bearing were recorded only every 30 seconds. The increase in scatter of the transmitter positions at the edge of the range is clearly shown.

Results were obtained when towing the gear in a straight line and steadily round curves of different radius. The gear was also towed on a straight course with a range of differences in the two warp lengths.

Regression analysis on each of these sets of data gave the equations of the smoothed curves through the points. These equations allow the calculation of the geometry of the vessel and gear at any given moment during the tow.

Detailed analysis is continuing but one particularly interesting result has already come to light. The elimination of random errors by using regression techniques has shown up very systematic errors in the relative positions of the four points on the gear. These errors may, for instance, be due to errors in the computed hydrophone positions on the sea bed. By minimizing these systematic errors it may be possible to obtain a more accurate set of hydrophone positions.

Further developments

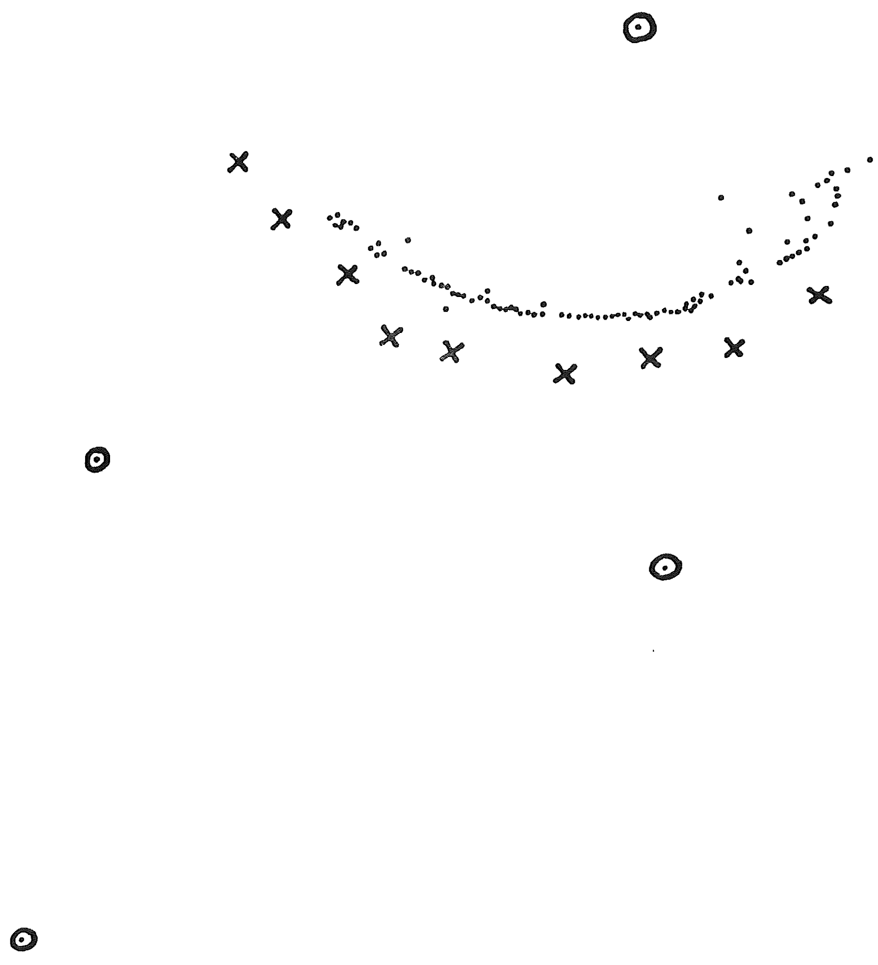
One of the most serious limitations of the present system is the need to measure depth by separate self recording depth meters attached to the gear. Two possible approaches to this problem are being considered. Firstly, a pressure dependent transmitter is being developed to give depth information by controlling the pulse repetition period. The other solution is to input the hydrophone co-ordinates in 3 dimensions and calculate the positions of the transmitters in 3 dimensions without assuming that the hydrophones are coplanar, but the errors involved in this calculation have not yet been fully assessed. A more basic development to improve accuracy is to employ a transponding system which gives slant range from the fixed transmitter/hydrophones to the transponders directly. In this way a 3 dimensional fix is possible using only 3 hydrophones rather than the 4 which are required at present.

The towing vessel is tracked by taking range and bearing measurements using an optical range finder and a magnetic compass. The use of an additional transmitter or transponder attached to the vessel to locate its position relative to the hydrophones directly would be an improvement over the present system.

Greater accuracy could be achieved by measuring water temperature and salinity in the vicinity of the range to allow for changes in the velocity of sound. This should be done when measurements are made of the array dimensions and repeated when the range is in use. Ideally, temperature and salinity should be continuously monitored so that the correct velocity of sound is used at all times. At present a standard figure of 1498.6 m/sec is used corresponding to a mean temperature of 10°C and salinity of 33‰.

The 4 channel receiver is being replaced by a multi-channel receiver which allow all the hydrophones in the system to be connected to the computer simultaneously. Further software development will allow alternative computation programs to be used in varying circumstances. In future it should be possible to select automatically the signals required to give the best possible fix. Many other refinements are possible by software development to give greater accuracy, better presentation of data and less operator involvement.

TYPICAL TRACK OF VESSEL (x) AND TRANSMITTER ON PORT DOOR (·) DURING A TURN SHOWING SCATTER OF INDIVIDUAL POSITIONS.



CIRCLED POINTS SHOW POSITIONS OF HYDROPHONES AT WHICH SIGNALS WERE RECEIVED.

FIGURE 1.

DEVELOPMENT OF A PELAGIC TRAWL IN FRANCE - verbal contribution by: J.C. Brabant.

Last year in the progress report of France experiments with a two-boat midwater trawl having very large meshes (16 m stretched) in the front part of the net were reported. Because of the success of this initial experiment the development of these trawls was continued for both one- and two-boat operation and followed by an introduction in the fishing industry at the end of 1977.

In his verbal contribution Mr. Brabant explained the specific design and construction characteristics of three of these very large meshed trawls.

The smallest gear has a circumference of 28 "meshes" with a stretched length of 16 metre, equivalent to 2440 meshes of 20 cm stretched. This gear can be towed at a speed of 5 knots by two vessels of 350 hp each. The length of headline and footrope is 87 metre; the length of the side ropes is 70 metre.

For stern trawlers with a propulsive power of 1000 hp a trawl with a circumference of 24 "meshes" of 16 metre stretched length (equal to 1920 meshes of 20 cm stretched) was tested. The length of headline/footrope is 76 metre; the side ropes are 70 metre in length.

For very large stern trawlers with a propulsive power of 3500 hp a design of a trawl with headline/footrope length of 183 metre and side ropes of 151 metre was displayed. This trawl has a circumference corresponding with a 4000 x 20 cm meshes (stretched) midwater trawl. The material for constructing the 16 metre "meshes" is nylon (PA) with a diameter of 16 mm. The bars of these meshes have at each side a spliced eye. So the construction of this large midwater webbing is very labour intensive.

Mr. Brabant stated that by applying these trawls in relation to the propulsive power available relatively large gears could be towed at fairly high speeds. To illustrate this once more he mentioned that the large meshed trawl with a circumference equal to a midwater trawl of 4000 meshes of 20 cm can be towed at a speed of 5.5 knots when a propulsive power of approximately 3000 hp is available.

With this new type of gears most experience is obtained during two-boat midwater trawling operations in the Channel and Gulf of Biscaye area's. It is of interest to mention that next to good catches of e.g. sardine also small quantities of very unconventional species were caught.

THE CALCULATION OF TOWING WARP LOADS IN THE EVENT OF A GEAR FASTENER

by: D.N. MacLennan

Introduction

When a towed gear catches on an underwater obstruction or when it is prevented from moving for any reason, the gear is said to have come fast. Such an event, or the obstruction itself, is described as a gear "fastener".

These fasteners can be caused by man-made obstacles such as a wreck or debris left on the sea bed, or by natural circumstances such as boulders on hard ground, but even on soft ground problems can occur through the gear digging into the soil. Sand banks are another natural hazard, where the steep gradient on one side of a dune increases the chance of the gear coming fast.

Modern navigational aids are of considerable benefit to the fisherman, enabling him to select a tow which avoids known obstruction, but where good fishing is available, fishermen are often prepared to accept the risk of coming fast against the prospect of a good catch even on suspect grounds. Thus fasteners are not rare events in the demersal fisheries, and so it is important to know the consequences as regards damage to the gear, loss of fishing time and indeed the danger element should the gear come fast.

Practical considerations

When a part of the gear stops moving because it has struck a sea bed obstruction, the ship will continue to move under its one momentum. The warp acts like a spring as it is stretched between the ship and the stationary gear, so that the warp load increases with time causing the ship to decelerate. The warp load continues to increase until the winch slips or some component part of the gear breaks, but if nothing happens to release the strain then the load will reach the maximum value only when the ship has stopped moving.

It is normal practice on trawlers for the winch brakes to be adjusted so that the warp will pull out if the load increases to a level well above the normal trawling loads but much less than the nominal breaking load of the type of wire being used. This helps to limit the damage to gear in the event of a fastener, and it is also a good practice from the safety point of view. One of the most dangerous circumstances which can arise in fishing is the breaking of a warp, because this will happen when a proportion of the ship's kinetic energy has been transferred to the potential energy of the warp, and this energy must be released as violent motion of the broken wire. The higher the level at which the winch brakes are set to slip, the greater is the potential energy in the warp which has to be released after the break.

On some trawlers and particularly on older vessels, the winch brake adjustment can be a rather arbitrary procedure, and it has to be recognised that through human error or poor maintenance the brakes may be applied too tightly on occasions. In any case it is sometimes necessary for the brakes to be applied more tightly than at other times, for example in bad weather when the warp loads reach higher peaks due to wave motion compared with the steadier loads experienced when trawling in calm seas.

For the beam trawl which is operated by one towing warp it is only necessary to consider whether or not the gear comes to a stop. The circumstances are slightly more complicated in the case of the otter trawl which has two towing warps. It is most unlikely that both otterboards would come fast at the same time, since they are about 70 m apart, and if one otterboard comes fast then the warp on that side of the gear develops the greatest strain while the other warp remains relatively slack. On the other hand, if it is the groundrope that strikes an obstruction, the increase in strain is more evenly divided between the two warps. However, the groundrope and the sweep system are weaker than the warps, and it is likely in the event of the groundrope coming fast that damage to the net will occur at an early time, releasing the remains of the gear before the warp load has risen to a drastic extent. The circumstances of an otterboard fastener are rather more severe because the strain is applied not to the net but to the stronger warp and its connections so that higher loads are developed. The case of an otterboard fastener is the one considered in most detail in the remainder of this paper, although the theory described below may also be applied to cases in which the strain is developed in both warps.

Theory

The motion of the ship in the plane of the sea surface could be described by simultaneous equations giving the ship's position in two dimensions, but movements perpendicular to the original direction of motion may be neglected because the distance between the otterboards is small compared with the warp length. Thus it is reasonable to describe the motion of the ship in one dimension only, allowing a single equation for "x" which is the horizontal distance between the ship and the bottom end of the warp (figure 1).

Applying Newton's second law to motion in the x-direction, the product of vessel mass M times the acceleration $\ddot{x}$ equals the sum of the x-components of the applied forces:

$$M \ddot{x} = g (P - R + W - F_s - F_p) \qquad \text{......(1)}$$

where P is the propeller thrust, R is the water resistance, F_s and F_p are the x-components of warp loads in the starboard and port warps respectively. The parameter W is included to allow for any other forces acting upon the vessel. In particular, W includes the wind resistance. x is the distance travelled and the acceleration $\ddot{x}$ is the second derivative of x with respect to time. "g" is the acceleration due to gravity, 32 ft/S^2 (9.81 m/S^2), which is included to allow the forces to be expressed in equivalent weight units.

The propeller thrust and the water resistance depend upon speed, but their variation is small compared with that of the dominant warp tension in the conditions of a gear fastener, so P, R and W may be assumed constant in this application.

To evaluate (P - R + W), equation (1) is applied to the case of towing at constant speed. Then $\ddot{x} = 0$, the warp tension components are known from experimental data and:

$$P - R + W = F_o \qquad \text{......(2)}$$

Where F_o is the average warp tension componente for steady state trawling conditions with the particular gear in question.

When one side of the gear comes fast, the value of F for the warp on the other side should remain approximately equal to F. Dropping the subscripts s and p since only the warp on the side coming fast is now being considered, equation (1) reduces to the approximate form:

$$M \ddot{x} = g (F_o - F) \qquad \ldots\ldots(3)$$

Suppose that initially the gear is being towed at a steady speed v_o, $F = F_o$ and $x = x_o$. At time t = 0, an otterboard comes fast and stops moving. The weight of the warp is negligible compared with that of the ship, so warp inertia forces can be ignored. Thus F may be calculated as a function of x and v_o using a steady state theory of towing warp geometry and loads (Crewe,1967). It is assumed that Hooke's law applies to trawl warps, so that the change in warp length is proportional to load, but in addition it is necessary to take account of the change in warp shape and the total dependence of F upon x is not linear. Given the initial conditions x_o and v_o at time zero, equation (3) can be integrated by numerical methods to find x at subsequent times. Euler's method for the numerical solution of differential equations provides a simple but satisfactory means of solving (3) so that F which is a known function of x can also be determined as a function of time. T, the magnitude of the warp load, is then given by:

$$T = F/\cos d \qquad \ldots\ldots(4)$$

Where the declination angle d comes from the prior calculation of warp shape.

Results

The warp load as a function of time after coming fast has been calculated for 27 different cases covering a range of initial towing speeds (2.5, 3.0 and 3.5 knots), vessel types (130, 600 and 1000 hp) and warp lengths (175, 250 and 350 fms). Vessels of a particular towing power will normally use the same size of warp, and the diameter of warp suitable for the vessel types listed here would be 13, 21 and 26 mm respectively. The physical properties of warps relevant to the calculation of towing loads are given in Table 1.

It has been assumed that the water depths appropriate to the specified warp lengths would be 50, 75 and 100 fms respectively.

The selected vessel types correspond to three fishery research vessels for which the data required were readily available. The relevant value for the mass M is the vessel displacement. The gross and net tonnages often quoted for ships are not relevant here since they do not describe the total mass of the vessel including all equipment on board. Details of the three vessels considered and of typical towing loads experienced at various speeds are shown in Table 2.

The first step in the calculation is to compute for each case the relationship between F, T and x at a constant towing velocity. The results from this calculation are very similar over the range of towing velocities considered. The variation of T with x is practically linear at high tensions when the warp is nearly straight, as can be seen from the examples in figure 2, while the curvature at low values of T arises from the effect of wire sag.

Computed values for F and T were then used with equation (3) to derive the time dependence of ship speed and the warp load T. The results are shown in figures 3-11, one figure for each selection of vessel type and initial towing speed. The three curves in each figure correspond to the different warp lengths as indicated. The load increases and the speed reduces more slowly for the longer warp lengths when the warp is in effect more elastic. Each curve is continued up to the point at which the tension has risen to the nominal breaking load, although this point is never reached in some cases where the warp is able to absorb the kinetic energy of the ship. As would be expected, the tension increases most quickly for the heaviest ship, the shortest warp length and the fastest initial towing speed. The times taken to reach the nominal breaking load, on the assumption that nothing occurs before then to release the strain, are summarised in Table 3. The breaking load was exceeded in all but a few of the cases studied.

Conclusions

The theory and the calculations presented in this report describe what happens in a serious fastener incident when part of the gear is brought to a stop within a short space of time. This kind of fastener could occur if the gear hit a wreck or if an otterboard snagged against a large boulder. In less serious fasteners the gear would decelerate less quickly so that the rate of tension increase is reduced from the worst case examples described here. The rate of tension increase will only be reduced significantly if the distance within which the gear comes to a stop is a significant proportion of the warp extension $(x - x_o)$ at the breaking load. This maximum warp extension is roughly proportional to warp length, but it is less dependent upon speed and warp diameter as shown by Table 4.

The warp tensions have been computed up to the nominal breaking load value, but in practice it is likely that some part of the gear would give way or that the winch would slip before such a dangerous level is reached. However, the warp tensions would still follow the computed curves from time zero until the point at which some event occurs to release the strain. Thus the results shown in figures 3-11 give an indication of how much time is available for corrective action to occur whether or not this occurs automatically.

Only three vessel types have been considered here. The behaviour of other classes of vessel in a fastener will depend upon the vessel displacement and upon the size of warp used. The warp diameter bears some relationship to towing power, but otherwise the engine power is not a significant parameter in this context.

Reference

Crewe, P.R. 1967
A theory for the geometry of and loads acting on a circular wire that is being towed steadily on a straight course.
British Hovercraft Corporation Report H/O/215, June 1967.

TABLE 1

Towing Warp Characteristics

Warp diameter	Weight		Nominal breaking Load		Metallic Area		Elasticity Modulus	
mm	kg/m	lb/ft	N	ton	mm^2	in^2	N^{-1}	ton^{-1}
13	0.64	0.43	87 700	8.8	66.8	0.103	$1.46\ 10^{-7}$	$1.45\ 10^{-3}$
21	1.52	1.02	211 000	21.2	174	0.27	$5.55\ 10^{-8}$	$5.55\ 10^{-4}$
26	2.56	1.72	359 000	36.0	267	0.414	$3.66\ 10^{-8}$	$3.64\ 10^{-4}$

Notes:

1. These data are approximate values as quoted by a major manufacturer for round strand fibre core warps and 6 x 19 (9-9-1) construction.

2. The elasticity modulus is the fractional change in warp length per unit load ($\Delta L/LT$). The figures quoted are for pre-stressed wire and would apply to wires in use for some time. The elasticities of new wires without pre-stressing during manufacture would be 20% higher.

3. The nominal breaking loads relate to steel of tensile strength 95/105 ton/in^2 (150/165 kg/mm^2).

4. The metallic area is the cross sectional area of the steel.

TABLE 2

Towing Vessel Characteristics

Ship	Displacement Tonnage	Engine HP	Typical load in one warp (tons) at 3.5	3.0	2.5 knots
Explorer	1 300	1 000	3.0	2.7	2.4
Clupea	330	600	2.0	1.8	1.6
Mara	130	240	1.0	0.9	0.8

TABLE 3

Times after coming fast for the warp tension to rise to the nominal breaking load. Figures within brackets are times corresponding to the maximum tension when that is less than the nominal breaking load. All times are in seconds. L is the warp length in fathoms, and V is the initial towing speed in knots.

V \ L	175	250	350
3.5	2.7	4.2	6.9
3.0	3.2	5.2	8.7
2.5	4.1	6.7	11.8

(a) 1 300 ton vessel

V \ L	175	250	350
3.5	2.9	4.7	8.2
3.0	3.6	6.1	(11.9)
2.5	4.7	(9.4)	(13.6)

(b) 330 ton vessel

V \ L	175	250	350
3.5	2.8	4.6	8.0
3.0	3.4	5.9	(11.6)
2.5	4.6	(9.0)	(13.2)

(c) 130 ton vessel

TABLE 4

Maximum values of $(x - x_o)$, the horizontal warp extension at breaking load, in feet. D is the warp diameter (mm) and V is the towing speed (knots).

D \ V	2.5	3.0	3.5	Warp length (fms)	Water depth (fms)
26	16.3	15.8	15.4		
21	16.9	16.3	15.8	175	50
13	17.4	16.7	16.3		

D \ V	2.5	3.0	3.5	Warp length (fms)	Water depth (fms)
26	26.2	25.0	24.1		
21	28.0	26.4	25.2	250	75
13	27.3	25.6	24.5		

D \ V	2.5	3.0	3.5	Warp length (fms)	Water depth (fms)
26	44.1	40.7	38.5		
21	48.9	44.3	41.2	350	100
13	47.3	42.8	39.8		

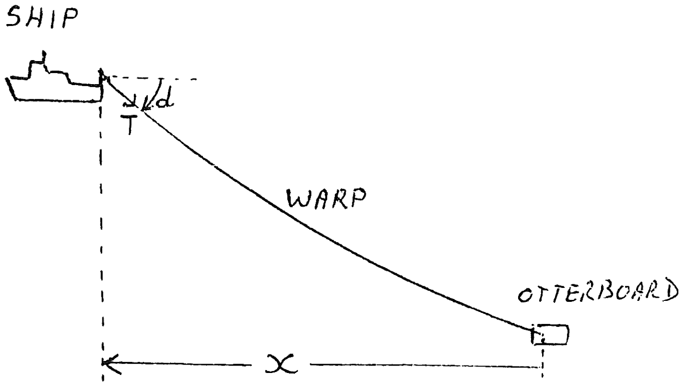


FIGURE 1. DEFINITION OF PRINCIPAL SYMBOLS

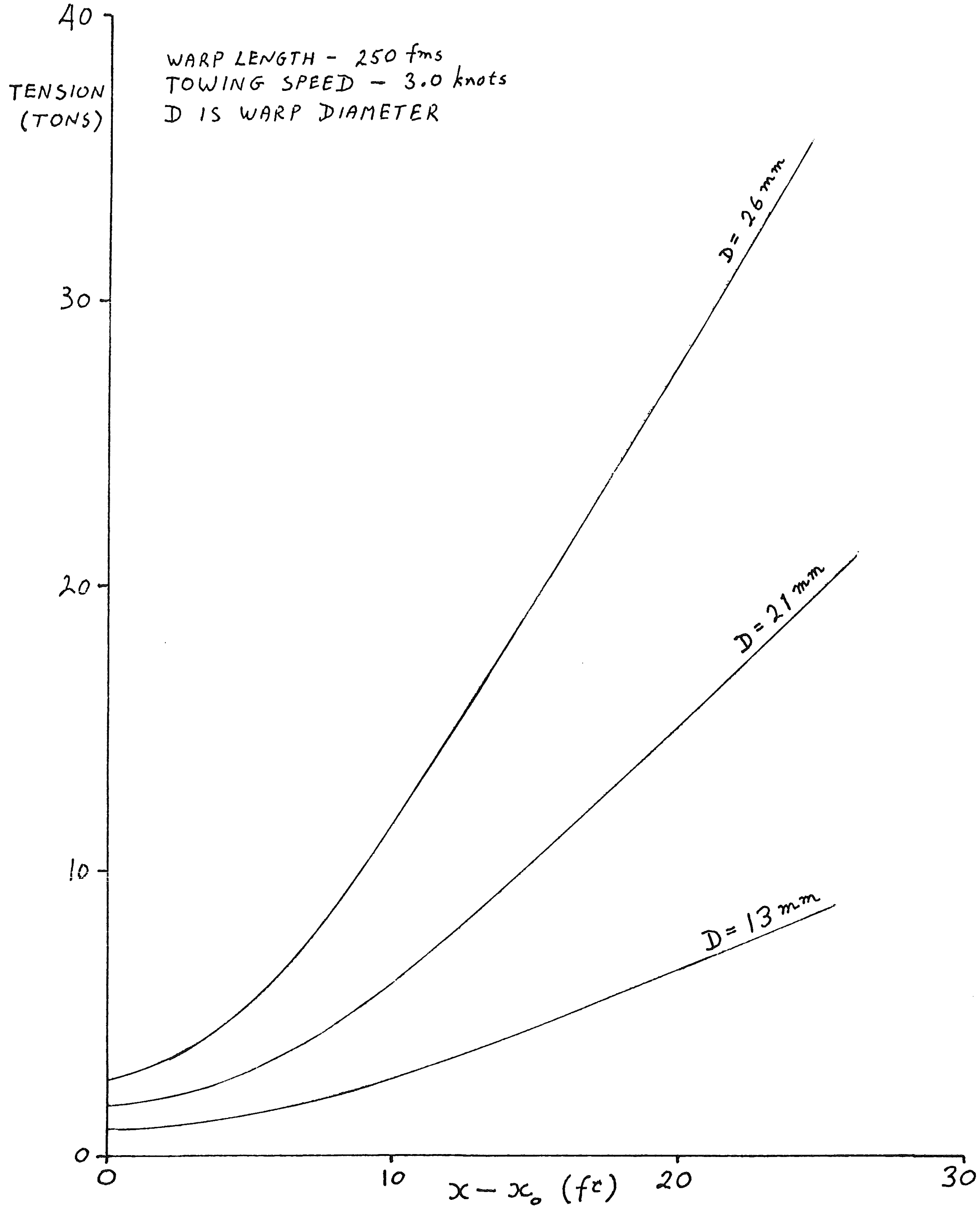


FIGURE 2. WARP TENSION VS. HORIZONTAL WARP EXTENSION (x) RELATIVE TO THE NORMAL VALUE (x_0).

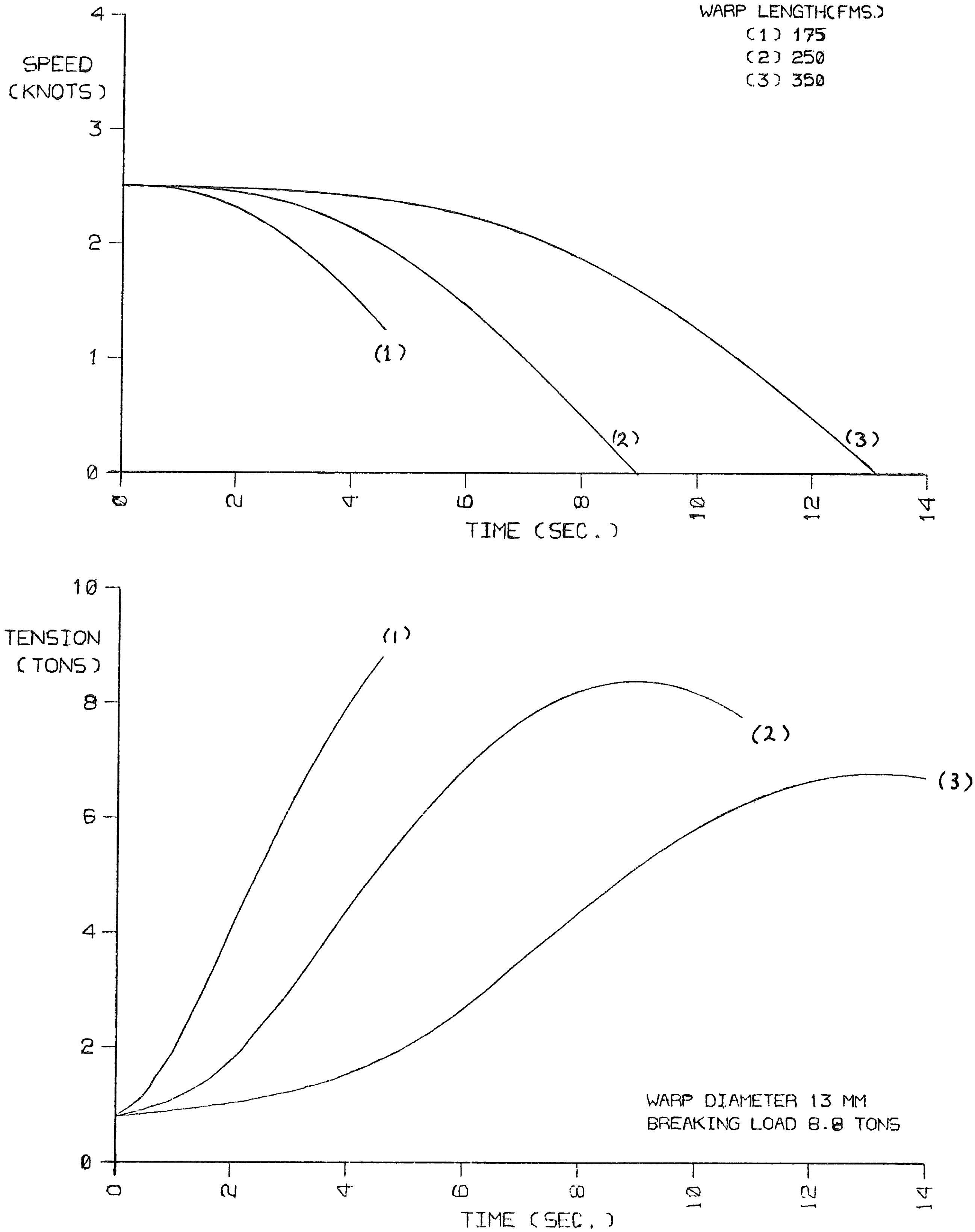


FIGURE 3. 130 TON VESSEL
INITIAL SPEED 2.5 KNOTS

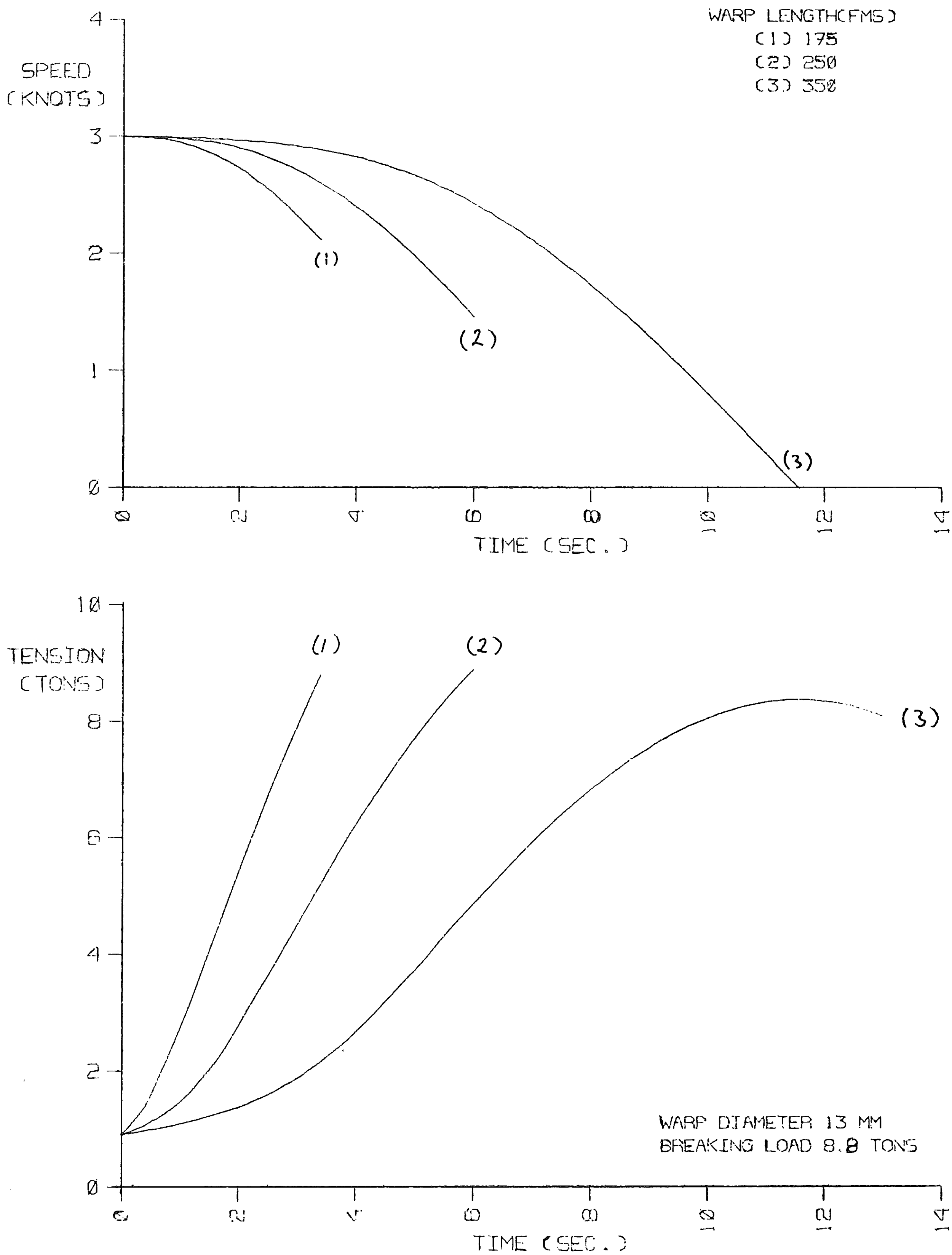


FIGURE 4. 130 TON VESSEL
INITIAL SPEED 3.0 KNOTS

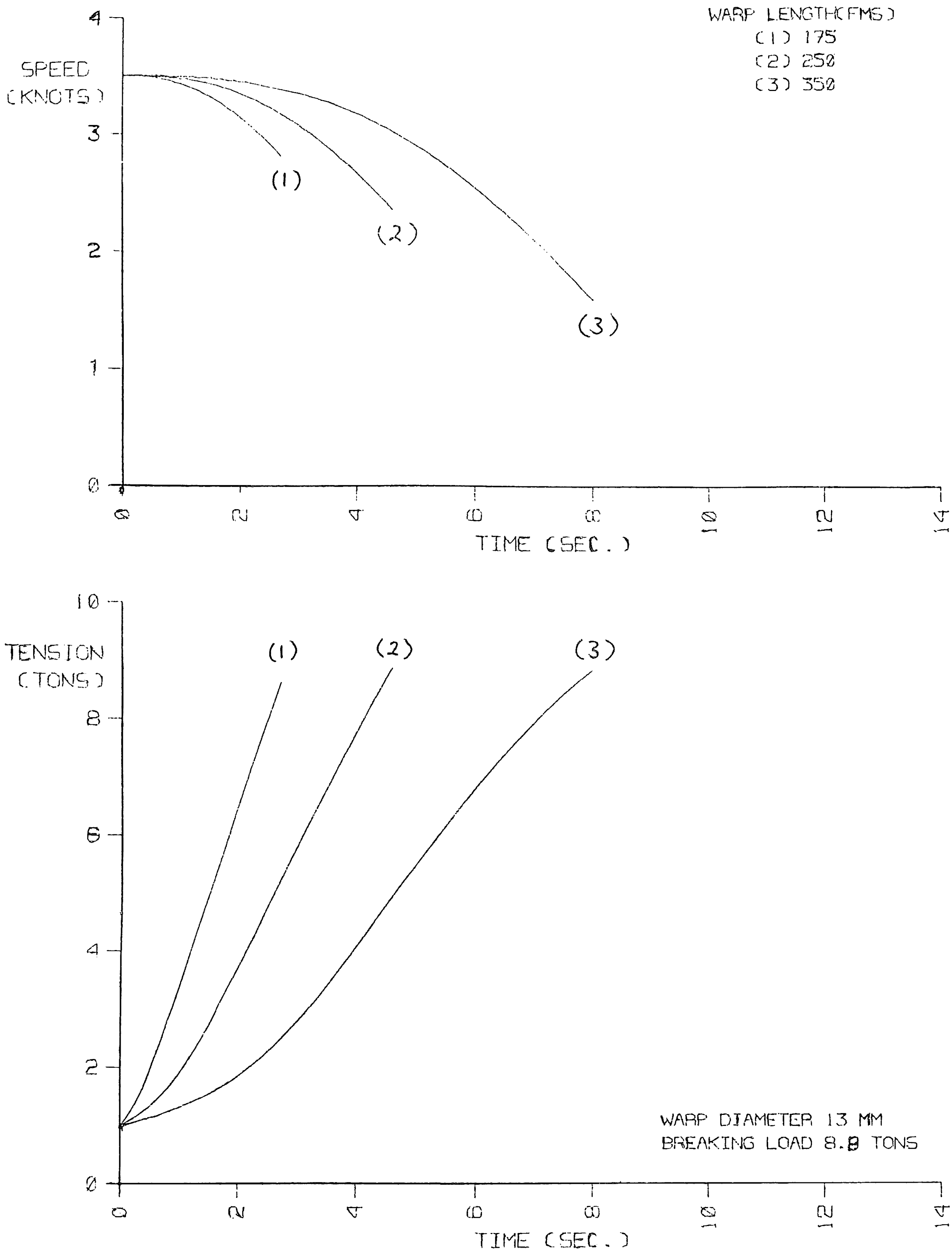


FIGURE 5. 130 TON VESSEL
INITIAL SPEED 3.5 KNOTS

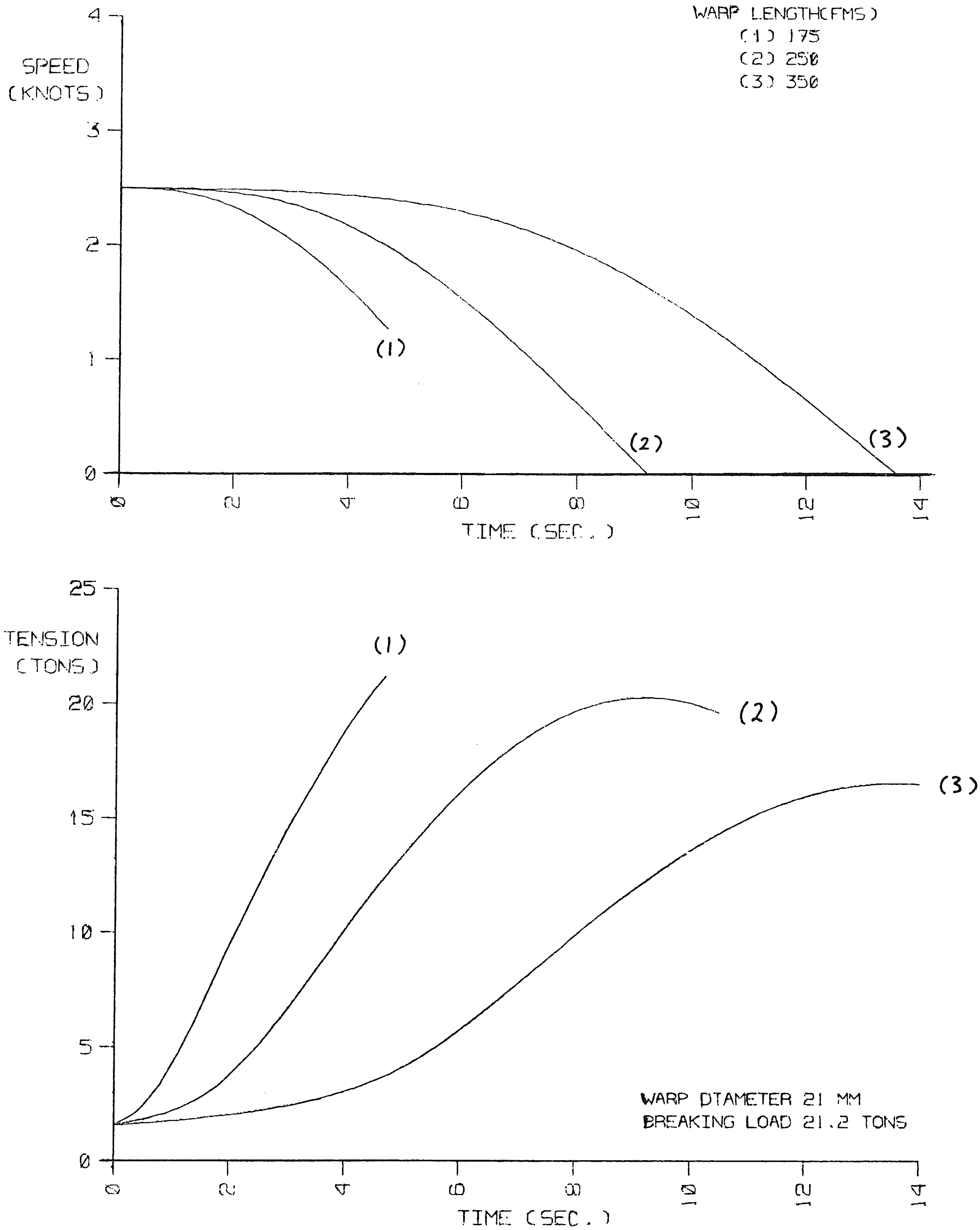


FIGURE 6. 330 TON VESSEL
INITIAL SPEED 2.5 KNOTS

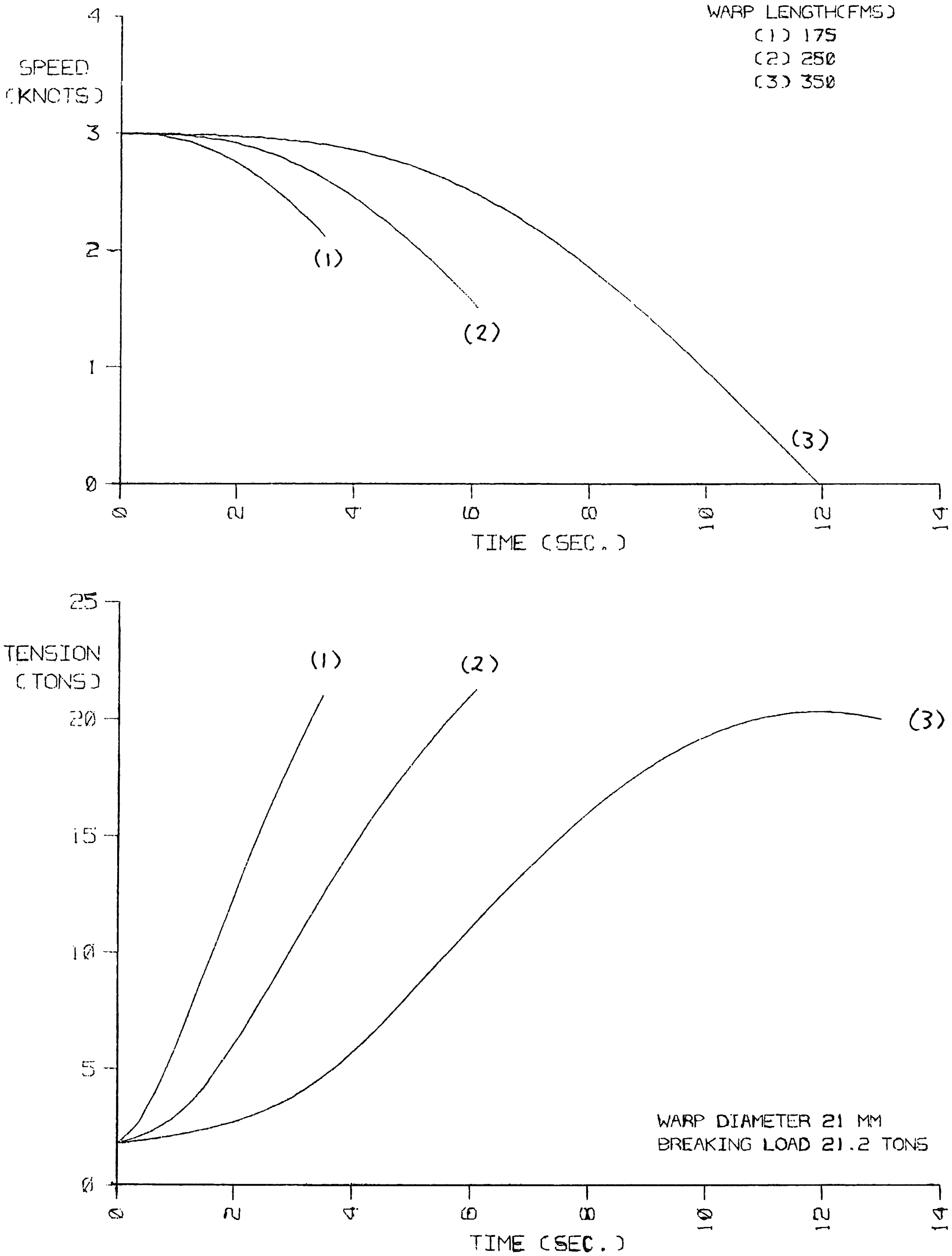


FIGURE 7. 330 TON VESSEL
INITIAL SPEED 3.0 KNOTS

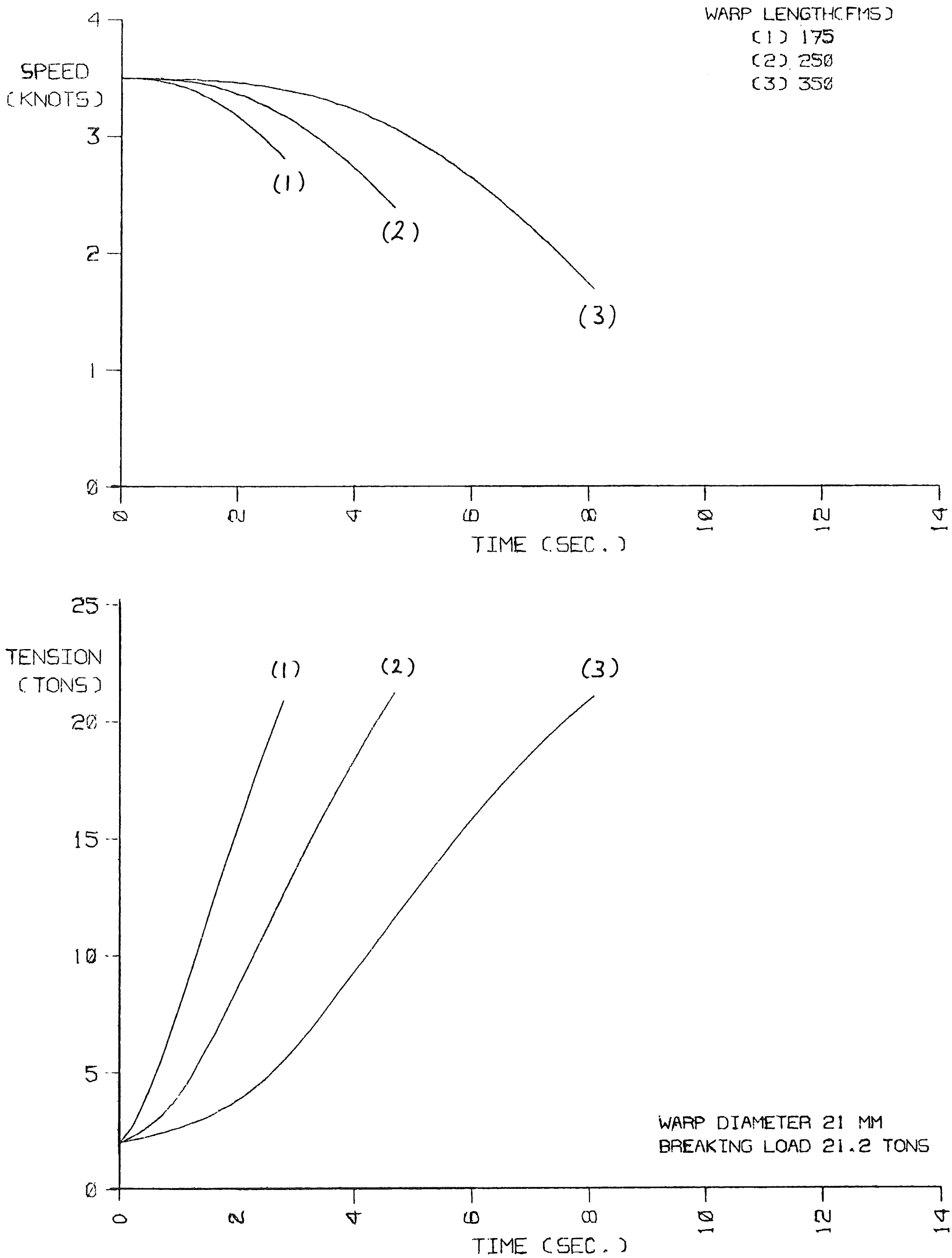


FIGURE 8. 330 TON VESSEL
INITIAL SPEED 3.5 KNOTS

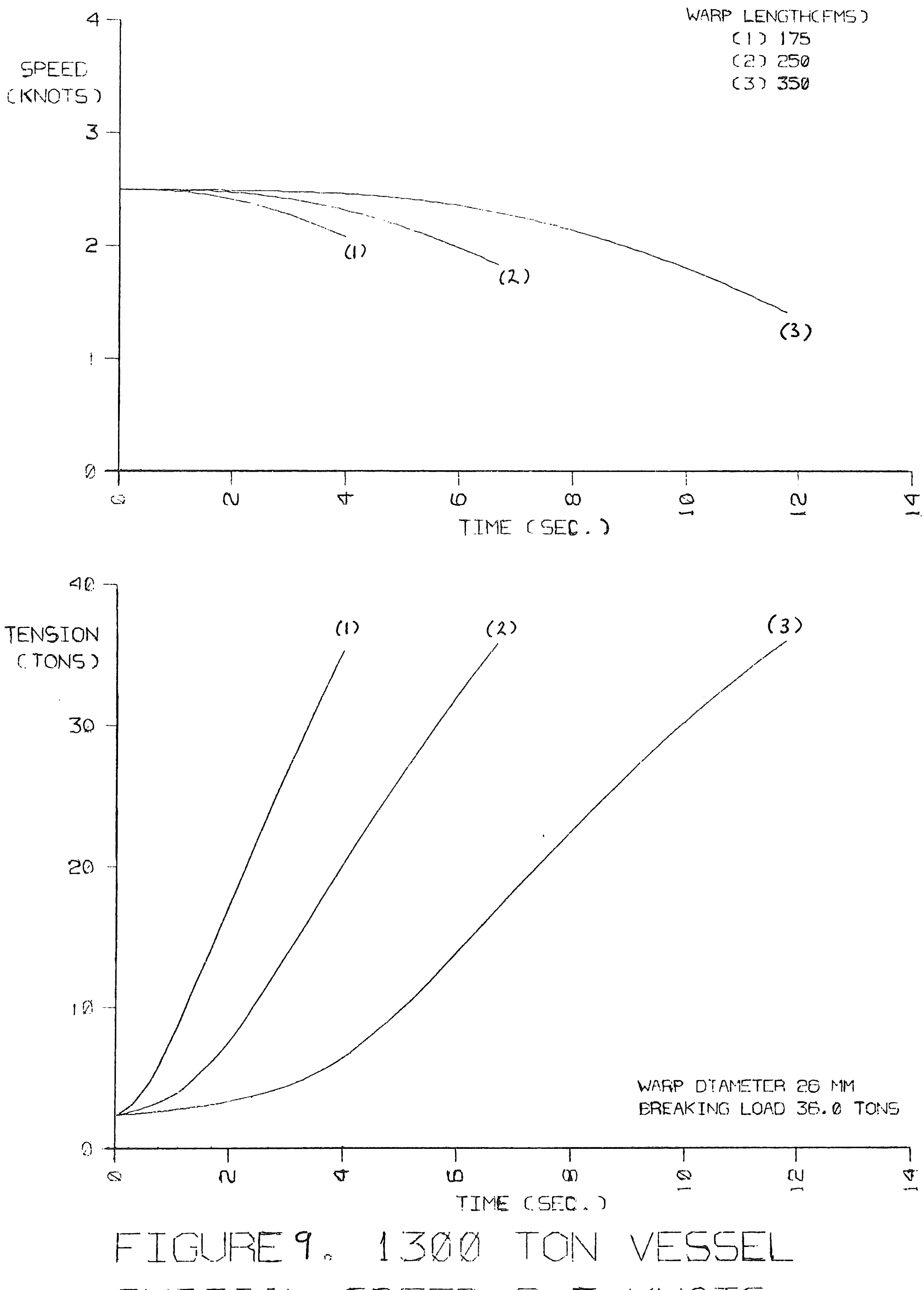


FIGURE 9. 1300 TON VESSEL
INITIAL SPEED 2.5 KNOTS

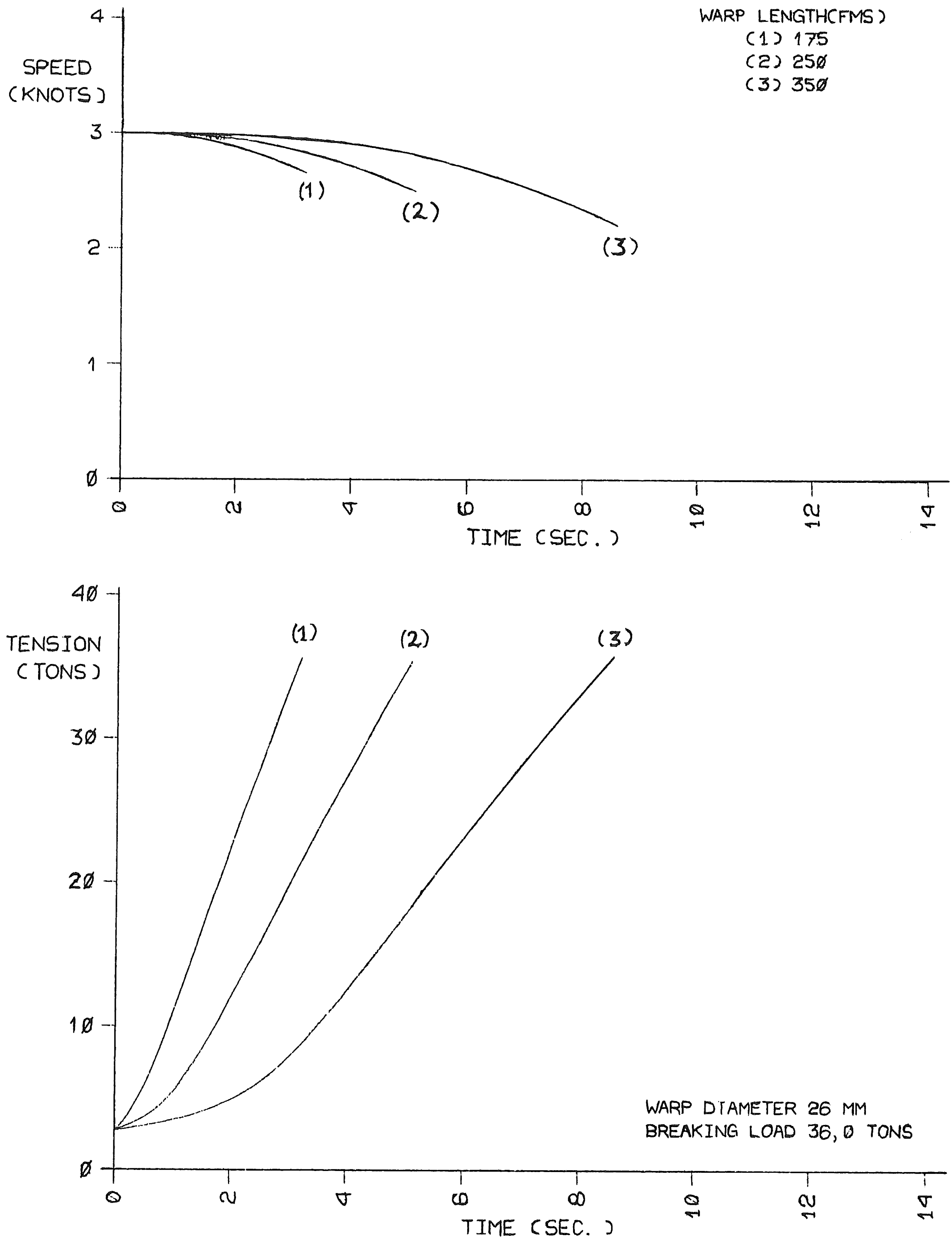
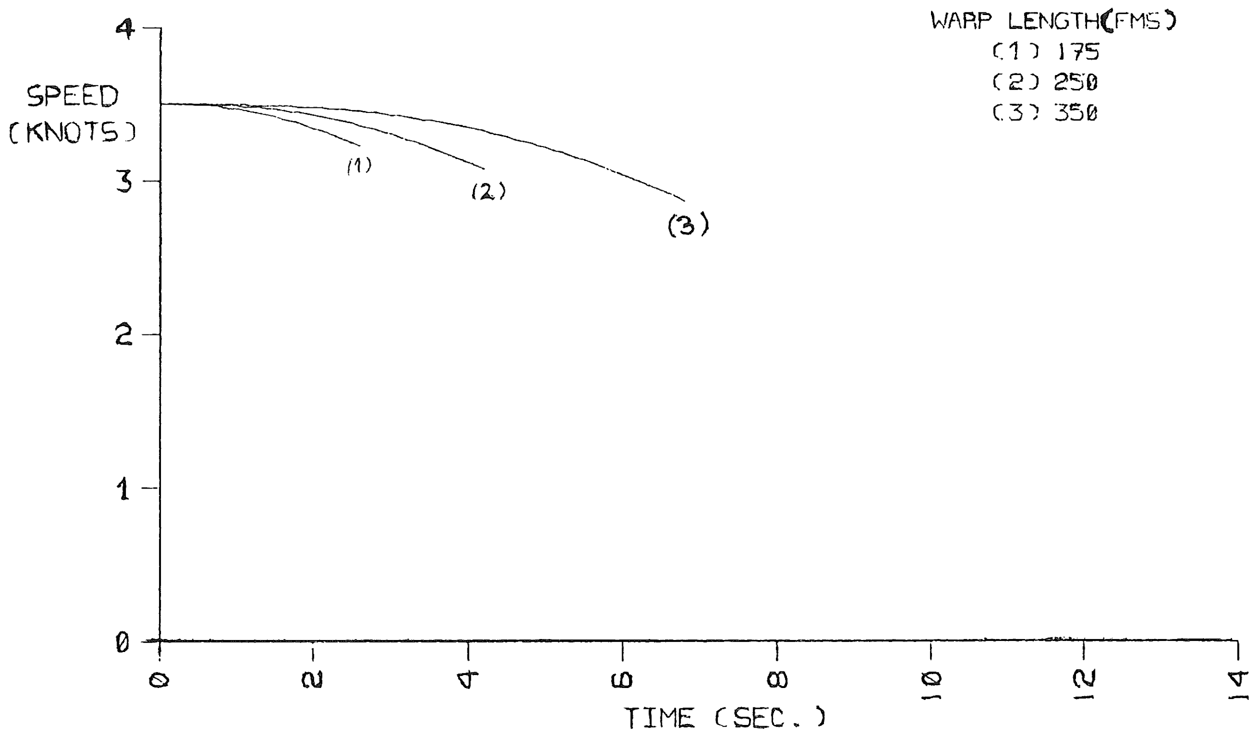


FIGURE 10. 1300 TON VESSEL
INITIAL SPEED 3.Ø KNOTS



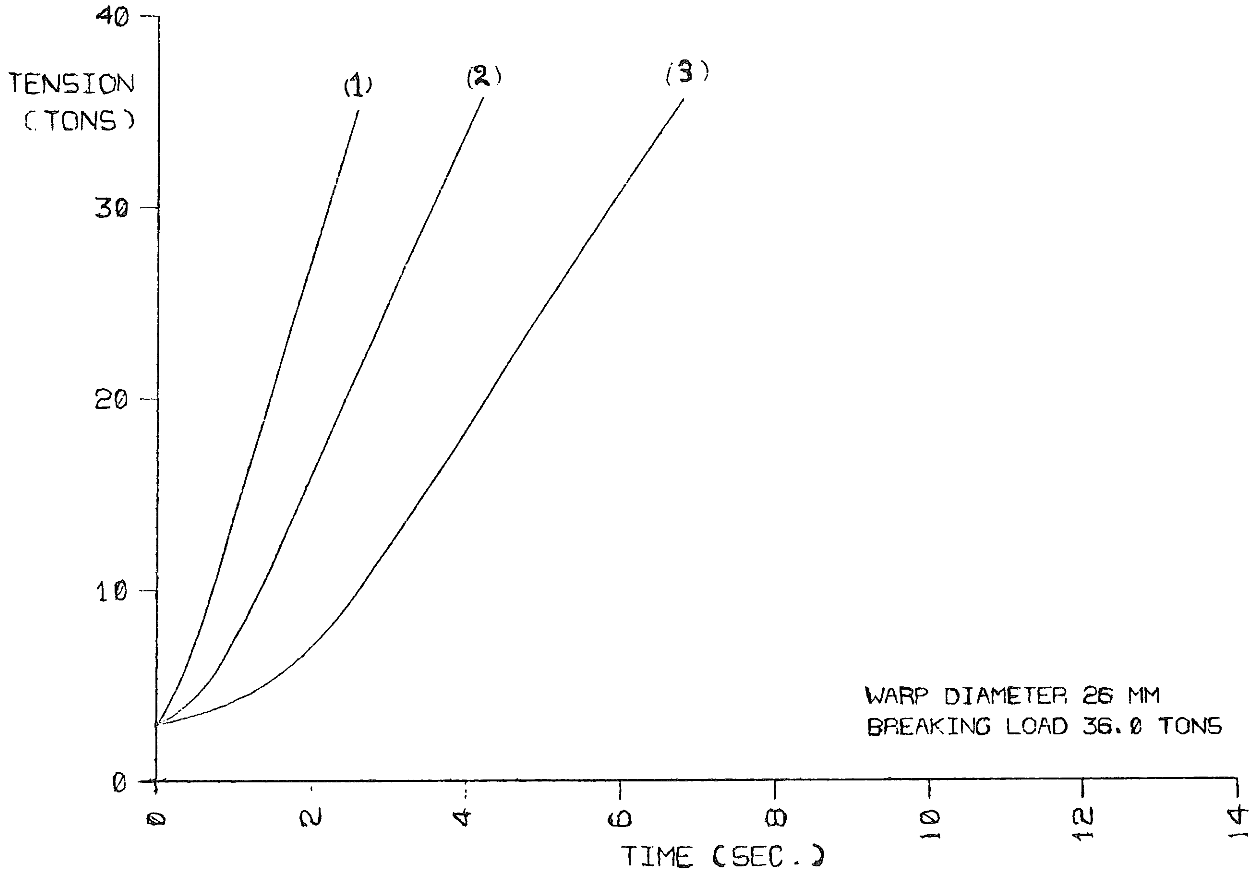


FIGURE 11. 1300 TON VESSEL
INITIAL SPEED 3.5 KNOTS

AUTOMATED GEAR HANDLING OF A PURSE-SEINE

by Arvid Beltestad

Nowadays on Norwegian coastal purse-seiners there is a great need for reducing the crew. The greatest manpower requirement during purse-seine operation is when hauling the net.

Most of the Norwegian coastal purse-seiners have the wheelhouse and accommodations aft, with the net stacked on the main deck aft of the wheelhouse. The net is hauled through a power block hanging in a fixed position in a boom or a crane. During hauling this system requires one man on the floatline, one on the leadline and at least two men to stack the webbing.

In order to release the two men stacking the webbing the Institute of Fishery Technology Research in 1976 started trials on a system, stacking the net in a deep net bin and with the power block hanging in a manoeuvrable hydraulic crane which can move the power block over the net bin during hauling.

The system has been installated and tested onboard M.S. "Bådsvik", a 70 ft coastal purse-seiner with the wheelhouse aft.

Figure 1 shows the arrangement onboard m.s. "Bådsvik". The hydraulic crane has four moveable parts. One for sideway movements, two for vertical movements and one telescoping arm which is long enough to reach from the aft end of the casing to the aftermost part of the net bin.

An aluminium net bin is mounted on the railing to get sufficient space for the net. Directly abaft the ring needle a vertical 5 m long roller is mounted to guide the net clear of the ring needle and the upper deck when the powerblock is hauling in the net on the port side of the bin. The roller is removed during shooting.

While stacking the net with the crane, only the horizontal swing cylinder and the cylinder controlling the telescoping arm are used. During the initial trials these cylinders were controlled manually. This year a small electronic computer for automatic control of the swing and the telescoping cylinders has been designed and installed.

When using the computer as control unit for the crane, the power block movement will follow a fixed pattern over the net bin. This pattern can be adjusted on the computer by means of thumb wheel switches.

Figure 2 shows the most suitable pattern for stacking the webbing on m.s. "Bådsvik". The floatline is stacked manually on the port side of the net bin and the leadline manually on the starboard side. The webbing is stacked below the power block without manual effort. The starting position for the stacking pattern is on the portside close to the end of the casing. As soon as the power block starts to haul the net the crane starts moving and the power block follows the pattern shown in figure 2. When one cycle is completed it starts a new one and this continues until all the slack is dried up. During the brailing operation the crane is usually controlled manually. The crane is arranged to stop and start at the same time as the power block. This is important.

The system has been tested in about 40 sets with manual control of the crane and about 10 with automatic control. The net stacking system has worked very well but a few small problems with the hydraulic circuits remain to be fixed. The net occupies no more space in the net bin than with manual stacking. No damage has been observed on the net during shooting, which may happen if the net is not stacked properly.

With this system the number of crew on coastal purse-seiners can be reduced by about two. It is expected that a similar system will be installed and tested on larger purse-seiners which use triple rollers rather than power blocks.

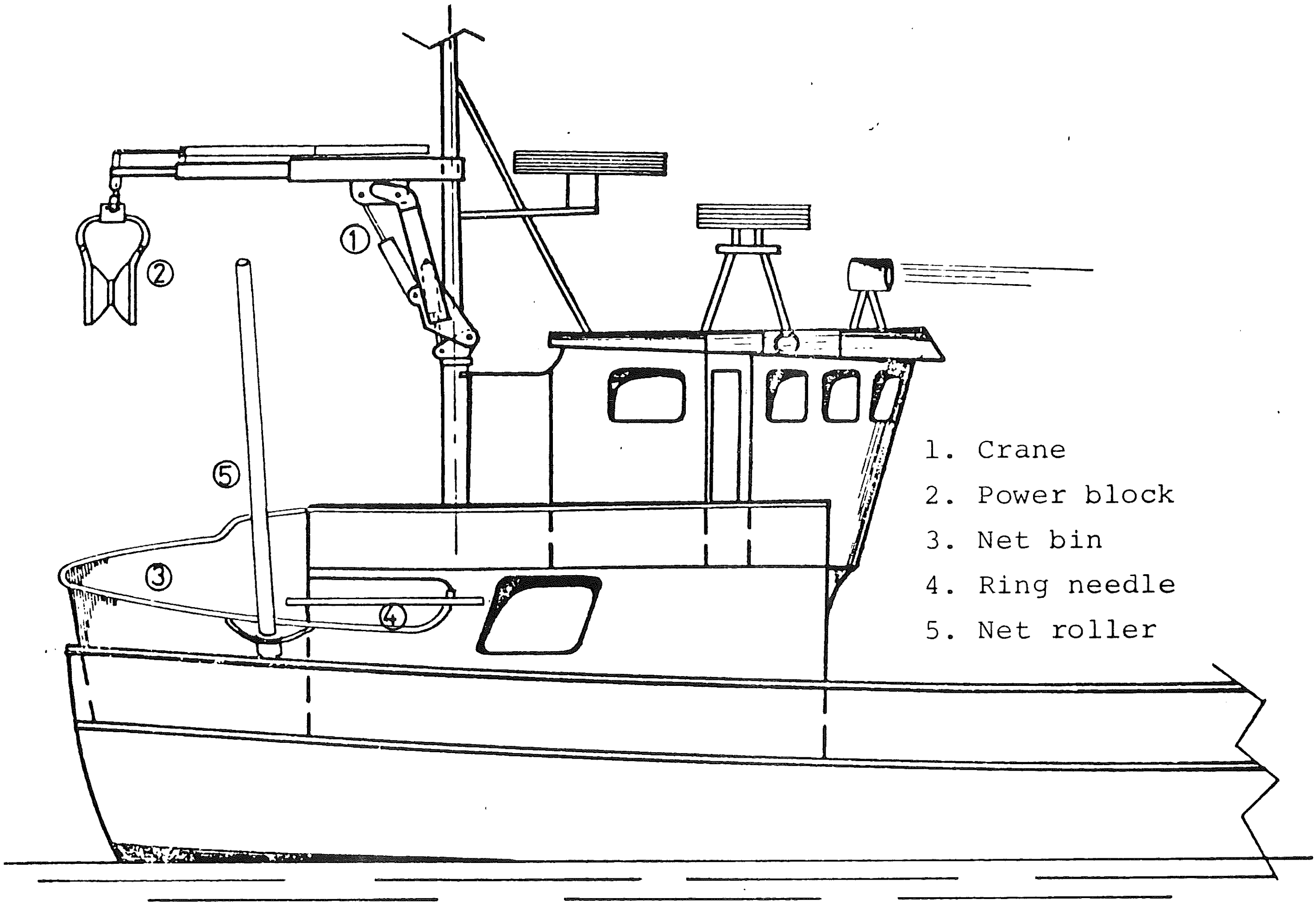


Fig. 1. Automatic net stacking system on M/S "Bådsvik".

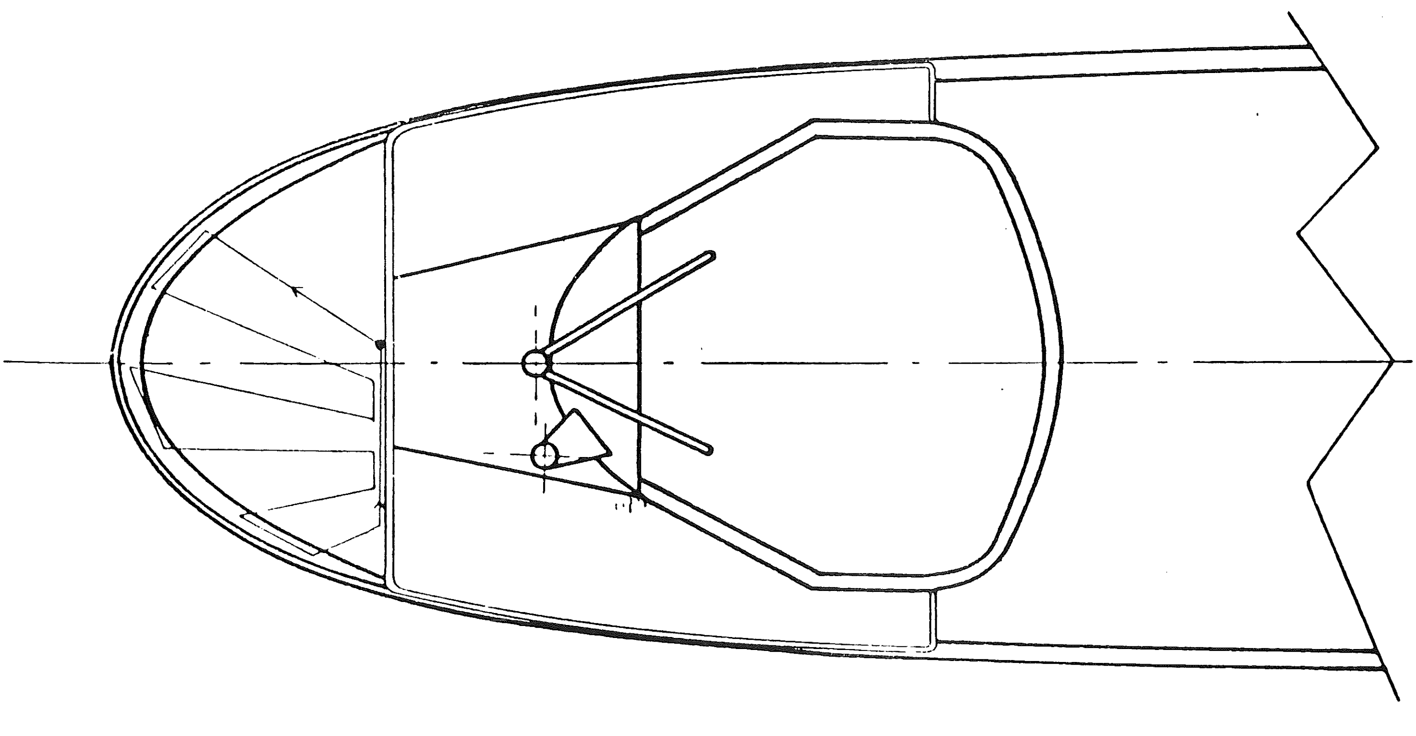


Fig. 2. Stacking pattern.

INVESTIGATIONS ON THE STRAIN OF NETTING YARN AFTER REPEATED LOADING AND AFTER APPLICATION OF STRESS IN DIFFERENT MAGNITUDE

by E. Dahm

Introduction

One of the best properties of man-made netting yarns is their capability to absorb energy. For comparison this is usually measured by the determination of their elongation under a given load. A recently adopted International Standard, No. 3790, defines the requirements for testing the elongation at half knot breaking load. Investigations on ropes (Himmelfarb, 1957) and own experience showed nevertheless that the measurement of elongation caused by a single loading is not sufficient to describe behaviour of netting yarn during its use. With regard to the capability to elongate when stressed it could be observed that considerable changes of this property take place already during the first few loadings. The aim of an investigation into this point was to find out which factors influence this change and to what extent they do this. The amount of samples to be examined was such that no more than three different netting yarns could be used. The results of this investigation are therefore somewhat preliminary. The tendencies observed in all three materials nevertheless seem so congruent and interesting that it seems worthwile to publish them already at this very early state of the research.

Materials and methods

The following netting yarns were investigated:

1. Twisted netting yarn of PA, R3345 tex } identical yarns,
2. " " " " , R3545 tex } differing only in the final conditioning
3. " " " " , R5780 tex

Table 1 gives results of other tests of all three yarns.

Table 1: further properties of the investigated yarns

Property	netting yarn no. 1.	2.	3.
Runnage (m/kg)	296	282	173
Diameter (mm)	2,03	2,16	2,81
Twist coefficient	213	230	192
Breaking load, wet, with weavers knot (according to ISO 1805 dN).	169	169	252
Elongation at half weavers knot (according to ISO 3790).	20%	23,3%	19,5%

Specimen of these yarns, with a length of 200 mm between the holding clamps were stressed 10, 20, 30, 50, 80 and 120 times by loads of 5, 10, 15, 20 and 25 p/tex. The last load value corresponds more or less to the one required in the elongation test according to ISO 3790.

After the end of one load-cycle series some of the yarns were immediately tested according to the mentioned ISO prescription on elongation. Some other yarns were not submitted to that test until 2 hours, 24 hours and 48 hours later to get an impression of a possible recovery after relaxation. To imitate fishing conditions all yarns were kept thoroughly wet during the previous stress phase and the following elongation test.
The constant rate of elongation or way of the straining gauge was 120 mm/min. Strain was calculated by division of observed elongation and previously defined distance of the holding clamps. To prevent mistakes by slippage in the clamps all specimen were marked at the beginning of the trials by coloured spots at the points where they left the clamps.
Ten tests were carried out for every combination (e.g. load: 10 p/tex, load cycle repetions: 50) and the average value calculated.

Results

Figure 1 to 3 show the results of all tests for each netting yarn compiled in a so called "Function mountain" (German standard DIN 461). This fairly complicated way of presentation allows it to make the relation of three different parameters visible. As can be seen, the x-axis represents the number of repeated loadings, the y-axis the strain to be measured after the stress and the z-axis the magnitude of the imposed stress given in p/tex as a function of the linear mass of the netting yarn.

Two main relations are revealed by figures 1 to 3:

1. The remaining capability to elongate under stress is influenced by the number of load repetitions only during the very first cycles.
2. The elongation capability is considerably effected by the magnitude of the imposed stress. A load as required by ISO 3790 reduces the elongation capability already after ten repeated loadings down to 55% of the value at the beginning.

According to Morton and Hearle (1975) the total extension of a stressed fibre can be divided into three parts: "the immediate elastic deformation, which is instantaneous and recoverable, the primary creep, which is recoverable in time and the secondary creep, which is not recoverable". The investigation showed that this is similiarly the case with netting yarns. When the stressed yarns were given time to relax after stress and not tested immediately after the last load cycle, a certain recovery took place. This is demonstrated in tables 2 to 4.
(In account of the necessary time only one load -15p/tex- could be examined).
Nevertheless it must be stated that the recovery is not complete. This is certainly to some extent caused by "secondary creep". Besides there will be a compacting process during the first loadings when the single yarns or strands reach their final position, which is also the reason for some permanent extension.

Table 2 Elongation capability corresponding to the requirements of ISO 3790 of the netting yarn No. 1 after relaxation of a 15p/tex stress (Average values of ten tested specimen).

Relaxation time	Number of previous loadings 10	20	30	50	80	120
immediately after relaxation	13,1%	13,2%	12,9%	13,0%	12,3%	12,5%
after 2 hours	19,2%	19,1%	18,0%	17,0%	16,6%	16,9%
after 24 hours	17,5%	17,4%	17,7%	18,1%	17,2%	17,7%
after 48 hours	18,6%	17,9%	17,9%	17,2%	17,2%	17,7%

Table 3 Elongation capability corresponding to the requirements of ISO 3790 of the netting yarn no. 2 after relaxation of a 15p/tex stress (Average values of ten tested specimen).

Relaxation time	Number of previous loadings 10	20	30	50	80	120
immediately after relaxation	14,8%	14,3%	14,6%	14,4%	14,0%	14,6%
after 2 hours	19,2%	19,1%	18,0%	17,0%	16,6%	16,9%
after 24 hours	17,5%	17,4%	17,7%	18,1%	17,2%	17,7%
after 48 hours	18,6%	17,9%	17,9%	17,2%	17,2%	17,7%

Table 4 Elongation capability corresponding to the requirements of ISO 3790 of the netting yarn no. 3 after relaxation of a 15p/tex stress (Average values of ten tested specimen).

Relaxation time	Number of previous loadings 10	20	30	50	80	120
immediately after relaxation	15,1%	14,6%	14,4%	14,5%	14,0%	14,8%
after 2 hours	18,0%	-	-	18,8%	-	17,2%
after 24 hours	-	-	-	17,8%	-	17,7%
after 48 hours	18,2%	-	-	-	-	-

Conclusions

If the magnitude of stress is the decisive factor for the reduction of the capability of a netting yarn to stretch and to absorb energy, this should be a challenge to introduce engineering methods into net construction which assure the more or less equal distribution of forces in a fishing gear. In parts of the net where during some operating conditions this cannot be the case as e.g. in the meshes close to the lashes in the forenet of a pelagic trawl during shooting and hauling precautions ought to be taken. This could be the use of stronger material to decrease the specific stress on the single netting yarn.

The investigation of the three materials showed which direction future research in this area should take. Apparently the largest part of the reduction of the elongation capability occurs during the first few load cycles. The detailed examination of this phenomenon seems already sufficient to make up an opinion concerning the behaviour of netting yarn in use. The single loading with the half knot breaking load as ISO 3790 prescribes will not reveal this information.

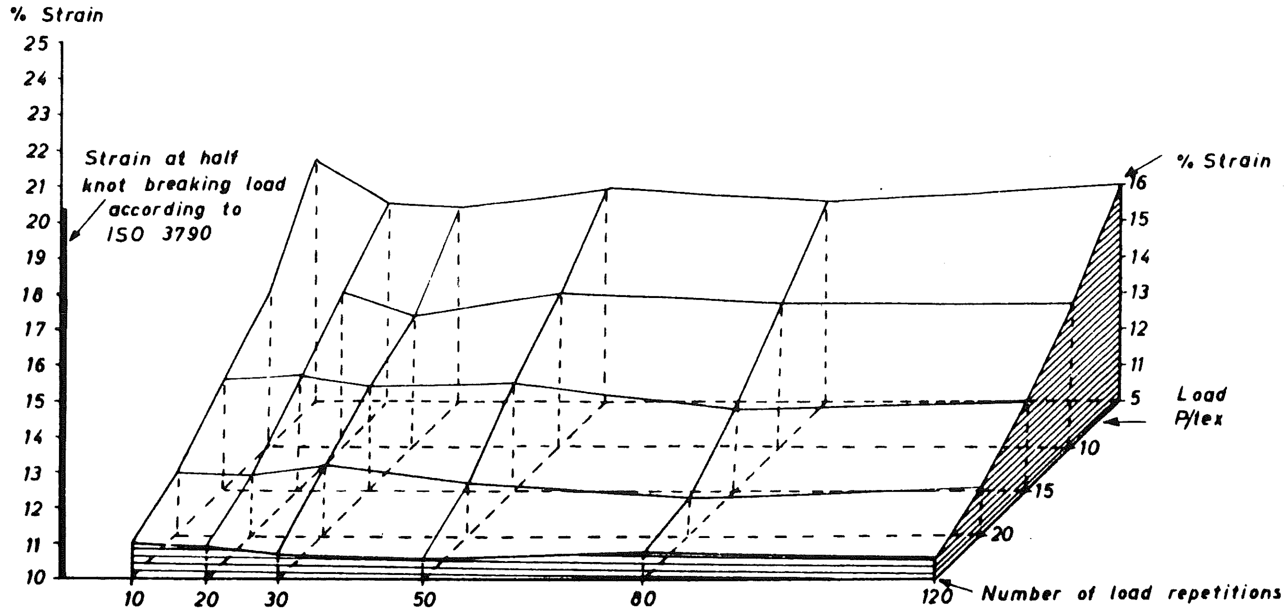


Fig.: 1 Correlation of strain and previous repetitions of load and magnitude of imposed stress in netting yarn No. 1

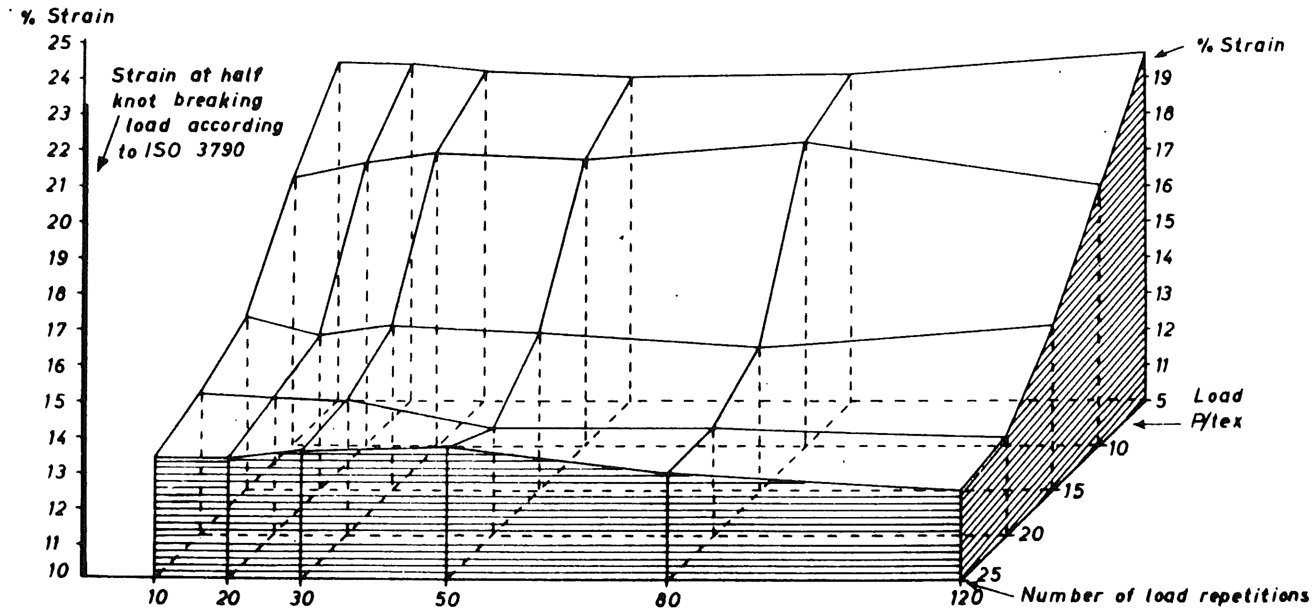


Fig.: 2 Correlation of strain and previous repetitions of load and magnitude of imposed stress in netting yarn No. 2

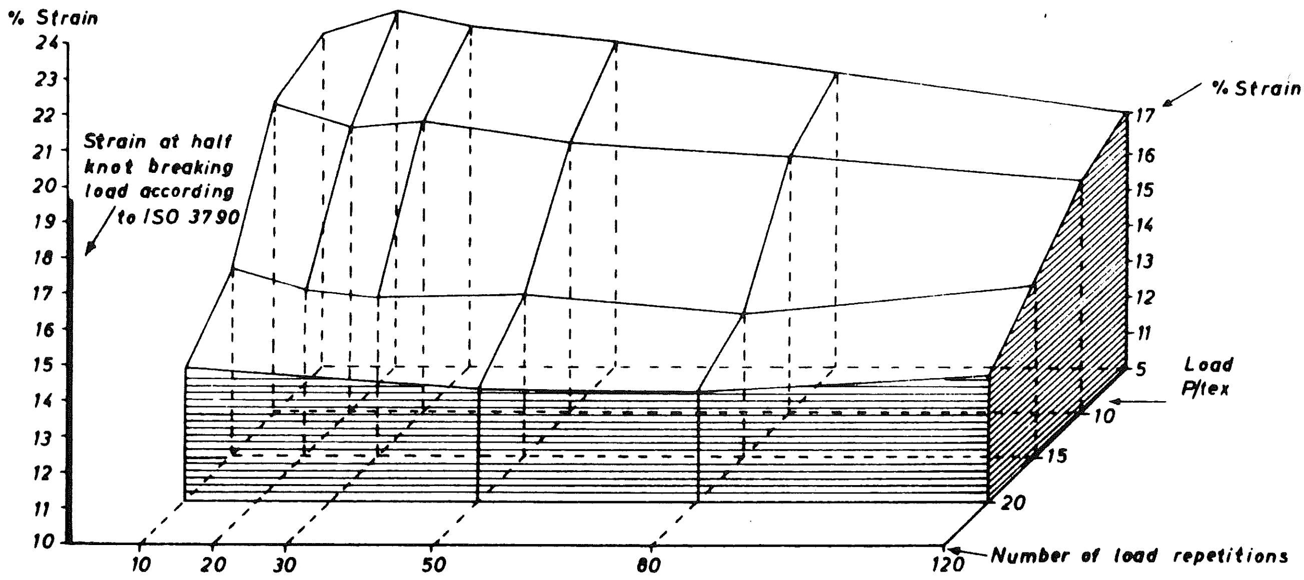


Fig.: 3 Correlation of strain and previous repetitions of load and magnitude of imposed stress in netting yarn No. 3

THE DEVELOPMENT AND TESTING OF A FLATFISH GRADER

by A. Verbaan

INTRODUCTION

In the "Administrative Reports" 1976, 1977 and in the "Report of the Special Joint Session on Biological and Technological Aspects of Electrical Fishing" issue CM1977/B:3 (page 23) it was mentioned that a flatfish grader was under development in the Netherlands.

It is common practice on Dutch beam trawlers to empty the cod-ends on deck. Depending on the season and the fishing area the cod-ends also contain a lot of benthos, debris and sand.

After shooting the beam trawls for the next haul, the crew sorts the commercial sized fish from the catch and processes them (see fig. 1-6).

These repetitive jobs, such as grading and gutting, must be done by the crew in a kneeled or stooped position on a rolling and pitching vessel, quite often leading to back troubles at a relative young age (35-40 years old).

That is one reason why the Ministry of Agriculture and Fisheries of the Netherlands stimulated the development of a catchgrader. When using a grader the crew can do grading and gutting while standing upright.

The other reason for the development was to look into the possibility to improve the survival chances of a part of the discards by the application of the grader.

The tests with the catchgrader on a commercial beam trawler were carried out in the periods November - December 1977 and March - April 1978.

THE CONSTRUCTION AND PERFORMANCE OF THE GRADER

Before emptying the cod-ends into the storage tanks these must be filled with seawater.
An elevator positioned between the storage tanks transports the catch to a conveyor at working level (see fig. 7, 8 and 9).
The transport of the catch in the tanks into the direction of the elevator is assisted by means of water jets. Each tank can be connected to the elevator by means of a sliding lid.
The stainless steel elevator is perforated to get rid of the water.
The conveyor has a dividing board which guides on one side the discards and trash to an outlet back into the sea, and on the other side the graded and gutted fish into a fishwasher (see fig. 10). Grading and gutting will mostly be done by three crew-members.
At the rear end of the fishwasher the fish is collected in baskets (see fig. 11).
One crewmember takes care of the baskets filled with washed fish, and places an empty one under the outlet of the fishwasher.
He sorts the different species in empty boxes so they can be seperately stored in the fish hold.

The elevator and conveyor are each driven by a D.C. electromotor, 0,34 hp/2000 revs.
The speed of the elevator can be adjusted between 0,35 to 2,0 m/min, and the conveyor between 0,4 to 2,4 m/min.
The required amount of water for the whole installation is appr. 60-70 m^3/h.
The capacity of both tanks is appr. 2,9 m^3.
To remove big stones the sides of the storage tanks can be tipped up.

THE INFLUENCES ON THE WORKING CONDITIONS

The introduction of a catch grader on a commercial beam trawler must be the first step to mechanisation of processing of the catch.
Figure 1 - 6 gives some insights in the working conditions of the crew on flatfish beamtrawlers.
A main part of these repetitive jobs are in contradiction with the ergonomical insights such as ..... preventing heavy physical labour in an unnatural position etc.
The tests with the prototype of the catch grader were carried out on a beamtrawler with a deck lay-out not entirely suitable for this machine.
It can be stated however that the catch grader improves the working conditions. This opinion was also shared by the crew. Grading and gutting of the fish can now be done while standing upright next to the conveyor at an easy working level. Especially heavy physical labour will now be reduced.

THE INFLUENCES ON THE SURVIVAL CHANCES OF THE DISCARDS

During the first testing period of the grader no research has been done on the survival chances of the discards. Nevertheless we could observe that the main part of the commercial sized flatfish was still alive when passing over the conveyor. This is most likely due to the fact that the catch is held in tanks filled with seawater instead of laying on deck.
By using this method the fish is seperated from the benthos under the best possible circumstances.
In the second testing period some research has been done on the condition of the discards when coming on board and also after being held in the storage tanks for a few hours. The first results of these survival tests appear to be successful.
In the latter period the fishing operations were carried out with one normal rigged- and one electrified beam trawl. The condition of the discards from both systems have been studied too.

CONCLUSIONS

At this moment a complete list of all the influences of the flatfish grader can not yet be given.
However, from the ergonomical point of view we can say that these influences are positive.
The biological aspects of the grader will be discussed in a separate report.
The prototype of the grader is now used on a beamtrawler fishing for flatfish commercially.
The skipper of that beamtrawler also has the intention to test the installation when fishing for roundfish with a bottom trawl.
Before taking the grader in production all technical-, ergonomical- and biological remarks will be discussed to come to an optimum design.
An important aspect in the application of the flatfish grader is the deck lay-out of a beamtrawler.

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Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

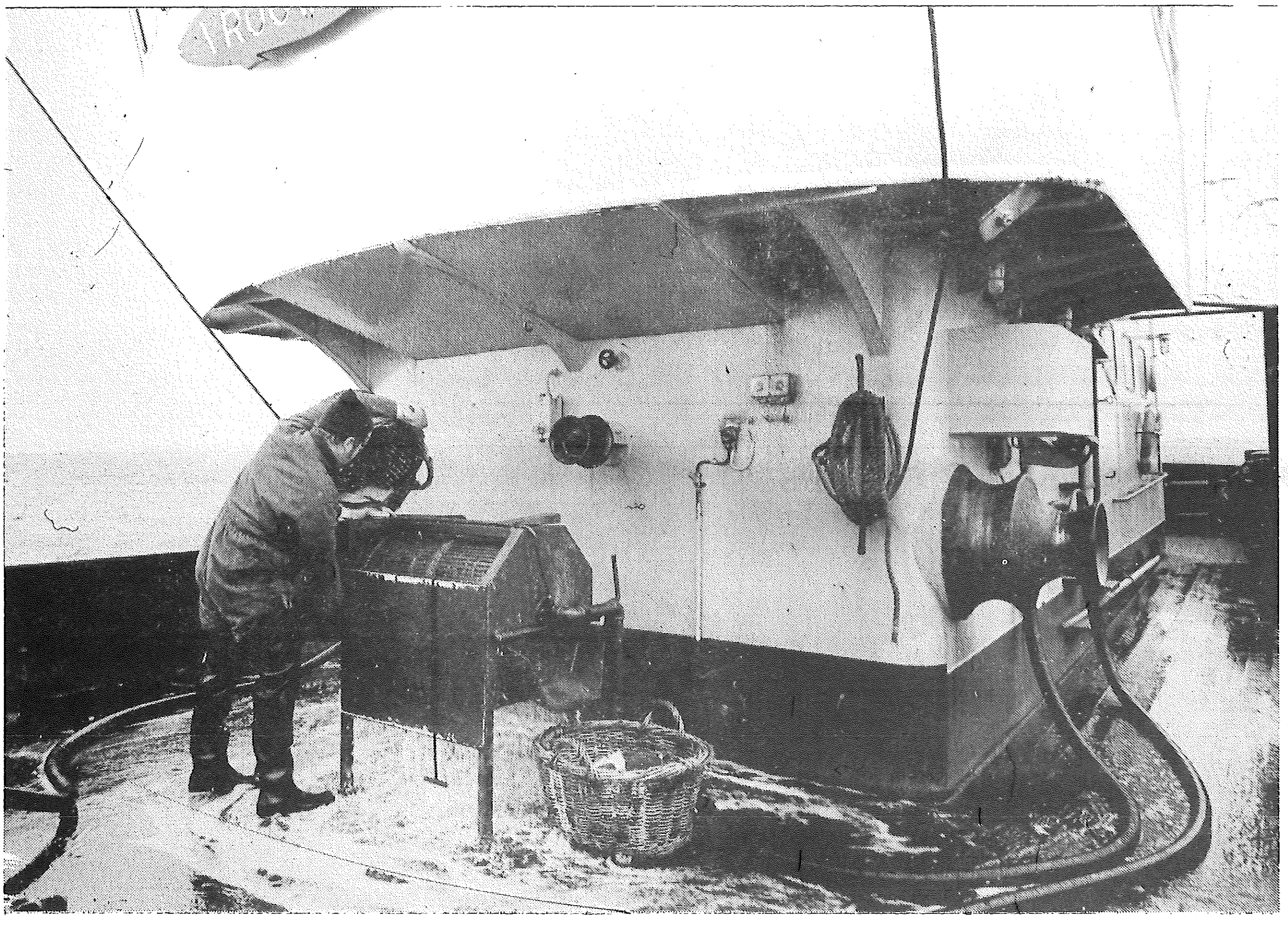
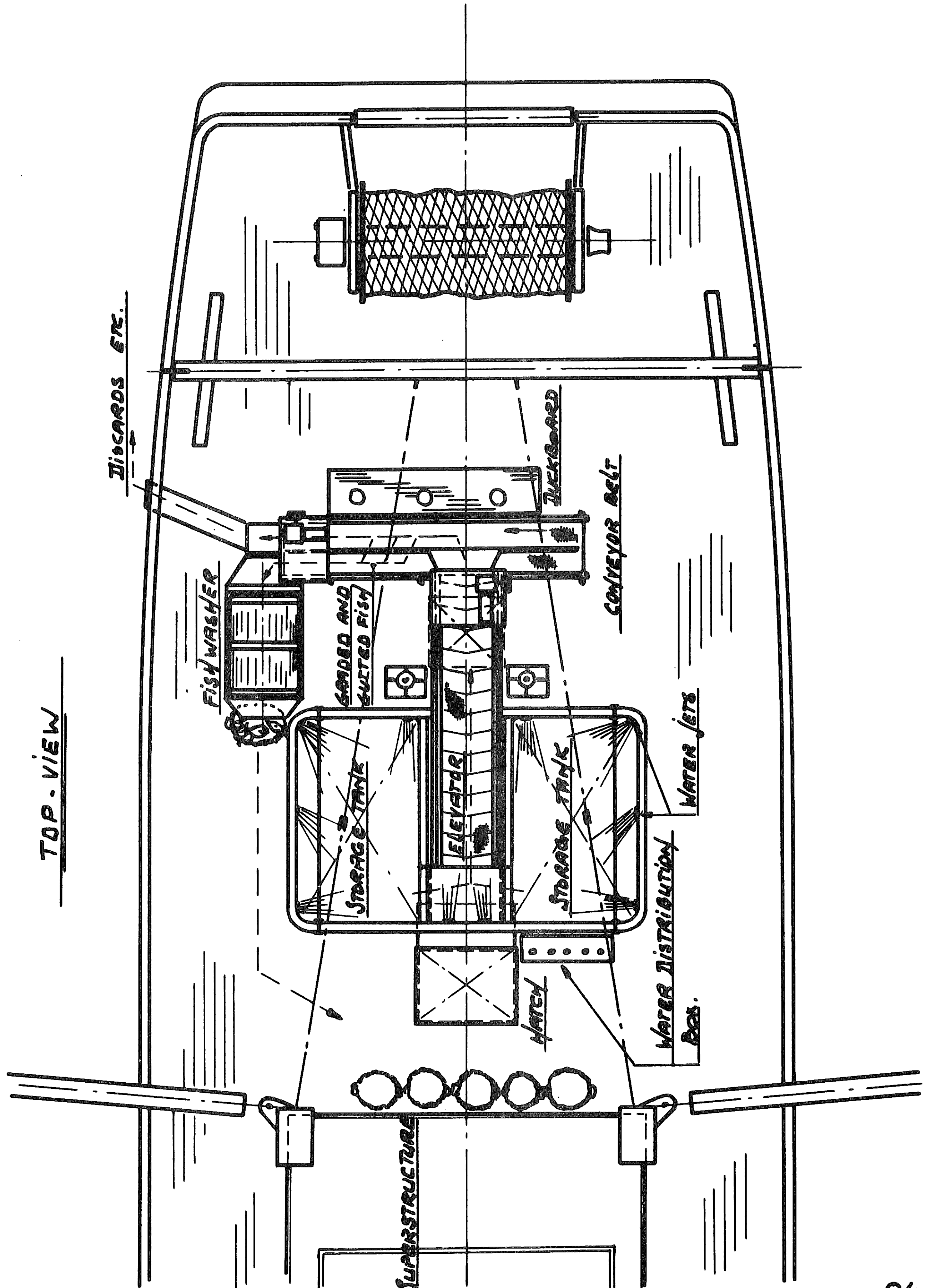


Figure 6



Benaming DECK LAY-OUT STERN BEAM-TRAWLER WITH CATCH-GRADER (PROTOTYPE)			Formaat A4
			FIG. 7
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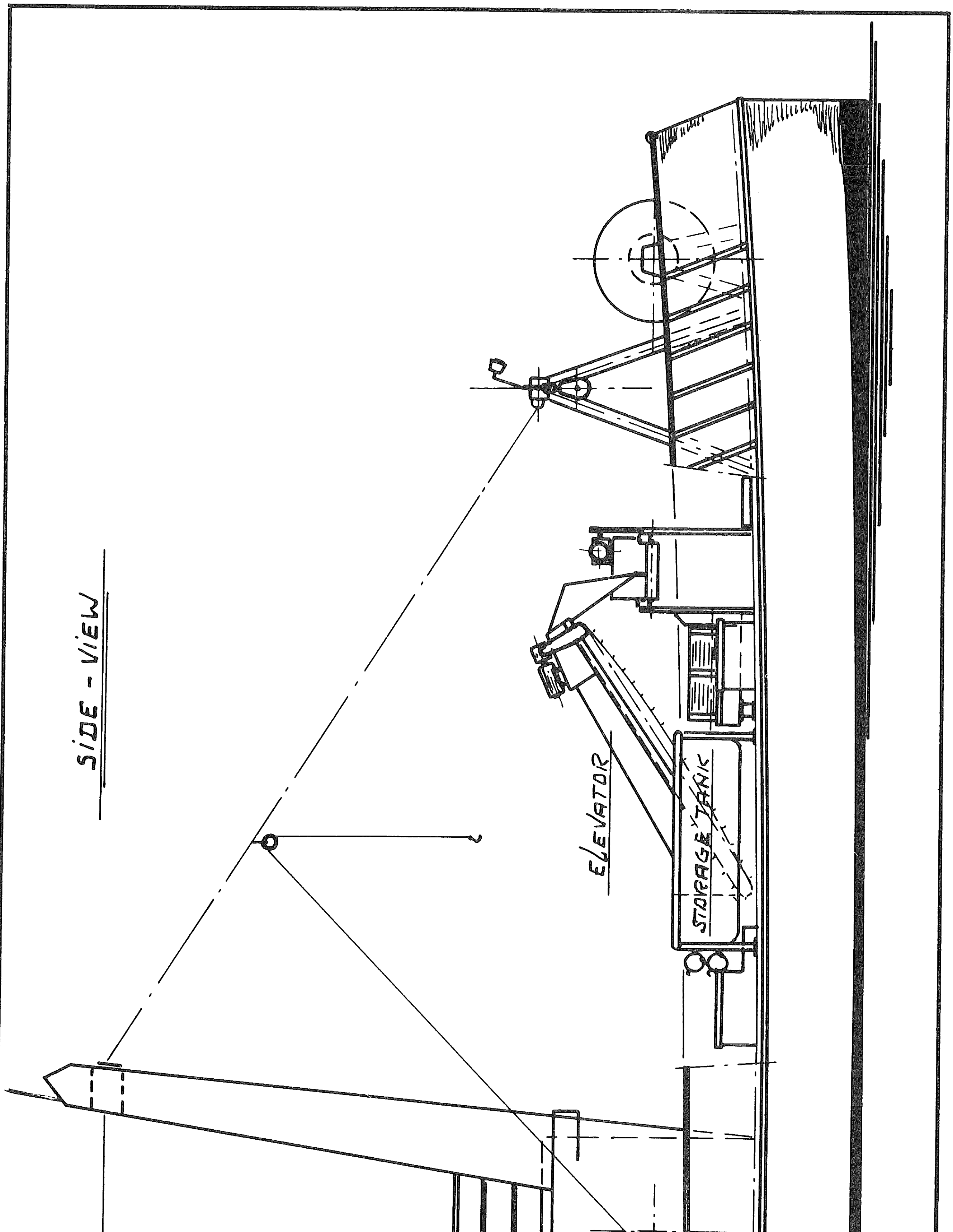

Benaming DECK LAY-OUT STERN BEAM-TRAWLER WITH CATCH-GRADER (PROTOTYPE)		Formaat A4	FIG. 8.
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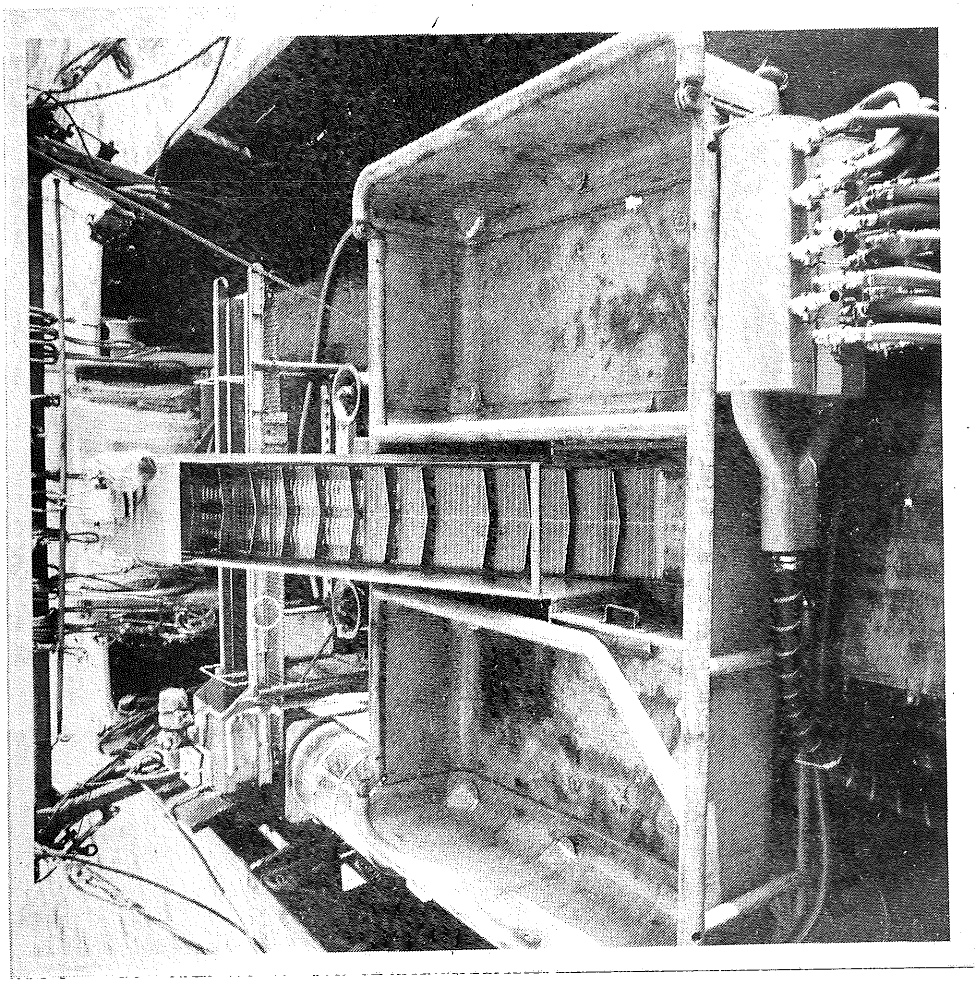


Figure 9

Figure 10

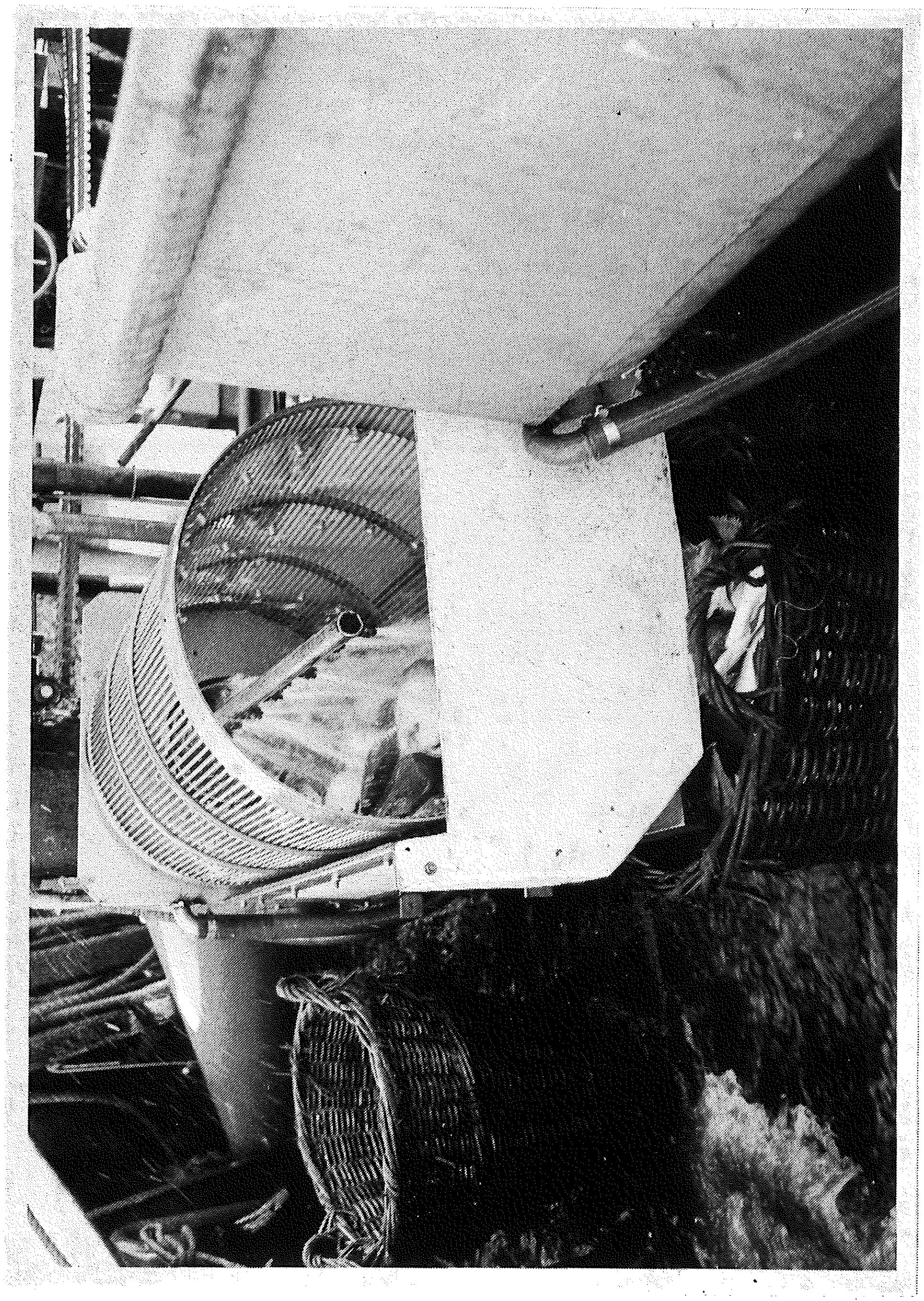


Figure 11

UNDERWATER OBSERVATION TECHNIQUES - PERFORMANCE OF TRAWL GEAR ON ROUGH GROUNDS - verbal contribution
by C.S. Wardle

In advance of the display of video tapes showing the performance of trawl gear components on rough grounds Dr. Wardle summarized the recent developments of underwater observation techniques at the Marine Laboratory (Aberdeen). Special attention was paid to the progress made in observing gears from a towed vehicle giving shelter to two divers.
Experience has shown that this vehicle can fly all round a gear in approximately 10 minutes.
One of the procedures for gear observation is to manoeuvre the vehicle close to a wing, go afterwards next and end on top of the upper panel to observe the behaviour of the groundrope and bobbin gear.
The limitations of this technique are the restricted operating depth (up-to 30 metres) and the diving time (max. 30 minutes).
In order to obtain larger observation time in deeper water a fixed camera can be mounted having in front a rotating mirror which can be directed to the part of the gear to be observed.
Recently tests were carried out to fly the vehicle remote-controlled with small electric motors activating the fins.
It is expected that this system will be ready next year. If the latter system performs well this type of work can be done also by institutes which do not possess a diving team.
At the moment also a new control system for the vehicle consisting of one horizontal and one vertical rotor (Magnus-effect) is in Aberdeen under discussion.

NEW FISHING VESSEL HULL FORMS
by Anders Endal

Introduction
FTFI's program for development of new coastal fishing vessels has the following goals:

- Reduction of the work load onboard.
- Development of a working environment with less physical and phychical strain.
- Development of vessels which will provide a more continuous flow of raw-materials for the processing industry.
- Development of a safe and hygienic catch handling and storage system on board.

In practice this must result in vessels with better social conditions (cabins, mess, w.c., etc), more comfortable sea behaviour, more space for technical aids to ease the workload and so on.

To achieve these goals, while not destroying other important functions, an increase of the vessel's breadth seems a reasonable way to go.

By increasing the beam one gets more deck-space, better stability, with increased possibilities for more advanced equipment on the vessel.

Further it is of interest to minimise the construction costs. In this connection the vessels with hard-chine hulls seem to be the cheapest to construct.

The work on new hullforms at FTFI's Vessel Division has therefore been concentrated on research into the properties of vessels with large breadth and hard-chine hulls, mostly on their propulsion and sea behaviour properties.

Propulsion in calm water

Little was known about the propulsion properties of these new hull forms. One used to think that large displacement/length ratio's combined with an extreme breadth would result in bad resistance properties and poor working conditions for the propeller.

A hard-chine hull with a single chine also risks an unfavourable flow along the hull, and this also could reduce the possibility for an acceptable speed (figure 1).

To determine these conditions for our hard-chine hull, a series of models were tested in the towing tank in Trondheim. Dimensions were systematically varied, the hull resistance and the flow-pattern along the hulls were registered. One model was also tested with a nozzle.

The analysis is not quite finished, and certain additional tests must be made. We can however, make some conclusions at this stage.

We found that a large breadth and large displacement/length ratio will not lead to inferior speed-properties in still water. The power is larger than for an ordinary hull to maintain the same speed. At the same time, we have by increasing the displacement got a larger vessel, and the horsepower per ton will not be higher than for the traditional fishing vessels (figure 2).

In addition the wake distribution and the working conditions for the propeller are favourable. The wide and comparatively flat-bottomed stern will cause a buttock flow with a strong upward component. This will make special demands on the positioning of nozzles on this kind of hard-chine hulls. A pronounced inclination ahead, will in all probability be favourable, but this will be further determinated this year (figure 3).

The streamlines along the hull are very dependent on the position of the chines. It was found possible to achieve favourable flow directions even along the fullest of these hard chine hulls.

Hulls with extemely large breadth and draught will easily have a too high angles of entrance and run, and this might cause high bow-waves. These problems will also be further investigated the coming years.

Sea behaviour

Initially the work has been concentrated on the roll-damping of these hull forms.

It is of basic interest to achieve the highest damping possible as this will limit the vessel's rolling amplitude.

The hulls of conventional vessels have relative small roll-damping, and the rolling is reduced by mounting bilgekeels or stabiliser-tanks (figure 4).

The preliminary tests carried out with our models show that hard chine hull vessels with large breadth and one single chine without bilge keels have the same damping properties as conventional vessels with large bilgekeels. Even if these tests so far are not verified by full-scale observations, we have resons to believe that bilgekeels could be omitted on beamy hard-chine vessels.

One of the models has been tested in natural waves, and the motions recorded on film.

The model had quite small rolling amplitudes, and other motions seemed quite normal for this type of vessel.

Further experiments will be carried out this Summer, with recording of motions and measurements of added resistance in waves.

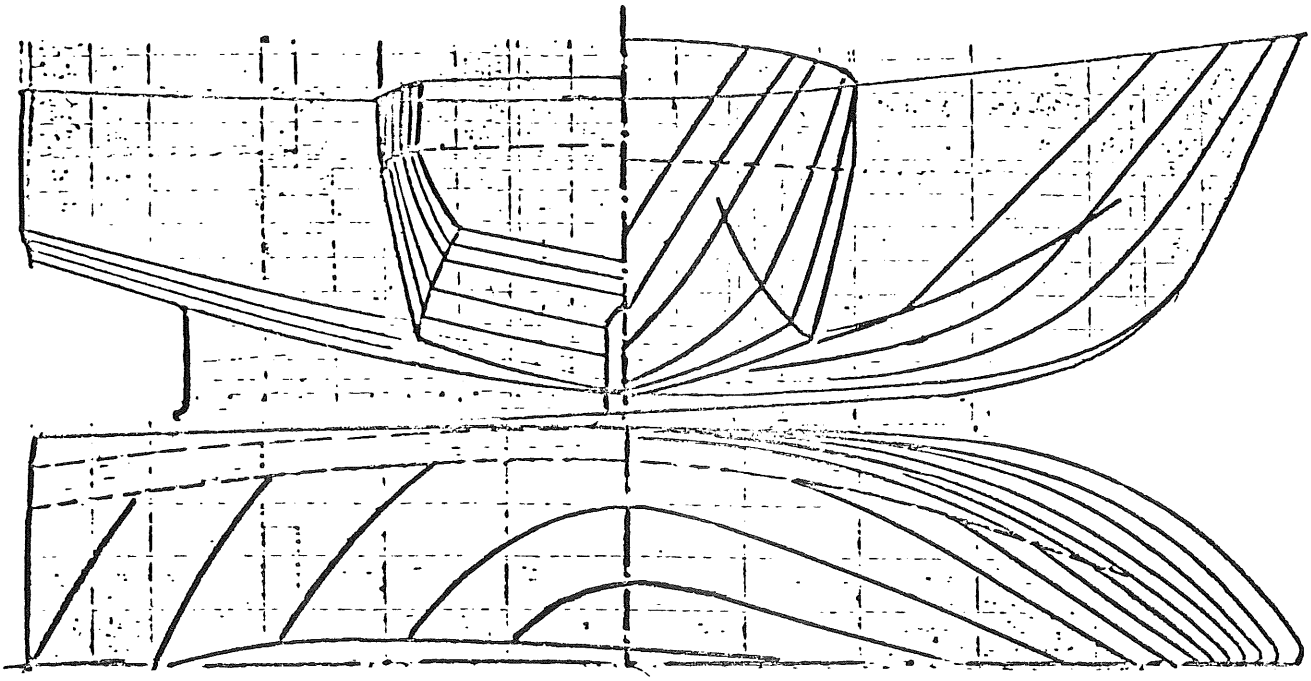


Fig. 1

HORSEPOWER PR TON DISPLASEMENT
BY DECREASING BEAM
(55 FT, 8.2 KNOTS)

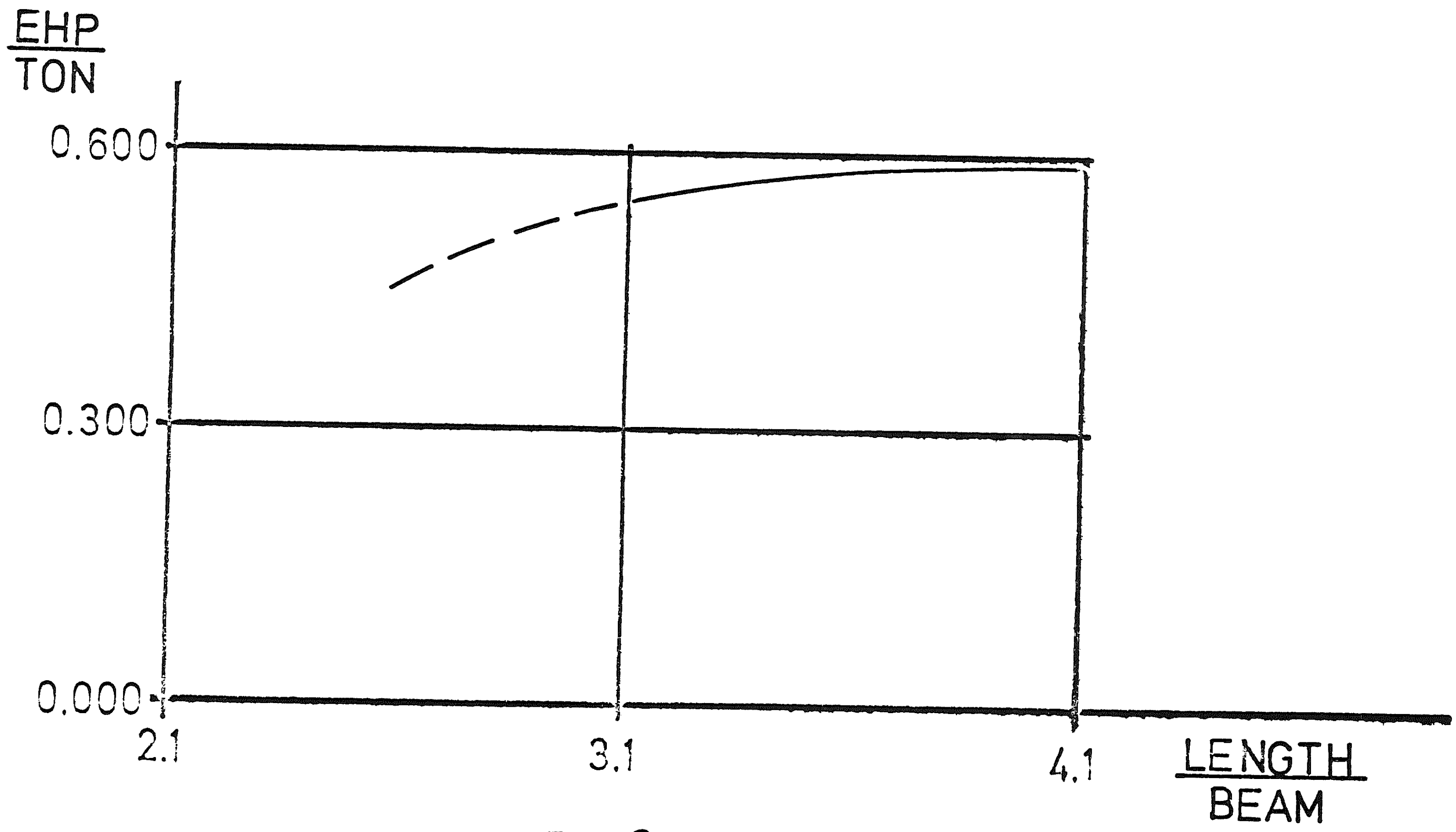


Fig. 2

Nozzle Inclination

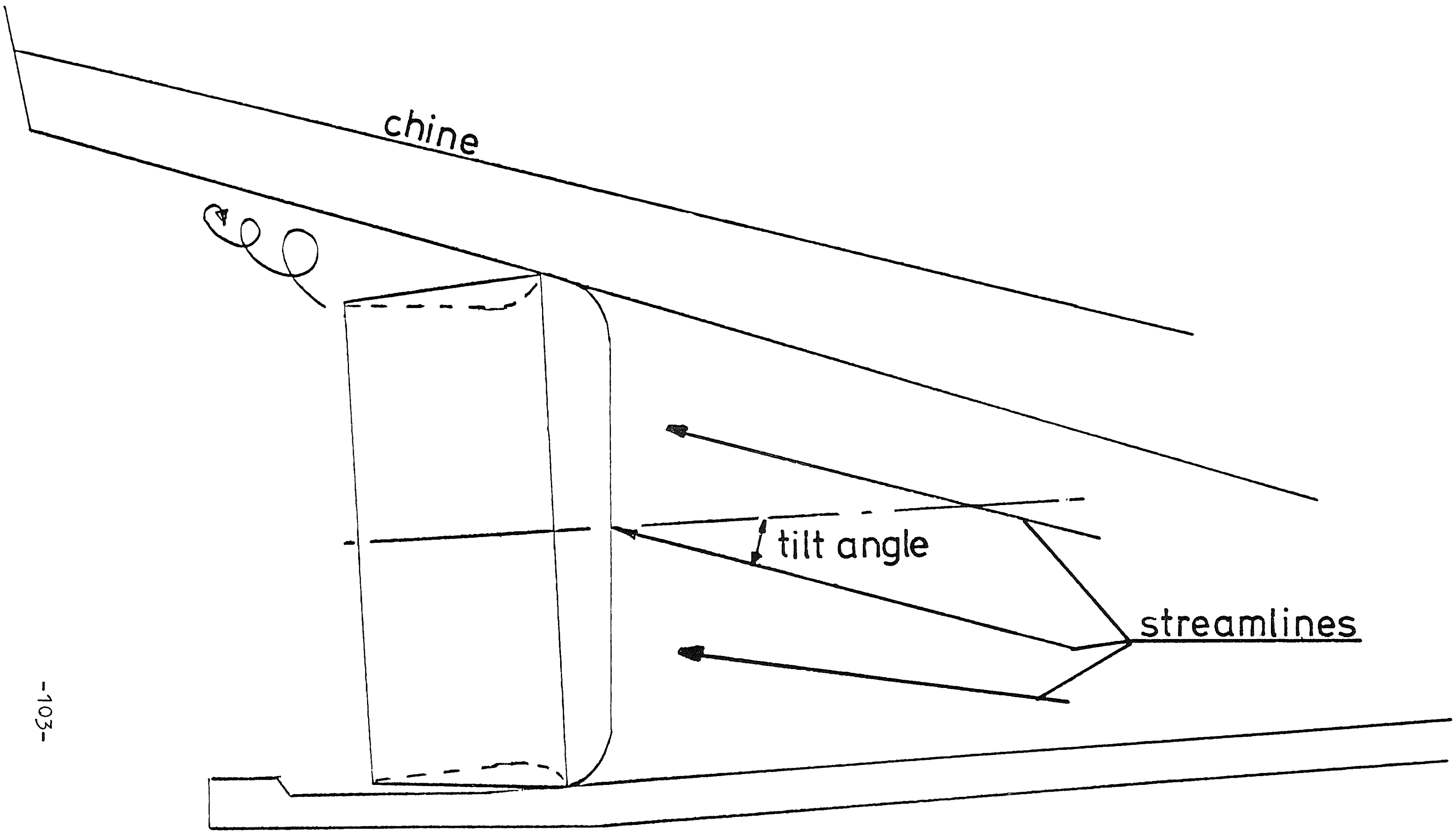
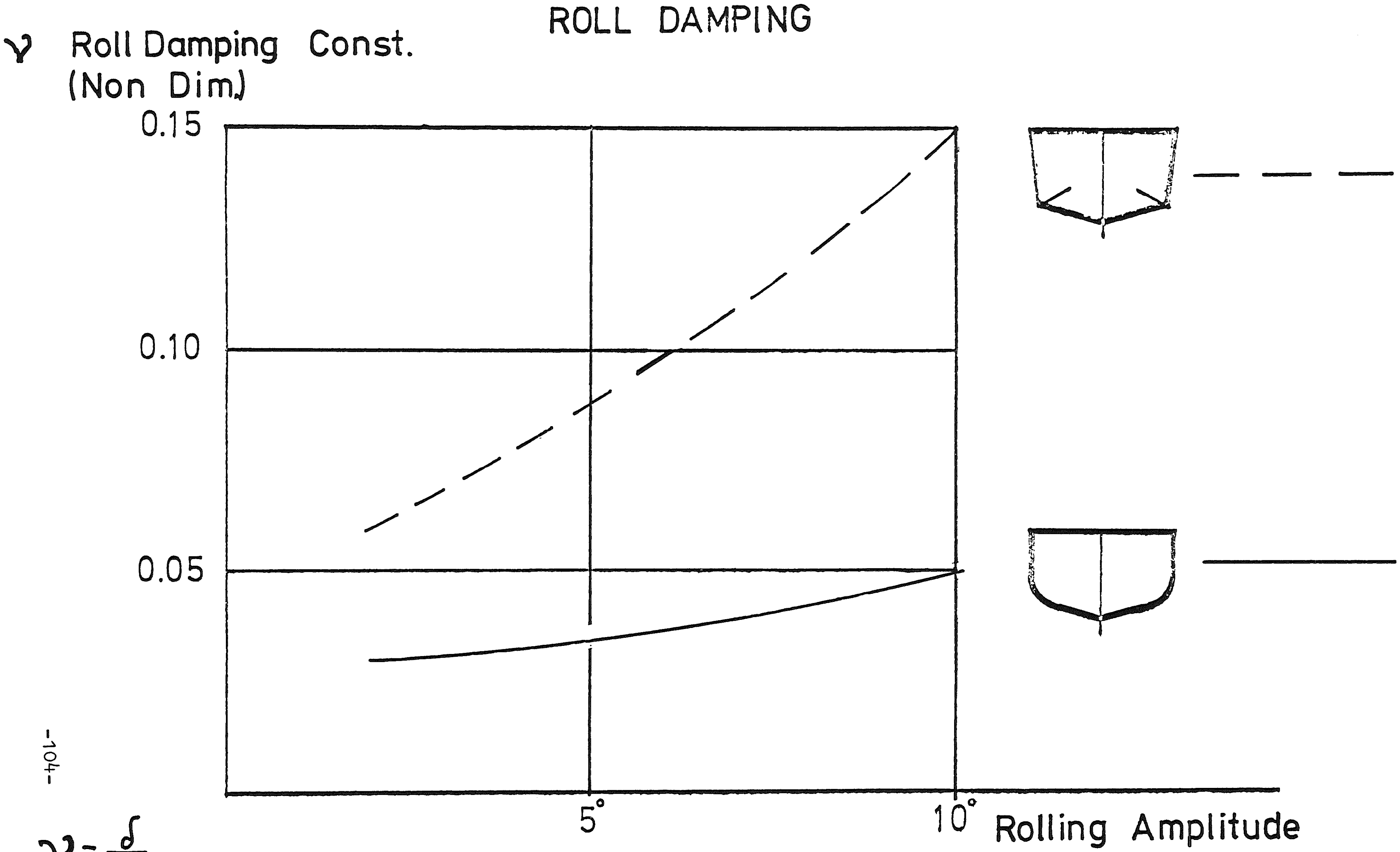


Fig. 3



$\nu = \frac{\delta}{\pi}$

Fig. 4

δ=Logaritmic decrement

THE APPLICATION OF ELECTRICAL FENCES - verbal contribution by E. Sølvberg

A subject of mutual interest for the Engineering and Fish Reaction Working Group came to the floor when Mr. Sølvberg presented the results of research into the application of electrical fences.

This research was carried out in a rectangular test area with a length of 100 metre and a width of 15 metre. The fishes (saithe) were prevented from escaping by nets. Breadthwise at half length an electrical fence was positioned. The electrodes consisted of steel plates of 8 x 0,2 metres spaced at 2 metre distance. The waterdepth at the position of the fence was 10 metres. The test area was positioned perpendicular to the shore.

Peak/voltage at the electrodes was 60 V, which resulted in an electric field gradient of 10-12 $V/_m$ half-way between the electrodes. In order to have a low-energy system an electric pulse system was selected which starts triggering at one end of the fence running towards the other end. The activating frequency of the electrodes was 1,25 Hz, resulting in an average power consumption of 200-250 $W/_m$ or 20-25 $W/_{m^2}$.

One of the experiments of interest to report is the effort to learn the fish that the fence area is unpleasant by flashing two T.L.-tubes which are connected to the electrodes each 0.5 sec. In order to observe behaviour and position of the fish 100 kHz acoustic tags which gave a pulse each 2 sec.

In 200 hours of observation with the fence switched on no passage of fish through the electric barrier was observed. However, in 170 hours with the fence switched off it was 120 times observed that a fish passed the fence area.
In contrast with this reaction is the behaviour of a school of approximately 1000 saithe of 40 cm length. This school was placed in the area between fence and shore. The fence was switched on and nevertheless 2 days later all fishes were on the offshore part of the test area.

INVESTIGATIONS ON ANTARCTIC KRILL WITH ADVANCED ECHOSOUNDING AND GEAR TECHNIQUES

by G. Freytag, H. Mohr and R. Steinberg

Like most crustacean krill can be detected only to a certain extent with standard fish-finding echosounders working with normal frequencies and power-output. For this reason already during the 1st Antarctic Expedition of the Federal Republic of Germany in 1975/76 vertical echosounders were used which were working with higher frequencies (up-to 200 kHz), respectively more power (4 kW). For krill detection in the top layer a 200 kHz device proved most suitable. This echosounder, therefore, contributed to the good krill catches obtained during this cruise. However, the relatively low range of this equipment due to the high frequency is regarded as a disadvantage.

The netsounder available during the first cruise did not meet all demands. This equipment was working satisfactory as an instrument for depth-control, but it did not indicate smaller schools of krill entering the netmouth. Besides, a further disadvantage for krill detection was the lack of a suitable sonar.

On the basic of the experience during the first Antarctic Expedition fishery sonars in the frequency range of 20-24 kHz showed negative results in the detection of krill targets. Despite of changes in the near- and farfield amplification it was not possible to pick up krill targets even in the case of high concentrations in the nearfield range. Because changes in the circuit-arrangement by the producer had no great reliability towards the forecast of definite representation of krill a new instrument was installed in an 8 inch tube next to the keel of the ship. This sonar worked with a frequency of 160 kHz with a pulse output of 1 kW and a beam width of 6,5° in both the horizontal and vertical plane. Constructed for installation on small trawlers the sonar had a maximum range of 700 m against bottom, 350 m against fish schools and 150 m against single fish. During the Antarctic Expedition the sonar was used in the mode of automatic sector search-light at an angle of 60° ahead. Great volume concentrations of krill could be observed on the PPI at distances of 250-300 m, small concentrations at distances up-to 150 m. For farfield detection the output energy was too small although the spreading conditions in the upper layer of Antarctic warm water were quite satisfactory and the krill generally stayed in this water body over the thermocline. In addition to this instrument on the research trawler, a special krill-sonar (Triple-sonar) was concentrated and installed on the research vessel. On the supporting plate in the sounddome 3 transducers were mounted for three different sounding frequencies of 50, 100 and 150 kHz with transceivers of 450 Watt each. As far as the results by this instrument are available, small krill-aggregations could be detected at distances of 300-500 m by using the frequency of 50 kHz.

In the field of vertical sounders a new generation of commercial sounders was installed on the research trawler and adapted for use in krill-fishery. In the case of the main fishery sounder (30 kHz) the output energy was increased to 4 kW and in addition to the normal combination-transducer of 7/14 elements a 28 element transducer was installed midship in the keel. This combination of high energy and narrow beam angle proved to be very successful for detection of the volume target krill. The envelopes of the targets were very precise. The resolution against small krill aggregations was poor (cf. figure 1) compared with the 100 kHz graphic records. Using the selector mode (digital storage) of the 30 kHz fishery sounder in the expanded range of 0-50 m depth (fig. 2 and 3 middle) a clear display of the maximum concentrations of krill could be obtained and the net depth could be adjusted accordingly. So this instrument with increased pulse repetition rate was a real improvement for the detection of the volume target krill despite of the low frequency of 30 kHz. For detection of fish schools or single fish the beam width was too small; stabilisation would be necessary. In these cases the 14 or 7 element transducer with reduced power showed better results.

The krill-sounder of 100 kHz had a rated output of 120 Watt at a beamwidth of 13°. The resolution of small targets was slightly better than on the 30 kHz graphic recorder but the envelopes were less precise.

A basic technical progress could be obtained with the netsounder. The attenuation of the netsonde cable was the main problem in the past. Krill targets could not be registrated in the mouth of the net consequently hampering an estimation of the catch. By increasing the pulse energy the real output of 25 Watt at the netsounder transducer obtained in the past could be increased to approximately 100 Watt at 2 kW pulse energy using 2000 m cable. In addition to this pulse repetition rate of the instrument was also increased. As presented in figures 1-3 (pictures at the right-hand side) on the graphic recordings of the netsounder the targets appeared in the same order as they could be recorded on the vertical sounders of 100 kHz and 30 kHz. So it was possible to get an estimate of the amount of catch and to avoid an overload of the gear.

Preliminary trials in the Summer of 1975 near the Azores led to the construction of a midwater trawl for krill, which was used successfully during the course of the entire first expedition. This fourpanel trawl had a circumference of 1200 meshes (meshsize 200 mm stretched in the beginning of the frontpart). Because of the small dimensions of krill the net was completely lined with small-meshed webbing from the beginning of the belly (meshsize 30-12 mm stretched). The single lining, however, was relatively large. Therefore, when the lining was damaged, timesonsuming repair had to be carried out. Another problem occured, when large quantities of krill entered the net within a short time. Then the krill piled up in the aft part of the trawl, which was too narrow in this area. This led to serious damage of both the lining and the outer net.

For the 2nd Antarctic Expedition, therefore, the construction of the krill-trawl was modified to a certain degree. The circumference of the net was not changed, but the panels of the belly were considerably less tapered. In this way the net part between belly and tunnel got an appropriate shape and thus it was avoided that large quantities of krill piled up in this area. In addition the size of the single lining was reduced. By this means repairing of a lining needed not as much time as before. Furthermore the meshsize of the lining in the front part of the trawl was enlarged from 30 to 40 mm in order to reduce the towing resistance. By all these conversions the krill-trawl was improved essentially.

Already during the first expedition in 1975/76 it became obvious that some behaviour patterns of krill, especially diurnal migrations and schooling, were decisive for capture. For observing these phenomena the different echosounding instruments proved very suitable. But because in the search for krill the fishing grounds were continuously changed it was most difficult to detect the rules of these behaviour patterns. The various concentrations behaved very different depending on the physiological stage and hydrographic conditions. Only when a uniform stock could be observed for a longer period the rules became obvious.

In April 1976 an isolated concentration of adolescent krill (length of the individuals about 30 mm) was detected near the S. Sandwich Islands and fished for a week. This krill permanently formed small schools, which usually did not exceed 100 m in the horizontal and 20 m in the vertical direction. During the night the loose, but not dispersed schools stayed within 20 m below the surface. In the early morning (04.00 h. local time), before dawn was detectable for the human eye, the schools tightened and dived rapidly to a depth of more than 100 m. At 06.00 h, with increasing daylight, the trend changed and the schools ascended in steps. During most of the day the krill stayed in depths between 20 and 60 m. At dusk all schools gathered again in the upper 20 m.

For trawling the best conditions occured at night, when the schools had concentrated in the layer below the surface, but also during daytime, when dense concentrations were indicated. Then catches up-to 30 t per hour were possible. But during the downward migration in the early morning fishing was completely inefficient.

During the second expedition in December 1977 a concentration of adult krill in prespawning condition (length > 50 mm) could be observed for about 2 weeks in the central Scotia Sea. In this case the diurnal migrations and schooling patterns were quite different from those reported from juvenile krill. In the late evening these animals formed a scattered layer immediately at the surface. About midnight dense schools of often large dimensions (diameter more than 300 m horizontally and 80 m vertically) developed out of the layer. During the forenoon these schools diffused more and more in a cloudy scattered layer; in the evening this layer rose to the surface.

For commercial capture only the tight schools in the early morning (between 04.00 and 07.00 h) were promising. Then catches up to 25 t in a quarter of an hour were achieved. In the scattered layers during daytime only occasional catches of 2-5 t per hour were possible.

In the first half of the night the krill was so close to the surface, that it was out of reach of the gear.

As many measurements proved, a direct influence of the light on schooling or migration could not be ascertained. These behaviour patterns seem to be ruled by intrinsic factors.

Whether reactions of krill to ship and gear may influence capture is still not proved. As mentioned already during the first expedition the netsounder was unsuitable for the indication of krill. Owing to the converted equipment at the second cruise the krill traces could be seen quite clearly in the netmouth, even in the cases of small schools and scattered layers. In general no reactions to groundrope or headline could be observed (fig. 1 and 2, right). At few occasions adult krill seemed to keep some distance above, and especially below, the groundrope (figure 3). It may be possible that this was no true reaction but an effect of the hydrodynamic pressure in front of the small-meshed trawl.

Graphic presentation of identical krill traces
by different echo sounders

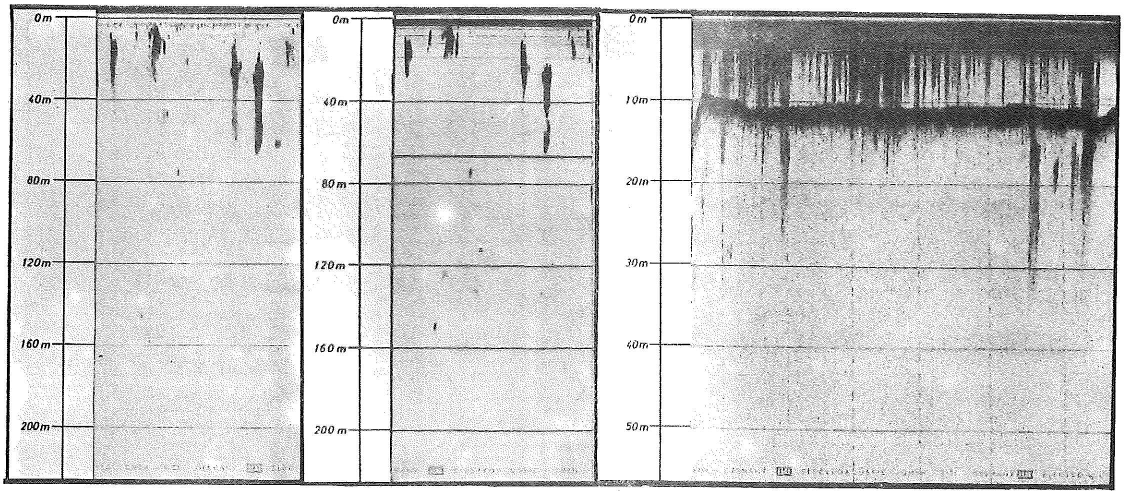


Fig. 1

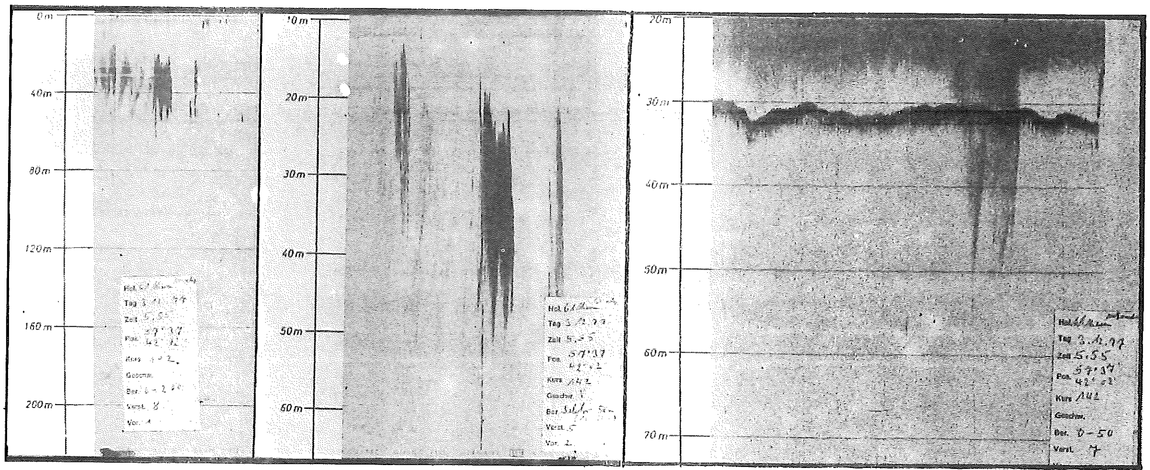


Fig. 2

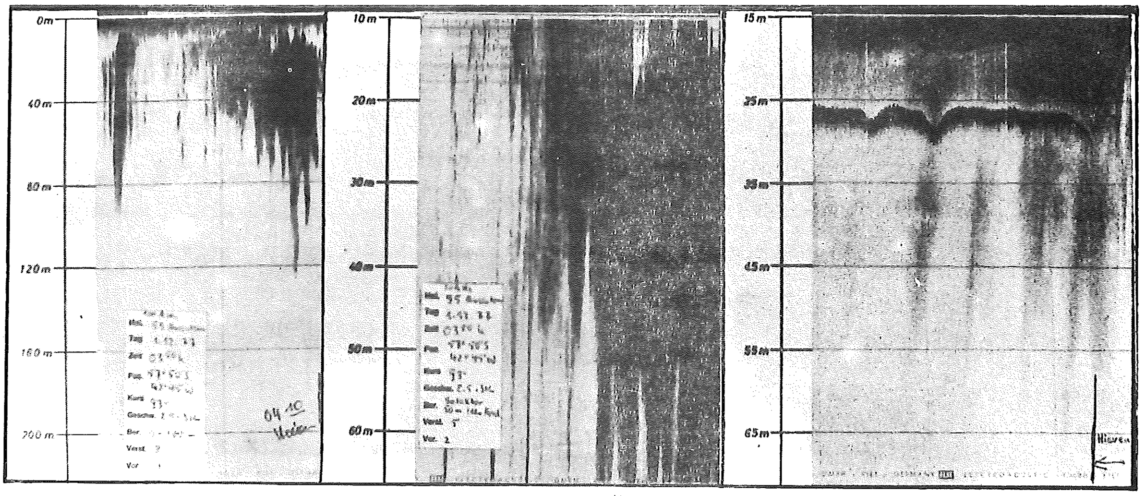


Fig. 3

The figures show corresponding charts of the 100 kHz vertical sounder, the 30 kHz vertical sounder and the netsounder.
In Fig. 1 the normal range, in Fig. 2 and 3 the selector mode by digital storage is chosen for the 30 kHz sounder (middle).