SEMINAR

THE AUSTRALIAN FISHING INDUSTRY - TODAY AND TOMORROW

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PROBLEMS, PRIORITIES AND PROGRESS

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Abstract

The major problems of the fishing industry are primarily related to escalating fishing effort on resources that are already heavily fished in many areas. However, the differing priorities and circumstances of various States, the Commonwealth and industry groups have sometimes contributed to the difficulty of achieving effective policies. Lack of an adequate data base for some fisheries and the outmoded nature of particular aspects of Commonwealth fisheries legislation have also played a part. The exclusion of industry from aspects of the policy making process has on occasion led to a lack of consensus and support for management.

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The priorities of the Commonwealth in fisheries management are to avoid excessive depletion of resources and the build up of chronic overcapacity in the fleet. Also, the Government wishes to foster expansion in undeveloped areas, replace foreign fishermen with Australians and support State objectives wherever possible. Industry should be closely involved in the management process and this should be self regulating and not impair efficiency of catching and marketing.

Significant progress is being made in the management of major fisheries and industry government management bodies for each fishery are being established. A number of other changes to Commonwealth administration have been completed or are being considered. A National Fishing Industry Conference is to be held in early 1985 to consider the main issues facing the commercial industry in relation to management, foreign fishing, research, marketing and Commonwealth-industry consultation.

Introduction

The aim of this paper is to provide an overview of the problems, priorities and progress in those areas of Commonwealth fisheries policies which fall largely within the bailiwick of the Fisheries Division of the Commonwealth Department of Primary Industry. These include:

1. Management and development
2. Foreign fishing
3. Administration
4. Research and monitoring of resources

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Commonwealth policies on other matters such as export inspection, fuel pricing and boat building subsidies are of great concern to industry. However, as DPI Fisheries Division has only an advisory role rather than prime carriage of these issues, they are not considered specifically or in any depth in this paper.

In a general sense, the policies of the Commonwealth Government in the four areas listed above are quite clear. The Commonwealth Fisheries Act lays down conservation (a biological objective) and optimum utilisation (an economic objective) as the basis for management and development. Detailed guidelines for foreign fishing, designed to provide maximum benefit to Australia while avoiding conflicts of interest with our fishermen, have been developed and implemented. Administrative arrangements are, on occasion, made fairly complicated by the need for Federal/State co-operation but some workable guidelines and practices have evolved. Very substantial amounts of money are being made available for fisheries research.

One might ask whether the problems of the industry are related to the fisheries policies of governments or whether the apparent discontent of some individuals or groups is purely a symptom of the normal, competitive economic process? I believe, however, that the facts at our disposal point to the need for a thorough review of the situation and a clear statement of priorities.

Problems

By and large the basic policies of the Commonwealth Government were laid down in legislation first drafted in the late 1940's and early '50's and at the time of the proclamation of the 200 mile Australian fishing zone in the mid 1970's. The underlying presumption of the Fisheries Act is that any Australian is entitled to a Commonwealth fishing licence unless the catch in the specific fishery in which he intends to operate must be restricted for management reasons, and a management plan, which usually must be fairly elaborate, has been established. This concept was embodied in the AFZ policies of the '70's. The existing arrangements for foreign fishing, administration and research were largely set in place also at that time.

The policy developments of the '70's occurred against a background of considerable optimism in many quarters about the resources available in the AFZ. Growth of the fishing industry in order to achieve the maximum economic benefits from new resources was high on the priorities of the policy makers of the day.

Some people in industry, government and the research community had reservations about this approach, particularly those who were aware of the relatively small foreign catches around Australia prior to the proclamation of the AFZ and of the general history of over-exploitation of fisheries in the developed countries of the northern hemisphere. Nevertheless the basic thrust of the policy was to encourage expansion until such time as clear evidence of over-exploitation appeared and industry, State governments and the Commonwealth could agree to do something about it.

To evaluate the consequences of the policies and arrangements of the late 1970's it is necessary to consider developments in our knowledge of the resources, in the industry itself, in Commonwealth/State arrangements and in industry consultative procedures.

The resource situation has been reviewed recently by Lilburn (1) and is set out in the paper for this conference by Dr. Jeffrey. Lilburn concluded that our major high valued resources, such as prawns, lobsters, scallops, abalone, those few trawl fish favoured by the domestic market and the southern bluefin tuna, are fully and, in many instances, over-exploited. The main avenues still open for expansion of Australian fishing operations are lower valued trawl and pelagic species frequently found only in areas which entail relatively high costs and/or marketing difficulties.

The extent of the factual information on recent developments in industry is rather patchy. The Commonwealth has good statistics on the operations and catch of foreign fishing vessels, substantial logbook data from the northern prawn fishery and the southern bluefin tuna industry and some broad information related to Commonwealth licences. Information from the other major fisheries primarily under Commonwealth jurisdiction is incomplete and not always reliable. The Bureau of Agricultural Economics has commenced a program of economic surveys of fisheries but it will be some time before a broad coverage is achieved.

State governments hold information regarding licences, operations of the fishing fleet, quantities of fish marketed, etc. However, this is of varying quality and coverage.

Nevertheless, the data that is available, together with general information from industry and State governments, clearly point to declining catch per unit effort in many major fisheries, excess fishing capacity and, in a few cases, severe biological pressure on the resource.

There are clear and valid reasons why good fisheries statistics are harder to collect than agricultural statistics. For example, it is frequently not in the

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(1) Bruce Lilburn, "Management of Fishing Resources", Department of Primary Industry, Canberra, May 1984.

interests of individual fishermen to reveal what they caught and where. Also the rapid nature of the development of the Australian industry and the fact that the AFZ has only been declared only for five years has mitigated against a good data system. Nevertheless, it seems technically and administratively feasible to have a much better data set than the one currently available, at a fairly reasonable cost, and we will be attempting to make some progress in this area.

This state of affairs - over-expansion of the fleet and lack of reliable data for some major fisheries - can be traced back to a number of causes. A common view in government and industry was that as long as the fish stocks were protected from severe depletion or extinction little else needed to be done. The body of resource management theory which indicated that unregulated expansion of fishing effort on common property stocks will often lead to a socially undesirable level of resource exploitation and a lowering of national economic welfare did not receive wide recognition or acceptance until, the circumstances of the industry made the conclusion obvious in the last year or so.

Nevertheless, some State governments have been able to largely overcome any data or conceptual problems to introduce quite satisfactory management arrangements for fisheries in State waters. So why had the Commonwealth such difficulty in following the same path?

Virtually all major fisheries in Commonwealth waters also overlap areas of State jurisdiction - usually of several States. The structure and convention of the Commonwealth-State fisheries committees have allowed individual States to, in effect, veto any management proposals, which might, for example have implications for fishermen operating out of ports in their State and which could have some impact on resources in the waters anywhere near their coastline or on any other grounds.

Because there are differences between governments in fisheries policies, aspirations, resources, and degree of development of marine resources it can be very difficult to achieve a consensus. Clearly each government will hold out for the best deal it can get. This however, sometimes leads to a "lowest common denominator solution" which leaves everyone worse off than they would have been if positive management action had been taken. Also, there does appear to have been, just occasionally, an element of "Canberra bashing" over and above the legitimate competition for resources which is part of a Federal system.

People in the fishing industry have been well aware of the problem and frustrated by a seeming inability to do much about it. This is clearly documented in the transcript of the 1981-82 Senate Inquiry and in a range of press statements, submissions to Ministers as well as in the files of Fisheries Division. However, industry was (and is) by no means unanimous on many issues. Sometimes differences of view between industry groups were transmitted to governments in a way which virtually ensured that no effective management action could be taken. Occasionally the lack of any clear industry voice left governments wondering whether a problem in fact existed. At a more pragmatic level, the federal body of the Australian Fishing Industry Council, (AFIC) has suffered from a severe lack of funds and only limited support from some State-industry groups. 201

The failure of industry to more fully support Federal AFIC stems from a range of factors, but clearly a major problem was the perception by many fishermen that a Canberra -based organisation could not do a great deal to help them. The major policy decisions were being taken in the Federal-State committees and sub-committees formed under the Australian Fisheries Council from which fishermen are largely excluded. While Federal AFIC played a clear role in representing the industry on matters such as foreign fishing or Commonwealth fuel policy, it had less impact in the increasingly important area of domestic fisheries management.

By the end of 1982 it was clear that steps had to be taken to improve industry consultative arrangements at the Commonwealth level. In mid-1983 the Interim Fishing Industry Conservative Panel was formed with a primary aim of developing a long term representative structure to enable the Federal Government to consult with industry and vice versa.

To show how these factors - poor data, interstate rivalry and inadequate industry organisation - can combine to achieve "lowest common denominator" management one does not have to look past the south eastern trawl fishery (SET).

The SET fishery is a relatively old (by Australian standards) demersal trawl fishery which has for years been showing all the classical symptoms of a fishery heading towards over-exploitation and excessive capitalisation. It has followed the path of innumerable similar fisheries overseas and provides writers of textbooks on fisheries management with living proof that their theories are valid.

The situation in the fishery is widely recognised by the five Governments and the various industry groups involved, there is nearly unanimous dissatisfaction with the current management regime. A number of proposals have been put forward that would make nearly everyone better off than under the status quo but it is impossible to completely satisfy all the competing interests.

Resolution of the problem is greatly complicated by the poor state of the resource data and a wide divergence of views between scientists and fishermen as to the state of the stocks.

Also fisheries administrators have not always accepted that the optimum level of utilisation of a resource may be quite different from the level of maximum sustainable biological yield (MSY). This is easy to prove theoretically and, intuitively, it is not hard to visualise a situation whereby catch per unit of effort declines sufficiently to make fishing unprofitable well before MSY is reached. Of course, in establishing the right level of fishing capacity in an area one needs to distinguish between situations where costs have been inflated by existing management regulations and to take care to impose constraints on economic efficiency and development. However when a situation occurs such as for gemfish with an MSY between 10,000 and 20,000 tonnes and a recorded catch which has declined from a peak of about 4,700 tonnes to about 3,000 tonnes despite a rapid increase in effort one must suspect, that *if* the MSY is correct, the economically optimum level of utilisation of the resource is well below the MSY.

Resolution of the SET situation is thus complicated by wide divergences of opinion as to the "right" level of fishing capacity. In the meantime the capacity of the fleet is steadily escalating as fishermen improve the capability of their vessels and work harder in order to achieve their individual share of a total resource that seams to be declining, or at least, getting harder to catch.

Unlike, for example, the northern prawn fishery, there have been no industry organisations with a history or experience in tackling major issues affecting the SET fishery. Officials have sought to avoid making any concessions and State and Commonwealth Ministers with fisheries responsibilities have become thoroughly frustrated by the lack of progress.

Despite all this, it would not be correct to conclude that management of fisheries that affect several States is impossible. Management plans are in the process of being introduced or improved in virtually all of Australia's major fisheries. However, before looking at recent developments and where they may be leading it is appropriate to briefly outline the role and objectives of Commonwealth fisheries management.

Priorities

As stated earlier the objectives set out in the Fisheries Act are conservation and optimum utilisation. These are capable of wide interpretation, particularly the latter. It is difficult to specify the objectives more closely without referring to specific fisheries or lapsing into rather meaningless, "motherhood" statements, however, the following probably provides a reasonable idea of what is intended.

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A. Avoid depleting resources below their long run maximum sustainable yield.

B. Avoid the build up of a large proportion of chronic excess capacity in a given fleet.

C. Involve industry in the management process.

D. Foster expansion of the Australian fishing industry in the less developed fisheries.

E. Accede to the fisheries management objectives of the States involved within the fishery as far as possible.

F. Avoid regulations which will impair efficiency of catching and marketing.

G. Keep the amount of regulation and fragmentation of industry to a minimum.

H. Minimise the costs of management.

I. Maintain co-ordinated biological and economic data bases for significant fisheries.

These are goals to aim for and will frequently not be fully achieved in the real world. In some circumstances there is considerable conflict between the goals, and they must be traded off against one another.

In practice the Commonwealth is trying to achieve a workable definition of each fishery in terms of the area, fishing method and species covered, number of vessels, state of the stocks etc., then it is attempting to identify the specific management objectives and research requirements for the fishery in consultation with the States and industry groups involved.

This is followed by a consideration of the management methods which may be appropriate, such as closed seasons, limited entry, catch quotas, etc. In many areas the Division is endeavouring to determine a relevant unit of fishing capacity such as boat numbers, boat tonnage or horsepower, quantity of catch, and to establish a management regime designed to ensure that the total of the units of capacity for the fishery does not increase or is reduced in line with the overall situation in the fishery. Generally the number of units will not be allowed to increase unless new resources are identified. Australian operators will, however, be encouraged to replace foreign fishing operators.

This approach is largely in line with the policies being adopted in most States, most recently in Western Australia. The aim is not to guarantee the incomes of fishermen. At any given time some fishermen will be doing well, others will be on the borderline of profitability and there will always be a sizeable number who are unable, for a range of reasons, to survive economically.

We should, I believe, keep any interference by Government with the normal competitive process between fishermen to the minimum necessary to avoid excessive exploitation and massive, chronic overcapacity. Also industry should be closely involved in the management process.

Management plans which incorporate most of these principles are in various stages of process of being agreed to and implemented in six major fisheries. (Table 1).

Progress

Over the last twelve months significant progress towards improved management of the major fisheries has been achieved but a great deal remains to be done. Many of the difficult allocation decisions have yet to be completed.

The distribution of quotas or of fishing rights for limited entry fisheries has major implications for the financial facilities associated with specific fisheries. In some cases the allocation decisions could have significant impact on the level of economic activity in specific regions or States.

Nevertheless, representative industry-government management groups, such as the Tuna Task Force (TTF) and the Northern Management Advisory Committee (NORMAC), have made significant progress in tackling the difficult issues. Similar groups are being established for other fisheries because they seem to provide an effective framework for the expression and resolution of the range of interests of the governments and sectors of industry involved with a specific fishery. All interested parties are able to work together to define the problem, establish objectives and priorities and try to achieve a reasonable compromise.

If industry does not meet on an interstate basis and if Government officials meet separately from industry, it is very difficult to present the issues, to obtain a common level of understanding of a problem or in particular, to ensure that all participants are able to be part of the negotiating process. Invariably the finalisation of a management plan involves some gains and some concessions by all groups in order to achieve an overall improvement. The industry/government management groups provide a forum and organisational structure for this to take place.

Increasingly these groups are reporting direct to governments and their recommendations are to the fullest extent possible incorporated in the management plans. Clearly, if the difficult compromises that are reached by the groups are not translated into policy, the incentive to reach agreement in the task forces will rapidly diminish.

These management groups will require sound scientific, economic and technical advice. Progress is being made in establishing specialised working groups to provide this type of support.

In addition to the management groups, industry/ government review or appeal committees are being established for each fishery under Commonwealth jurisdiction. The role of these committees is to consider and made recommendations where individuals consider that they have not been treated in accord with the criteria laid out in a management plan. These review committees will not have the power to change management rules but will endeavour to ensure that they have been applied correctly in individual cases.

A major issue still to be resolved is the funding of both the management and review committees. A number of options will be considered at the Australian Fishing Conference next year.

To imply that the management plans will, on their own, provide a long run solution to excess fishing effort would be overly optimistic. The level of fishing effort depends on a range of factors such as efficiency of vessels, and skill and dedication of fishermen which are not necessarily closely related to vessel numbers. Improvements in technology will continue to have a major effect on fishing effort and in, general, these cannot be restricted without increasing fishing costs. Also, fishermen will always show considerable ingenuity in finding ways around controls on their operations.

The adoption of the "buy-back" concept for the northern prawn fishery is a clear recognition of the need for reductions in fishing capacity. It is highly likely that some form of adjustment mechanism designed to reduce fleet fishing capacity in order to offset rising effort will need to be incorporated in most long run management plans.

The sheer volume of work is placing a great deal of strain on the DPI and State governments. All the plans fall short of the hopes of the participants to some degree but, to the extend that they are placing some restraint on the rapid build up of boat numbers and fishing capacity, helping to conserve the resources (SBT), and enhancing economic returns (NPF closures), progress is being made.

While a lot of effort is being directed into the new management plans, progress is also occuring in other areas.

A number of measures have been taken to improve the operation of the Fishing Industry Research Trust Account (FIRTA). An executive officer for FIRTA has been appointed and is available to assist in the development and implementation of research proposals.

A recent amendment to the Fisheries Act will remove the need for Commonwealth fishing licences for crew and streamline other aspects of fisheries administration.

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A number of joint venture proposals which should benefit both the fishing industry and the Australian economy have been approved.

The Commonwealth Interim Fishing Industry Consultative Panel (IFICP) has met on three occasions. It has made recommendations to the Minister for Primary Industry on a range of issues from scallops to foreign fishing to fuel prices.

IFICP has recommended that a National Fishing Industry Conference be held in early 1985. The aim of the conference will be to establish guidelines for a structure and machinery for long-term consultation and co-operation between the Australian fishing industry and the Commonwealth Government. It would also allow broad objective discussion of major policy issues affecting the fishing industry.

There will be five major topics on the agenda:-

Fisheries management;

Domestic and foreign fishing operations in the 200 mile Australian fishing zone;

Commonwealth-industry consultation;

Fisheries research and development; and

Fish handling and marketing.

Discussion papers are to be prepared on each of these issues for the conference, based on submissions being invited from experts and key organisations. However, submissions will be welcomed from any individual or organisation with an interest in any of the topics.

Attendance at the conference will be mainly by representatives from major organisations associated with the production, processing, marketing and distribution of Australian seafoods. Also, invitations will be sent to appropriate Commonwealth and State agencies.

The conference is being organised to ensure that all those attending will be closely involved in the debate. The emphasis will be on consolidating the progress made over the last few years, identifying solutions to problems and reaching some conclusions and recommendations that can be widely disseminated and accepted by industry and governments as a basis for future policies.

In conclusion, while there are still plenty of problems facing governments and industry, priorities are becoming more clearly identified and gains are being made in most areas. For the future we are looking to a greater role for industry at the Commonwealth level and continued close consultation with State governments to achieve further progress.

TABLE 1: FISHERY MANAGEMENT PLANS: STATUS REPORT

FISHERY	INDUSTRY-GOVERNMENT TASK FORCE	INDUSTRY-GOVERNMENT APPEAL/ REVIEW COMMITTEE	DRAFT MANAGEMENT PLAN	INTERIM PLAN	FINAL MANAGEMENT PLAN	FISHERIES COUNCIL APPROVAL	IMPLEMENTATION	BRIEF DESCRIPTION OF PLAN
Northern Prawn Fishery	Yes	Yes	Yes	No	Yes	Yes	Incomplete	Closures aimed at optimising prawn yield. Vessel numbers limited to 292. Fishing capacity units (based on horse-power and underdeck tonnes) controlled a "buy-back" scheme being developed.
Southern Bluefin Tuna	Yes	No	No	Yes	No	Interim only	Interim	Interim plan based on total quotas for WA purse seiners and east coast pole boats. Final plan to be developed for 1984/85. Individual transfer-able quotas recommended for the longer term.
East Coast Prawns	Yes	Yes	No	Yes	No	Interim only	Interim	Total vessel numbers limited. Final plan to be implemented in 1985.
Bass Strait Scallops	Yes	Yes	No	Yes	No	Interim only	Interim	Total vessel numbers limited. Final plan being developed.
South East Trawl	Yes	No	Yes	No	No	No	No	A limited entry plan is proposed but a number of major issues are still to be resolved.
Shark Fishery	Yes	No	No	No	No	No	No	Management discussions have only recently commenced.

LESSONS FOR THE FUTURE - A LOOK AT COMMONWEALTH/STATE RELATIONS IN FISHERIES.

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Dr. D. Francois
Executive Director (Fisheries)
NSW State Fisheries

1984 is an appropriate year to speculate on future Commonwealth/State relationships and, whilst I would not put myself on a par with George Orwell, my message will be somewhat similar.

The year is 2014 and the colour video radio telephone has just bleeped for 30 seconds indicating that a communication is about to be sent to your multi-purpose fishing/processing vessel somewhere off the south eastern coast of Australia.

> "Tasman Venture, Tasman Venture, this is Fisheries Command Canberra, this is Fisheries Command, Canberra. Do you read me? Do you read me? Over."

"Fisheries Command, Canberra, Fisheries Command, Canberra, this is Tasman Venture, Tasman Venture. I read you loud and clear, over."

"Tasman Venture, this is Fisheries Command Canberra with your new fishing instructions. You are to cease trawling at your present location and proceed to latitude 35^0 30 minutes, longitude 151^o 40 minutes. I repeat, latitude 35^o 30 minutes, longitude 151^o 40 minutes and commence trawling along the 220 fathom contour where you will use Department of Primary Industry prescribed net FB128. I repeat, Department of Primary Industry prescribed net FB128, and fish until you have taken 24 tonnes of mixed fish. You will then proceed to Launceston, Tasmania, and unload the fish at the Soviet factory vessel "IVANOFF". Under no circumstances, I repeat, under no circumstances are you to process the catch aboard the 'Tasman Venture'. Please acknowledge this instruction with a repeat of pertinent details. Over."

"Fisheries Command, Canberra, this is Tasman Venture. Message received, new location - latitude 35^o 30 minutes, longitude 151^o 40 minutes at 220 fathoms, 24 tonnes to "IVANOFF" at Launceston. Now with that out of the way I want you to know I have about had you lot. I know when I got my limited entry licence the fine print said I would have to observe all Canberra Fisheries

Command regulations but these regulations were not known then and I want to get home for my son's 21st Birthday....."

I don't think there is much point in pursuing this 193
fictitious conversation of the future but make no mistake that, in view of what has happened over the past thirty years, it is not an exaggeration to see controls by Government agencies, particularly Commonwealth agencies, developing to this extent within thirty years.

As far as I am aware, the first fisheries legislation in Australia was enacted in New South Wales and Queensland during the 1860's and concerned oysters. In New South Wales there was great concern about live oysters being burned for building lime and the Government sought to afford these molluscs some protection. Historically, this is how all of the lime burners creeks along the coast of New South Wales were named.

Fisheries administration developed for the next eighty years with the States running their own administration with some co-operation from the Commonwealth in surveys and, of course, the involvement of C.S.I.R.O. in fisheries in 1937.

C.S.I.R.O., by the way, was located at Cronulla on a reserve for pisiculture proclaimed by the New South Wales Government in 1901 where a fish hatchery had been established to re-stock New South Wales estuaries with edible fish - so much for scientific fisheries thinking at the time. It is interesting that, after some forty odd years, the C.S.I.R.O., Division of Fisheries, is going to Hobart and the New South Wales Department of Agriculture, Division of Fisheries, is to occupy the Cronulla site.

It was not until after the Second World War that things really started to move in fisheries. Because of the problems associated with the import and export of fisheries products, and quarantine and trade implications, as well as possible fishing by foreign nations around Australia, it was apparent that the Commonwealth Government needed a Fisheries Act.

Many conferences took place with State fisheries officers and a number of principles and divisions of responsibility were agreed upon and documented. In 1952 the Commonwealth Fisheries Act was passed but it was not proclaimed until January, 1955, when for the first time Australian fishermen were required to be licensed by the Commonwealth.

I joined the Fisheries Branch of the New South Wales Chief Secretary's Department in January, 1962, when the Commonwealth Fisheries Act had been operating for only seven years and the details of the agreements for the Division of Fisheries' responsibilities with the States were fresh in everyone's minds. What were the arrangements? Well, I don't intend to bore you with all the details but some of the pertinent points of the 1947 Agreement were, and I quote:

"5. The State Authority will be responsible for:

(a) Carrying out on behalf of the Commonwealth, where practicable, the control of fisheries in extra-territorial waters when Commonwealth legislation is enacted governing this question.

(b) Carrying out, where practicable, in the respective States on behalf of the Commonwealth Authority, any functions which come under Commonwealth control. Where work is carried out on behalf of the Commonwealth Authority by a State Authority, suitable financial adjustments will be made.

(c) Co-operating, where practicable, with the C.S.I.R.O. Fisheries Division in any exploratory, experimental or research work which has been undertaken at the request of the State Authority (where the State is likely to enjoy the principal benefit) on such financial basis as is mutually agreed upon.

(d) Control of fishing in its territorial waters.

(e) Co-operating with the Commonwealth Authority in relation to any fisheries schools.

(f) Information and Extension work for the fishing industry in the State.

On the question of licensing, it was agreed in 1952 "...that a pre-requisite for a Commonwealth licence should be that the applicant is the holder of a State licence.", and that "...such licence to be issued by that State Authority on the Commonwealth's behalf." On the question of fees, it was recommended that any fee charged should be purely nominal.

Over the past twenty years important departures from this thirty-year-old Agreement have been made and I am certain that a number of more recently appointed fisheries bureaucrats are not really aware of the historical background to our current fisheries management arrangements.

What are the deviations? Without going into minor departures and even some of the more important ones, I will mention a few which demonstrate my point. An important deviation from the Agreement between the States and the Commonwealth was the change from a "nominal fee" for a Commonwealth fishing licence to one which covers administrative costs. The intention of the earlier Agreement was to ensure that the revenue raising aspects of fisheries licensing remained with the States and that the issuing of a Commonwealth licence was a legal formality. The agreed pre-requisite of holding a State licence before a Commonwealth licence was issued again places the emphasis on the State's role in fisheries administration. As only so much revenue can be reasonably extracted from the fishing industry and, as we are aware, the States have limited revenue raising powers, breaking the precedent of the "nominal fee" principle has to be an unnecessary burden on the fishing industry. In fact, we have the situation of two sets of bureaucracies being supported by the same industry. A senior New South Wales public servant once said that there is only so much power and if you create another bureaucracy the power has to come from somewhere. In the case of fisheries, it has come from the States and in my view the competition that occurs between the States and the Commonwealth is, in many cases, unnecessary and wasteful and can be traced essentially to an expanding Canberra administration.

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Fisheries management requires many complicated rules and fishermen, in many instances, resent the rule maker and enforcer. Some sections of the industry welcome an increasing involvement by the Commonwealth, but I think this will be transitory. Remote control - no pun intended - from Canberra in a fishery such as the Tasmanian scallop fishery seems unnecessary and really not in the long term interests of the industry.

Another important departure from agreements made prior to the enactment of the Commonwealth Fisheries Act was the establishment of the Fish Export Inspection Service. When this service first came into existence, New South Wales had over eighty fisheries inspectors stationed throughout the State and was both willing and able to carry out the work on behalf of the Commonwealth. We now have a situation where both State, and Commonwealth fisheries officers visit the same establishments for various fisheries inspections. Needless to say it is the fishing industry which ultimately foots the bill for this duplication.

In the case of the oyster industry, however, Fish Export Inspection Service inspection of oyster purification plants processing oysters for export has been rationalised with State inspections for domestic consumption. This, I might say, was accomplished only after the most rigorous campaign and great drama.

Over the past few years, a more suitable and, in my view, serious development has taken place. Previously all major fisheries matters were discussed at the yearly conference of State and Commonwealth Officers and, when necessary, by the Australian Fisheries Council. Now the Commonwealth frequently advises the States of what they intend to do, makes a press release and then talks about it after the decision has been made. Another development which is somewhat of a mixed bag is consultation with the fishing industry through task forces. This type of liaison has proved highly successful in the tuna industry but less so in other fisheries because of the inadequate industry organisation and the lack of common industry policies. A good example of the difficulties which could arise is the current situation in the South Eastern Trawl Fishery where a major group of New South Wales fishermen has equal voice with small groups from other States.

In speaking of future Commonwealth/State relationships, I am obviously a State man, but the numerous examples of cumbersome State fisheries administration argue against my trying to convince you that State administration is good and Commonwealth administration is bad. In fact, much of the George Orwell type administration comes from State administration.

I think we need strong Commonwealth administration in major multi-State fisheries, but where a State can manage the fisheries off its coast this should be facilitated. It would be great if, out of the seven major fisheries administrators in Australia, the best was always in Canberra. This, however, is not always the case and outstanding State administrations, such as that of Western Australia, lift everyone's game.

Unless we are careful, however, the trend toward Commonwealth control and limited entry regimes could lock fishermen into fisheries in a way which gives them little flexibility. I think it is important that aspects of the Offshore Constitutional Settlement that relate to fisheries be implemented as quickly as possible. In the hiatus which now exists, procedures and rules are being established which will be more difficult to change as time goes by. I also consider it is absolutely essential that either the Australian Fishing Industry Council or a similar organisation be re-established in all States to support a viable Federal body.

In conclusion, I would like to say that the views expressed by me are solely my own and certainly do not reflect the views or policies of the New South Wales Department of Agriculture nor the New South Wales Government.

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AUSTRALIA'S FISHERY RESOURCES, WITH PARTICULAR REFERENCE TO DEVELOPING AND POTENTIAL FISHERIES

Dr. Shirley Jeffrey
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The Australian Fishing Zone

In November 1979, the Australian Government declared its jurisdiction over the 200 nautical mile fishing zone, and became responsible for the management of fish stocks in an area equal in size to the continent itself. This declaration carried the obligation to grant access by foreign vessels to that part of the total allowable catch that was not taken by Australia. Both CSIRO and the Commonwealth Department of Primary Industry have roles in meeting these national responsibilities. DPI plays a legal and management role, whereas CSIRO supports these requirements by the conduct of basic research on the ecology and dynamics of key fisheries. The oceanic environment and the food chains which support these fisheries are also important areas for study.

The discharge of Australia's AFZ responsibilities requires answers to a number of questions:

- What are the resources of the AFZ?

- What is Australia's capability to exploit these resources?

- What are Australia's needs, both for domestic use and for export, for marine products?

- What scientific knowledge is required for sound management of our fisheries?

- How can this knowledge be obtained?

These questions were asked by a former Chief of the Division of Fisheries Research, Dr. K. Radway Allen in 1977, and today we will focus on significant developments in knowledge gained since that time.

Types of Fisheries

Australia's fishing grounds occur in a wide range of climatic and oceanic conditions, from tropics to temperate areas, and fishing is pursued from the upper reaches of rivers to the deep ocean beyond the continental shelf. The resources vary from immobile species such as oysters, to wide-ranging migratory oceanic tunas. Some species may live for one year, others for 20 years or more. These animals are as specific in their environmental requirements as are land animals, each species occupying a specific niche at each stage of its life. Although the catch is dominated by fewer than 200 species, many hundreds more may be caught as a by-product.

If fish are divided into the particular ocean regions they inhabit, eight categories of marine fisheries resources can be defined:

- Inshore species inhabiting intertidal and subtidal areas (oysters, mussels and abalone)

- Bottom species of the continental shelf inhabiting estuaries or coastal regions for the early part of their lives (prawns, rock lobsters, snapper, bream, flathead, mullet, whiting)

- Bottom species of the continental shelf for whole life cycle (morwong, arrow squid)

- River species, using estuaries and adjacent coastal areas for spawning (barramundi)

- Bottom species of the outer continental shelf, and slope and oceanic plateaux (royal red prawns, orange roughy, gem fish, scampi)

- Midwater species of the continental shelf (spanish mackerel, jack mackerel)

- Midwater species of oceanic waters (oceanic squid)

- Pelagic ocean species (southern bluefin tuna)

Some species in these groups are fully exploited in Australian waters, others not at all. Some are utilized by the domestic industry, others are shared with foreign companies and some are fished exclusively by foreign interests.

Present Status of Australian Fisheries

Despite optimism that the AFZ would yield a dramatic increase in fishery resources, recent increases in the value of Australia's fisheries (in 1983, $450 million) have come almost exclusively from seven traditional fisheries. These are prawns, rock lobsters, south east trawl and southern sharks, abalone, southern bluefin tuna, scallops and "other fisheries".

In the international scene, although Australia has one of the world's largest ice-free coastlines, and one of the largest declared economic fishing zones, it contributes only 0.2% of the world's total fishery products. One reason for this is that fish is traditionally not a major source of protein for Australians and Australia has not developed wide-ranging deep-ocean fishing fleets such as those of Japan, Russia and North Atlantic countries. The industry has operated near-shore and on a small scale. 187

Low Productivity of Australian Waters

A second and more fundamental reason for Australia's low level of fish production is the generally low productivity of its waters, which are basically tropical and subtropical in origin. Deep oceanic water (below 200 m) is usually rich in nutrients and where it is brought to the sunlit surface layers by vertical movements such as upwellings, convective overturn etc., microscopic marine plants flourish. This plant production can support huge food chains leading to fish. Upwellings which support highly productive fisheries generally occur off eastern margins of northern hemisphere continents and on the western margins of southern continents. The rich anchovy fishery of the Humboldt Current was a notable example.

Unfortunately Australian oceanic circulation does not follow this pattern. The subtropical convergence lying south of the continent separates the nutrient-poor waters of the tropical and subtropical Indian and Pacific Oceans from the nutrient-rich Southern Ocean. Instead of being bounded by a nutrient-rich northerly current, Australia's west coast is subject to a southerly nutrient-poor tropical Leeuwin

Current, which flows intermittently down the coast and then turns eastwards into the Bight. On the east coast, warm core eddies of tropical Coral Sea origin can bring enrichments to the surface by convective overturn mechanisms.

CSIRO has found evidence of local upwellings and enrichments off N.S.W., South Australia, the North West Shelf, the Arafura Sea and the Gulf of Carpentaria. Recent discoveries have also shown that catch size relates more to the availability of nutrients and food for larvae after spawning, rather than to average levels of nutrients during the year. Local or intermittent enrichment phenomena may thus support productive fisheries.

Recognizing the complexity of Australia's fishery resources, CSIRO undertakes studies aimed at understanding why stocks fluctuate, and the effects of fishing and other human activities upon particular species. Studies of food chains, ecology and biological oceanography are therefore integrated with research into the biology of particular species during critical life cycle stages. Long term strategic research is necessary to understand inter-annual environmental variability, which can affect recruitment to fisheries as much as fishing pressure.

Future Fisheries Development

With existing inshore resources almost fully exploited, demersal fisheries off the northern shelf areas could provide opportunities for domestic expansion if markets are available and fishing by foreign vessels is reduced appropriately. Since such fisheries take a wide range of species, there is a need to know not only the total abundance and productivity of the various species, but also how fishing changes the relative abundance of the species. CSIRO is currently examining these problems in a study of the Northern West Shelf multi-species fishery. 18b

Other known potential fisheries resources which could be developed by Australian industry include:

- The Coral Sea tunas - yellow-fin tuna, big-eye tuna, and western Pacific tuna.

- Southern open-ocean species, e.g. jack mackerel, pilchard and blue mackerel.

- Southern deep-water species, e.g. orange roughy and blue grenadier.

- Arrow squid, a southern Australian resource (successfully taken by Korean interests).

- North West Shelf multi-species demersal tropical fishery (presently fished by Taiwanese pair trawlers).

- Pelagic species of northern waters (e.g. tuna, shark and mackerel) (currently fished by Taiwanese gill-netters).

- Deep water scampi recently discovered by CSIRO off the North West Shelf. Three potentially commercial grounds have been identified.

Examples of CSIRO research into the biology, ecology and population dynamics of some of these stocks will be described.

Conclusion

The potential for some expansion into new fisheries by the Australian industry is obviously a possibility. Increased awareness of the beneficial effects of Australian fish lipids on the prevention of heart disease which costs the nation millions of dollars a day in work lost and health care would catalyse further local demand. This would benefit not only the fishing industry but human health as well.

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HOW DO WE GET THEM?

IDEAS ON THE HIGH TECHNOLOGY METHODS NEEDED FOR THE CATCHING OF TUNA IN THE WESTERN PACIFIC

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C O N T E N T S

1. Abstract

This paper describes the technological being used by tuna purse seine fishermen in the developing W.P. fishery to locate, catch and freeze tuna and skipjack. It briefly traces the development of the fishery and the participation of the major operators, as well as the history of the purse seine technique.

Fish are being located with the aid of vessel based helicopters and sophisticated sonar equipment. In order to cover larger search areas, many fishermen are working together in radio code groups.

The fishermen are becoming increasingly successful at catching the fish. The most widely utilized technique involves locating logs or floating debris which have attracted fish and setting the purse seine around the object and body of fish shortly before daybreak. Some of the larger American vessels have recently developed a means of catching moving surface schools during the daylight hours, a technique which is yielding good catches but requires the strongest nets and machinery.

The most efficient size of vessel for use in a particular area depends upon local variables, but it is possible to determine a favourable size range given the basic parameters of the operation. In general, those operations which are based far from the fishing grounds

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require large vessels, while those located very near to the grounds can more efficiently utilize smaller boats. It is anticipated that as local operators enter the fishery, they can enjoy advantages over many of their competitors by using smaller, more fuel efficient vessels which have been built specifically to accommodate the newest developments in net and fish handling equipment.

Although alternative systems have been developed and are being refined, the most popular method of handling the net still uses a single puretic power block suspended from the main boom. The fishermen have begun to agree on the proper dimensions for nets, typically about 1200 fathoms long by 125-140 fathoms deep.

In conclusion, the fishery is such a recent development that few of the vessels operating today have been built to suit the specific requirements of the area. New entrances, particularly those with bases of operation close to the fishing grounds, can start with established technology and can benefit from the use of vessels and modes of operation which offer savings in operating costs.

2. Introduction

In less than a decade the south-western Pacific tuna purse seine fishery has developed from an experimental testing ground into the world's leading production centre for tuna and skipjack. While the timing and the rapid growth of the fishing effort are due primarily to economic factors, the harvest of the resource was made possible only by relatively recent technological developments. 183

Although this paper is intended to concentrate on the methods and machinery of the fishery, the temptation to comment on the growth of the catching effort and the overall potential of the fishery is irresistable. While shadowed somewhat by the industry's preoccupation with over-supply of product and falling prices, the movement of effort into what has become known as the western pacific could be likened to a major goldrush. In 1973 the purse seine catch in the area was negligible. By 1976-78 it was only about 25,000 metric tons per year. By comparison the American fleet alone landed some 281,000 metric tons from the eastern Pacific in 1976. In 1983 the catch by just the American fleet in the western Pacific was approximately 151,000 metric tons. It is estimated that the total catch in 1983 by purse seine vessels in the area approached 300,000 metric tons, with a value to the vessels of nearly US$300,000,000.

The inevitable questions involve the limitations of the resource. Whether it is a lasting resource or only temporary, or whether present or increased fishing efforts can be sustained, are questions which may be answered only through experience. Data is being collected and analysed by leading technicians, including the South Pacific Commission, the Inter American Tropical Tuna Commission, the Japanese, and independent processes such as Starkist. However, the fishery is such a recent development that several years will probably be required to collect the information required for meaningful projections to be made.

In the opinion of veteran tuna fishermen, the western Pacific appears to contain a resource several times greater than they have been exposed to elsewhere (e.g. eastern Pacific African fisheries). Considering the sizeable area of ocean over which the fishermen are recently finding large concentrations of fish, the present effort may be relatively light. That being the case, the limitations on the harvest for the foreseeable future may be imposed by economics, not biology.

3. Background

The future of the fishery will be determined by the following factors:

(i) The decisions by those countries whose 200 mile exclusive economic zones contain some of the fishing grounds

(ii) The degree of restraints to free trade imposed by the consumer nations of raw and processed fish.

(iii) The ability of individual operators to harvest the resource profitably.

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(iv) The annual sustainable yield of the fishery.

(v) (a) Exploitation of relative natural advantages (base location, fishing rights, etc).

(b) Utilisation of the most efficient technologies from around the world (USA, South Africa).

4. The Fishery

The area commonly referred to, in the tuna industry as the western Pacific encompasses the zone between approximately 134 degrees east and 150 degrees west longitude, and about 10 to 15 degrees both north and south of the Equator. While long line and pole fishing vessels have harvested tuna and skipjack in the region for several years, the catch and the fleet of catcher vessels have increased dramatically during the past two or three years and continue to do so. The bases of major fishing operations are American Samoa, Guam and Jaizu (Japan).

The leading processors in the area are the USA, Phillipines, Taiwan and Thailand.

Thailand alone is expected to import up to 100,000 metric tons of frozen tuna and skipjack in 1984 for canning and eventual export to the United States and Europe.

Accurate data on the fleet size and catch was available until about 1982, but competition in the fishery has caused the sources to become quite secretive.

A rough computation of reported figures results in the following breakdown of the fishing effort by large purse seiners.

	Country		Vessels in the Area
1.	United States of America (including Panamanian vessels)		70
	(a) American Samoa	50	
	(b) Guam	10-15	
	(c) California and Hawaii	8-10	
2.	Japan		32
3.	Korea		9
4.	Republic of China (Taiwan)		4
	(Three new fishing ventures starting as from now.)		
5.	Mexico		4
6.	Nauru		2
			121

In addition the Phillipines, New Zealand, Australia and Indonesia operate vessels in their own waters.

Several Venezualan vessels are expected to move to the western Pacific in late 1984.

While present involvement of most of the nations skirting the fishing areas or lying close to them is somewhat limited, because of financial restraint or lack of expertise, the potential for development is tremendous. It will shortly become one of the major fisheries in the world.

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While tuna has traditionally been harvested using a variety of techniques it is prudent to say that most of these techniques are fast becoming obsolete and don't warrant further discussion.

5. Purse Seining

This method is ideally suited to the tuna and skipjack fishery because it works best with fish found at or near the surface and with fish which congregate in concentrated schools.

The purse seine fisherman can harvest up to several hundred tons with a few sets of his net before being forced to begin his search again.

A purse seiner uses a surrounding net to entrap schools of fish. A typical purse net as used in the western Pacific is 1200 fathoms long by 125-140 fathoms deep. Mesh size is 4¼ inches, mesh knot to knot nylon. A net is 30 to 35 tons heavy when wet.

6. Finding The Fish

Much progress has been made recently in the development of fish finding equipment, resulting in increased catches. The present revolution in electronic technology will undoubtedly provide the fishery with further advances in this area. Both American and European vessels are using helicopters in order to increase search areas when looking for fish. Although helicopters are expensive, they have come to be considered a necessity by many fishermen. Those fishermen estimate the helicopter operation cost between 300 to 400 tons per year. Production increases through helicopter operation is at least that amount.

In the western Pacific the use of helicopters has so far been limited to the American, South Korean and Mexican vessels. Other operators have yet to be convinced that the extra cost is justified. Recently however, the catch rate of helicopter equipped vessels has begun to increase far more dramatically than those vessels without helicopters.

Most successful vessels operate in groups, communicating by radio code to cover large search areas. Japanese vessels working close together in large groups have not yet found helicopter operation necessary.

Schools of tuna and skipjack are usually found by spotting one of three signs through binoculars on board or from helicopters:

(i) A flock of birds hovering over the water generally indicates that birds have found food, probably bait fish which have also attracted tuna and skipjack.

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(ii) The fish are sometimes seen causing a commotion while feeding at the surface, with or without the presence of birds. Such a commotion is known as a "breezer", because it looks like a local gust of wind disturbing the surface of water.

(iii) The third sign is a surface object of any kind, including one or more porpoises, whales, logs or some floating debris. In each case tuna and skipjack schools are often found underneath, searching for bait fish.

The technique used most widely for locating fish in the western Pacific fishery is to find as many floating logs as possible and check them for fish, using a scanning sonar. Unless several tons are present, the logs are marked with radio transmitter buoys so that the vessels can return later when more fish may have collected.

A critical piece of equipment used with the technique mentioned above is the sonar, which "looks" at the fish under the log and displays a picture of its target on a video screen. Both the equipment itself and the operators' experience and skill are improving, and many fishermen now consider sonar as important as the helicopter. The Japanese fishermen, who do not use helicopters, rely heavily on sonar.

Sonar equipment designed specifically for fish spotting is marketed by several firms, the most popular sets coming from Furuna, Simrad and C-Tech. Most of the newer vessels use vertical, cone-type depth sounders and omni-directional scanning sonars. The omni sonars use eight inch to twelve inch spherical bulb probes with multiple transducers, and have CRT video read-outs in the bridge, the crows nest, or both. Some vessels even have remote transducers in small light boats or on buoys, which transmit information by radio to the seiner's readout screen.

The maximum range of today's sonar equipment for fishing vessels is approximately 4000 metres, with an effective range of about 1500 - 2000 metres. While the equipment rarely detects fish that the fishermen have not already presumed to be present (such as under a log), future advances in technology will likely increase range and sensitivity. Presently, the sonar is very useful for determining the quantity of fish in the school, and for monitoring the movement of the fish.

7. Catching The Fish

In the western Pacific fishery, the most early attempts to catch the fish were so unsuccessful, due to relatively clear water and a very deep thermocline, that the fish were considered to be uncatchable. Most early attempts involved setting around large "breezers", pulling in the net and finding it empty. 179

Success increased as the fishermen began to rely almost exclusively on logs, and/or man-made fish attracting devices (rafts), around which they set their nets just before daybreak. During the past two years, a few of the vessels have developed a technique for successfully catching school fish ("breezers") during the day, accounting for a larger percentage of an overall increasing catch. The "log" fishing technique has been developed in the Phillipines where fishermen construct man/made fish attracting rafts, or "payaus", which are anchored in one location and "harvested" as schools of fish collect. The payaus sometimes are rather complex, with kelp and ropes attached to promote natural marine growth. Some people living on board monitor activity. Outside the Phillipines, most log fishing in the western Pacific utilizes natural logs or floating debris.

When a log is located, it is checked for fish by either a small sonar vessel, the helicopter, or the seiner itself, using a long range scanning sonar. If several tons or more fish appear to have congregated under the log, the body of fish will be monitored by sonar through the remaining daylight hours and most of the night.

The seiner will quietly set its net around the log and the body of fish about one hour before dawn, and purse the net slowly so as to make as little noise and commotion as possible. An additional advantage of pursing slowly is that it tends to keep the bottom edge of the net deeper, allowing the purse seine to close under the fish instead of raising up into them and allowing some to escape.

The technique described above is used widely by the Japanese vessels and was one of the key developments which first allowed the Japanese fishermen to successfully harvest the "uncatchable" western Pacific tuna and skipjack in the med 1970's. Although some fish had been caught elsewhere with similar techniques, two changes were necessary for success in the western Pacific.

First, setting the net before daybreak helped to counteract the clarity of the water. Second, the fact that the thermocline level in the western Pacific is much deeper (up to 200 meters or more) caused the fish not only to swim and congregate at deeper levels, but to dive deeper when dispersed by commotion. We find similar conditions in Australia also from time to time. The use of considerably deeper nets allows the fishermen to operate at the proper depths.

As the fishermen gain experience and skill handling the larger nets, some have continued to pursue school fish ("breezers") during the daylight hours. Here, only a few have succeeded, but their new discoveries may prove to be more productive than log fishing. Those vessels successful at catching school fish are predominantly the largest American super seiners, which are equipped with deep, heavy duty nets, and the latest and most powerful winches and fishing machinery. The technique requires high speed sets which risk net damage due to snags and roll-ups, different tide layers and high-speed pursing which demands powerful machinery.

When operating on school fish the captain will often remain in the helicopter during the entire setting operation so that he can judge the movement of the fish and direct the vessel accordingly. In a sense, the helicopter becomes a remote pilot house, from which the captain steers the vessel and directs the crew by radio.

The captain will direct the vessel to set out approximately half of the net across the path of the moving fish, far enough ahead of the leaders that it will be in position, fully extended in depth, before the fish arrive and bump into it. As the fish approach the fence, the vessel completes the circle, getting behind as much of the school as possible. Now, the power of the new machinery is called upon. The fishermen must purse the net tight before many fish have a chance to react and dive down and out.

As success with catching school fish has increased, the catches have also increased. It is not uncommon for a boat to wrap up 250 - 300 tons of fish, whereupon if the captain is quick to react he will spill out about half of the live fish in order to save the remaining 100 - 150 tons of catch. Usually, if the fishermen tries to keep too many fish, he will lose some or all anyway. When the net is "sacked up" for removal of fish, too heavy a load will burst the net and all will be lost. Or, if the net does hold, the crew will provably be able to brail out only 100 - 150 tons before those dead fish remaining in the net have spoiled in the hot tropical water.

8. Handling The Fish

While getting the fish out of the net and bringing the net back on board has always been a problem for fishermen wishing to set again quickly, it was rare, before the western Pacific fishery, that fish spoilage limited brailing time. Brailing has become a problem in the hot waters of the tropics and much effort is being made, especially by Marco Engineers to develop a faster system of removing the fish from the net.

Today, most brailing is done with a dip net. This is directed by a role from the skiff and hoisted over the rail of the seiner, where a purse line at the bottom is released and one to three tons of fish is spilled into the deck hopper. Shark and most other non-tuna species (which have little value when frozen directly in brine) are removed and discarded, and the tuna is transported by chutes into fish wells below deck.

9. Freezing the Fish

Freezing methods have become an important issue lately, due mainly to a sudden move by the tuna marketing industry to adapt to the increasing health consiousness of food buyers. While canned tuna once needed a certain amount of salt to satisfy the taste of the buyer, low-salt tuna is now being sold at premium prices. Since most of the existing boats were built around freezing systems which produced product intended for yesterday's market but too salty for today's, change is in order.

To some extent, the salt penetration and fish damage due to a slow or incomplete freezing is due to a lack of knowledge on the part of the operators. If used with thorough understanding and monitored carefully, immersed brine freezing systems are capable of producing frozen products of a higher quality.

The majority of the vessels use insulated steel wells of between 60 and 100 tons capacity, which are lined with approximately two inch diameter galvanised steel coils through which cold ammonia gas is circulated. The well is filled with dense brine, which is cooled to about -15 to -18°C before being loaded with warm fish.

The problem is to freeze the outer layer of the fish as rapidly as possible, so as to minimise salt penetration, and to freeze the remainder equally rapidly to avoid deterioration of the meat. In general, this required maintaining a maximum temperature differential between the fish and the brine.

The brine is circulated, in order to keep stratification from occurring in the well (warm areas where fish do not freeze, and cold areas where the brine freezes to ice around the coils).

Operators face several limitations with the existing systems. Firstly, the maximum brine velocity is very limited due to potential damage to the fish. Therefore, operating at or near freezing point of the brine (about -20°C, assuming just the right density has been achieved) produces a risk of icing the coils and greatly reducing the efficiency of the system altogether. In addition, putting 60 to 100 tons of warm fish into the cold brine causes the brine to warm considerably, increasing initial penetration and damage.

10. The Sashimi Market

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The latest development and light on the horizon for the industry is going to be this market. We are still in the development stages in Australia, but the financial gains are great for operators who are going to fish for the sashimi market and keep the fish on board vessels to achieve the quality which is required for a complete success.

11. Vessel Characteristics

Since the western Pacific fishery is such a recent development, few of the vessels in operation today were designed specifically to fit the local fishing conditions.

The single exception might be the Japanese vessels, but their design is so constrained by their limitation to 499 gross tons that they are far from optimized for their use.

As the older vessels are gradually replaced, the fleet will be increasingly orientated towards:

(i) Handling large nets

(ii) Handling large catches

(iii) Utilizing new technology fish finding equipment

(iv) Utilizing new technology net handling and fish Handling equipment.

(v) High speed freezing (also for sashimi market)

(vi) Minimum fuel complement

(vii) Minimum crew complement

(viii) Working rough weather conditions

The vessels with those characteristics which are already on the drawing boards of Marco and other specialised shipyards will be the big money maker of the Pacific for years ahead.

12. Choosing Correct Vessel Size

Fishermen who operate their own vessels tend to buy the largest vessels which they can afford, the constraining variable in this case being initial construction cost. The reason is that fishermen often find larger schools of fish than their vessels have room to hold, and usually remember those lost fish as lost revenue.

In the case of new operators entering the fishery, it generally pays to start out with a vessel which has at least the capabilities of those of the established leaders.

The size of Australian vessels entering the fishery will depend upon:

(a) The size and weight of net required for the condition in the north of Australia.

(b) Manning regulations and licensing requirements to operate vessels of somewhat larger size than is usual in our own fisheries.

(c) The never ending threat of possible union interference.

(d) The short distance of Australian based vessels to travel to those "hot spots".

It is my belief that economically and operationally the optimum vessel size should be from 350-500 tons in carrying capacity, specifically orientated towards large catches and short trips. They will cost less to build and less to operate than the majority of existing vessels, and their owners can therefore enjoy a competitive advantage in the catching operation.

13. Machinery and Nets

Machinery

Fishing and net handling machinery can be categorized into four major systems:

(i) Marco

(ii) Petrel

(iii) Triplex

(iv) Abbas

There are a number of other systems around the world but they are of little significance and don't warrant further comment.

Marco is used on 90% of the tuna purse seine vessels world wide. Petrel, Triplex and Abbas have traditionally handled other purse seine fisheries like fish meal, herring and pilchard fisheries. I will comment on the other systems briefly later.

The centre of the system is the main purse winch, which closes the bottom of the net. Main purse winches are available in a variety of sizes to suit different cable capacities and power requirements of specific applications. The largest winches have three drums, one each for the aft end of the purse line, the forward end of the purse line and the towline which is used in case the net is set in a larger diameter than the net can circumscribe. The largest winches have a power capacity of nearly 500 horsepower, which can be applied to any or all of the three drums with continuous speed control.

The puretic power block located on the main boom, pulls in the net. The simple device consists of a single hydraulic motor turning a rubberised, V-groove sheave. The performance and versatility of the block are increased with the addition of a tensioned roller called a "power grip", which increases the friction between the block and the net, and an inhaul winch which is used to "shake" the block. The operator can use these devices to vary the relative speed of the corkline and the leadline during hauling, and to shake out gilled fish and debris from the net.

On the largest vessels, the hydraulic system is powered by a single diesel engine of approximately 500 horsepower, operating several hydraulic pumps through a hydraulic pump drive unit. Aboard smaller vessels the power is derived from the ship's electrical system, and transmitted through an electro-hydraulic power unit, consisting of large electric motors connected to hydraulic pumps.

Control of the system takes place at winch control consoles, which are located where the operator has a clear view of both the equipment and the work in progress. The control console is tied to the main system through small hydraulic lines to pilot control valves located below deck, which allows the consoles to be placed in remote locations without complicating the main piping system.

Nets

During the initial stages of the fishery, it seemed that each fisherman preparing to operate in the western Pacific would build a net slightly longer and slightly deeper than the last. Power block diameters were increased from 42 inches, and eventually to 56 inches in order to accommodate the increased bundle of webbing, and Marco Engineers prepared for an eventual need for 60 inch power blocks. As the net piles grew, fishermen and building began to question the limitation of space, machinery power and the capability of the crews to handle larger nets. It now appears that fishermen are independently approaching a consensus on net size of about 1500 metres (hung) length, by about 210 metres depth. A typical hanging ratio includes an extra 23% webbing in the length, which means that 1800 metres (hung evenly) of netting are hung from 1500 metres of corkline.

While the American and Japanese fishermen are moving toward the same net sizes, they continue to use nets of substantially different weight and construction. A typical Japanese purse seine is constructed of predominantly light-weight "Japanese knotless" two strand braided web, uses rope bridles to attach the rings (with several lead weights to aid sinking), and weighs a total of about 30 to 35 tons. An American net of the same size contains 30 to 35 tons of braided, knotted nylon alone, which when added to the remaining components (including chain bridles) produces a complete net weighing in at between 50 and 60 tons.

The hanging ratios used to construct the two different types are similar (23% to 25%). However, while the American nets combine 20 to 25 horizontal "strips" of 5 fathoms (9 metres) webbing each, the Japanese "strips" are approximately 28 metres wide and are orientated vertically. The wider strips are made possible because the knotless webbing is produced on circular looms of about 28 metres circumference, while the knotted net is provided on a straight loom of 9 metres length. Since vertical reinforcement seams must be inserted every 75 metres or so as rip stops anyway, the Japanese netmakers believe that the vertical panel design reduced construction labour.

Whether one net style is superior to the other has not been proven. Due to their lighter weight, the Japanese type are less expensive. Due to smaller twine diameter, they also require less weight in metal to achieve a given sink rate, but since the American nets contain so much more metal in the form of chain bridles, the sink rates are comparable. The American fishermen are reluctant to use the knotless webbing because they claim that it is not as durable and that it is more difficult to mend. The Japanese claim that their nets are technologically superior, but is doubtful that the Japanese seiners are capable to handling a full size American net, because it produces too large and heavy a pile.

Perhaps the only unbiased opinion has come from a leading Korean operator, who bought a used European vessel and initially equipped it with a lightweight knotless type, claiming that durability was the deciding factor.

14. Purse Operation

The purse seine operation can be viewed in five stages, or operations, which may be addressed with improvements:

1. Setting out the net;
2. Pursing the net;
3. Retrieving the net;
4. Drying up the fish;
5. Removal of the fish from the net.

The most cumbersome aspect of the present method of setting the net is that is utilises a skiff. The skiff is a useful workboat for a variety of tasks, but if the tasks could be accomplished without it, there would be no need for the seiner to carry an extra 25 tons mass of steel around the ocean.

Pursing a net in the western Pacific takes between 20 and 40 minutes, depending upon the power of the machinery used, the size of the net, and the preference of the captain. As discussed above, there are times when pursing speed is reduced intentionally. Advances will be made in both pursing time and power requirements. Both could be effected by a reduction of the friction in the system and by advances in net design.

Retrieving the set cannot be accomplished unless the purse line, a cable, is removed from the rings at the bottom edge of the net. Presently this is done by slipping all the rings on to a steel bar and parting the cable at a link - overall a very dangerous operation because of the loads involved.

Retrieval of the net itself is done with the aid of a single puretic power block suspended from a boom. The limitations to speed (and consequently areas for development) are the friction created between the net and the block, and the speed at which the net can be stacked. Presently stacking the net takes more crew members than any other task in the operation, and therefore determines the size of the crew.

Drying up the fish is an operation which must take place before the fish are concentrated enough for brailing. It is accomplished by manually hauling excess webbing over the rail of the vessel (or "strapping" bunches of webbing and raising it with a winch) until the fish are concentrated into a small bag of net. Speeding up this process would allow larger catches, since most of the fish have already died and begun to spoil when the drying up operation begins.

Removal of the fish from the net, as has been explained, is generally done with a dip net brail. As in the case of drying up, brailing limits the size of maximum catches.

15. The Triplex System

One alternative to the single power block system was developed in Norway and is known as the Norweigen system. Its trade name is Triplex. A similar system in manufactured by Petrel Engineers in South Africa. Both systems have achieved notable success in some purse seine fisheries, including anchovy, sardine and herring.

The system is based on wrapping the incoming bundle of net over, under, and over a series of three rollers located near the gunwhale of the vessel, a situation which produces greater friction for hauling, than a single power block sheave. Consequently, hauling power and speed can be increased.

An additional big potential advantage of the system is its associated automatic stacking device, which helps in significantly reducing crew requirements. Also, this system lends itself to work in extremely bad weather conditions, with the gunwhale mounted hauling block so close to the deck.

The system has a big advantage in tuna fishing where there are gilled and snarled fish, because of the bunched webbing being so close to the deck.

16. Conclusion

The tuna and skipjack catch in the area which has become known as the western Pacific has increased dramatically over the past few years. While the methods being used to catch the fish are based on technology originally developed over two decades ago, much of the success in the area is due to recently developed equipment and techniques.

A typical example is Starkist which, four years ago, had three vessels (Island Princess, Western Pacific and Frontier) fishing the south western side of New Caledonia over a six month period and failed completely. After a complete upgrading of the fishing equipment over a period of time, the same vessels in the same area were extremely successful.

Many of the vessels operating in the area of the western Pacific were originally built and designed for the eastern Pacific. Gradually they will be replaced because of age and poor economics,

Although the major existing operators will most likely remain in the fishery, it is expected that most new entrants will be locally based. The potential cost advantages of local operation are substantial.

Local and future Australian operators will utilize smaller vessels designed specifically to accommodate a large net, as well as the most efficient net and fish handling equipment. Studies show that vessels of between 350-500 tons capacity would be the most economical.

As fishermen establish common techniques of operation, their requirements for net size and machinery capability are stabilising. The development of a consensus on methods and equipment will allow new operators the opportunity to start out with technology equal to that of the existing leaders.

Although the most popular net handling method is still based on the Marco power block, there are new systems under development. As these and other technological innovations are refined, the productivity of tuna and skipjack purse seining in the western Pacific will continue to increase. The question for the Australian fishing industry is;

17. How Do We Get Them?

(A) Shake Canberra out of its apathy and encourage a positive approach by the Government (similar to other countries).

(B) Introduce taxation concessions for a period of time.

(C) Provide development finance for starting ventures.

(D) Provide no hand-outs but make long term finance available at reasonable rates to proven operators, to take advantage of the resource which lies on our doorstep to the North.

(E) Set up laws favourable to bona fide operators who are taking advantage of this fishery.

(F) Stop import restrictions on second hand vessels so that we can take advantage of overseas technology and build up a fleet of efficient purse seine vessels capable of holding their ground against overseas competition.

(G) Keep on fostering and supporting the Australian Maritime College and industry training committees in the various states to create a pool of fishermen capable of working highly sophisticated fishing vessels.

I know there are fishing operators in Australia who are willing and, without doubt, capable of taking up the challenge if given just a little encouragement from the people in power. The benefits for Australia are many.

My sincere hope is that the race for the rich resource to the north of us is not being lost by Australia because of difficulties of finance and short sightedness.

Note: I could have gone into the various subjects in far greater detail and introduced a number of other important issues relating to the paper, but I felt that the reader would prefer an overall glimpse at what is required in this fishery. I hope this paper achieves this as well as promoting discussion and a good deal of thinking.

In closing I would like to thank:

* Mr. Tom Hutton, Vice President - Marco Pacific for his help on the above subject when I was in Taiwan,
* My son Marcus who fished the area extensively,
* Julius Zolessi of Zolessi Enterprises who has a number of super-seiners fishing the "hot spots".

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IS THERE A BUYER?

A LOOK AT THE MARKET FOR NOVEL FISH AND FISH PRODUCTS

Mr. David Townsend

General Manager

ASP Seafood Producers

I suppose I should first of all establish with you whether fish is novel or completely non fictional! The average species may not make a "good read" - but invariably will be a "good feed". Suitable titles we might consider could be:-

HOW ROUGH IS MY ORANGE

by an "Ex Grenadier"

(a very deep book)

ONE ALONE, ABALONE

(very shallow)

However, apart from considering the novelty or absurdity of fish nomenclature, which is a problem in itself, let me at the outset say there is very little fish caught which cannot find a market somewhere or which cannot be considered as suitable for further processing.

Every processed seafood we take for granted today was novel at its conception and subsequent adoption. Many other possibilities have not been accepted or await more favourable economic circumstances.

In terms of evolution we can look at the various processed fish products over the centuries, dried, smoked and pickled processes being the forms of processing until recent times.

The introduction of canning and then refrigeration gave the fishing industry and other food industries the opportunity to overcome the inherent difficulties in distributing a range of products which were highly perishable in their natural state. Apart from facilitating preservation these various processes also assist the fishing industry to look to higher value for their raw material and to avoid the day to day pressure of marketing raw fish in its natural state.

In Australia the conventional State metropolitan markets have a limit to the amount of fish which they can handle without a significant quantities of Australian caught fish have to be marketed domestically. This remains as a mauor problem should any significant quantities of Australian caught fish have to be marketed domestically.

What then are the areas where innovation can still be used to mutual advantage. Many overseas examples are available to point the way. I will use two major innovations to illustrate the potential.

In Japan, the availability of large qualities of Alaskan pollack was known for many years but its suitability in terms of size and colour for the traditional Japanese market was limited. A few years ago after many years of experimentation, a major breakthrough was achieved through food technology so that this fish could be processed to achieve a suitable finished product.

The fish fillets are minced and ground, soaked repeatedly, washed and soaked. Over the processing period, salt, monosodium glutamate, sugar, starch and various flavourings and colouring agents are introduced. The mixture is cooked and shaped by extrusion or moulding procedures and subsequently frozen. This procedure to make what are known in Japan as "Kamoboko" was perfected for pollack a few years ago and followed traditional methods applied to more highly prized species of fish such as salmon and snapper.

What has this to do with markets other than Japan, you may ask. Well about three years ago this range of Kamoboko was launched in other markets including Australia. Here the first product presented was cylindrical sticks with crab meat flavouring resembling Alaskan crab meat leg segments which are now difficult to obtain and expensive. In the first 12 months, 1200 tonnes of product was sold in the Australian market. Subsequently breaded scallop flavoured portions and shrimp like portions were introduced and now "crab claws" are here. All of these products have about 85-90% pollack content and can be eaten cooked or uncooked.

In Denmark, landings of fish have been declining for some years as the yields from the heavily fished North Sea grounds reduced. The Danish producers had built up over many years good markets for high quality particular flatfish. They had sophisticated freezing factories and all the necessary staff, equipment etc. How could they support their companies following a major reduction in raw material? Obviously their answer was to look for higher value for their fish. Firstly, there was the far from usual method of breading and coating of fish fillets, but in one company's case more radical developments were carried out.

The first range of products were of fully cooked (poached) fillets which were then frozen in a "tornedo" style. Accompanying each carton of numbered and size graded fillets were sachets, one per fillet which was of the fish stock, also a sachet of the specified sauce, eg. Mornay, Americane etc. These cooked fillets are now widely distributed throughout Europe and will shortly be introduced into Australia with a view to later production here.

Another trend overseas is the mixing of various foods. In the UK currently the biggest seafood seller is now frozen seafood pasta - a blend of fish pieces, prawns, mussels etc. with noodles and spaghetti. An attractive product reasonable priced. (67)

What is the position here? While fish fingers continue to be a major seller, about 5000 tonnes annually, there is an increasing popularity for oven baked fish portions (crumbed or battered) which are taking a significant share of the processed fish market.

What is of interest in local fishing terms? A big percentage of processed fish depends on the production of fish blocks. From South Africa and South America a processor obtains hake blocks in fillet or minced form; in New Zealand the block will be made from hoki (blue grenadier).

Nobody has yet produced fish blocks in Australia on a continuous commercial basis. It would be of value if an answer to this question were found. I would emphasise that fish blocks are produced from sound fish not inferior fish, nor can they be effectively produced from mixed species.

There are many other interesting developments taking place such as the many uses to which squid is being directed but I have preferred to concentrate my remarks on the volume market.

I am convinced there is a market for virtually all seafoods. The problems we all face in Australia are ones of time and distance and the fragmented nature of Australian fisheries.

Let me close by stressing that as fishermen you are the first processor, as without doubt the food is going to be affected by your actions which, if correct, will secure a willing buyer. Failure to relate to good practices will directly affect your chances of a good and regular market outlet.

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IS AQUACULTURE AN ALTERNATIVE?

Dr. Trevor G. Dix

Tasmanian Fisheries Development Authority

Introduction

Aquaculture concerns the farming or husbandry of aquatic plants and animals, but most of my talk will be confined to the marine sphere in common with other papers at this seminar.

Mariculture, or seawater aquaculture, has a long history illustrated particularly by various forms of culture in Asian countries. It was only in the 1960's however, that the message finally came clear - traditional harvesting of marine resources had limited development potential. In contrast, aquaculture was seen as an area capable of considerable development - albeit from a smaller baseline than the harvested resources.

In the early 1970's, Pillay in FAO predicted ten-fold increases. By 1975 he changed this to a five-fold increase giving about 30 million tonnes by the year 2000. Nearly ten years later, the latter prediction appears quite realistic as interest in aquaculture has intensified and introduction of improved technologies has occurred.

Cultured techniques vary markedly between and within countries and with cultured species but all aim to provide some degree of care for the organism under culture, often emphasising the vulnerable young stages of the life cycle.

The less sophisticated methods rely on capture of stock from natural populations, then exertion of varying degrees of control on subsequent growth and survival until harvesting. Our Sydney rock oyster industry illustrates this type of system.

More sophisticated systems utilise hatcheries to produce farmed stock. Juveniles raised in the hatchery may be released into the wild and captured at a later date. Overseas ranching of salmon and abalone are examples of this approach. Progressing further, the hatchery reared juveniles may be kept under care in nature until harvest, a system seen with Pacific oyster culture in Tasmania. In some even more sophisticated experimental systems, complete care from hatchery production to harvest has been achieved, for example in the Delaware closed system oyster culture experiments.

Australian Mariculture and Potential

The questions to address are:-

"Is aquaculture an alternative" (to traditional harvesting practices) for increasing production of Australian marine resources? Related to this, "Could Australia achieve development potentials predicted by Pillay for the world as a whole?

Aquaculture is an alternative, but the question really is one of quantity rather than kind. If the basis for comparison is a five-fold increase from 1975 to 2000, we have a head start - the baseline at the time of Pillay's predictions was (and still is) low. Just the same, five times 7000 tonnes is not insignificant when compared with the 140,000 tonnes annual Australian marine harvest presently taken - no one would predict similar percentage increases in harvested resources from Australia.

At present there is considerable interest in mariculture in Australia, but only a handful of species contribute by way of established production systems (Table 1).

The Sydney rock oyster and the tropical pearl oyster contribute significantly to fishery incomes in the regions where they occur. Neither industry is likely to undergo five fold increases and other species, whether in Table 1 or not, must be examined for their development potential.

The searching question is not one of whether Australia could ... but will Australia? I have no doubt that we could boost our marine harvest by aquaculture but will we? Under 20 years is not a long time to see culture through experimental to pilot scale and thence to developed production systems.

We know roughly how much coast we have in Australia. How much of it is suitable for mariculture, what species will be farmed where and what are the constraints to development?

Constraints Affecting Mariculture Development

A range of factors affect development of aquaculture. These may be -

Biological: species suitability and productivity potential, pests and diseases, behaviour at different stocking densities, selective breeding, life cycles;

Technical and manpower: design and use of production systems by skilled personnel;

Social and legal: administration of lease areas, shore and waterway rights;

Environmental: pollution, hydrological factors, available area;

and

Economic: marketing, commercial assessment of pilot and experimental systems.

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It would be easy to dismiss this last as a set of motherhood statements. Having witnessed the development of Pacific oyster farming in Tasmania - from a low technology hit and miss situation, with pollution, with leasing problems and so on - to a situation where utilisation of modern technology provides probability of commercial development to 3,000 tonnes annually on currently leased areas, I can assure you that factors within all headings in the list have been involved. The sobering thing also is that the factors don't disappear as development takes place, a situation that all fisheries managers recognise with harvested resources.

Identification of key constraints to development is critical if aquaculture development is to occur within Australia. I believe it fair comment to say that much of our research and development efforts have centred on biologists studying biological constraints which are only part of the exercise. Furthermore, much of the world's aquaculture production is derived from practices which simply would not be economical in Australia, a country with high labour costs and living standards. Accordingly, if aquaculture is to develop in this country it will need to have sound technological and economical bases. Legal use of unpolluted waterways is essential in aquaculture; gaining such right of exclusive use is often a reason for placing aquaculture development in the "too-hardbasket".

Potential: Promise or Pipedream?

Whilst suggesting that Australia has a potential, I have avoided the topic of will aquaculture develop and instead have emphasised points which are constraints to development. This is not because I am negative but simply because aquaculture conjures many unrealistic pipedreams, not only within government circles but within industry itself. Many see aquatic farming as the last unconquered frontier, an eldorado unequalled where millions are the norm in consideration.

This aside, could there be a promise of development?

Given a demonstrated biological reality, resolution of socio-legal and environmental constraints, market potential and evidence of economic feasibility using a basis of conservative technology, aquaculture has a potential to develop in Australia, a country offering environments from tropical to cool temperate.

I say given - and emphasise this - because many projects have foundered through inadequate attention to the various constraints, any one of which, if overlooked, can be a key factor.

Whilst I say conservative technology, I am assuming that participants in the present and future aquaculture ventures are fully aware of the global state-of-the-art, not only in a research sense but also in production scale systems.

One should not repeat the multitude of mistakes made by others in the business but instead recognise that there is ample scope for development of further technology particularly in intensive culture systems involving both finfish and shellfish.

We have examples of how to obtain appropriate technological baselines, e.g. by overseas study, hire of consultants or employment of experienced personnel. All avenues might be considered in any given project and we have demonstrated that we can adopt and then tailor overseas technology to our benefit.

Such technological developments must be made within a realistic, attainable, commercial context. Scaling up from experimental through pilot scale to commercial technologies takes time and is not easy even with an applied research motive.

Aquaculture development implies industry development. There are numerous overseas examples in countries as different as China and Norway to show how such development demands strong governmental agency support. The success stories have not just happened, they have been made to happen!

Conclusion

Mariculture offers Australia a development alternative to harvesting of wild stocks. Whilst cultured tonnages will not approach those of harvested resources, increases predicted by F.A.O. for the world as a whole could be achieved within Australia.

A range of constraints affect aquaculture development. These include not only biological but technological, socio-legal, environmental and economic considerations, any or all of which can contain key constraint factors.

Integrated programmes with strong governmental agency support are required if industry is to develop viable culture practices in Australia. Sufficient biological data probably exist to select key candidates for emphasis - it remains for us to mount active multidisciplined programmes in close association with industry if the aquaculture promise is to be fulfilled.

TABLE 1: Australian mariculture species and development status

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		Status*	Approx. Production and value t	$
Shellfish				
Abalone	*Haliotis ruber*	C		
	H. laevigata	C		
Oysters	*Crassostrea commercialis*	A	8000	> 20 m
	C. gigas	A	≈ 600	> .9 m
	C. echinata	A-B		
	C. amasa	A-B		
	Ostrea angasi	B		
Mussels	*Mytilus edulis*	A-B	n.a. (<100t)	n.a.
Scallops	*Pecten fumata*	C		
Pearl oysters	*Pinctada maxima*	A		>17 m
Prawns	*Penaeus plebejus*	C		
	Metapenaeus macleayi	C		
Finfish				
Rainbow trout	*Salmo gairdneri*	B		
Other vertebrates				
Crocodile	*Crocodylus porosus*	B-C		
Turtle				

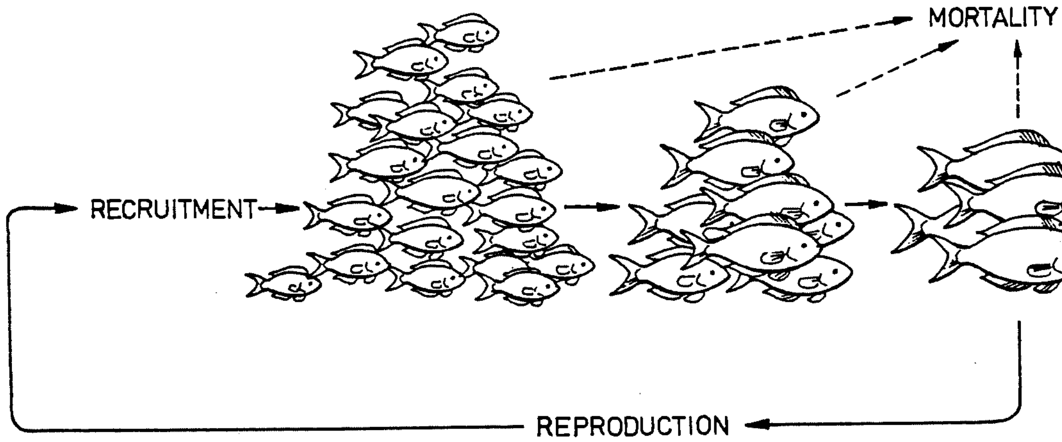
* A = established commercial; B = pilot scale; C = research and experimental; D = stocking for recreation.

THE ROLE OF BIOLOGY IN FISHERIES ASSESSMENT AND MANAGEMENT

Dr. Michael King
Lecturer
Australian Maritime College

Fisheries science is a multidisciplinary science involving oceanography, chemistry, economics, statistics, sociology, biology and, some may say unfortunately, politics. My talk, as the title suggests, is going to be biased towards biological aspects of fisheries assessment and management.

Fisheries biologists contribute to fisheries science in two main areas - (1) the assessment of new fisheries resources and (2) the management of existing fisheries. In order to discuss these two areas, it is useful to consider a fishery as a simple biological system. In this system, the fish stock is being increased by growth of individuals and recruitment to the fishable stock. The stock is also being reduced by natural mortality (mostly by predation) and, in the case of exploited species, by fishing mortality as well.



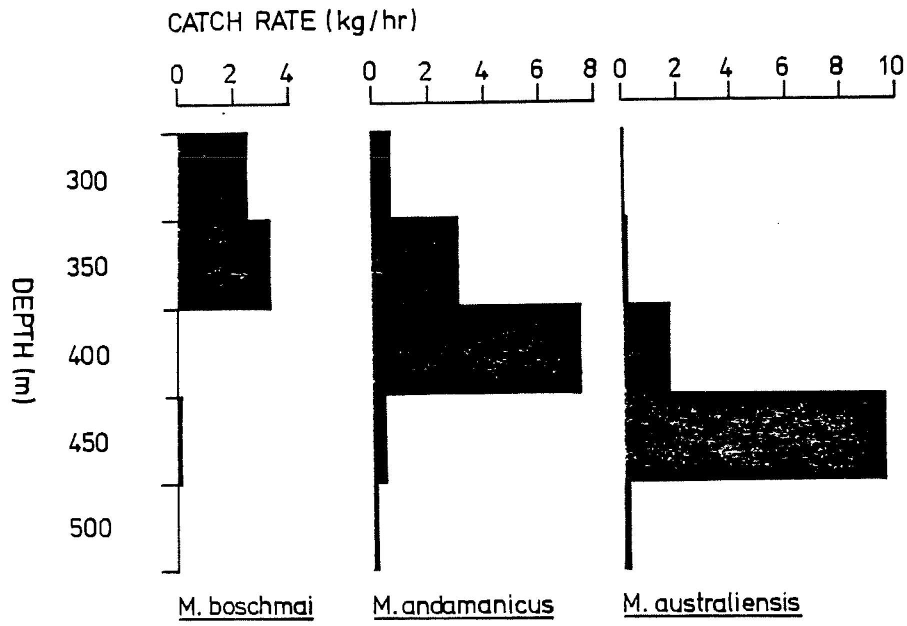
The above system, in species which are unexploited or exploited at a low level, is in equilibrium with mortality being balanced by replacement. Stock abundance will, therefore, fluctuate around a mean level. In an over-fishing situation, high mortality will reduce stock to a level where reproduction and replacement are affected.

Let us first consider the assessment of unexploited fishery resources. Two biological questions are of primary importance; firstly, what is the distribution and abundance of stock? Secondly, what sustainable yield can be taken from the proposed fishery?

In many cases, the investigation of new resources is a high risk business and cannot be done without financial assistance, usually from government funding. The recent surveys of crustacean resources off the northwest shelf of Australia, for example, were carried out by the CSIRO as well as a private fishing company with government funding.

These surveys were, in fact, successful in finding stocks of scampi (three different species of Metanephrops) on the northwest shelf. A related species is highly prized in European countries and forms the basis of a valuable fishery. The three major species found had the depth distributions shown below.

The mean catch rate of scampi is, of course, the parameter of most immediate interest to fishermen considering the potential fishery. It could be expected that catch rates would improve as gear and techniques relevant to this particular species improve. Catch rates and a knowledge of likely market prices may encourage commercial interest, but that is only one side of the story.

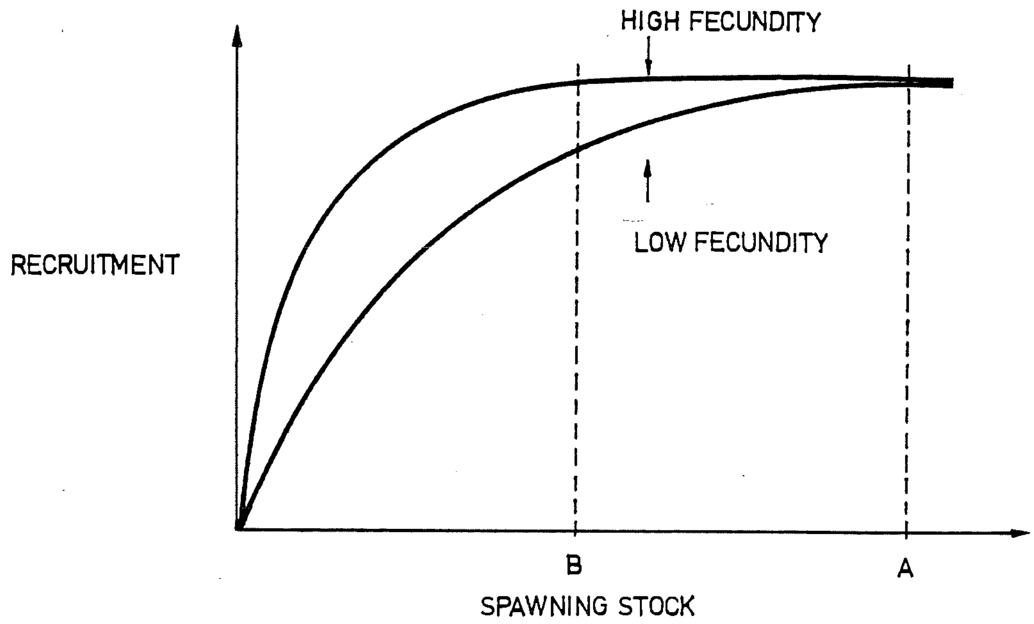


Biologists responsible for resource assessment are further interested in the possible continuing yield from the proposed fishery. That is, from a commercial viewpoint, is the available stock able to support a fishery of say two, ten or twenty trawlers?

This question is more difficult to answer and requires further knowledge of the biology of the species. In the case of scampi in Australia, very little is known at present. It may be instructive to indulge in a little speculation and compare some biological parameters of scampi with those of another commercial crustacean, a penaeid prawn. The most important biological parameters are growth, lifespan, size at first reproduction and fecundity - which are all related to the ability of the stock to maintain itself in the face of increases mortality due to fishing.

	PRAWNS	SCAMPI
GROWTH	fast	slow?
LIFESPAN	1 to 3 years	> 5 years?
AGE AT FIRST REPRODUCTION	reached within 6 to 12 months	> 2 years?
FECUNDITY	high (>50,000 eggs)	low (approx. 1000 eggs)

The number of young produced is related to the abundance of adults. This relationship is easier to demonstrate in a species with slow growth and low fecundity (such as scampi?). In this case, any large reduction in adult stock by fishing, say from A to B in the diagram below, will cause a decrease in the recruitment of young. Species, such as prawns, however, can be subjected to similar fishing pressure (reducing the stocks from A to B without reducing recruitment.



The above suggests that although prawns may be heavily exploited without biologically affecting stocks, scampi may not. In fact, there is no valid biological reason for restricting fishing on prawns (although there may be valid economic reasons). Further work on scampi is needed to estimate appropriate levels of fishing effort.

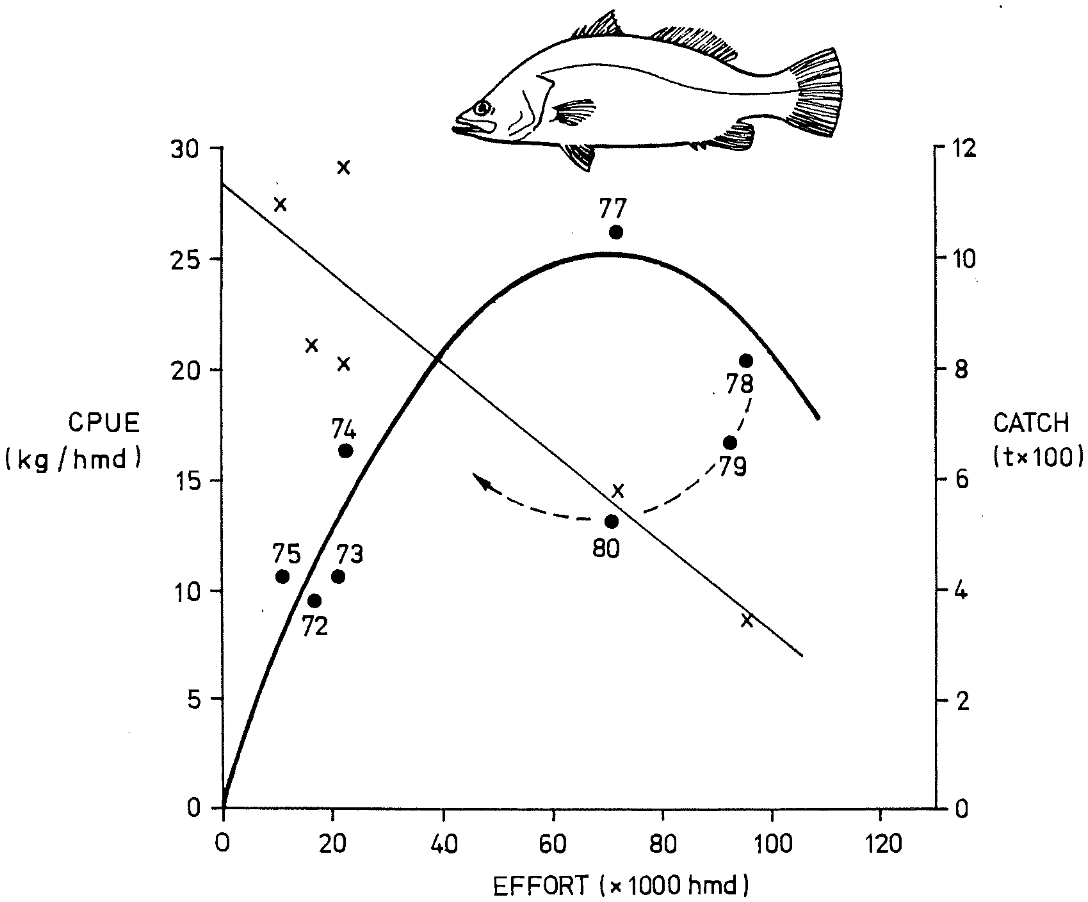
I have concentrated on the biological components of resource assessment but these are merely academic without economic and marketing considerations.

Over the past five years I have been carrying out resource assessments and studying the biology of deepwater prawns in south Pacific islands as well as Australia (King 1984). It is now known that there are huge stocks of caridean shrimps in depths of about 800m around the tropical globe. The problems associated with exploiting these shrimps include the high cost of fishing in such depths as well as marketing a high quality product in isolated tropical areas. In spite of the magnitude of this resource it will probably remain virtually unexploited for several years to come.

Let us now consider what happens when a fisheries resource is exploited; in its most simple case this would be a single species fishery. In a developing fishery each increase in fishing effort is rewarded by a corresponding increase in catch. That is, if the number of fishing boats is doubled, so is the catch. This trend cannot continue. As the intensity of fishing increases, catch rates (or more strictly catch per unit effort) will decrease even though total catch from the fishery may continue to rise. With further increases in fishing effort, total catches will continue to rise until the point of maximum sustainable yield (MSY) is reached. Beyond this point, the reproductive capability of the stock is affected and the total catch may decline (see figure below).

Several Australian fisheries, as wide apart geographically and biologically as the rock lobster in south eastern Australia and the barramundi in the Northern Territory, are presently overfished. I will use the data from the barramundi fishery (Rohan et.al. 1981) to illustrate some properties of, and problems with, one type of yield curve (usually called the Schaefer model).

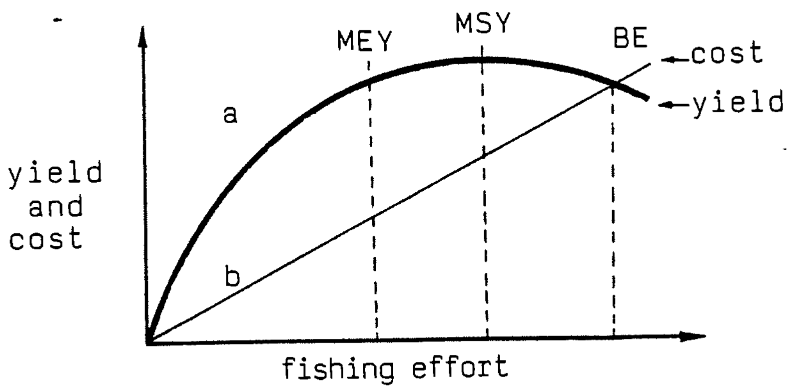
Although the total catch weight (yield) of barramundi has increased over the period from 1972 to 1977, catch rates have been decreasing. Since 1977 both total catch and catch rates have decreased. A yield curve fitted through 1972-78 data indicated a maximum sustainable yield of about 1000 tonnes and an optimum fishing effort of about 70,000 units of a hundred metres of net per day.



The position of the data points for 1979 and particularly 1980 illustrate an important point in estimating yield. When effort on an overfished stock is reduced by management regulations or other factors, total yield does not immediately increase as may be expected from the yield curve. Following a reduction in effort, yield will also tend to decrease and approach the yield curve from below as shown by the broken line in the above figure. This effect is related to the time taken for stocks to recover biologically from the effects of over-fishing. 158

Note also, that this method required a long series of catch and effort data to estimate maximum yield by which time the fishery is already fully if not over-exploited. There are, however, other methods of estimating yield - e.g. Beverton and Holt's yield per recruit model and Gulland's initial estimate based on biomass and mortality.

Profits, of course, are a major consideration in any commercial fishery. As fishing costs rise with increases in fishing effort, a point may be reached where there is no net profit from the fishery (i.e. where total catch value equals total fishing costs). The point along the curve where profits are greatest is called the maximum economic yield (MEY).



It is generally agreed that some form of management is necessary to most fisheries. In some fisheries there is a case to be made for having no management at all. In penaeid prawn fisheries, for example, there has been no convincing evidence that over-fishing will biologically affect the stock (this effect is associated with the species' high growth rate and fecundity as previously discussed). In such fisheries, however, uncontrolled fishing may result in the resource being shared by so many fishermen that no-one makes a profit. This introduces the idea of management on an economic rather than a biological basis.

The objectives of fisheries management are usually either to restrict fishing effort (i.e. to some acceptable point on the yield curve) or to conserve selected parts of the population (either spawning females or small individuals). These objectives are usually accomplished by the types of regulations discussed below.

(a) Limiting the efficiency of fishing gear

These may range from restrictions on the length of net or the numbers of hooks used, to limiting boat length or engine power. Limitations on gear may allow the resource to be used by a large number of fishermen. Adverse effects may be associated with restrictions which, in effect, force "a man to work with one arm tied behind his back". In some cases, we have the incongruity of gear technologists developing highly efficient fishing gear while fisheries managers are attempting to restrict efficiency in the interest of conservation.

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(b) Catch quotas

Catch quotas may be applied on a individual fisherman basis, or a total fishery basis. Problems include the high level of policing required and the fact that boats must work on alternative fisheries or lie idle once the quota has been reached. For these reasons, catch quotas seem most applicable to amateur fishermen.

(c) Limiting the number of fishing units

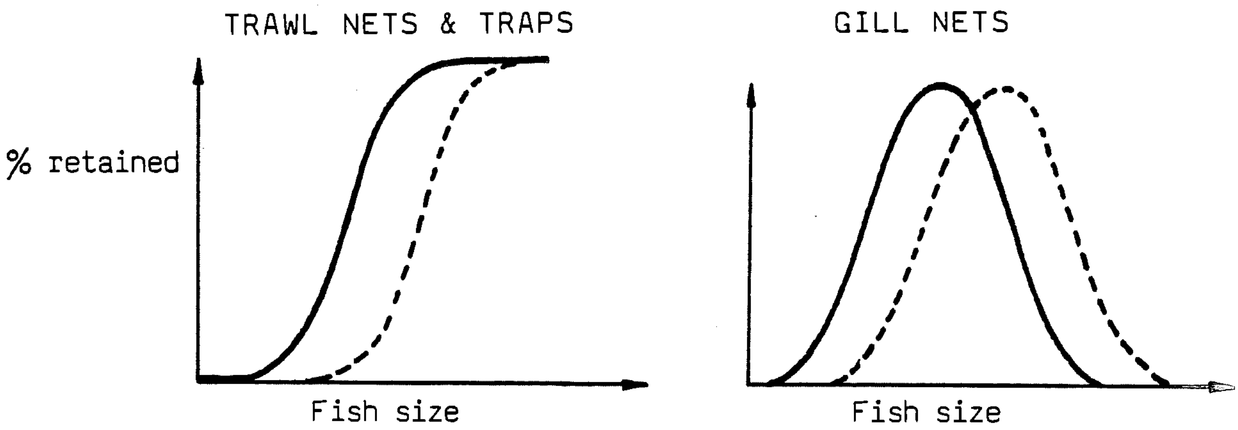
Licence limitations, as opposed to a free entry system has been introduced in many Australian fisheries. Problems include the methods of selection of licence holders and, in the case of highly profitable fisheries, the jealousy of fishermen outside the fishery.

Where licence limitation restricts fishing effort to an area where profits are maximised (see MEY in the previous figure), the profit itself becomes a problem. Large profits may be made be licence holders by virtue of fishing authorities limiting entry into the fishery. In such cases, large licence fees may be collected and diverted to other areas of fishery development.

(d) Minimum gear sizes

Minimum mesh sizes are applied to many trawl and trap fisheries. In the case of trawl fisheries in particular, there is much debate on aspects such as the survival of small individuals passing through the meshes.

The method relies on having information on the selectivity of various fishing gears. Mesh selectivity curves for different gear are shown below.



(e) Minimum sizes

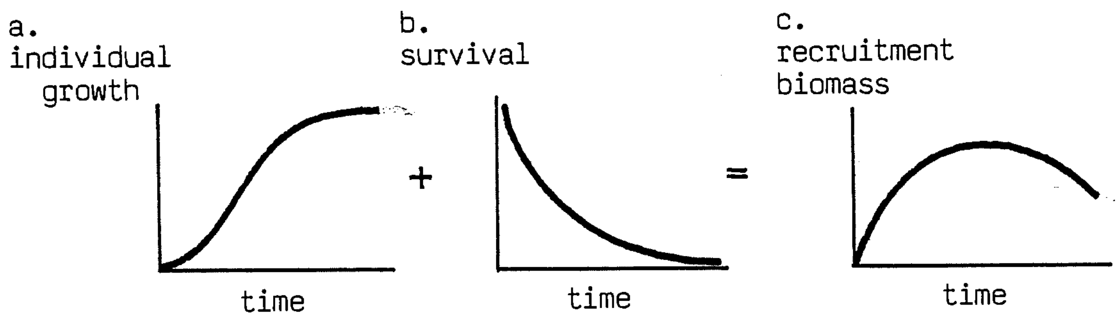
Rejecting or "throwing back" marine organisms below a certain legal size may have application in certain fisheries (e.g. trap fisheries) where individuals are not harmed by the catching method.

(f) Protection of females

Protection of females, particularly during spawning seasons is one method of conservation which is widely favoured, usually on anthropomorphic grounds, by fishermen. In fast growing species with a high fecundity, however, there may be no value in protecting females (see previous discussion). 156

(g) Closed seasons

If the period of recruitment is short and well defined, closed seasons may allow small individuals to grow to a more marketable size. In addition, the total biomass of the particular recruitment may be increased, depending on natural mortality rates.



The total biomass (graph c) changes over time in relation to individual growth (curve a) and survival (curve b).

(h) Closed areas

Banning fishing in particular areas can be used to protect juveniles where these exist in well defined nursery areas. Shallow water mangrove areas, for example, are known to be nursery areas for many important commercial species.

One of the important results of biological studies over the past decade has been the introduction of legislation to protect mangrove areas from developers and town councils wishing to use such areas as rubbish dumps.

The role of biologists in providing advice to fisheries managers is often poorly understood by the fishing industry. Much of the blame lies with the scientists themselves who are unwilling or unable to communicate with people in the industry. Agricultural scientists do much better in communicating with farmers - they call a spade a spade not a hand-held horticultural implement. Their research work is better directed to industry requirements and research results are made known to the industry. It is unfortunate that the same situation does not exist in the fishing industry.

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THE NSW TRAWL GEAR MEASURING PROGRAM

Mr Terry Gorman - Senior Biologist, and

Mr Ken Graham, Biologist

FRV "Kapala",

NSW State Fisheries

1. Introduction

The F.R.V. "KAPALA's" underwater gear observation and measurement programme was begun in 1977 in response to our own need to determine how the fishing gear used in our surveys looked and behaved in action.

Many fishermen have shown an interest in the work we have carried out. We anticipated a significant involvement with them and their trawl gear, but surprisingly efforts to enlist their co-operation to observe or measure their trawl gear in action has met with very little response. There has been no response from other government institutions.

2. Methods

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The two principal methods used were:

- Direct observation and measurement by divers using SCUBA gear;
- Electronic measurement using a trawl instrumentation system (TIS).

Recently we were able to carry out some trials with a Remotely Operated Vehicle (ROV).

2.1 SCUBA Observation

All our underwater observations were carried out in three to five fathoms along the western shore of Jervis Bay. The water is calm and the available light and thus underwater visibility is generally fair to good. The bottom is composed of clean sand and the particles are large so that they do not remain suspended in the water for very long after being disturbed by the passage of the trawl. Repeated trawling therefore has very little effect on underwater visibility.

After the trawl has been shot, and the towing speed established, at least two divers enter the water from an outboard-powered inflatable dinghy directly astern of "KAPALA". The divers descend towards the sea bed using the trawl warps as a guide and wait for the trawl doors and/or net to come into view.

(i) Headline Height: This is measured by using a weighted line. A diver moves into position close to the centre line of the approaching net with the weight just resting on the bottom and the line held taught vertically. The diver simply marks with a knot the point on the line where it is struck by the headline. Measurement to the knot is made after reboarding "KAPALA".

(ii) Wing Spread: After measuring the headline, the divers surface and signal to the "KAPALA" to stop. The brakes on the winch are released and the doors and net stop in the same configuration as when under tow. The headline, and netting (if the netting of the trawl is polyethylene), float upwards from the sea bed. Lower wing spread is measured by tying one end of the measuring line to one wing and swimming the line to the other wing. The distance is again marked by a knot.

(iii) Trawl Door Spread: A trawl float is secured by a short line to each trawl door to mark its position. When "KAPALA" stops, the doors collapse and the floats surface. Divers are collected by the inflatable and taken to one of the marker buoys. The divers then stretch the measuring line between the two doors across the sea bed.

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(iv) Observations: General observations and photography were carried out by the divers as the gear approached or when hanging on to a suitable part of the headline. At three knots, the water resistance is formidable and the purging valve on the breathing apparatus may be opened causing considerable loss of air. Still camera work, particularly with a Nikonos II camera fitted with a 15 mm wide angle "fish-eye" lens, proved to be very satisfactory using both fast black and white and colour film. Available light must be good as the use of a flash results in light being reflected back from suspended matter which obscures the object being photographed.

Super 8 movie cameras had only limited value because neither their films nor their lenses provided sufficient depth of field or field of view. They were most useful in photographing slow-moving objects such as dredges. However, since they are small and easy to handle they can provide useful footage for study, but the film has limited public viewing potential unless it is transferred to video tape.

(v) Advantages and Disadvantages: The value of diving is the ability to directly observe and photograph the gear in action. An experienced diver can move freely about the net and make a mental and photographic record of events. However, because the measuring process is very slow and laborious, it is logistically difficult to carry out a series of measurements over a range of speeds. Recently, hand held underwater distance measuring units developed for the oil industry have been successfully used overseas for this purpose and it is our intention to acquire a unit for trial in the near future.

2.2 The Trawl Instrumentation System

This equipment was manufactured by the White Fish Authority of the U.K. and was purchased with a grant from the Fishing Industry Research Trust Account. It consists of two separate instrument packages:

(i) Net Height/Wing Spread System: This comprises a headline transducer and switching unit connected by a cable to an inward-facing transducer secured to each wing-end. A standard netsonde cable carries the signals of either headline height or wing spread to the display unit on the vessel. The cable is carried on a self-tensioning winch.

(ii) Door Spread System: This consists of two separate units: a transducer (incorporating a chart recorder) and a transponder, both encased in identical pressure housings. Each unit is mounted in a floatation jacket and is connected to the trawl warp by means of a running shackle just ahead of the trawl door. Both units are switched on before being secured to the warp. The chart recorder continuously logs door spread and a timing mark is recorded on the chart for event correlation. Unfortunately, these units never worked satisfactorily and, at the suggestion of the Sea Fish Industry Authority, (which superseded the W.F.A) a system using a wing-end transducer was subsequently developed for door spread measurement. The transducer was secured to one warp in the manner described above and a suitable target in the form of trawl floats, secured to the other warp. The wing-end transducer was directly coupled to the cable from the self-tensioning winch and the door spread recorded on the chart recorder on "KAPALA".

(iii) Rigging the TIS: The headline of the net to be measured is marked at 1 m intervals with a marker pen. The connecting cables (heavily armoured) are then secured to the headline with heavy duty plastic electrical cable ties. To provide slack, the cable is secured at 1.2 m intervals to the 1 m marks on the headline.

Four additional 203 mm trawl floats are secured to the headline to compensate for the weight of the cable. A small net pocket is braided into the centre of the headline to hold the headline transducer and switching unit. All connections are made using standard underwater connectors.

During the period the net is being rigged with the T.I.S., the principal dimensions and design of the net are noted. The whole rigging and measuring procedure can take several hours.

The net is then stowed on"KAPALA's" net drum ready for the trials. When shooting and hauling, the transducers are connected and disconnected readily. The armoured cable has proved to be immune to damage on the net drum.

(iv) Trial Procedure: Measurements of each net are taken over a range of speeds and often with varying warp lengths. Ground speed is estimated by satellite navigator and/or radar, and two trawls in opposite directions are usually made with each net to identify any effect of current.

The TIS is designed to transmit the headline height and wingspread measurements separately, but recently the switching unit has developed a fault and we are now receiving both together. This has certain advantages provided the separate recordings can be identified by following the bottom signal as the gear descends to the sea bed. Since one signal is quite distinct from the other, this fault has not really caused any problems.

A full trial over a satisfactory range of speeds and with different warp lengths can be conducted within one day.

(v) Advantages and Disadvantages: The wing-end transducer units have twice suffered from water penetration and have had to be replaced. There is also the switching problem referred to above. The underwater connectors can pull out readily unless firmly secured with cable connectors. The original inter-unit connecting cables were very prone to damage and had to be replaced by the heavy armoured ones referred to above.

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The units are tested during rigging and immediately before shooting away. The transmission signal is quite audible so checking is easy. The gear enables a large number of readings to be taken readily over a wide range of speeds and is much more suitable for this purpose than divers.

2.3 Remote Operated Vehicle

Trials were held in April 1984 with the ROV "DART". This submersible is fitted with thrusters for lateral, vertical, astern and ahead movement. It has a depth sensor, an underwater television camera and lights and can also carry a 35 mm still camera with a strobe flash. It is controlled via a thick umbilical cord connected to the parent vessel. The television monitors, remote focussing, tape recorder and control position are located in a single console.

For these trials the trawl net was towed in midwater at about 10 fathoms and the headline was connected to "KAPALA" by the netsonde cable on the self-tensioning winch. After gear was at its selected depth the ROV was attached to the cable via a forward and aft bridle to provide stability. The forward bridle was secured to the cable via a snatch block and the after one to a running shackle. The unit was allowed to run freely down the cable to the net.

The thrusters were not powerful enough to change the attitude of the R.O.V. under tow, but the remote control pan and scan facility on the camera was adequate to permit good coverage of the net, particularly when it was hauled up the self-tensioning winch cable to increase the camera's field of view.

Advantages and Disadvantages: The unit we tested was more sophisticated than necessary for this particular application. The only thrusters of any use in this mode were the ones required to drive the ROV down the cable. The umbilical cable is heavy and was handled manually. In most ROV applications this is handled by a separate self-tensioning winch.

The ROV "DART" has to be sent down the cable to a fixed point on the net or trawl door for observation purposes. Therefore it is not as versatile as a diver. However its ability to record high quality pictures using either video or 35 mm still film is excellent. In particular, the low light TV camera facility is important, as often the camera is able to see more clearly than a diver in conditions of poor visibility.

This particular ROV was provided with power by a large deck-mounted generator, but in a custom built unit this would probably be provided by the ship. Additional trials are planned in the near future to further assess the effectiveness of the ROV "DART" with the trawl gear on the bottom. 150

3.0 Results

Some examples of work carried out are described below.

3.1 Faults in Fish Trawl Net Design

(i) 21 m Headline MARA II Trawl: This net was used during our original deep water trawl-fish survey work. It was a small robust net suitable for hard bottom use and it was rigged with 305 mm diameter bobbins in the bosom and 152 mm of rubber discs in the wings. This net suffered repeatedly from damage near the junction of the lower wing and side panel.

Underwater observation by divers showed clearly that this was caused by the lower wing panels being tapered equally on both selvedges. The bunt bobbins at this point were trying to follow a curved line around the bosom but there was insufficient netting in the parallel sides of this panel to allow this to occur without causing undue stress. Not only did this damage the netting, but it also tended to lift the bobbins below this netting clear of the sea bed. This problem was solved by creasing the meshes on the upper (or outer) selvedge at the rate of 1:5 to increase the width of the lower wing to 50 meshes. However, a major design improvement could have been effected by creasing the whole selvedge and also by increasing the width of the side panels to match this change.

The upper and lower quarters also gave trouble. The usual remedy is simply to reinforce these points (by doubling) to prevent breakages. However, since the headrope and footrope at this point naturally try to form a curve, it seemed more logical to braid shaped quarter panels into these areas to help the formation of a natural curve. This modification was also successful.

(ii) 21 m Headline Boris Box Trawl: This net was manufactured by Boris Networks of the United Kingdom. It is a small robust net with a headline opening of about two m. We adopted it as a standard net for preliminary reconnaissance work instead of the more complex MARA II. It fished well and was rigged with a variety of footropes depending on the bottom. Two nets were generally carried on the net drum. One was rigged with bobbins and the other with bobbin spacers. If the net with bobbin spacers was damaged by hard bottom, then the bobbin net was shot away instead.

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Our diver observations showed that a bulge formed at the sides of the net, at the junction of the square and the baitings. We largely eliminated this by increasing the length of the side panels. We also suggested to Boris Networks that the design could probably be improved further by redesigning the square to a single tapered panel, thus eliminating the large step between the 4.5" (114 mm) mesh section and the 3.5" (89 mm) mesh section.

One net was rigged with a triple bridle to enable the gear to be fished on "catchy" bottom. The principle is to keep the lower wing clear of the seabed by letting it go from the footrope and then adjusting bouyancy of the net so that it bounces lightly over the bottom. Catches were reasonable but underwater observations showed a very large escape gap between the lower wing and the footrope, and because the lower wing was slightly longer than the footrope it tended to hang back. The rig was successfully modified by shortening the centre bridle and re-securing some of the bosom toggles to the lower wing. This relieved the strain on the footrope and reduced the escape gap considerably. Ideally bull nosed bobbins on larger discs should be rigged between the toggles or the lower wing when working rough bottom.

(iii) <u>56 m Headline Engel Balloon Trawl</u>: These nets were procured because we had a requirement for a high opening light weight trawl capable of working rougher bottom.

The footrope was rigged with 305 mm diameter discs, and the netting was large mesh nylon twine. The catch rates in our preliminary trials were very low and it was obvious that the footrope was fishing well clear of the bottom.

Underwater observations by divers in Jervis Bay showed that with the extension chain in the lower leg fully shortened, the centre of the footrope was at least two m clear of the bottom. By removing 20 of the 54 floats, the discs in the centre of the bosom just skimmed the bottom. With the extension chain at the full length of 2 m, good contact was achieved along the whole footrope. Subsequent fishing showed, however, that we had removed too many headline floats and the light netting on the belly suffered badly from abrasion damage caused by prolonged contact with the sea bed. As a result of further underwater observations the number of floats was increased to 48.

3.2 Faults in Australian Prawn Trawls

A number of nets of popular designs have been observed in action underwater. Most of these nets are very simple in design and are extremely economical in their use of netting. However, several major design faults were apparent, and an example is described below.

Seibenhausen Prawn Trawl ("Stevenhauser"): This is probably the most popular design used in N.S.W. The upper and lower bellies are formed by panels cut on the bar, which, while simple to make, result in a very acute taper. Our underwater observations showed that this resulted in a marked constriction between the upper and lower bellies and the codend, trapping many fish at this point. Since it is common practice to make a step-down reduction of 50 meshes into the codend at this point, this constriction would be even more marked in many nets. 148

High stress points were clearly evident where the upper and lower bellies joined the wings, because the design does not provide for an easy radius at this point to ease strain on the meshes.

The net was stretched very tightly between the doors and the footrope was observed to lightly skim over the sea bed. Because the net is stretched so tightly between the comparatively large trawl doors, the headline does not rise to form the normal arc associated with fish trawls, but is rather flat. These nets are commonly used without floats, or perhaps with only one, and we noted that when fished this way the headline was at about the same height as the trawl door.

When each bar mesh was included in the hangings or staplings no distortion was evident in the meshes forming the leading edge of the upper and lower bellies. However, an obvious design improvement, at the cost of more netting, would be to redesign the upper and lower bellies to hang on full meshes in the more conventional manner.

3.3 Trawl Doors

Observations on trawl doors have been carried out as a routine matter since the programme commenced. These have included Vee doors, Polyvalent doors and conventional flat wooden doors. Unlike trawl nets, trawl doors behave much as expected. However, one noticeable feature was the marked difference in the degree of turbulence caused by the passage of Vee and flat doors compared to the Polyvalent ones. The sand cloud generated by the Vee doors, by contrast created minimal disturbance.

We were also able to observe the Vee door's inherent ability to resume a normal towing attitude after having been deliberately collapsed. Because their natural attitude in action is to heel inwards, they are inclined to fall on their pressure face. When towing is resumed they gradually regain their normal position assisted by the inclined upper section of the door.

3.4 Measurements of Gear Spread Towing Resistance and Trawl Door Spread Using the T.I.S. Equipment.

The "KAPALA" is fitted with a dynamic warp load system and it is possible to measure loads during hauling, towing and shooting. During trawling most fishermen have a more than casual interest in the towing load of their gear as many would like to be in a position to assess for themselves the various claims advanced by net and trawl door manufacturers regarding the relative merits of their particular designs. Surprisingly, warp load systems are still only rarely fitted and therefore few fishermen know very much about the comparative performances of the various types of gear they use. (47)

We have carried out some comparative trials on our own gear as well as on equipment used by some N.S.W. fishermen.

(i) <u>56 m Headline Engel Balloon Trawl with Vee Doors and Polyvalent Doors:</u> It is important to note that our divers were able to measure only the spread of the footrope, whereas the T.I.S. gear measures the spread of the headline. There can be quite a difference depending on the net design, but it is probably constant for any particular net.

Comparative trials were carried out using 2.5 m Vee doors and 2.4 m Polyvalent doors. These doors are similar in weight but the Vee doors have 34% more surface area. The larger Vee doors increased the wing spread by between 10-15%, which confirmed earlier measurements made underwater by divers. Surprisingly however, there was very little difference in the total drag of the gear regardless of which set of doors was being used.

During one set of trials, it was found that although the wing spread using the Polyvalent doors was less than with the Vee doors, the headline height was also less. Quite by accident we found out that this was almost certainly caused by excess cable being accidentally paid off the self tensioning winch. It is therefore most important to ensure that the tension setting on this winch is properly adjusted to the required duty.

(ii) 38 m Belbara Trawl: This general purpose 4 seam net was loaned to "KAPALA" by Neil Kelly the owner/skipper of the Eden trawler "BELBARA". It features a large mesh lower bosom panel to allow rubbish to fall through. The wings were very deep but it is clear from the design that the net is unable to take full advantage of this feature.

The trials showed that both wing spread and headline height decreased with towing speed. This behaviour is not widely appreciated by fishermen, many of whom believe that net spread normally increases with towing speed.

(iii) 42 m Headline Frank and Bryce Wing Trawl Towed with 2.35 m Poly-Ice Doors and 2.3 m Vee Doors: The Frank and Bryce wing trawl is a New Zealand designed net which was loaned by Paul Pota the owner/skipper of the Eden trawler "VENDETTA". At the time of the trials about 15 Eden boats were using nets of this design. The Poly - Ice doors, manufactured in Iceland, were introduced to N.S.W. fishermen

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by Paul Einarsson of South Coast Nets and were being used by about 10 Eden trawlers. The Poly-Ice doors resemble the French-made Polyvalent design. The set tested measured 2.35 x 1.45 m (2.6 sq.m) and weighed 450 kg; they were very similar to the polyvalent trawl doors used by "KAPALA".

The net was towed with 180 m sweeps and 33 m bridles of combination rope, and when it was first shot away with the Poly-Ice doors in 31 - 36 fathoms we noted wide fluctuations in wing spread and warp loading. Believing that this was being caused by unstable doors we adjusted them to a finer setting and shot away again. It soon became apparent however that the fluctuations were being caused by the very long sweeps digging into the rather soft bottom at this depth, and then breaking free. The test was repeated with Vee doors with similar results.

A comparison between the warp loads for the two types of doors indicated that the Poly - Ice doors required less power in tow than the Vee doors. However, wing spread and headline height were very similar. In this instance both the wing spread and headline height were similar for both sets of doors and varied only slightly with speed.

(iv) <u>36 m Einarsson Trawl</u>: This is a high-opening trawl designed and constructed by the Eden net maker Paul Einarsson and is intended for use on catchy bottom. The net was rigged with 64 x 203 mm floats to fish lightly on the sea bed, and trials were conducted using the Poly-Ice doors; the warp lengths were either 150 or 200 fathoms.

Interestingly, the warp loads were slightly higher using the shorter towing warps and there was a slight decrease in wing spread. At speeds of 2 knots the doors tended to collapse with a consequent sharp decrease in wing spread and increase in headline height.

3.5 Trawl Door Spread

So far our only successful measurements have been made in Jervis Bay, in 10-14 fathoms. Tests in the open sea have so far not been successful.

The target array and position was varied but no change was apparent in the signal from the target. Work on improving this system is continuing.

Boris Box and Kapala Prawn Trawl Net Using 1.8 m Vee Doors: The measurements were made using either 50 or 100 fathoms of warp over a range of speeds. With the Boris box net the door spread using 100 fathoms of warp was substantially greater than with 50 fathoms, but the total variation with speed was low. The door spread increased with speed until the drag of the net overcame the spreading power of the doors.

The prawn trawl was fished with 53 m bridles, so predictably, the door spread was much less than for the Boris box net. The spread using 100 fathoms of warp was once again greater than when using 50 fathoms but when using either length of warp the variation was less than 2 m.

4.0 Publications

Full details of all of the results of the underwater observations carried out during the programme have been published in "KAPALA" Cruise Reports Nos. 41, 49, 50, 56, 62, 65, 73, 76, 80, 84 and 87.

Acknowledgements

Grants from the Fishing Industry Research Trust Account provided the necessary funds to purchase some of the trawl gear and the T.I.S. equipment described in this paper.

The photographs were taken by J. Matthews of the Division of Fisheries, and many other Division divers assisted in gathering this information to whom we are grateful.

LIST OF FIGURES AND LEGENDS

1. Divers observing the approach of the Mara trawl II. Small stingrays are swimming away from the approaching footrope. The headine forms the typical high arc found in fish trawls.

2. Divers measuring the headline height of a prawn trawl note that the headline is comparatively flat.

3. Divers hitching a ride on a Mara II trawl. The water pressure on the diving gear has operated the purging valves causing loss of air. Note that the divers do not disturb the configuration of the net.

4. The wingend and headline (centre) units of the Trawl Instrumentation system (T.I.S.) showing the transducer faces and connecting cables. These cables were subsequently replaced with armoured ones.

5. Schematic configuration of T.I.S. system on a trawl net.

6. Mara II trawl net plan, modification to lower wing are shown by dotted lines.

7. Damaged area of Mara II trawl showing bobbins lifting off sea bed broken lastridge and tearing was caused by poor design.

8. Boris Box net showing square made from 3 separate panels and large step between 3.5" and 4.5" sections. Modification to side panel to eliminate bulging is shown by dotted line.

9. Diver measuring headline of Boris Box rigged with 3 bridles; large escape gaps were evident on both wings above the footrope. These were subsequently reduced by resecuring a number of toggles.

10. Junction between codend and upper and lower bellies in Seibenhausen prawn trawl showing large numbers of fish trapped in bulges caused by the very sharp taper in the upper and lower bellies.

11. Footrope of Kapala prawn trawls showing spacer bobbins in very light contact with tops of sand ridges on sea bed. The netting is carefully tapered around the quarters to avoid distorted and broken meshes in this area.

12. Typical T.I.S. recording of wingspread and headline height. Chart is marked with each set of data relating to the particular test.

13. T.I.S. recording showing fluctuating wing spread caused by very long sweeps digging into soft bottom and breaking free.

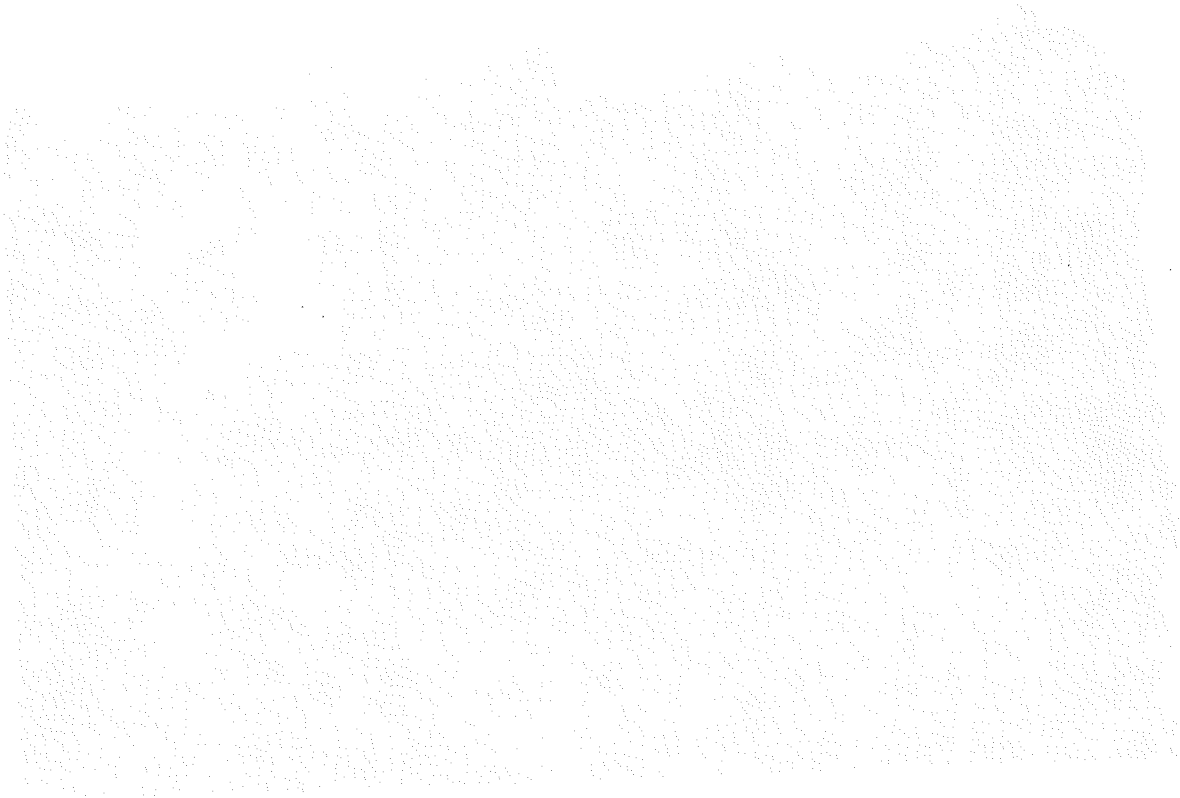
14. Typical graph showing plots of wing spread, headline height and warp tension. These data are from the Belbara net loaned by Neil Kelly the skipper/owner of the Eden Trawler Belbara.

15. 2.4 metre Vee doors travelling at about 3 knots showing the characteristic upward tilt, heel down position, which when coupled with their inward heeling enables them to clear sea bed obstacles or avoid bogging down in soft mud. Note the large cloud of sand disturbed by the passage of the door.

16. 2.4 metre flat prawn trawl door at 2.2 knots. Note the large sand cloud originating from behind the door. These doors were very stable and held the bottom well.

17. Recording of trawl door spread on a Kapala prawn trawl using 50 and 100 fathom warps. The "peaks" in the recording are caused by the doors collapsing when the towing speed is reduced to the point where they loose their sheering power. After collapsing on the seabed, the doors rapidly close on one another, but separate and spread again as speed is increased.

18. Launching the ROV Dart from Kapala note the vertical and lateral thrusters and the bubble protecting the camera. The lights are at each side of the ROV.



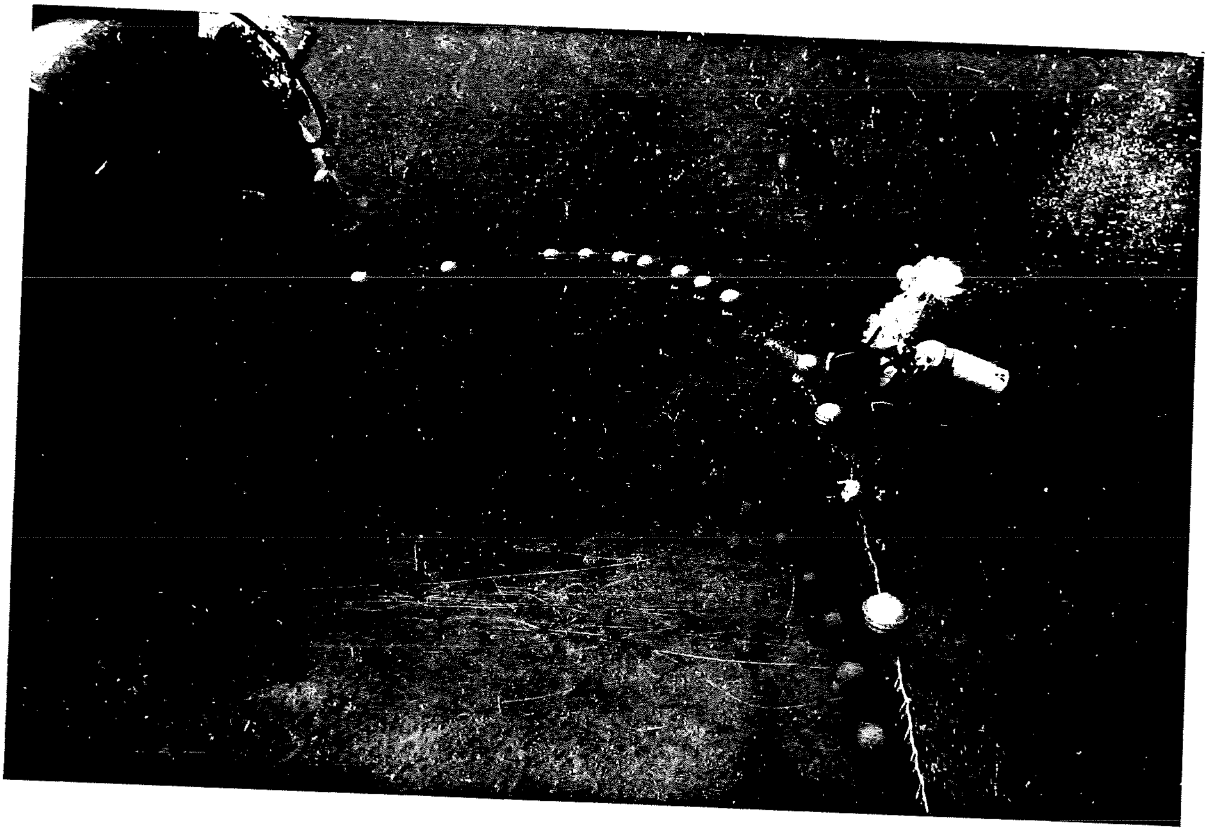


FIGURE 1

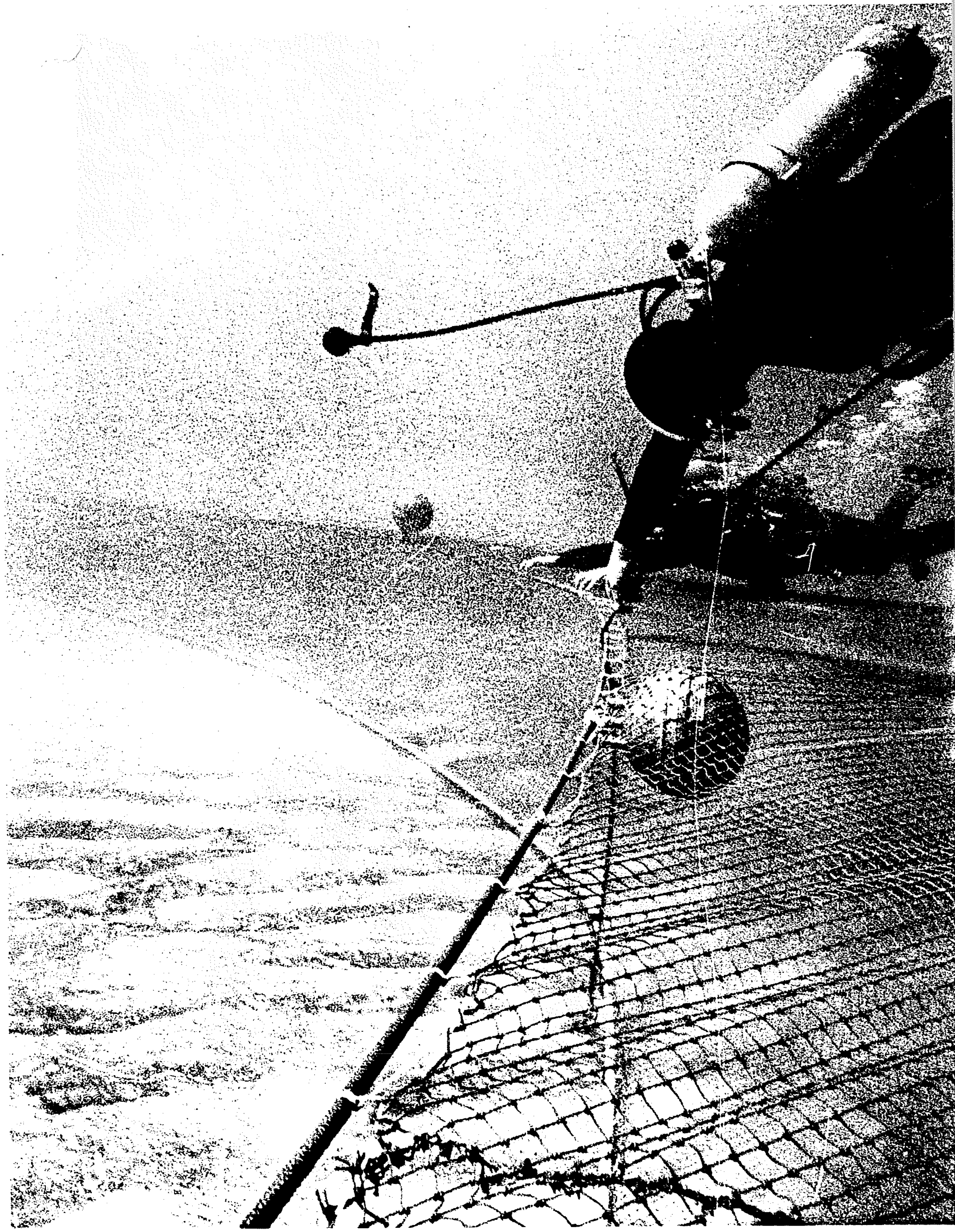


FIGURE 2

FIGURE 3

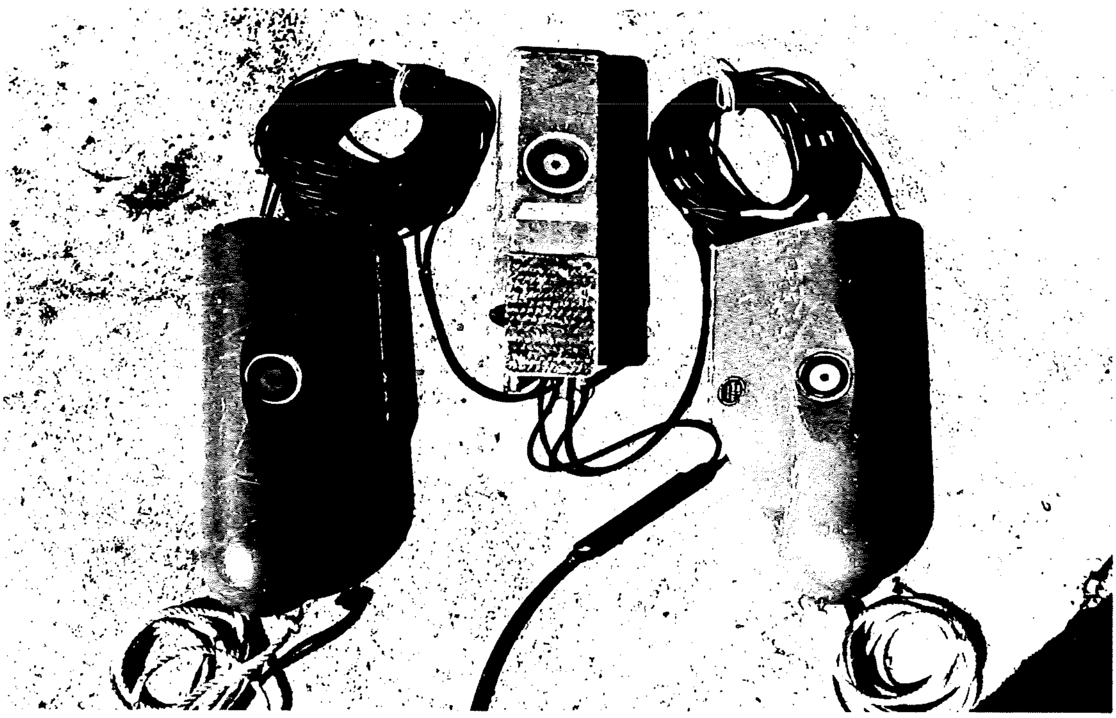


FIGURE 4

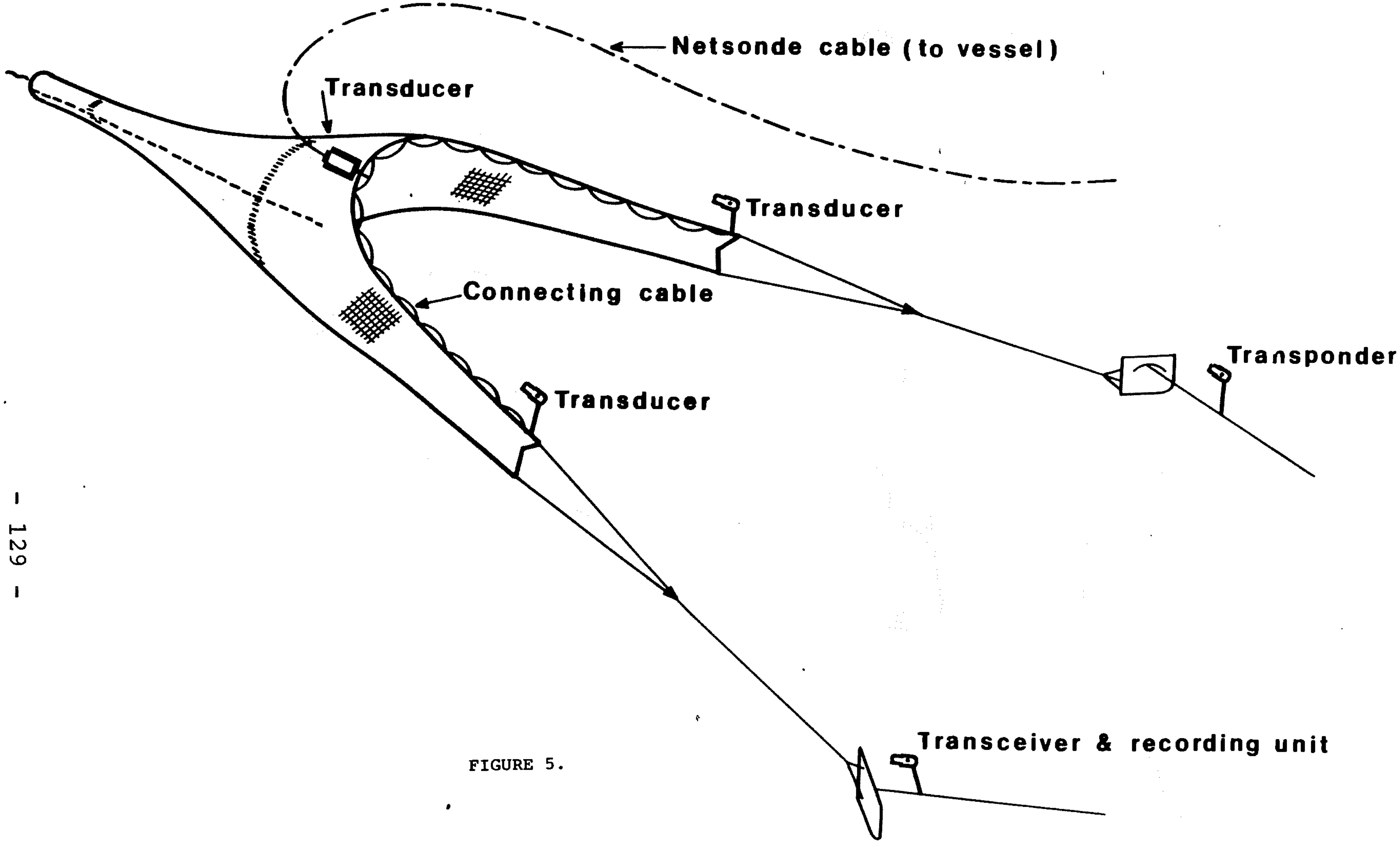

Netsonde cable (to vessel)
Transducer
Transducer
Connecting cable
Transducer
Transponder
Transceiver & recording unit

FIGURE 5.

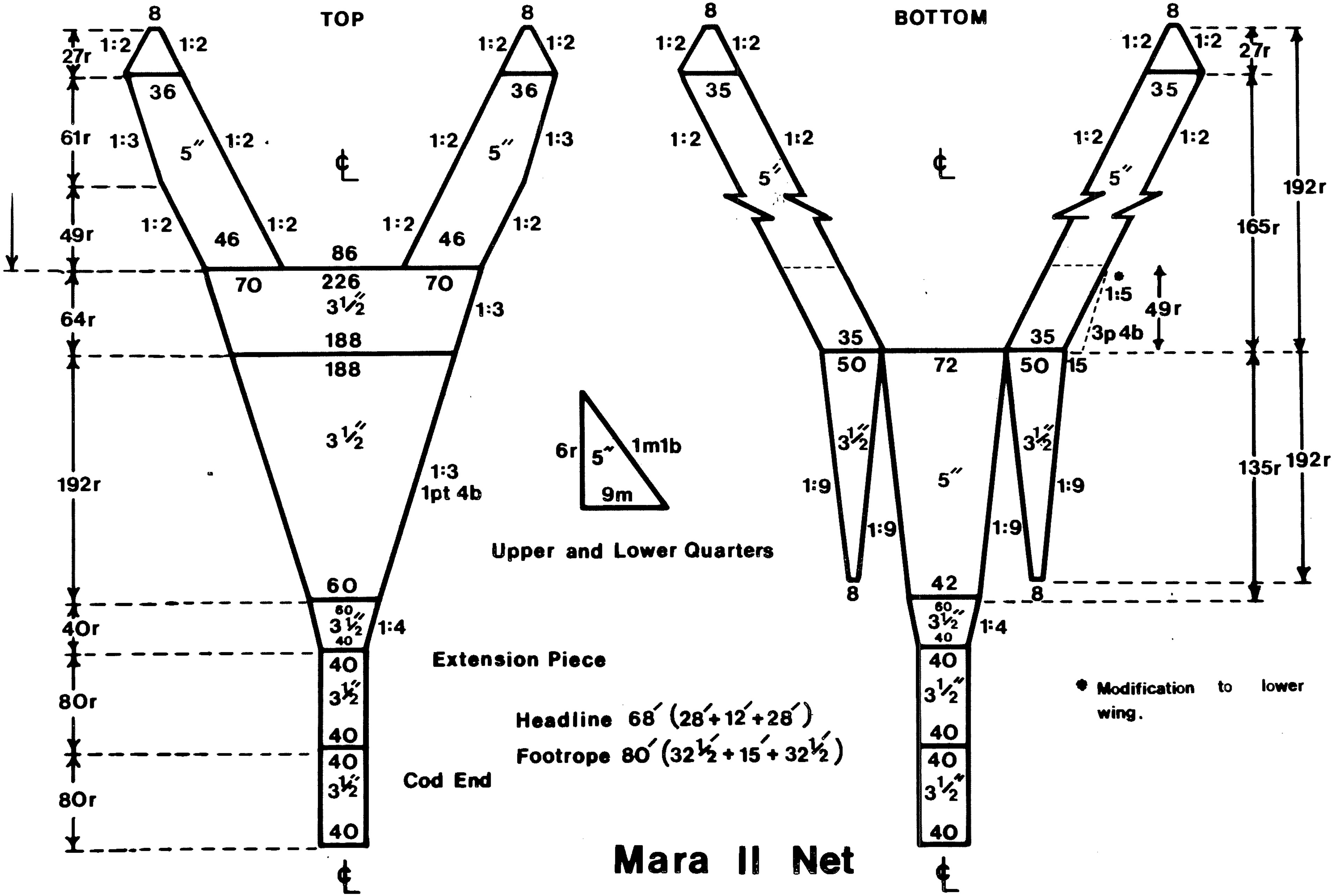

TOP
BOTTOM
Upper and Lower Quarters
Extension Piece
Cod End
Headline 68′ (28′+12′+28′)
Footrope 80′ (32½′+15′+32½′)
* Modification to lower wing.
Mara II Net

FIGURE 6

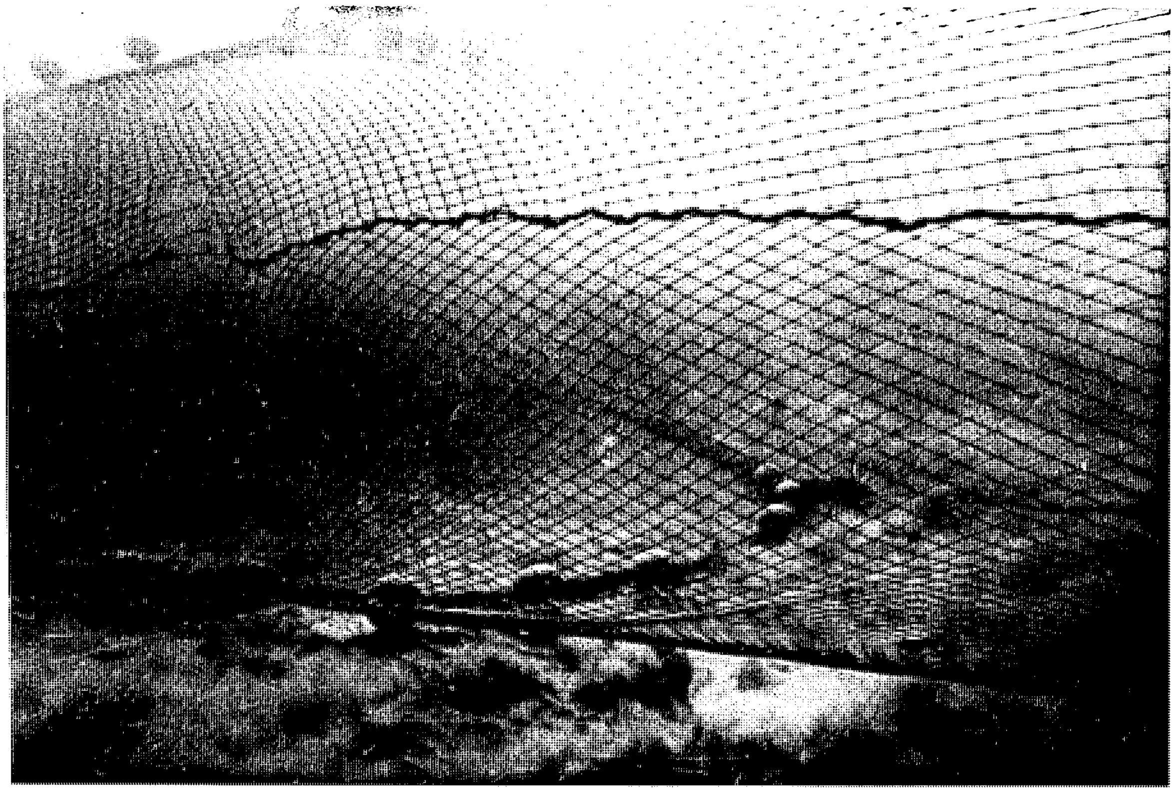
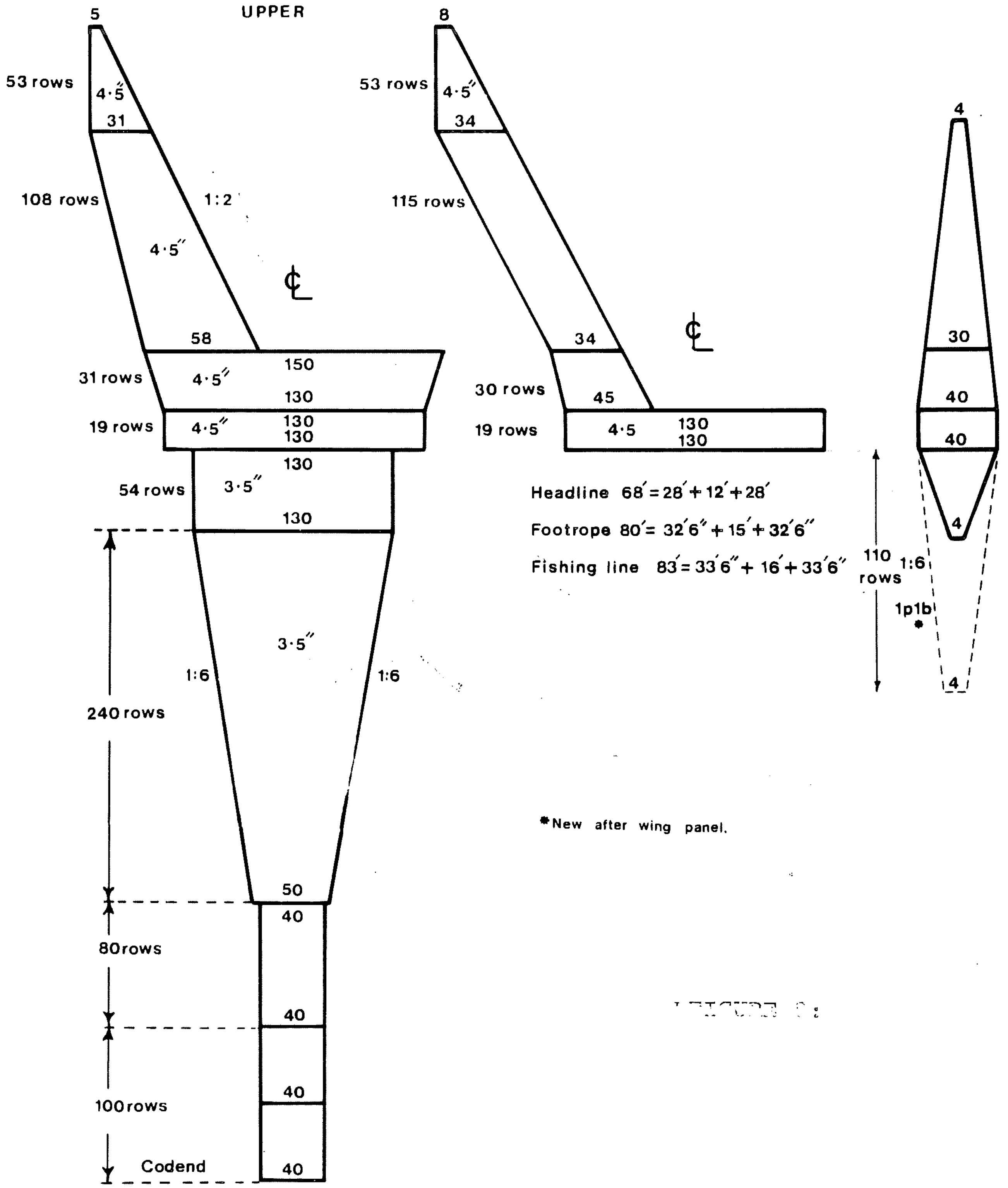


FIGURE 7



UPPER
5
53 rows
4·5"
31
108 rows
1:2
4·5"
58
31 rows
4·5"
150
130
19 rows
4·5"
130
130
130
54 rows
3·5"
130
240 rows
1:6
3·5"
1:6
50
80rows
40
40
40
100rows
Codend
40
8
53 rows
4·5"
34
115 rows
34
30 rows
45
19 rows
4·5
130
130
Headline 68′=28′+12′+28′
Footrope 80′= 32′6″+15′+32′6″
Fishing line 83′=33′6″+16′+33′6″
4
30
40
40
4
110 rows
1:6
1p1b
4
*New after wing panel.

FIGURE 8

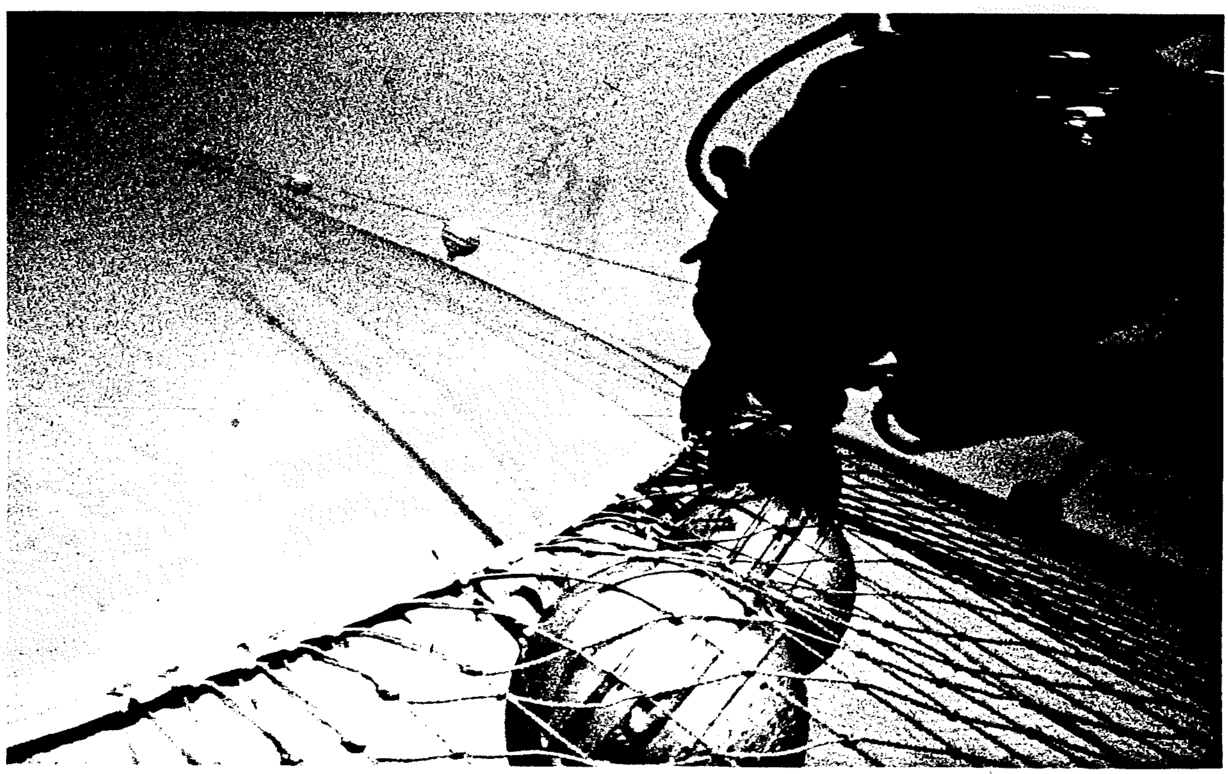


FIGURE 9

FIGURE 10

FIGURE 11

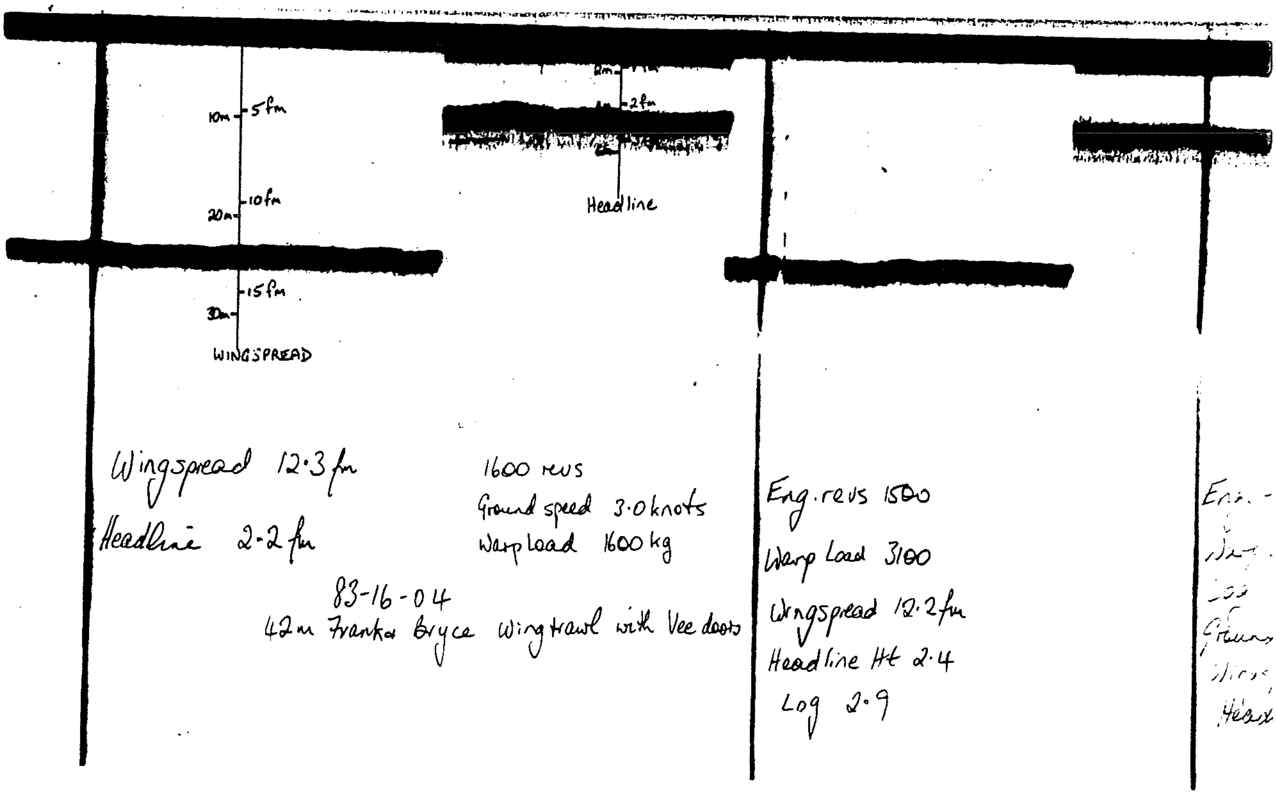


FIGURE 12

13

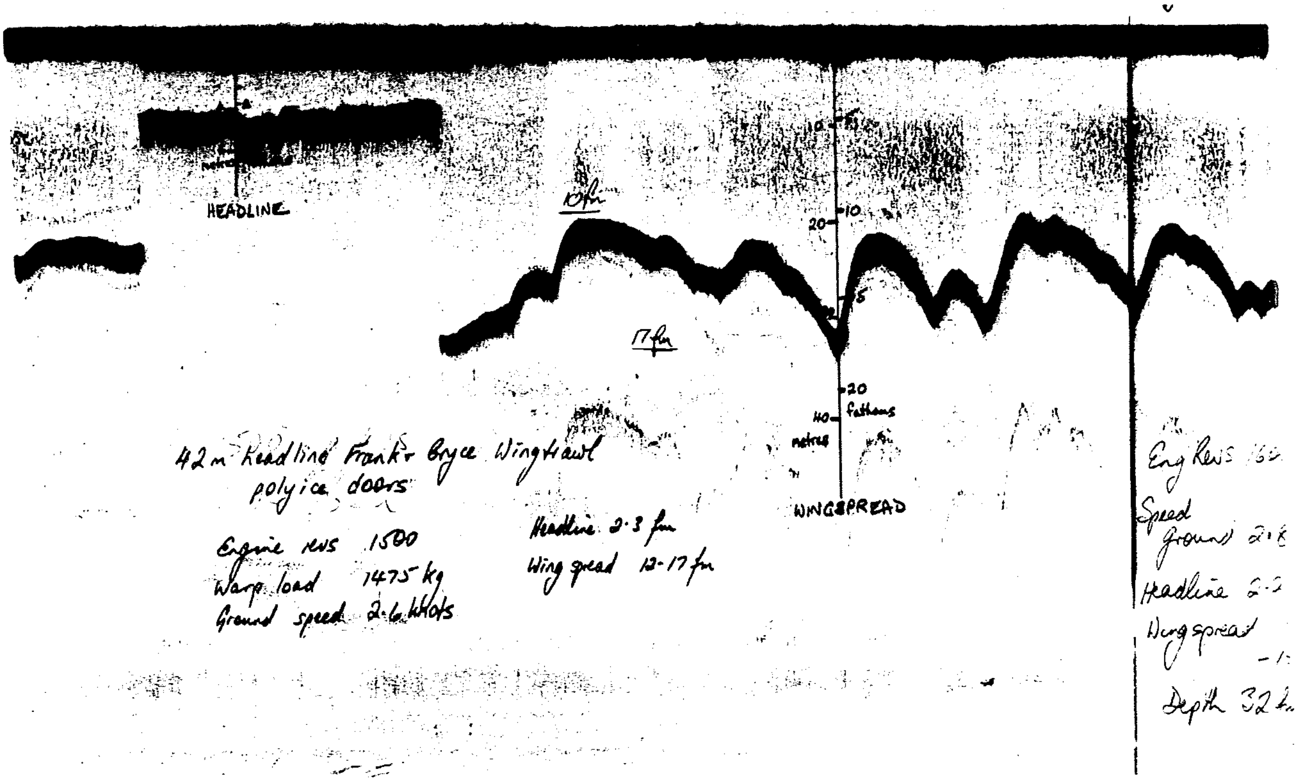

HEADLINE
10 fm
17 fm
20 fathoms
40 metres
WINGSPREAD
42m Headline Frank & Bryce Wingtrawl
polyice doors
Engine revs 1500
Warp load 1475 kg
Ground speed 2.6 knots
Headline 2.3 fm
Wing spread 12-17 fm

FIGURE 13

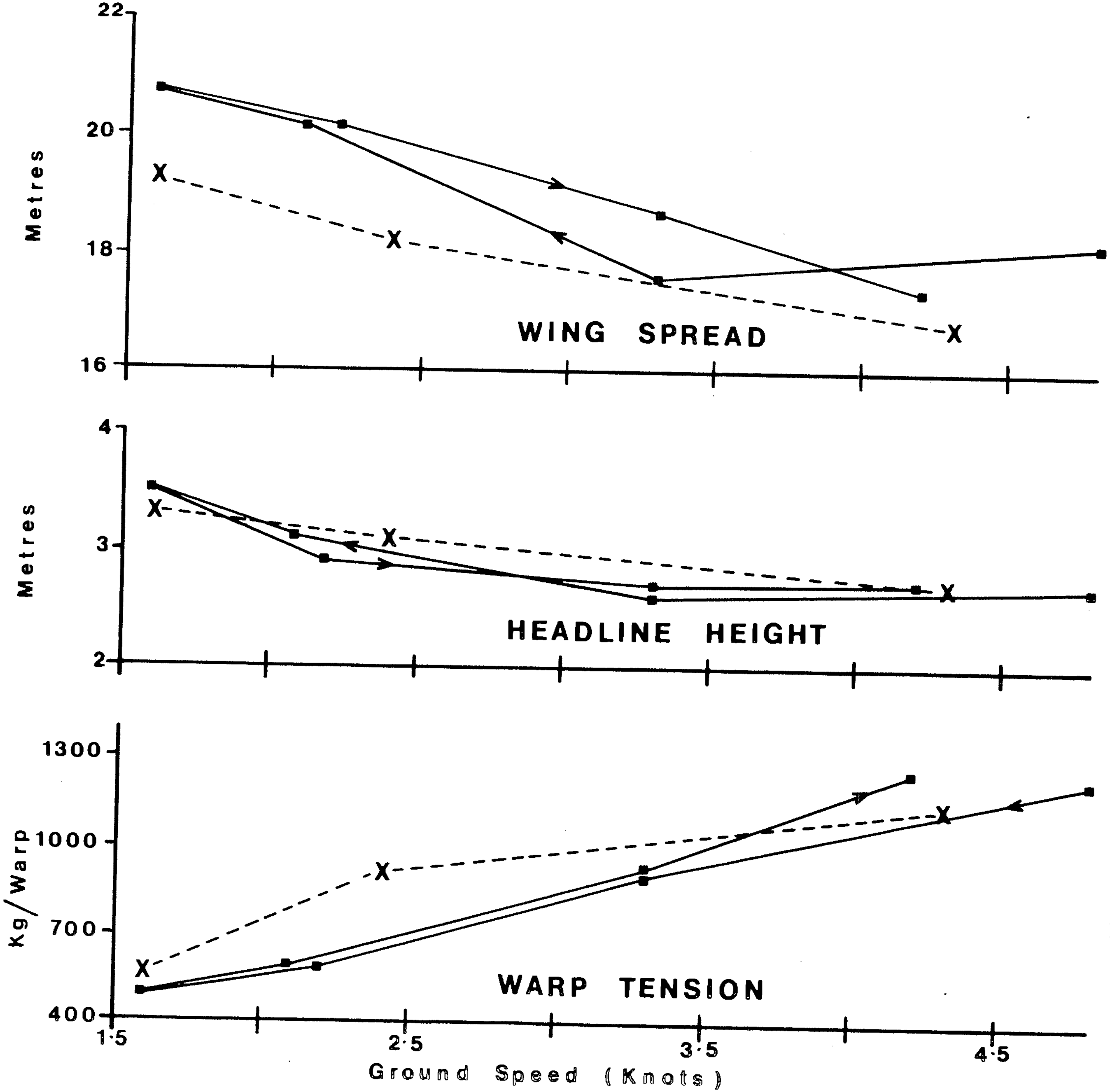

22
20
18
16
Metres
WING SPREAD
4
3
2
Metres
HEADLINE HEIGHT
1300
1000
700
400
Kg/Warp
WARP TENSION
1·5
2·5
3·5
4·5
Ground Speed (Knots)

FIGURE 14:

FIGURE 15

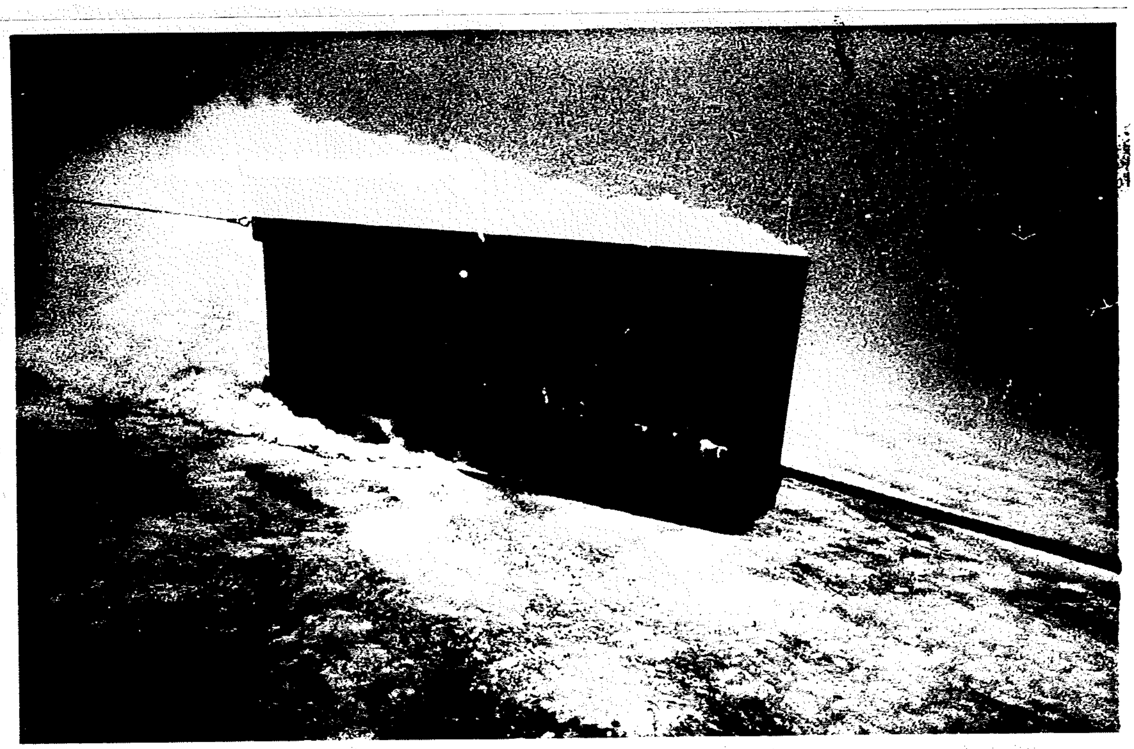


FIGURE 16

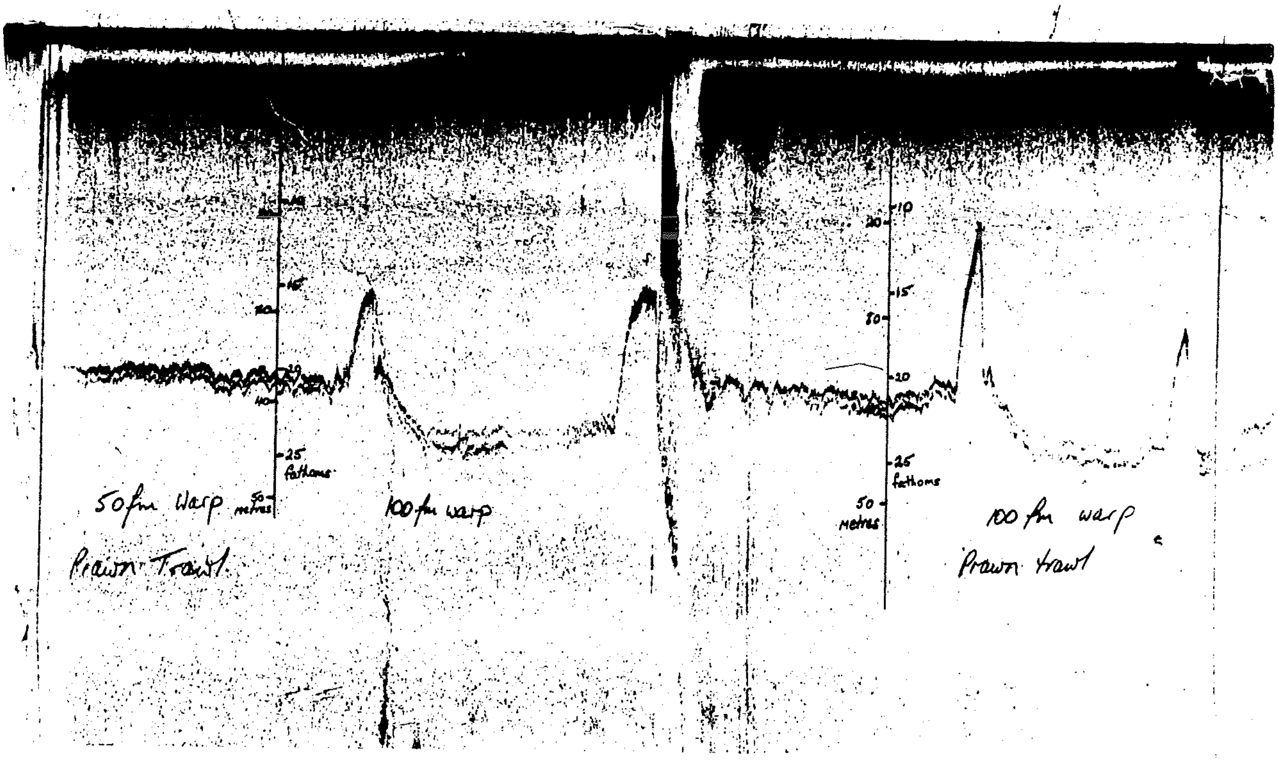


FIGURE 17

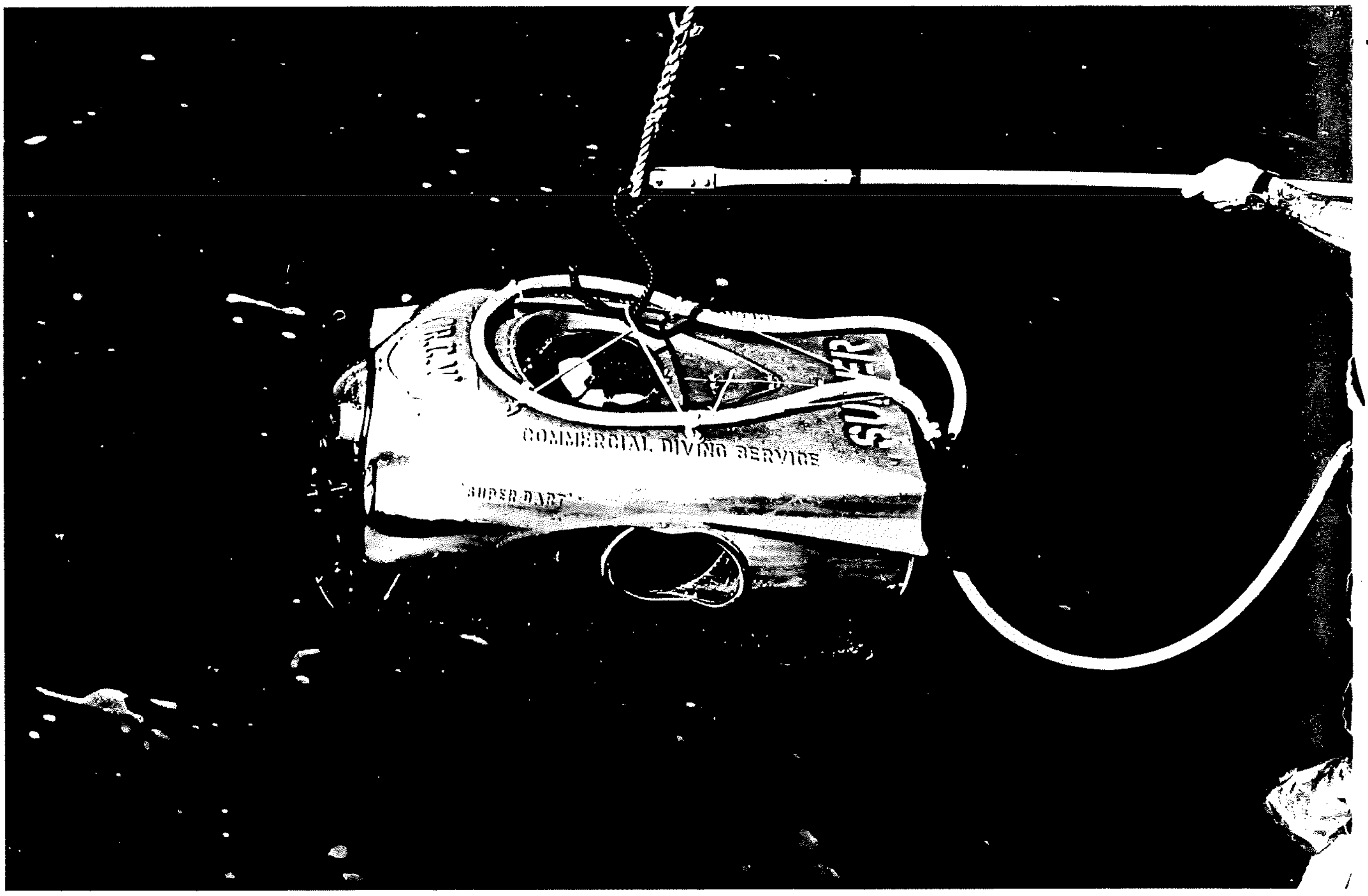


FIGURE 18

DEVELOPMENTS IN PRAWN TRAWLING

Mr Norman Stevens

Net Designer

Townsville

The Northern Prawn Fishery - Changes in Fishing Gear and Methods. 1978+

The northern prawn Fishery extending from Bowen in North Queensland to Broome in Western Australia has seen many technological changes in relation to the electronics used in the location and targeting of the vessels on to schools of prawns (shrimp). But very little has changed with regard to the types of trawl nets used, and the otter boards and the methods used in catching the prawns (shrimp).

The three main types of prawns (shrimp) which are fished for are:

Banana	: Penaeus Merguiensis.
Tiger	: Penaeus Esculentus
	: Penaeus Semisulcatus

Endeavour : Metapaneus Endeavouri

: Metapaneus Ensis

In recent years good catches have been made in Joseph Bonaparte Gulf of a species related to the Banana prawn :Penaeus Indicus.

In the D.M.Z. the banana prawn has traditionally been the main species on which the emphasis of fishing effort has been placed. They have been known to form rather large schools enabling the skippers of the vessels to take catches on average of several tons for a very short duration of trawl. The catching process is repeated several times until either (a) the tonnage caught is sufficient to fill the freezers or (b) the school is either taken up in catch or is spread out over a larger area.

Many vessels having missed the main school have the choice of either leaving the area and trying to locate another large school or to continue fishing with trawls of a much longer duration, hoping to increase their tonnage of prawn (shrimp) by this method. To the operator (skipper) this method is known as scratching.

Up until the 1980/81 season the most common type of net used was the "YANKEE DOODLE" for the taking of banana prawns. The vessels using this style of net in the northern prawn fishery vary in length from 13 m up to 29 m in the

D.M.Z. ("Declared Management Zone").

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The vessels are all twin boom rigged and vary in horsepower from approximately 120 h.p. up to approximately 500 h.p. In the D.M.Z. nearly all vessels engaged in the taking of banana prawns use the common rectangular flat otter board, most with wide keel (shoe), being mainly of timber construction with steel shoe, straps, lugs etc and adjustment lugs for towing chains.

Widely used and the most common are the towing chains (or spiders) which give the operator a wide scope in adjustment on these style of otter boards. The use of this methods gives easy vertical and horizontal adjustment enabling them to alter the angle of attack to suit either fishing for banana prawns or fishing (trawling) for tiger prawns. Most operators graph out their angle of attack in relation to the positioning of the front spider chains and set up the towing chains on the otter boards from this method.

For the taking of banana prawns it is not unusual to find operators using an angle of attack of approximately 42° and positioning their towing chains from three inches (0.762 metres) in front of one third, to one third the length of the otter board from the front. The positioning of the towing chains in relation to the height of the otter board varies greatly and appears to be governed by the design of the net and the operator's opinion as to the estimate working height and spread efficiency of the net and the type of rig being used. There are two types of rig being used either diagram A or diagram B. Diagram B shows the most common type used in the D.M.Z.

The accepted method of using floatation for achieving maximum lift to enable sufficient working height of the headrope of the banana nets, was dropped around 1973 and development of what is today the most common method of achieving this goal - the fly-wire was introduced. This is simply a small diameter wire of approximately 6-8mm, 7 strand construction, approximately 9.144 metres - 13.716 metres in length.

This wire has a towing eye in one end and is attached simply by laying the wire out alongside the warp with the towing eyes level. The tail is spliced into the main warp simply by passing approximately a tail length of one metre up through the main strand of the main warp and then a bit further back down through the strands of the main warp. This process is repeated several times until the tail of the fly-wire is used up.

By introducing this wire into the rig, operators were able to enlarge the height of the wings of the net to an average height of 150 metres at the wing end and then taper the top edge of the wing down to the required height of the codend. The towing eye on the headline of the net was then attached to the fly wire with a short length of chain in between which took into account the relationship in length between the towing point on the otter board and the normal attachment point for the fishing net on to the rear end of the otter board.

Also taken into account was a slight adjustment for the relationship of the positioning of the fly wire in position in the warp with regard to the length of the bridle warp. This calculation is similar to that of the calculated bridle arc on four gear rig. With this method of achieving lift, a belly rope was introduced into the wing (lower 50 meshes of wing) and this was attached to the top of the otter boards, replacing the position where the headrope was normally attached.

The leading portion of the belly rope was made of 12-14 mm combination rope either galvanised or stainless steel. A soft eye is spliced in to enable a rope of 12-18 mm to be carried on from there to the codend, being lashed every first or second mesh through to the codend. When used on twin gear rig it was found that these nets worked exceptionally well with a sweep length (overhang of combination rope and headrope footrope - belly rope past last hanging, of approximately one foot of sweep per fathom of net.

Also to assist the working height, the wing (outer) end was tapered similar to mid water trawl wings. This method allowed a working height of approximately 16-18 feet (5-5½ metres) and has been responsible for the high degree of success experienced annually by some operators. At present because of the use of four gear rig for the taking of banana prawns, an extra fly wire of approximately 10-12 mm diameter is introduced into the centre bridle to take the headrope attachments. In addition, in order to control the spread characteristics of the nets, the sweep length has been reduced to a ratio of approximately one half foot (.1524 metres per 1.828 metres of net headrope length).

These nets have not lead ahead in that the top and bottom panel are identical in dimensions and points of attachments. But the new generation of combination nets have had lead ahead introduced, giving the footrope a longer length than the headrope. This length is determined by the extra number of bar cuts, size of mesh and length of hangings.

Materials Used in the Northern Prawn Fishery Inclusive of D.M.Z.

Netting Material - polyethylene - 3 stranded

Ply Rating - N.P.F: 18 - 27 ply

D.M.Z: 27 - 30 ply

Mesh Size - N.P.F: $1^3/4$ - 2¼ inch mesh

D.M.Z: 2 inch mesh

Material Stretch - N.P.F: length wise

D.M.Z: length and depth wise

Headrope - N.P.F: 6 - 8mm st/steel, 12 - 14 mm galv. rope

D.M.Z: 12 - 14 mm st/steel comb rope,
14 mm galv. comb rope

Footrope - N.P.F: as above

D.M.Z: as above

Belly Rope (if attached) - N.P.F: as above

D.M.Z: as above

Ground Chain - N.P.F: 8 - 10 mm galv. or black steel

D.M.Z: 10 mm galv. or black steel

Drop Chain - N.P.F: 6 - 8 mm galv. or black steel

D.M.Z: 8 mm galv. or black steel

Number of Nets Trawled - N.P.F: 3 - 4 + try net

D.M.Z: 4 gear rig + try net

Type of Hanging Twine - N.P.F: 210/120-150 ply tarred nylon
No. 15 - 20 venetian blind
cord (nylon)

D.M.Z: No. 15 - 20 venetian blind
cord (nylon)

Codend (polyethylene) - N.P.F: $1^{5}/8$ - $1^{3}/4$ inch mesh

D.M.Z: $1^{3}/4$ - 2 inch mesh

Codend Ply Rating - N.P.F: 42 - 60 ply

D.M.Z: 60 ply

Dimensions - N.P.F: 100 M.R. x 100 M.D.

D.M.Z: 120 - 150 M.R. x 100 - 120 M.D.

Warp Wires (Galvanised)
6 Strand x Fibre Core - N.P.F: 8 - 12 mm diameter

D.M.Z: 10 mm + try net cable only

7 Strand Construction - N.P.F: 10 - 14 mm diameter
D.M.Z: 14 - 16 mm diameter

Bridle Lengths - N.P.F: 36.58 - 73.152 metres
D.M.Z: 54.864 - 73.152 metres

Otter Boards - N.P.F: mainly rectangular flat
D.M.Z: rectangular flat

Northern Prawn Fishery - Catching Tiger Prawns

Good catches of tiger prawns have been taken and are still being taken on grounds found throughout the N.P.F. In recent years, however, a noticeable decline has been seen. Most of the blame has been directed at (a) effort, (b) taking of juvenile prawns, (c) working areas with high concentration of soft shelled prawns, (d) water temperature and weather conditions.

Most catches in the N.P.F. are taken with either triple or four gear rig or, as in the case of the D.M.Z., exclusively with four gear rig. Ground discrimination and bottom life are sought with the use of colour echo-sounders and the length of the run is gauged by the use of try-gear (a sampling net). This enables the operator to position his vessel on an area of ground where he can achieve good catch without wasting fuel in trawling over ground where little or no catch is available.

For this type of fishing the use of the try-net is invaluable, as it enables the operator to mimimize (a) effort, (b) fuel usage. Operators within the D.M.Z. use their try-nets nearly all the time during fishing, some using small otter boards, others preferring to tow small beam trawl frames to give easy winch drag which they insist helps with fuel consumption.

On the east coast in the N.P.F. use of the try-gear is considerable in the Torres Straits, Princess Charlotte Bay area, but a lot of operators cannot see that the cost of installation of this system is far outweighed by the monetary and psychological advantage that this will give them. Most operators consider that radar bearings are sufficient enough to enable them to position their vessels on a run. With the added advantage of tri-gear, a substantial increase of prawns caught per litre of fuel used for area travelled will be noticed.

Catching of tiger prawns is an area where operators cannot afford to be lazy. Every setting, adjustment, ratio etc., must be exact as it is the one side of the fishery in which the word nearly should never exist. The difference between having everything exact compared with nearly right, could be one of possibly 25% in catch for identically powered and rigged vessels. In the D.M.Z. this figure can at times be possibly as high as 30% on a night of good catch.

This exercise of exacting commences with the winding on of new main warp wires where a mark, usually a piece of coloured rope, is passed through the wire at a given length (example every 18.288 metres). At the next mark, two strands are put through, then three strands at the next, then one again and so on. The use of this simple method enables the operator to keep his gear side by side equal when shooting his nets.

When the bridles are attached they are ordered equal in length and a tail is left to enable them to cut splice the bridles to the main warp wire, again making sure equal lengths are used. The three bridles are formed by running a centre wire with a towing eye in one end and sufficient length, usually 10 metres longer than required, so that the wire can be cut spliced into the main warp. The two bridles lie alongside the central bridle with towing eyes all equal and they are in turn spliced in one above the other by a distance of one metre approximately between, using either the Liverpool or Board of Trade splice, with tapering lock to enable it to free run through the trawl block.

When choosing the trawl block it is essential to choose a block of sufficient diameter to give added warp life. Most importantly the sheave between the shoulders should be at least three and a half times the diameter of the trawl warp wire on the flat to enable the wires to be winched in evenly. The use of grooved or concave sheaves should be avoided because with this set up of multiple wires with a grooved block, one wire will be coming in at a greater diameter, endangering anyone near or operating the winch. Also it scrubs the galvanising on the wires shortening their life.

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Referring again to the otter boards, they are set with the use of towing chain (spiders). The intended angle of attack taken from the method of graph is then calculated. In most cases the front spider chains are set either square of the front quarter of the board or within two inches behind the front quarter.

Some experienced operators then do a graph of the front end elevation of the otter board and draw in position the centres of their adjusting lugs, their choice of setting either ½" to 1½" below centre. (This is required to help depress the otter door because of the difference in length of the top and bottom line). They transfer from their graphed angle of attack the height of the face of the door relationship for the front spider. From this graph they have the length of the front spiders that is required plus their exact positioning.

From here the back spiders are set accordingly. Much care is taken to ensure that all four chains are equal in tension so as not to de-stabilise the otter door.

Next the calculation for the bridle arc is taken to ensure even tension on the seams of the net. The calculation attached has been in use for some years. Its accuracy has been gauged through performance and feedback and appears to be reasonably accurate.

Thanks to Mr. Frank Chopin, testing of this theory in the flume tank should provide the necessary information as to its accuracy. Possibly more accurate up-date can be formulated by him, thus improving on what is a highly efficient fishing rig.

The sleds or dummy otter door is attached to the centre bridle on to which the inner wings of the nets are attached. The weight of this sled is very important as if it is weighted too heavily the sled can sink faster than the otter door causing it to plane out and then downwards causing it to possibly tangle with the other set of gear on the opposite boom, thus becoming (double trouble) tangled.

When shooting your gear the sled warp must ride above the warps to the otter doors. This will ensure trouble-free fishing.

Once you have calculated your four gear bridle arc you can take advantage of this information in several ways.

(a) If just changing to four gear rig you can order your otter boards - do your bridle arc calculation for the length of warp, spread characteristics etc., and have a shorter sled ordered so you can shackle your nets on square.

(b) If otter board and sled are equal in length from towing point to shackle on point, shorten the sled wire by the amount calculated. (This method could cause damage in rough weather).

The most commonly accepted method is to extend chain sweeps from the back of your otter boards to the wing of your net, but not between your sled and the wings attached to it.

This type of rig is used also for taking of king prawns in the area from Mackay to Innisfail in depths up to 38.4 metres - 49.5 metres very successfully, and also king prawns found in the Torres Straits and Callidon Bay in the Gulf of Carpentaria. Of these prawns there are two species caught:

Blue Leg King (Penaeus Longistylus)

Red Spot King (Penaeus Latisulcatus)

An average board sled weight ratio would be $^{3}/5$ to $^{2}/3$ of the board weight. Most use the figure of $^{3}/5$ for tiger prawning but increase the weight when using the combination type of nets.

Impact of the Fuel Pricing Parity on the Northern Prawn Fishery Relating to the Banana Prawn Fishery

Costs of maintaining both very efficient banana nets (Yankee Doodle) and tiger nets (Florida Flyer) are very high. The efficiency of both rigs is well proven with extremely good results, but with the onset of higher and higher fuel prices the northern prawn fishery has tried to combine both on cost.

For many years the northern prawn fishery has used the method of towing Yankee Doodle nets, which are very labour intensive, to construct and rig up for the taking of banana prawns. The use of this type of net meant carrying an extra set of banana-style otter boards to efficiently spread the nets - a ratio of approximately 4 to 5:1 ratio of square foot of otter board per fathom of net.

This type of fishery although highly efficient meant that the operators had to invest in a two bridle rig exclusively for the banana prawn season, then once the season was over, replace the two bridle rig with triple bridle rig to enable them to go fishing (trawling) for tiger prawns.

To try to reduce these costs the operators chose to use four gear rig of two nets of smaller construction (Yankee Doodle) on either boom, triple rigged. This enabled them to save the cost of changing from two to three bridle rig and also to tow a set of otter boards suitable in size for both banana and tiger nets.

Still the cost of construction of both a set of banana nets and a set of tiger nets per vessel, per season, was very high so most operators, especially in the D.M.Z. chose a compromise.

<u>The Compromise</u> (Combination net, diagram C)

The compromise was to construct a net using the top and bottom panels of the Florida Flyer design suitable for tiger prawns plus a wing panel suitable and similar in design from the Yankee Doodle wing panel, then to use this design of net with belly ropes attached for the taking of banana prawns, once the season is over the method is either to (a) discard the fly wires and attach the headrope back to the top lug of the otter board or (b) cut down the wing panel and re-sew the seam to give a standard Florida Flyer net for the taking of tiger prawns.

One of the main reasons for the choice of this rig related to fuel costs. If the vessel missed the main school of banana prawns, it was found that to scratch (trawl for a long time) with a Yankee Doodle caused considerable wear to the bottom and lower wing panels of the net, thus resulting in either (a) expensive maintenance for the following season or complete replacement of the nets at high cost to the operators.

Also scratching for banana prawns with Yankee Doodle nets was inefficient compared with Florida Flyer design nets. It was found that Florida Flyer nets maintained better bottom contact but schooling banana prawns were most effectively caught with Yankee Doodle nets, whether trawled double rig or with four gear rig.

The efficiency of the combination net, during the 1983-84 banana season has been very good with different companies using differing styles of this net with varying success. Some experienced operators, though, claim the height of the wing panel achieves better results when increased in height. To this day most of the cost of development of the combination net has been bourne by both the operators within the northern prawn fishery and the D.M.Z. Useful feed back has been given to the combination net manufacturer on its performance and catch characteristics.

The whole northern prawn fishery is now pleased that the Australian Maritime College has available to it the flume tank and the expertise of Mr. Frank Chopin to enable further refining and development of fishing gear currently in use and for the future use of operators within the N.P.F.

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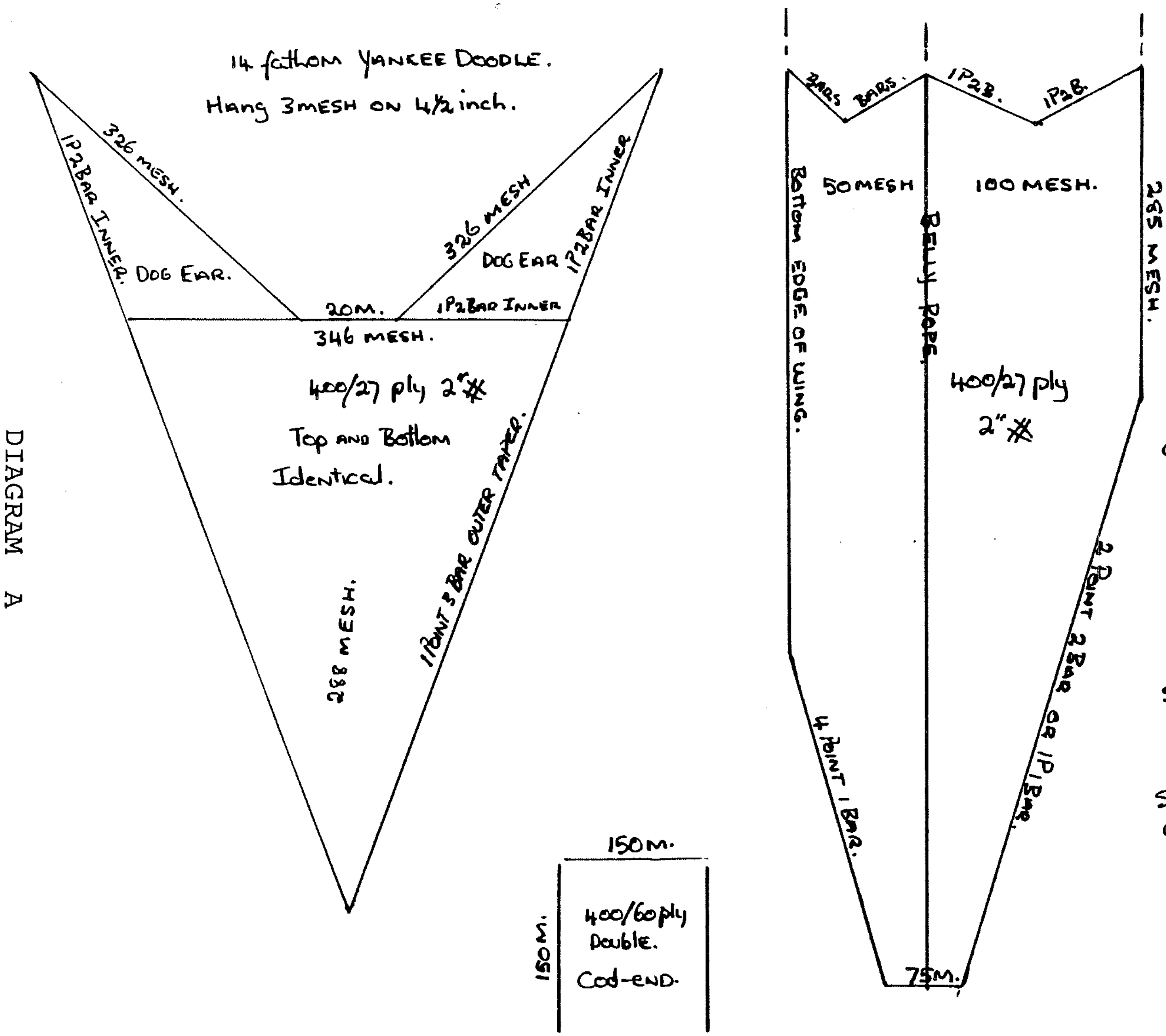
It is also hoped that in future the Government will play a greater role in funding research and fishing trials, mainly to provide trials in the future development of fishing nets suitable for the N.P.F. In the past, operators have had to stop further testing and trials of some net designs because the costs being borne by them had reached too high a level, causing them to return to their proven conventional nets.

For the millions invested in the N.P.F. and the amount taken back by the Government, the Government must be seen to be behind the industry Through seminars like this we can see some light at the end of the tunnel. Hopefully, this time it's not a train coming the other way.

GOOD FISHING



SWEEP LENGTH 14 FOOT.
DROPCHAIN 6mm SPACE 1mtr.
GROUNDCHAIN 10MM REGULAR link.
HEADROPE 14mm st/steel Comb/Rope
FOOTROPE. 14mm st/steel Comb/Rope.
BELLYROPE 14mm st/steel Comb/Rope
SECTION OF ROPE BELLY ROPE.
18mm SILVER ROPE.

COMBINATION PART OF BELLY ROPE.
FIRST 50MESH 3MESH ON 4 inch
NEXT 30 MESH 3 MESH ON 4½ inch
NEXT 30 MESH 3 MESH ON 5 inch
MAKING LAST 3 Hangings 3MESH ON 6inch

SILVER ROPE SECTION OF BELLY ROPE LASH EVERY MESH OR EVERY 2ND MESH. MESH TIGHT. STOPPING 20 MESH SHORT OF Cod-END UNTIL MATERIAL STRETCHED, THEN ATTACH.

DIAGRAM A

YANKEE DOODLE. FLY WIRE RIGGED.

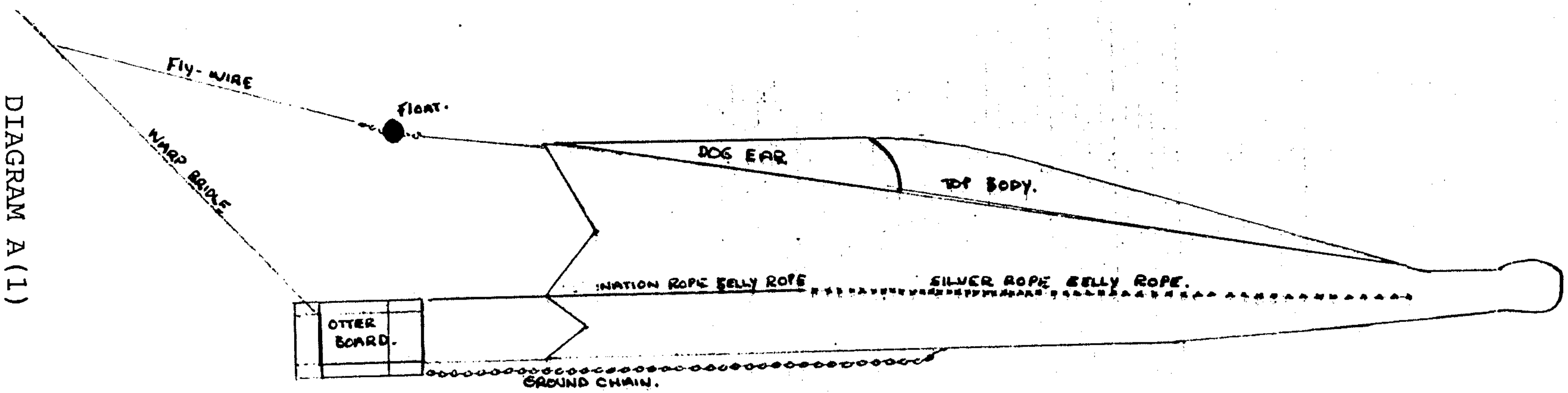


DIAGRAM A(1)

6 FATHOM 4 SEAM FLORIDA FLIER NET.
N.P.F.

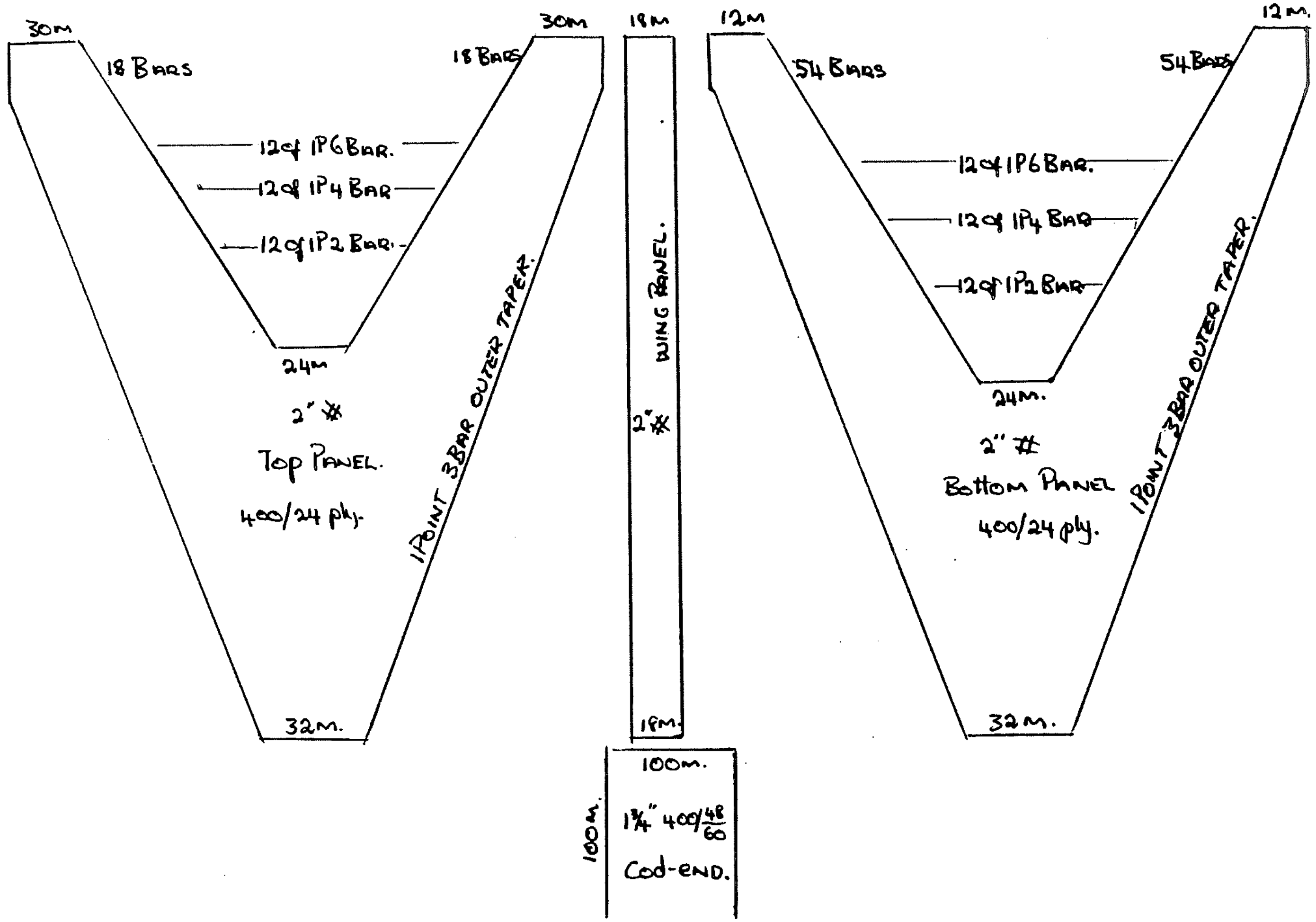


DIAGRAM B

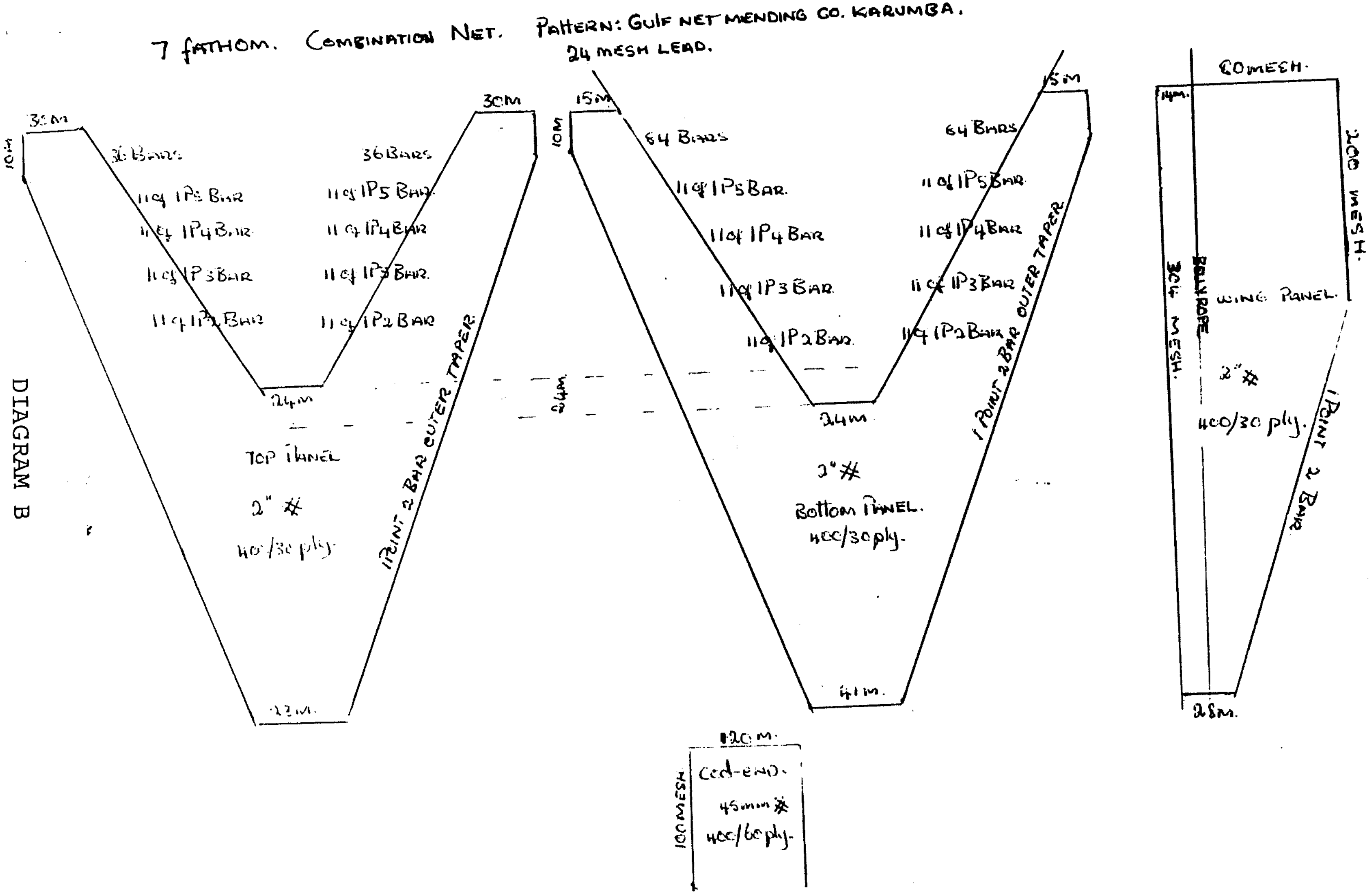
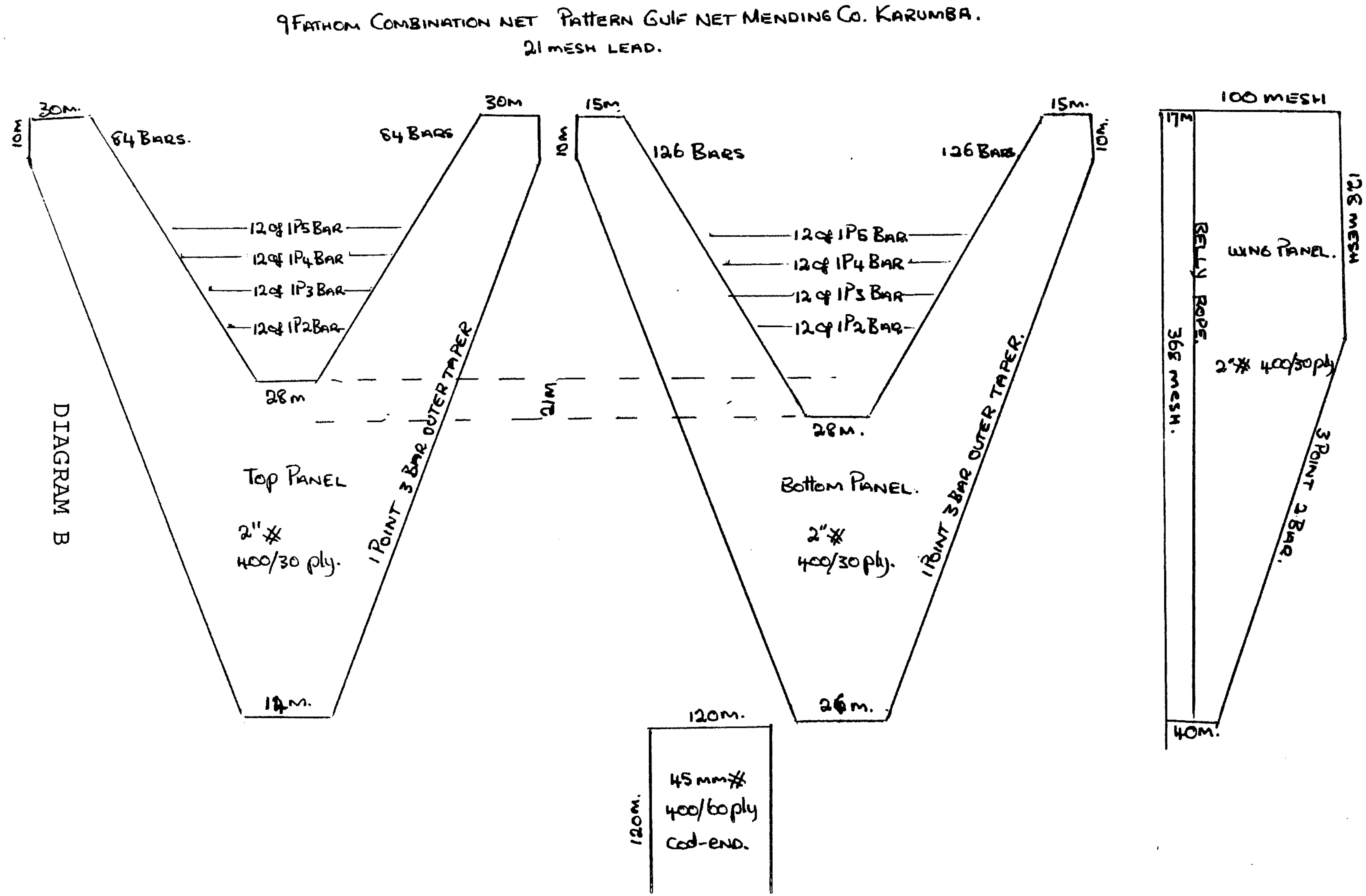

7 FATHOM. COMBINATION NET. PATTERN: GULF NET MENDING CO. KARUMBA.
24 MESH LEAD.
30M
10M
36 BARS
11 of 1P5 BAR
11 of 1P4 BAR
11 of 1P3 BAR
11 of 1P2 BAR
30M
36 BARS
11 of 1P5 BAR
11 of 1P4 BAR
11 of 1P3 BAR
11 of 1P2 BAR
24M
TOP PANEL
2" #
400/30 ply
1 POINT 2 BAR OUTER TAPER
15M
10M
64 BARS
11 of 1P5 BAR
11 of 1P4 BAR
11 of 1P3 BAR
11 of 1P2 BAR
15M
64 BARS
11 of 1P5 BAR
11 of 1P4 BAR
11 of 1P3 BAR
11 of 1P2 BAR
1 POINT 2 BAR OUTER TAPER
24M
24M
2" #
BOTTOM PANEL.
400/30 ply.
41M.
120M.
100 MESH
Cod-END.
45mm #
400/60 ply.
80 MESH.
14M.
200 MESH.
304 MESH.
BELLY ROPE
WING PANEL.
2" #
400/30 ply.
1 POINT 2 BAR
28M.

DIAGRAM B


9 Fathom Combination Net Pattern Gulf Net Mending Co. Karumba.
21 mesh lead.
30m.
10m
84 Bars.
30m
84 Bars
12 of 1P5 Bar
12 of 1P4 Bar
12 of 1P3 Bar
12 of 1P2 Bar
28m
21m
Top Panel
2"
400/30 ply.
1 Point 3 Bar outer taper
14m.
15m
10m
126 Bars
15m.
126 Bars
10m.
12 of 1P5 Bar
12 of 1P4 Bar
12 of 1P3 Bar
12 of 1P2 Bar
28m.
Bottom Panel.
2"
400/30 ply.
1 Point 3 Bar outer taper.
26m.
120m.
120m.
45mm
400/60 ply
Cod-end.
100 mesh
17m
128 mesh
Belly Rope
Wing Panel.
368 mesh.
2" 400/30 ply
3 Point 2 Bar.
40m.
DIAGRAM B

8 FATHOM COMBINATION NET. PATTERN GULF NET MENDING CO. KARUMBA.
24 MESH LEAD.

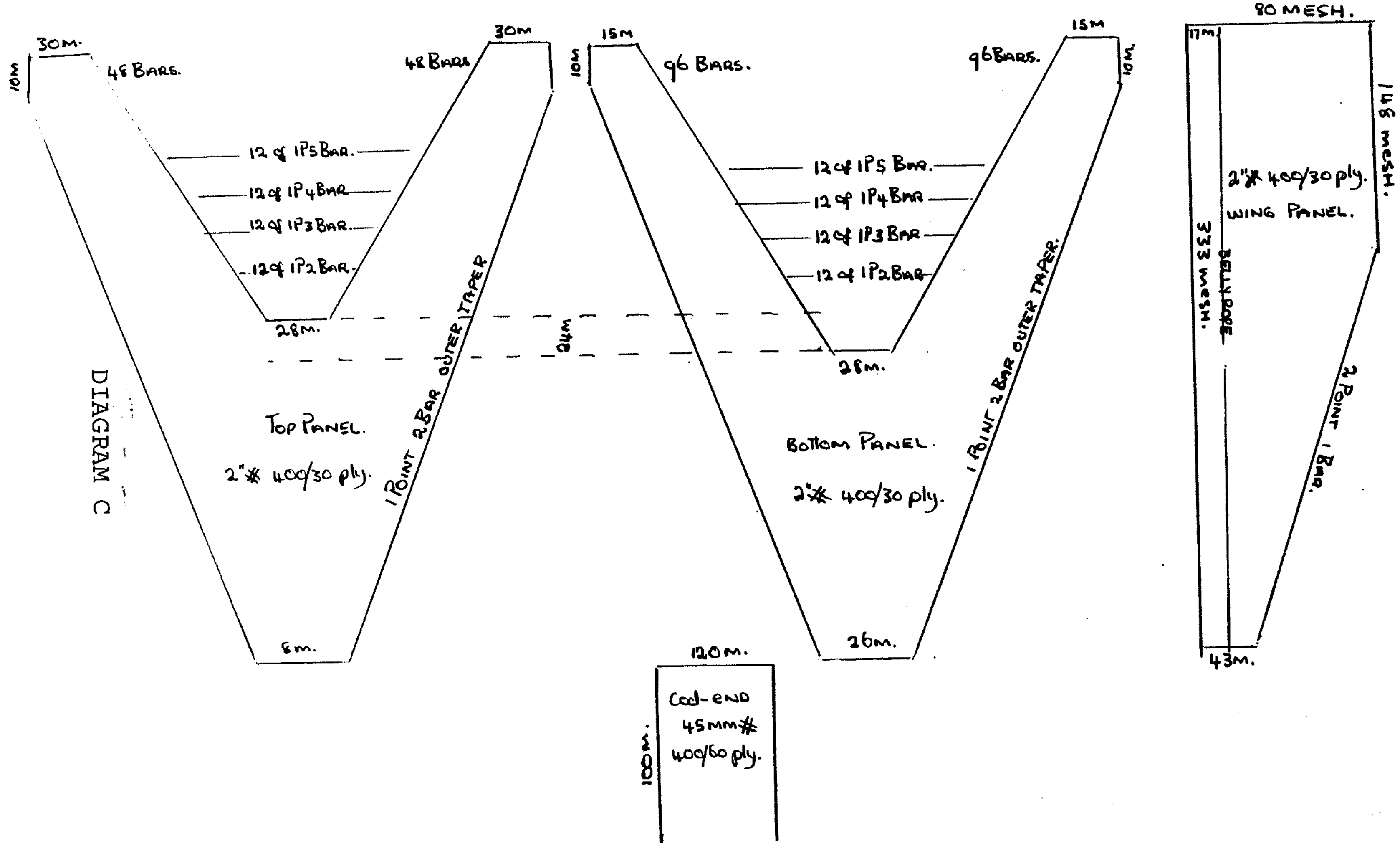


DIAGRAM C

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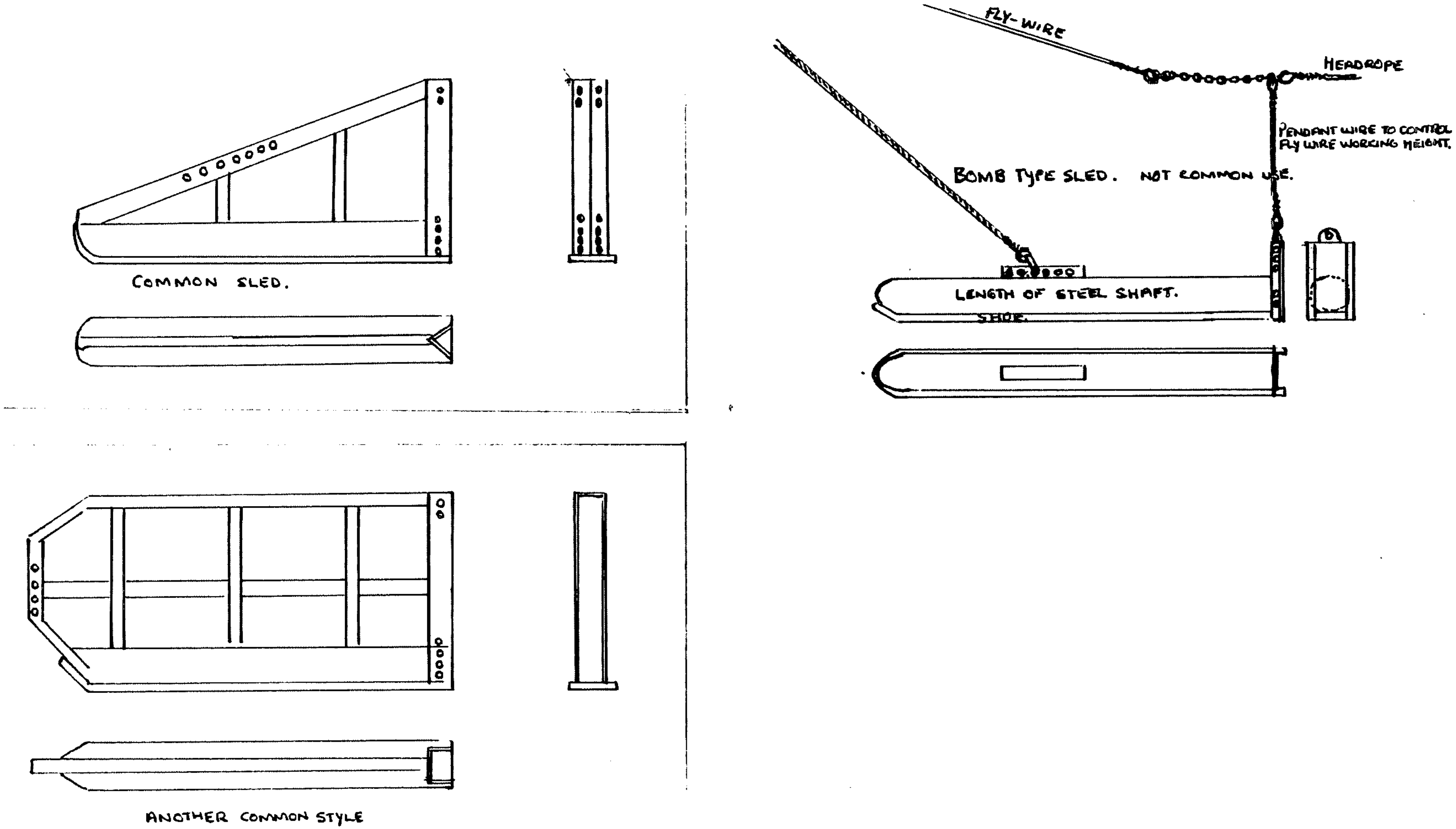

COMMON TYPES OF CENTRE SLED ARRANGEMENTS

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DEVELOPMENTS IN PRAWN TRAWLING

Mr. John Derrick

Lecturer

Australian Maritime College

We are shortly to hear from Norm Stevens on recent developments in the Gulf and associated regions; so I would like to employ a little time leading up the the present day.

Until 1950, the only prawns caught in Queensland were by small beam trawlers or "hand" methods; that is, cast nets, stripe nets or small seine type nets. That year, N.S.W. fishermen prospecting with otter trawls found reasonable quantities of prawns in Moreton Bay. In the next couple of years, legislation came into effect to allow trawling for prawns - net sizes and lengths were gazetted and machinery set in motion to establish an industry.

Initially the boats were all single rigged, usually with nets incorporating long wings - a hangover from seine fishing. The early nets showed European influence (English and Italian), but gradually local designs began to take over.

The Seibenhausen - very simple to make and repair, became widely adopted. Certainly not a good net by modern standards, but responsible for catching enormous quantities of prawns and scallops even today. Its big advantage was that having no tapers anyone could quickly learn to make and mend them - a distinct advantage over "complicated" nets.

"Dawns" were quite popular in some areas - again a simple net, not very pretty, but quite effective. The side "pockets" formed were later removed by cutting the panels with a 1pt 3 bar taper - an improvement but still not the best.

Probably one of the first local attempts to "shape" a net was the Monin designed "Sad Sack" (named for obvious reasons). This was an improvement to the Seibenhausen - retaining the "no taper" configuration, making mending easy, with a rounded mouth opening. I consider it to be still a very good net, even today.

Then a boat called "Yankee Doodle" arrived in Queensland and she had a peculiar sort of net with tapers going in all directions. It was unsurpassed on bananas. This was the original of the net that is still the tap banana catcher today.

Other nets have been tried, for example the Japanese "Ishiara" but without the same success. This, by the way, is very similar to the popular American semi balloon trawl, and as you can see, a lot of work to make or mend.

Banana prawning saw the conversion of most northern boats to double rig, because a lot of searching was required with gear ready to shoot, and single gear was too slow and cumbersome. A twin rigged boat could steam all day with the codends dragging on the surface, no great strain being placed on the net or hangings, and very little loss of speed.

Twin gear was also easier to handle - smaller individual nets and boards, winching and lazylining in a straight line rather than circling, which made rough weather more bearable. In addition it was found that catches went up dramatically.

I refer here to the King and Tiger fisheries. Initially, most fishermen simply cut the wings off their existing nets "to use them up"; suddenly it appeared that the wings didn't do much anyway. There are instances of boats, changing from 1 x 16 fathom to 2 x 6 fathom nets and having better than a 50% increase in catch rate compared with known "unconverted" vessels.

On the central coast there was a certain reluctance among smaller boats to convert to twin gear. This was because net restrictions at Gladstone allowed 1 x 8 fathom headline or 2 x 4 fathom. As the major fishery is banana prawns and height of headline is the dominant feature, the 8 fathom was the better net.

However, in Moreton Bay where the same restrictions apply, the prawns are "bottom contact" species, so the preference was for the twin gear.

A popular trick at Gladstone, particularly by visiting boats, was to cut the outer headline hangings of larger nets to leave 4 fathoms of hung length. This stayed within the law, but retained the advantage of height given by the larger net. Once outside the area the net was quickly returned to its correct size.

The "height" of absurdity was reached when 10 fathom nets were being "modified" to a 4 fathom headline - effective, but not quite what the regulations envisioned. I believe this loophole has since been closed.

Then the "Florida Flyer" came on the scene. This was a complicated "step cut" net with a fully shaped mouth, and tiger catches improved immensely. The shape gave better ground contact and smoother flow than the old nets. Over the years, they have been modified by altering cutting ratios, altering hanging ratios and adding side panels, but are still used in their original form in many places today.

The next step was "quad" gear - four nets in two pairs.

This also improved catches, which again proved that the centre part of the net did most of the work. On top of this, smaller nets required less spreading as they contained less net. For example, 2 x 8 fathom tiger nets require two bundles of net while 4 x 4 fathom can be cut out of one and a half bundles - a saving of around 25%.

Thus smaller boards could be used allowing greater towing speeds, or larger nets could be towed without increasing horse power.

Tongue nets were the next step - two mouths in one net. There has been mixed success here. These nets are very touchy but, when set up properly, are extremely efficient. The single tongue - conventional bottom and double top is the first truly all round net. By varying the warp/depth ratio, the net can be made to spread on the bottom or lift high for bananas. However, it is very critical and much work is still to be done here. The main advantage is ease of towing as much of the weight is taken on the third bridle and the boards only have to hold the extremities of the net apart - thus smaller boards or bigger nets can be used. Incidentally, these have been measured to give 85% spread, so extra ground is covered.

While all this had been going on "up north", the deep water boats "down south" had their own revolution. Twin rig was tried but given away because of problems in deep water; that is over 30 - 40 fathoms.

Getting the gear to the bottom and back without "plaiting" the two sets was a serious problem, as was the danger factor of long booms and stability factors.

Multiple nets had definitely proved to be superior, so how to have this with a single, tied together unit? Triple gear was born.

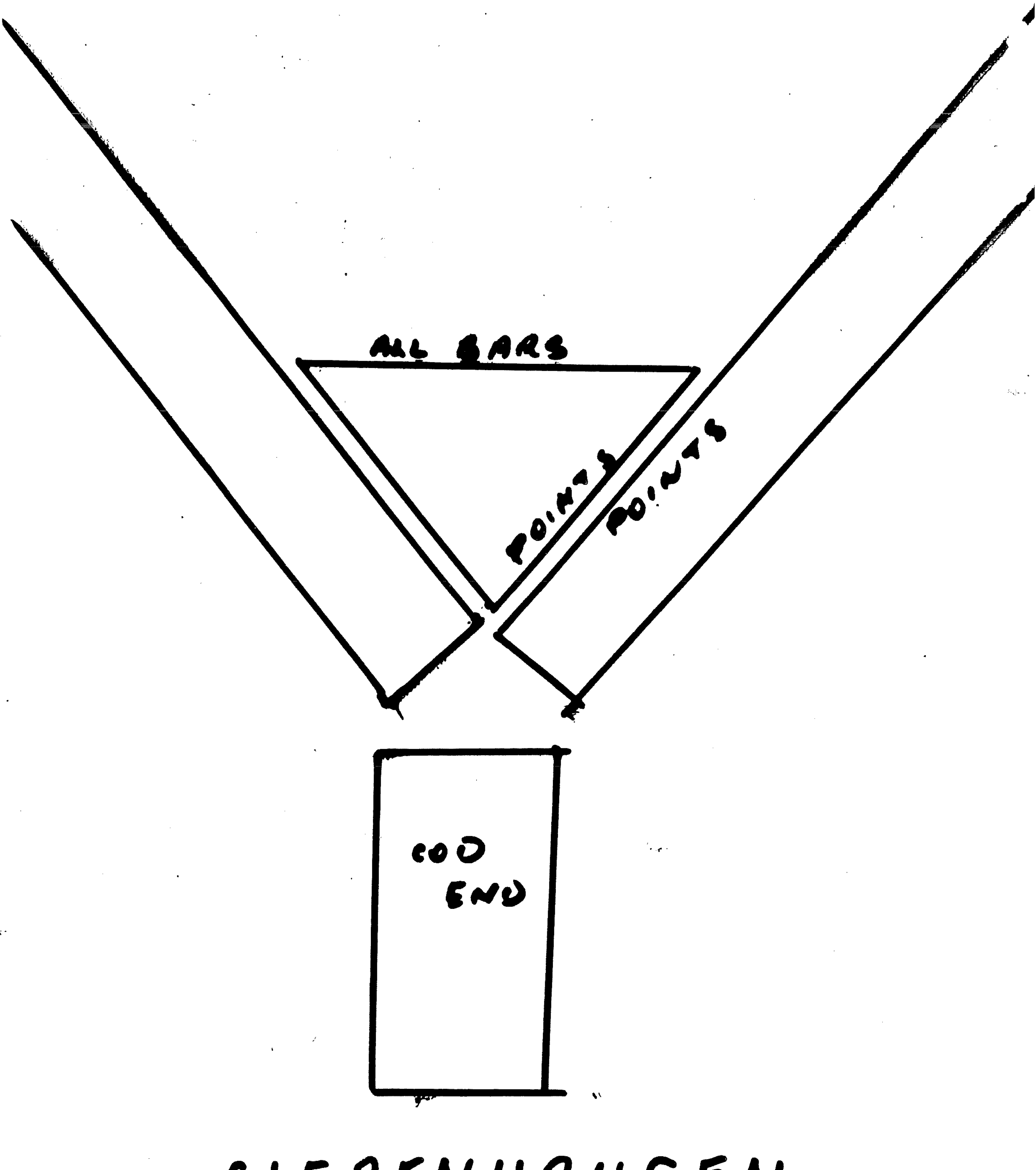
Here we have the ideal rig. It can be towed from long double gear booms, short single gear arms, or from stern trawler gantrys.

Now it is used very widely - off the shelf in N.S.W., deepwater in southern Queensland and is most effective for scallops in central Queensland.

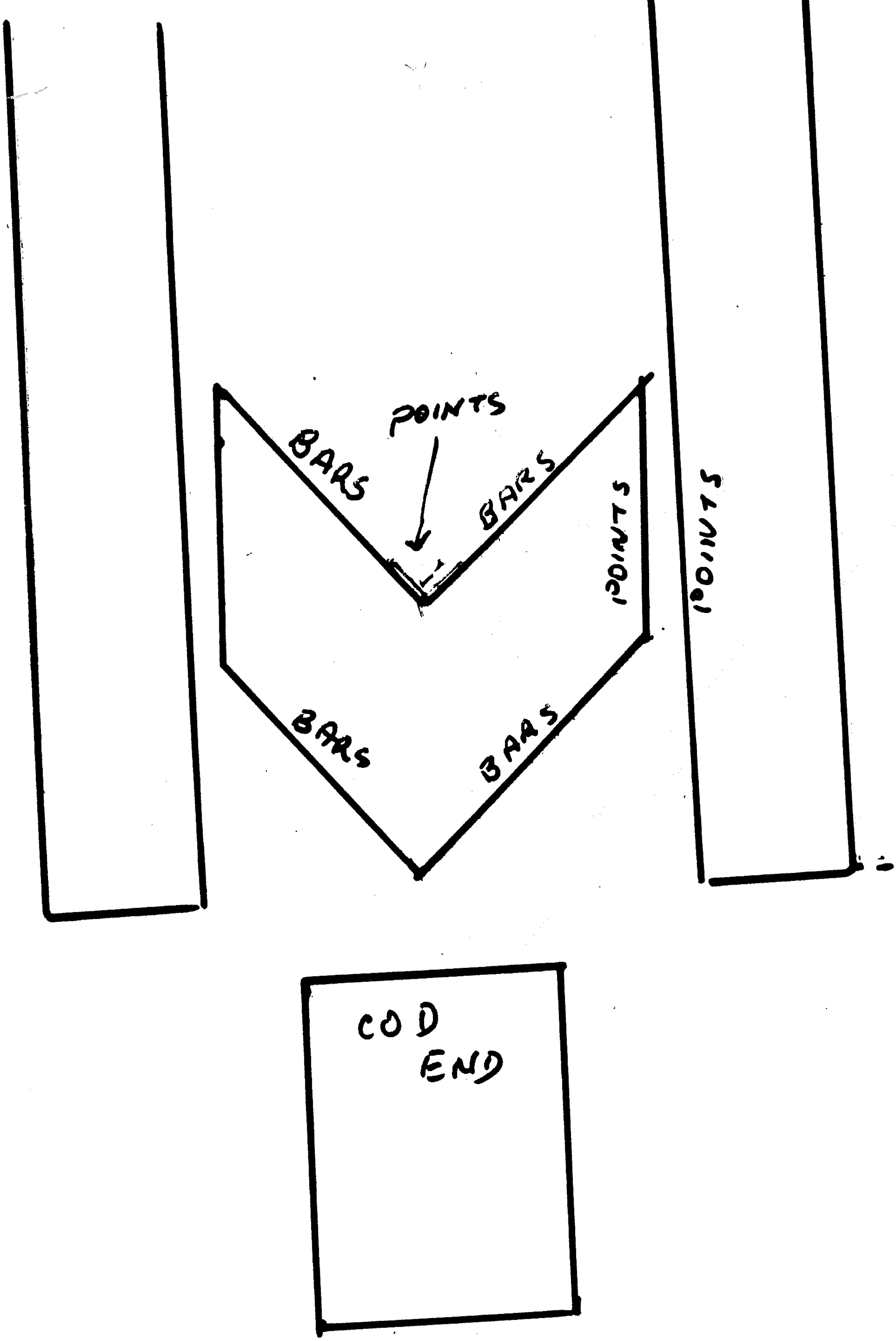
It also allows boats to tow extra gear - by removing two boards from twin gear and replacing with an extra net, small underpowered boats can increase their effectiveness.

I haven't said anything about one pretty big prawn fishery - that is South Australia. The reason, is that few changes have taken place over the years. The fishery is highly regulated and the fishermen tend to stick to the same gear. They settled on the English Gundry net - a scaled down fish trawl and it seems to suit their fishery quite well. So change hasn't really been warranted.

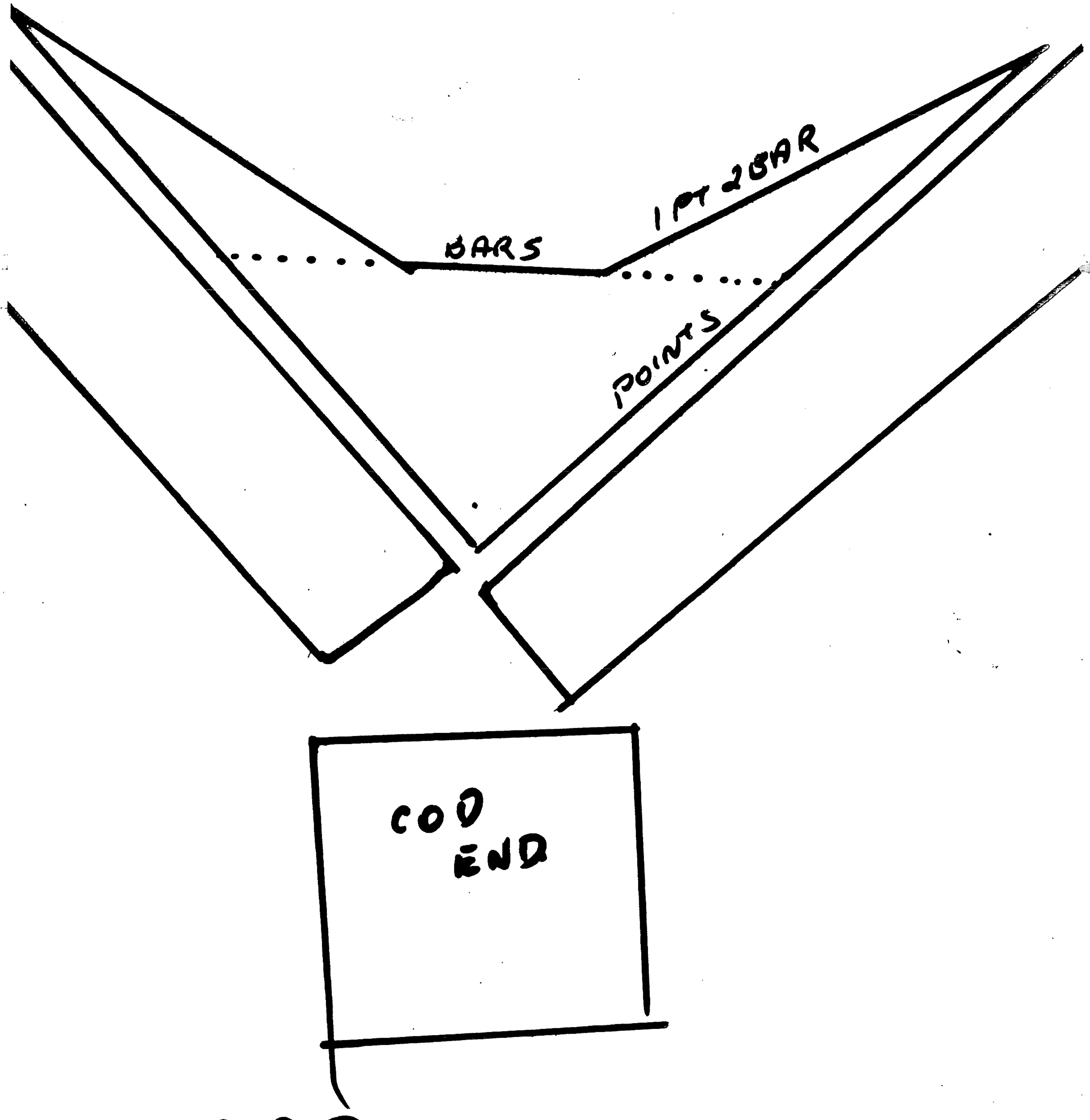
That just about covers the situation up until a couple of years ago when I left Queensland to come here. Now Norm Stevens is in close contact with the alterations and improvements at the present moment, so I'll look to his paper to bring you up-to-date with the present trends.



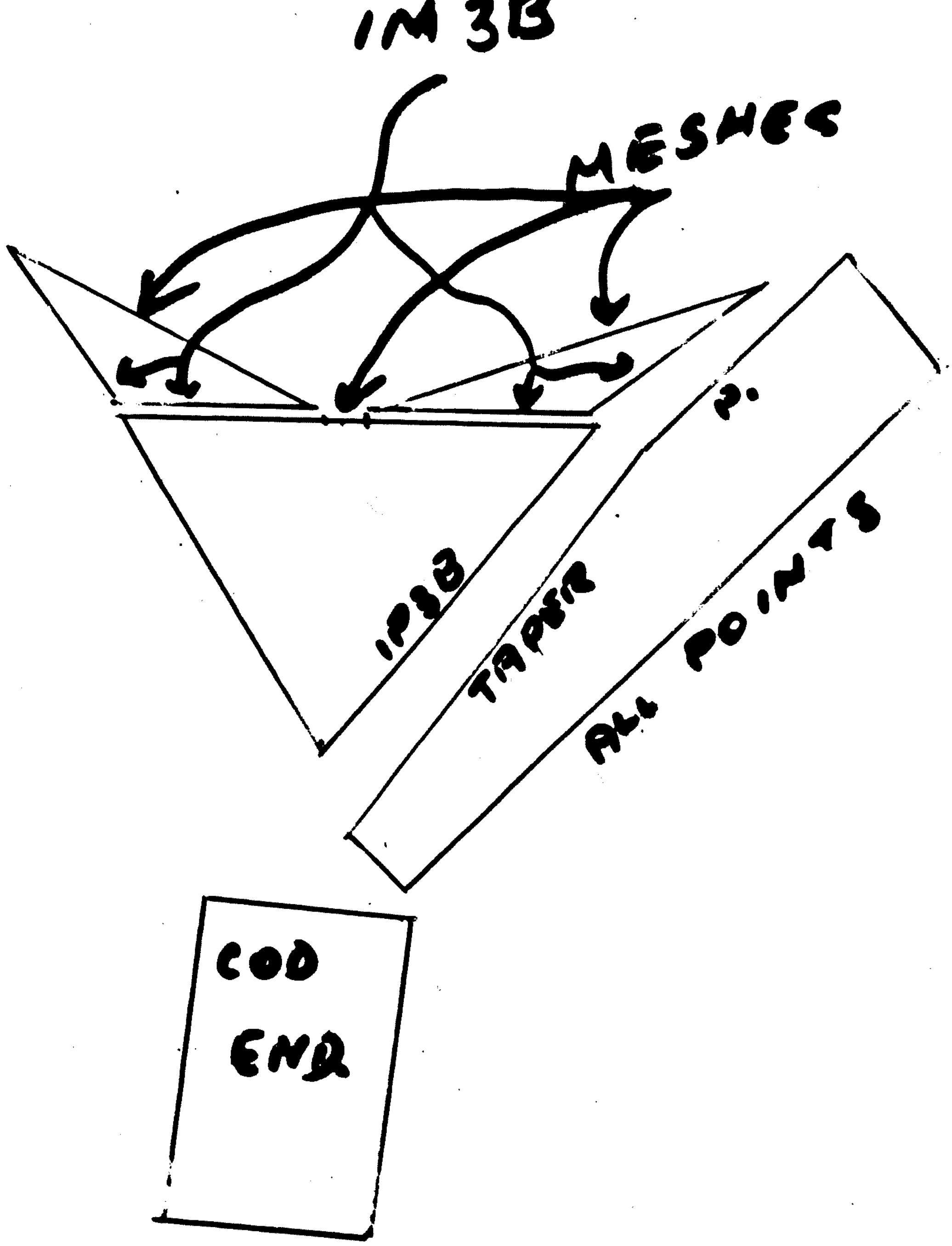
SIEBENHAUSEN



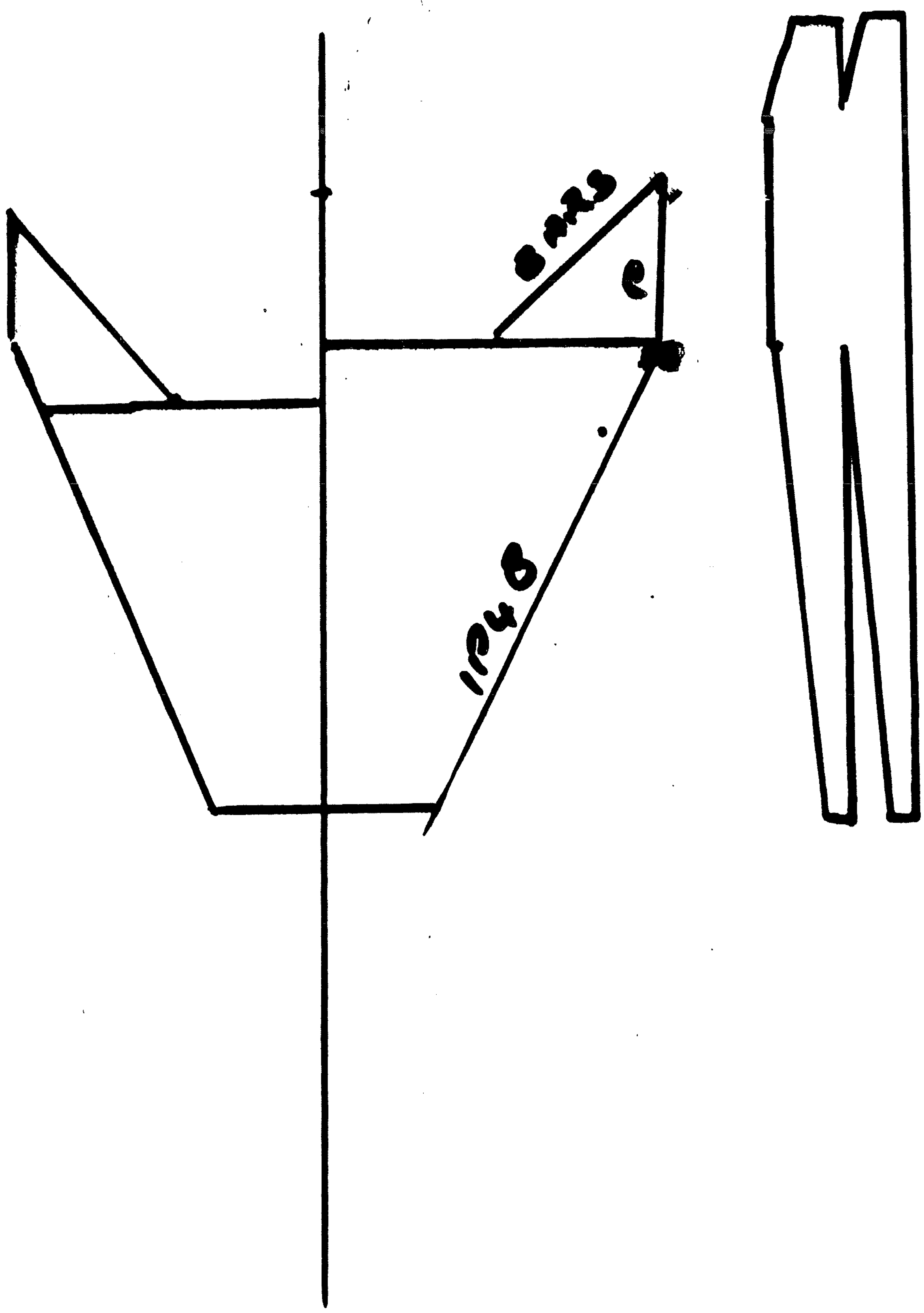
DAWN



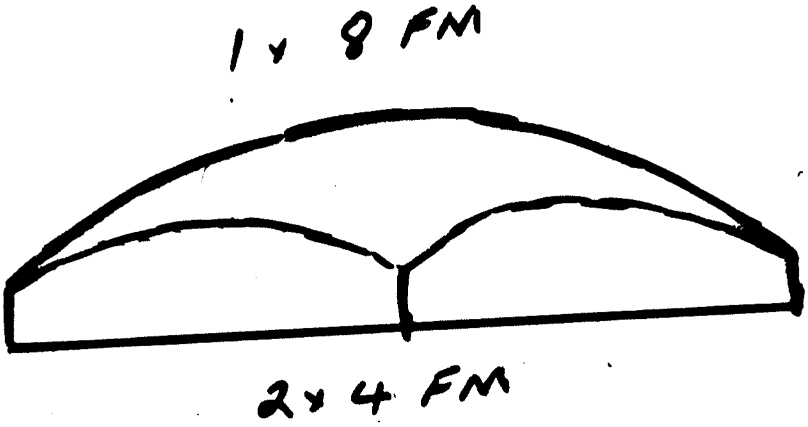
SAD SACK.



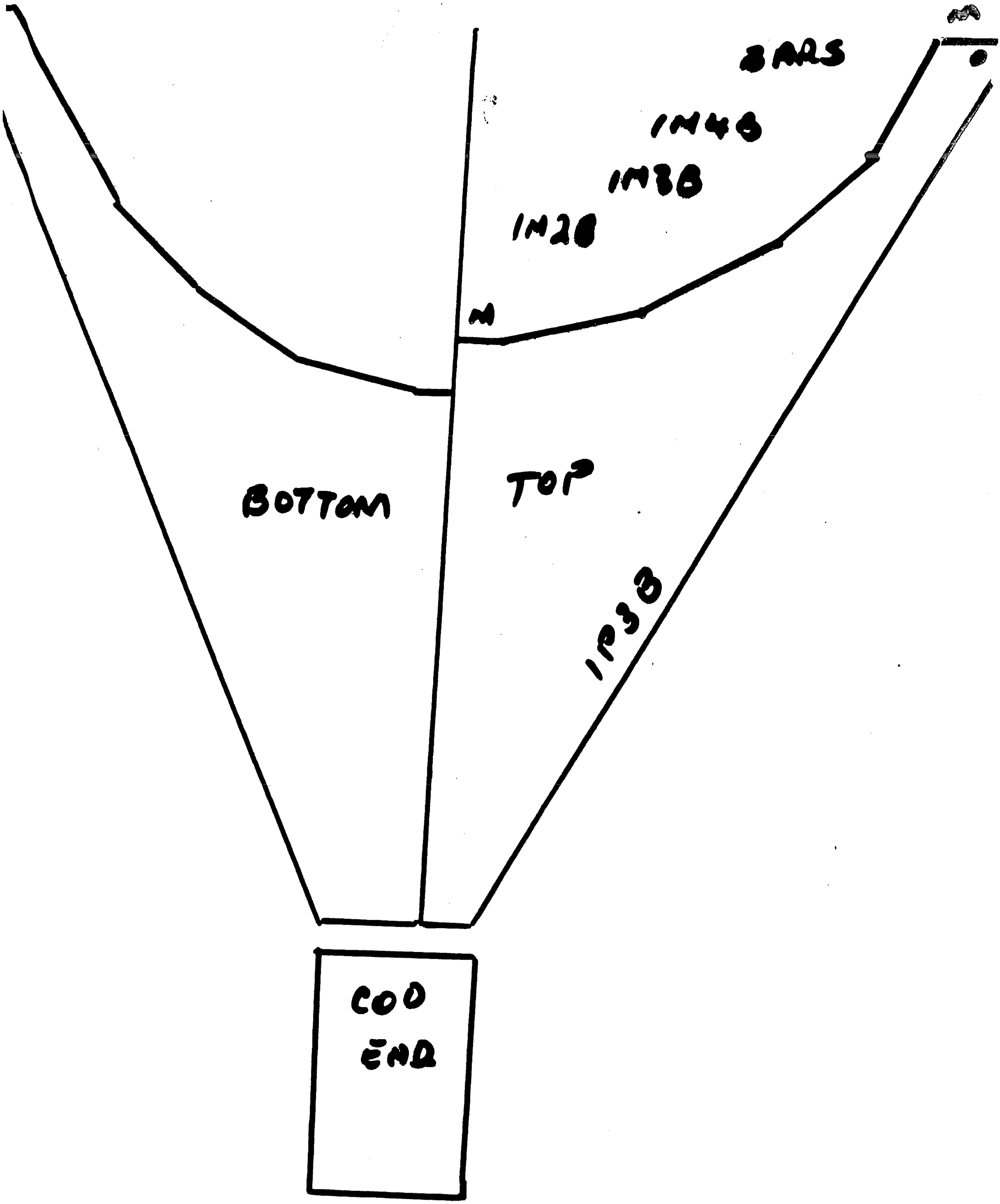
YANKEE DOODLE



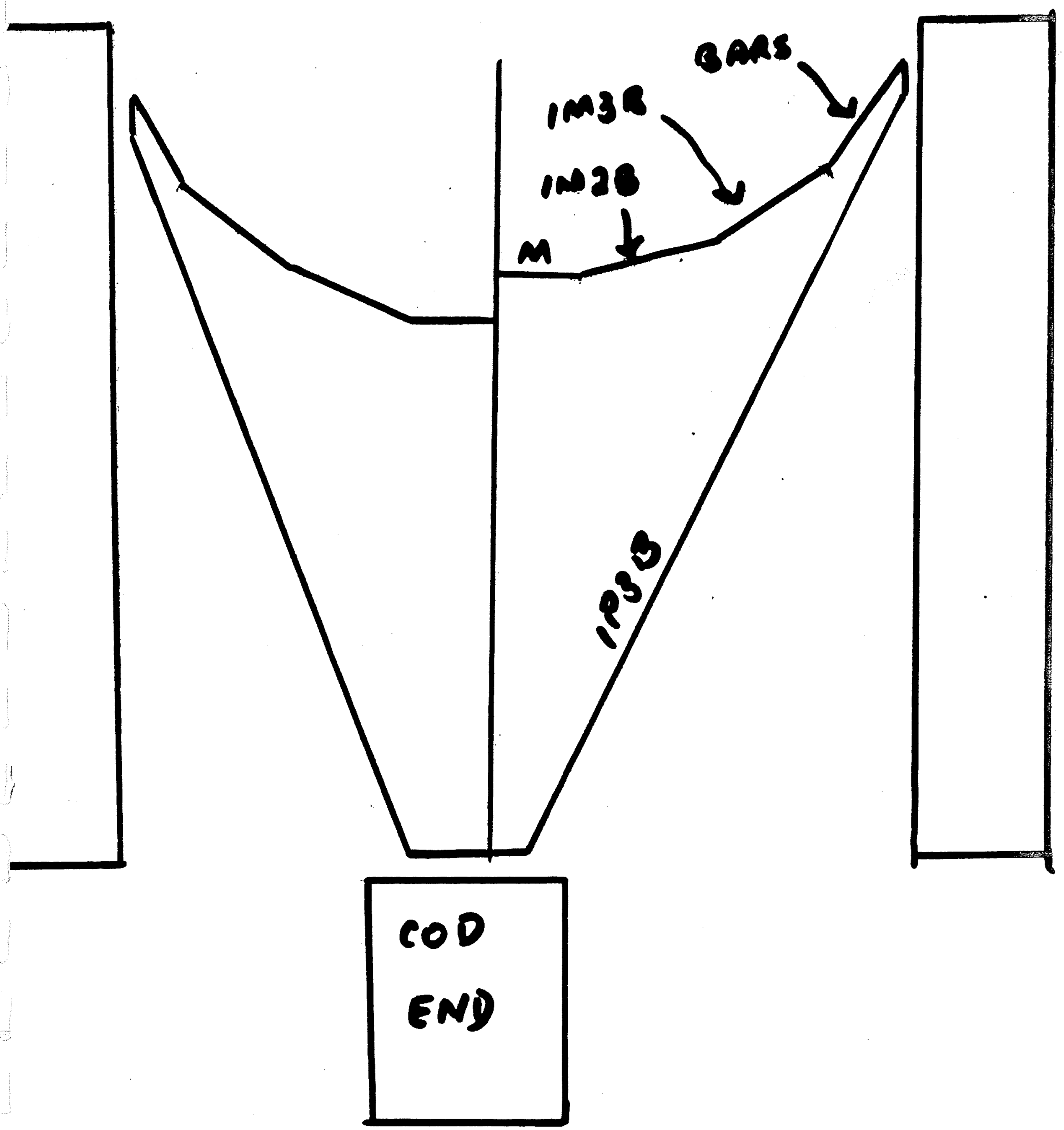
ISHIARA (ISHI HARA?)



YANKEE DOODLE



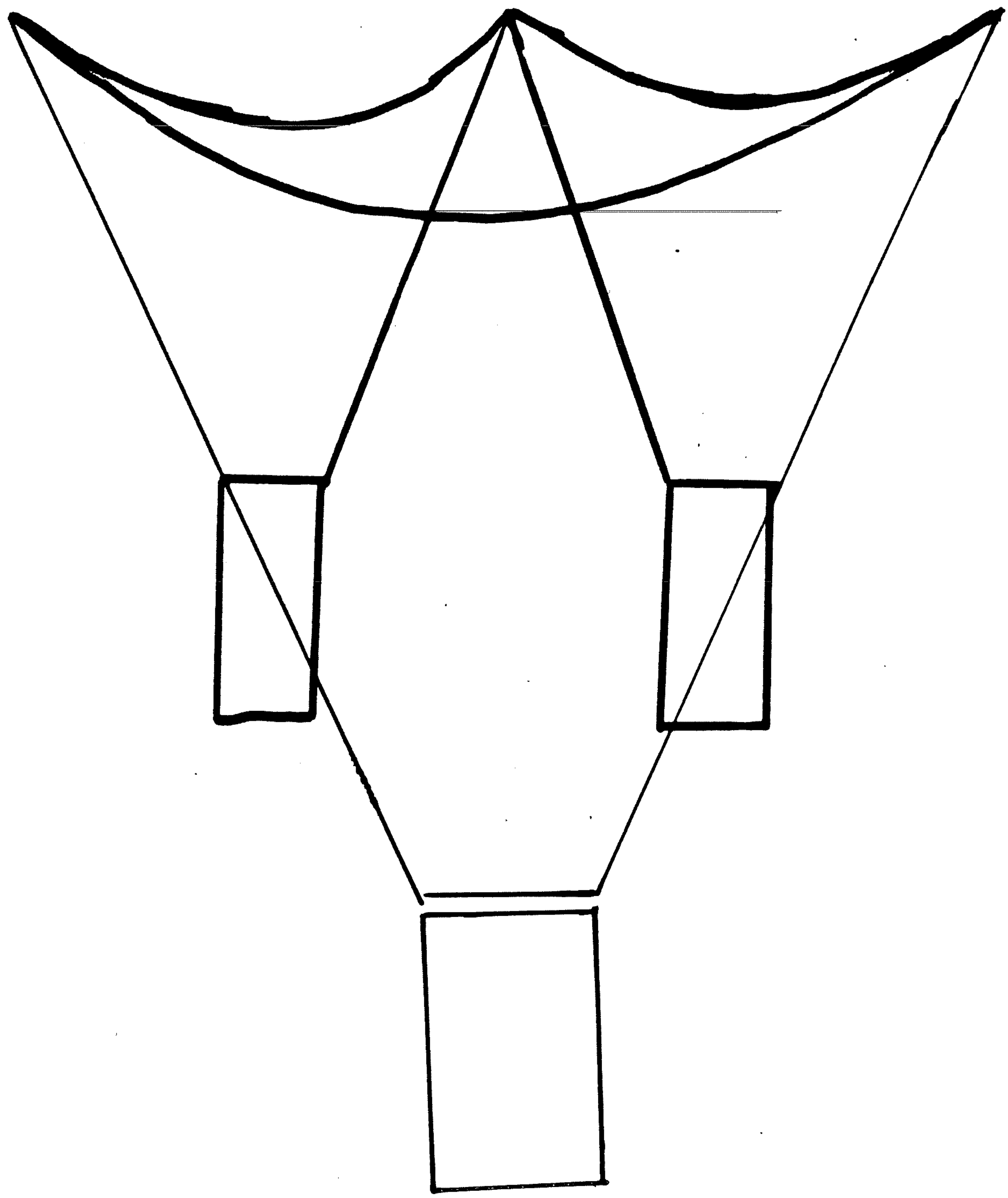
FLORIDA FLYER

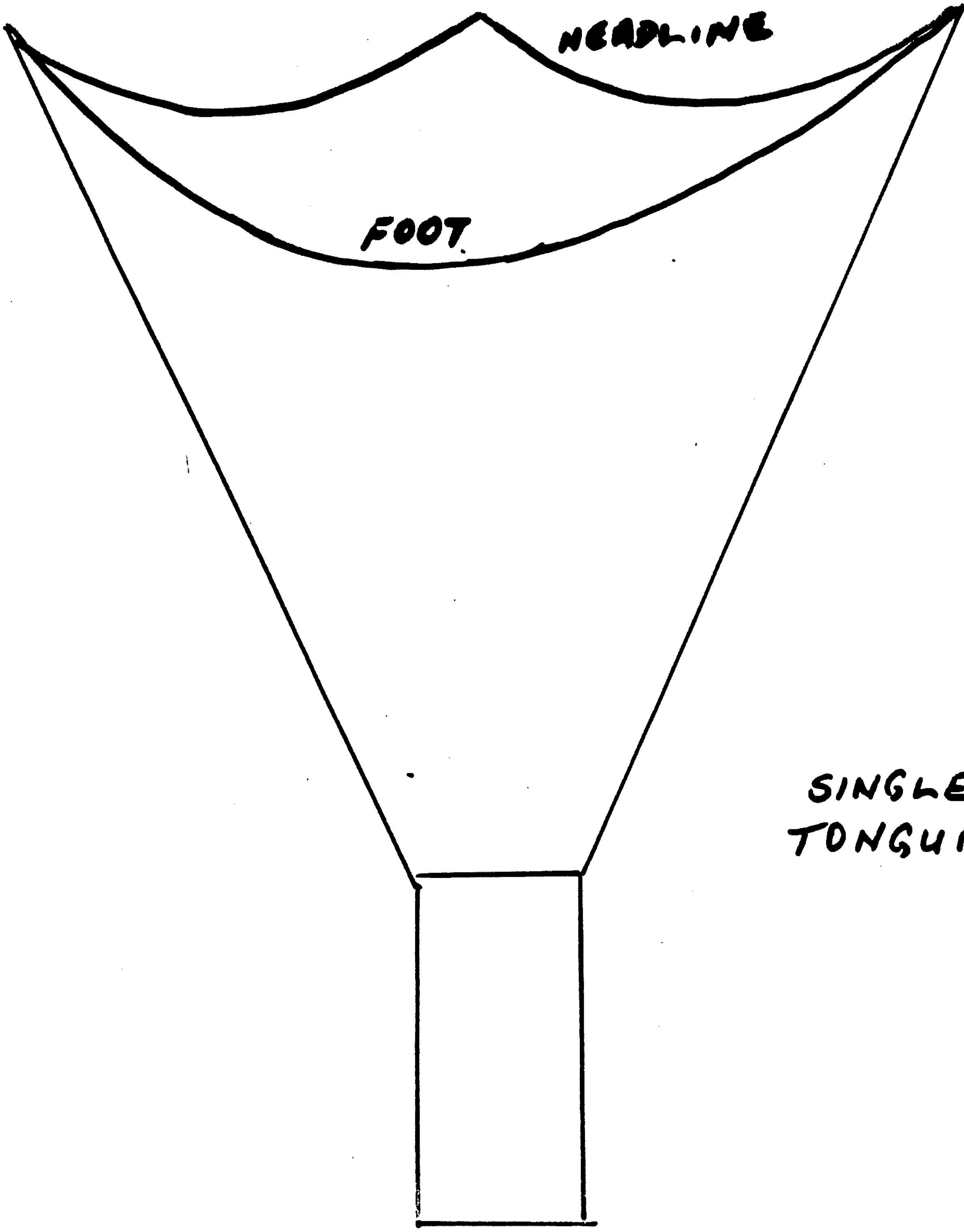


SANDAKAN (J.D)

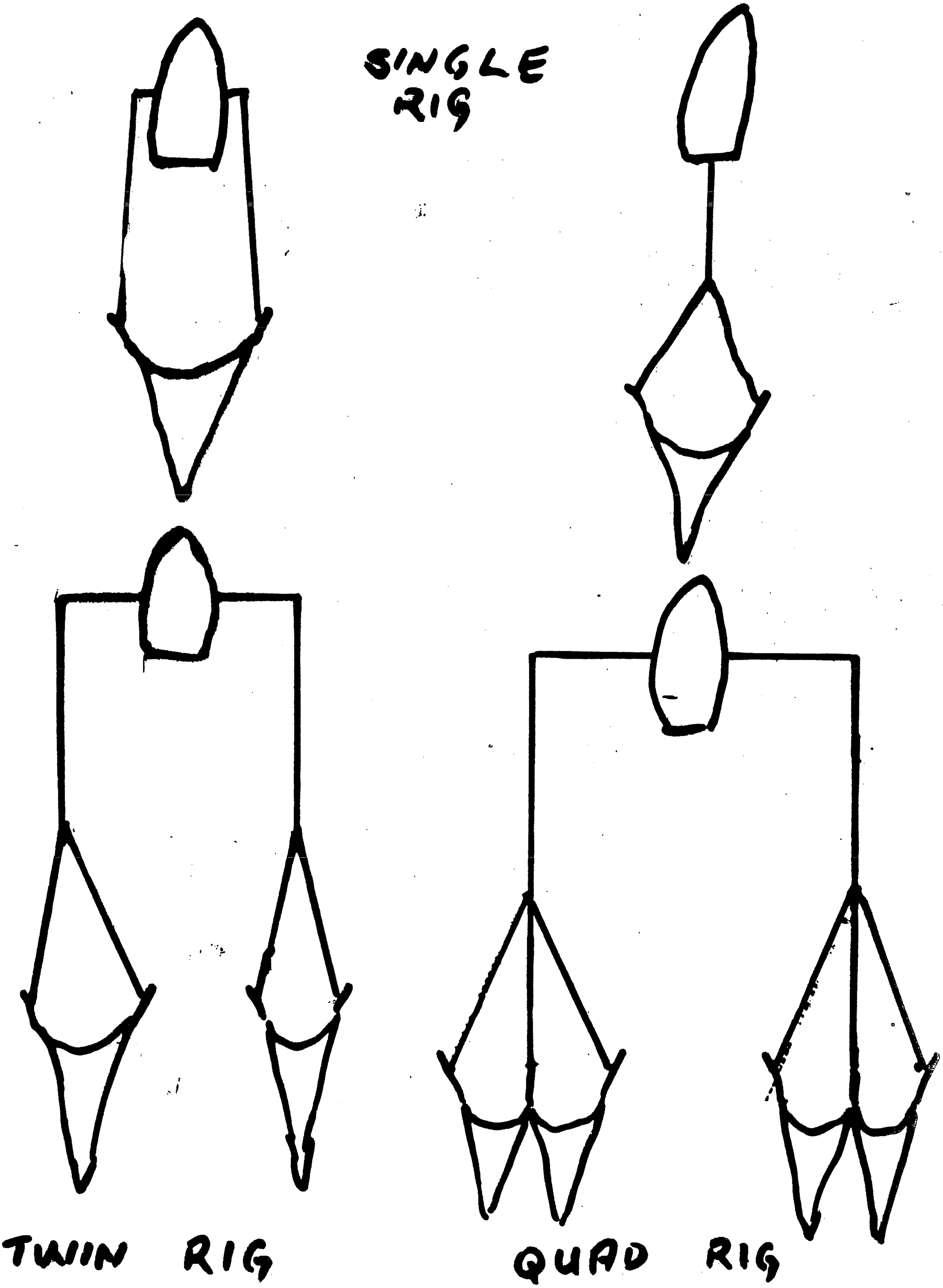
2 x 4 FM

1 x 8 FM

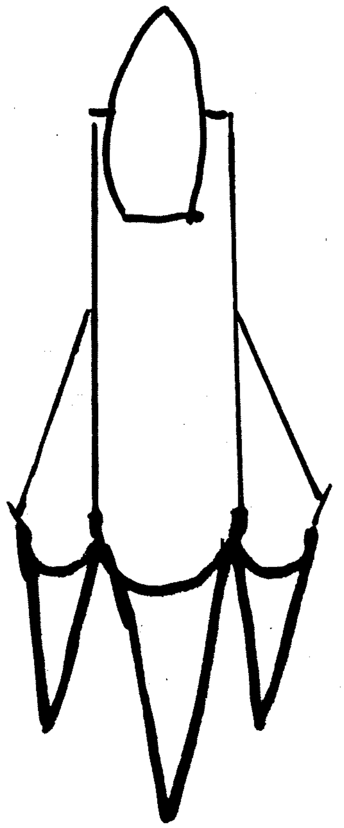


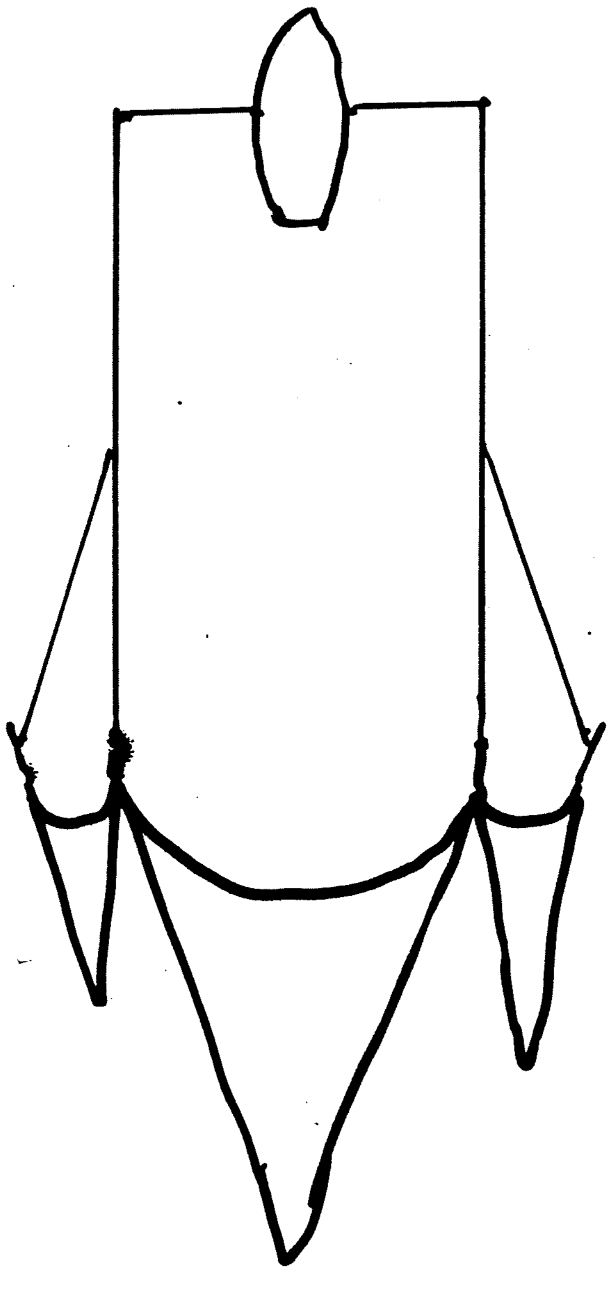


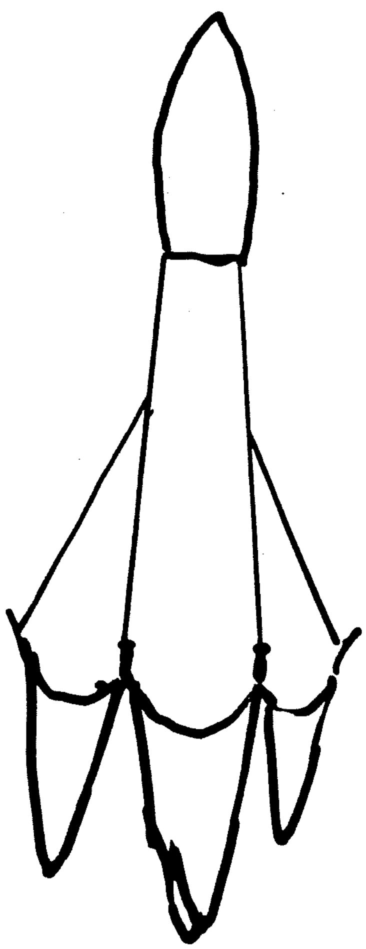
SINGLE TONGUE.

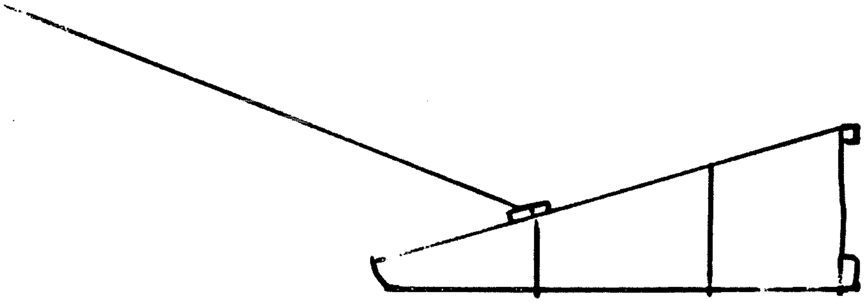

SINGLE
RIG
TWIN RIG
QUAD RIG

TRIPLE RIG

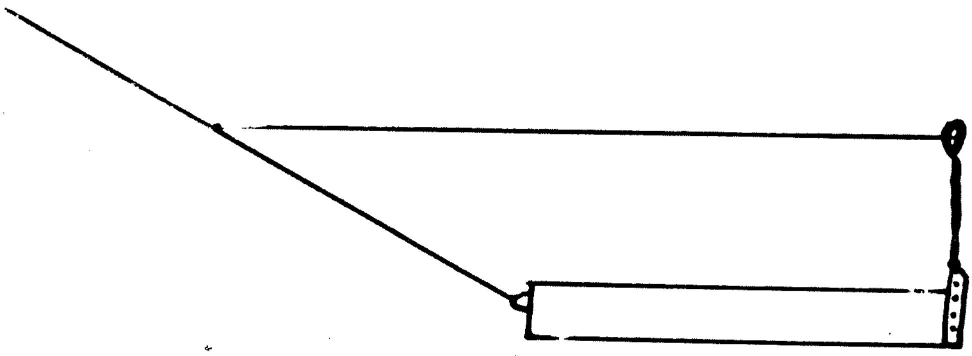




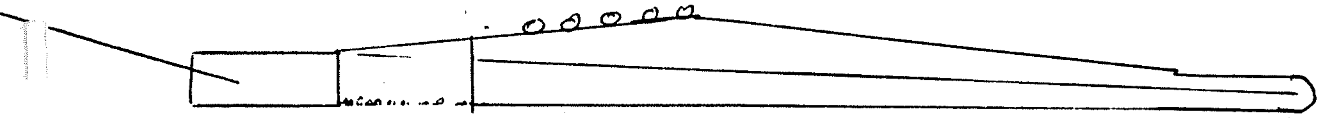




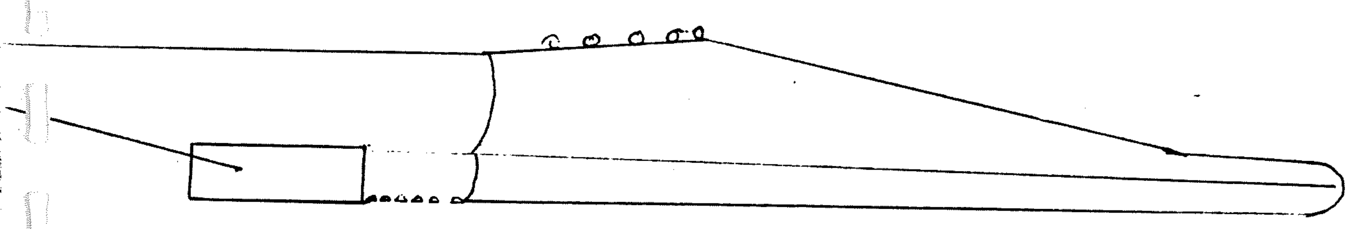
TYPICAL SLED



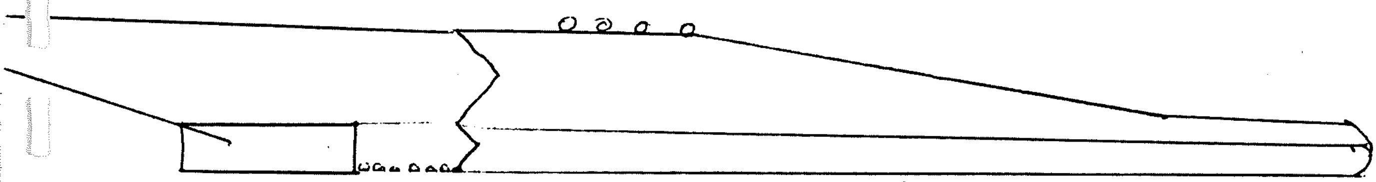
"BOMB"



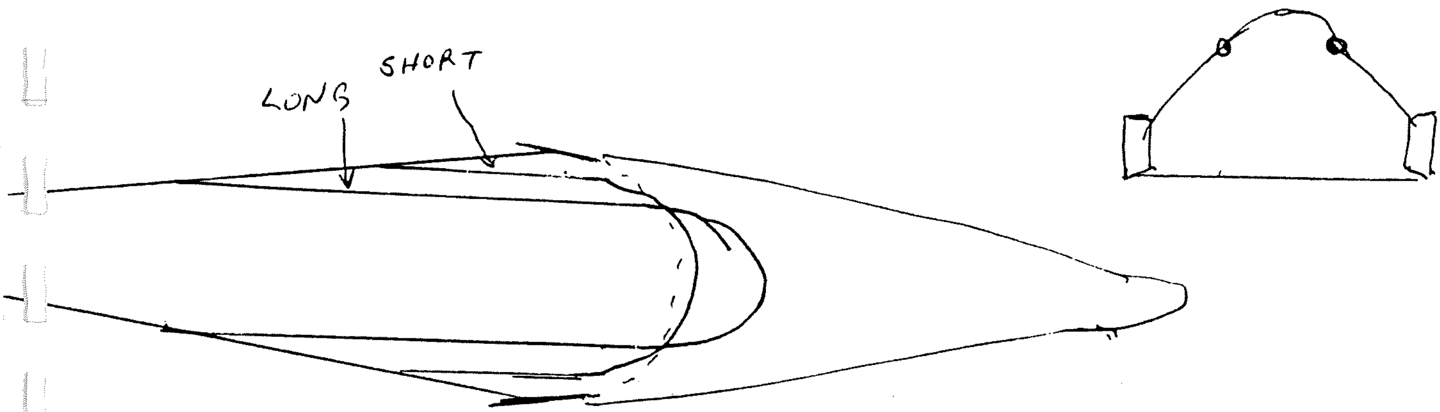
CONVENTIONAL YANKEE



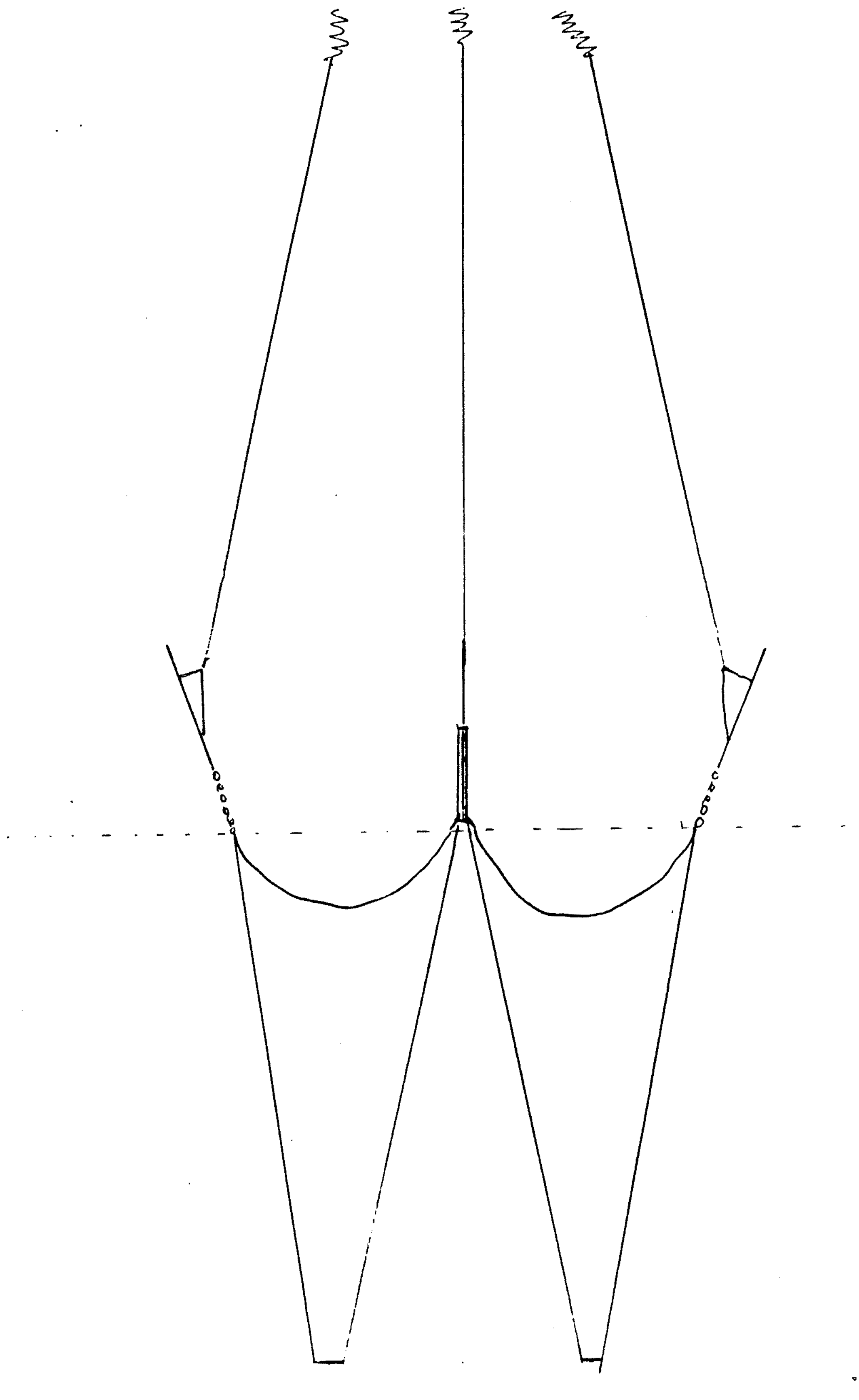
YANKEE WITH FLY WIRES.



COMBINATION WITH FLY WIRES.



EFFECT OF OVER LONG FLY WIRES



DEEP WATER TRAWLING
BY NEW ZEALAND VESSELS

Mr. John Greening
Fishing Gear Technologist
MAFF, Nelson, New Zealand

Several years ago 30 metre trawlers commenced fishing for spawning hoki, 40 miles off the west coast of the South Island of New Zealand in depths of 500 to 600 metres. At that time only one vessel was fitted with a net monitor.

The recent introduction of deep water colour sounders has dramatically transferred a coastal fishing operation into a highly technical deep sea operation, demanding a high degree of fishing skills and tactics. This has resulted in large catches from the deep water fisheries resource. Of these species, orange roughy forms the major catch.

Most of the larger vessels are stern trawlers designed with a long working deck area, and fitted with powerful main trawl winches, including a heavy fleeting winch.

The main trawl warps are 22mm diameter steel wire rope of either 6/19 or 6/24 construction. The steel trawl boards are either of the polyvalent or vee type design.

The main sweep wires vary in length, between 15 and 80 metres depending on ground conditions. The double bridles are usually 40 metres long. The trawls designs are of the four or six panel type with 300mm mesh in the wings and mouth area, reducing in mesh size to 100mm in the codends.

The average vertical opening of these trawls is approximately 7 metres at 3.5 knots.

Fishing Tactics

On arrival at the fishing grounds, the skipper commences searching with his main sounder to locate suitable marks. Taking into account tide and weather conditions, he target shoots the marks at 1000 metres allowing 20 minutes for his gear to settle, after running out the correct warp length, which is normally a ratio of 2.2 to one. The technique he employs is to shoot slightly deep for the marks and then increase towing speed as the gear settles to maintain a light ground rope contact with the sea bed as shown by the recording on the net monitor.

Tide direction plays an important role in this type of fishing, as currents often flow in other directions to those on the surface, resulting in the gear either fishing too hard down or lifting unexpectedly off the bottom, requiring immediate changes to towing speed for correction.

Using the short sweeps improves the response time for vertical gear control particularly when fishing the sides of pinnicals and encountering changes in the vertical distribution of fish marks throughout the course of a tow.

FISH BEHAVIOUR WITH REFERENCE TO FISHING GEAR

Mr. Andrew Smith
Senior Lecturer
Australian Maritime College

The subject of fish behaviour in the region of fishing gear is not an exact science, belonging more properly in the area of systems analysis. The rigorous methods of science are therefore not applicable to the study of fish behaviour with relation to fishing gear.

If we approach the subject with a system analysis approach there is really a proliferation of different systems to be studied, each one a different entity.

i.e. There are many types of gear.
There are many types of fish.
There are infinite configuration of ambient conditions (i.e. temperature, salinity, light, bottom type etc.).

In order to made the model a little more manageable, one of the most important criteria in fish behaviour has to be left out (i.e. fish location). It is the most important factor in most fisheries operations, and is the result of aquired knowledge and observations by fishermen over a number of years (indeed in some cases centuries). They know When, Where, What! As one old fisherman once said to me "10% of something is greater than 100% of nothing!".

Having dispensed with the most important factor in fisheries operations as irrelevant to the subject, and to admit that when in Rome do as the Romans do! is the best policy with regard to this subject, let us look at a possible break down of the model.

Types of Gear

Von Brandt lists a broad category of gear that takes into consideration various methods for third world countries, many of which are illegal in Australia, and others that are for other reasons unpractical in an industrialised nation. For these I propose a simpler system of more technologically advanced types that are at present used in Australia.

Trawls	Active gear - vessel and net chases fish
Purse seines	Active gear - vessel chases fish and surrounds the fish
Lines includ. pole and line	Passive gear - fish attracted and retained by hook
Traps	Passive gear - fish attracted and retained by trap.

Fish Types

Rather than a Linnaeus classification used by scientists, it is suitable in this case to look at a niche type classification.

(a) Demersal fish - Tend not to school but to aggregate at spawning time.

(b) Semi pelagic fish - Tend to school when spawning and at other times - (facultative schools)

(c) Pelagic fish - Spend most of their time in schools - (obligate schools).

Sense

(a) Sight
(b) Smell
(c) Sound (far field)
(d) Vibration (near field)
(e) Electrical
(f) Taste
(g) Temperature
(h) Salinity

Time

(a) Day

(b) Night

(c) Time of year

(d) Lunar cycle

Position

(e) Geographical position (related to a geographical fixed location

(f) Relative position (relative to a floating point)

In looking at this model we have to decide what variable we look at systematically. As a fisherman my natural choice is the fishing method. I will start first of all with the most important fishing method in Australia.

Trawling (Demersal)

This can be broken into two types:

1) Fish trawling - otter board trawling

2) Prawn trawling - twin boom trawling

Let me start with the fishery I know the best of the two - fish trawling - It is also the one that most has been written about.

Anyone who thinks that a fish trawl is merely a device that is pulled through the water to filter fish out of the total volume of water that the net passes through, had better go back to square one. One of my favourite stories about fisheries research concerned that carried out by the Saunders-Roe Organisation on behalf of the W.F.A. The net was to be the scientific creation which would revolutionise the backward fishing industry and replace the dated Hull-Granton net. Tests in wind tunnels indicated that the net had half the drag of a similar Hull-Granton. Thus a net twice the crosssectional area could be pulled at a similar speed, indicating that twice the fish could be caught. The net was a failure to the delight of fishermen and to the embarassment of scientists. What the scientists hadn't considered was that the fish could see and react positively to the trawl gear and components, and that the efficiency of the trawl gear was a combination of fishing gear geometry and fish behaviour.

Since the early 1960's a great deal of research has been done in the geometry of fishing gear at the W.F.A. Flume Tank in Hull and into the behaviour of fish reaction to trawl gear at the D.A.F.S. Marine Laboratory Aberdeen. On your visit to Beauty Point you will be given an indication of the type of research that has been carried out in the U.K. in the flume tank and also in the films produced on underwater observation of fish behaviour in the mouth of trawls.

At this point I will state only that the fish see and feel the fishing gear as it moves towards them and they swim away from it. In order to look at the nature of the reaction we have to look at the normal rig of the trawl, sweep, bridles and otter boards. See figure 1.

The normal reaction of fish is to swim directly away from the disturbance (which is usually the sweep) and swims away at an average speed of V.Sin O where V = speed of fishing gear O = angle of attach of bridles. See figure 2.

It is obvious by swimming away at right angles to the advancing sweep the fish is going to come into the path of the net at which point it then has to swim at the speed of the net. If the fish cannot swim at the speed of the net they eventually drop back into the net and are caught.

When considering swimming speeds we can roughly divide fish into two groups, and each fish ascribe two swimming speeds.

FIGURE 1.

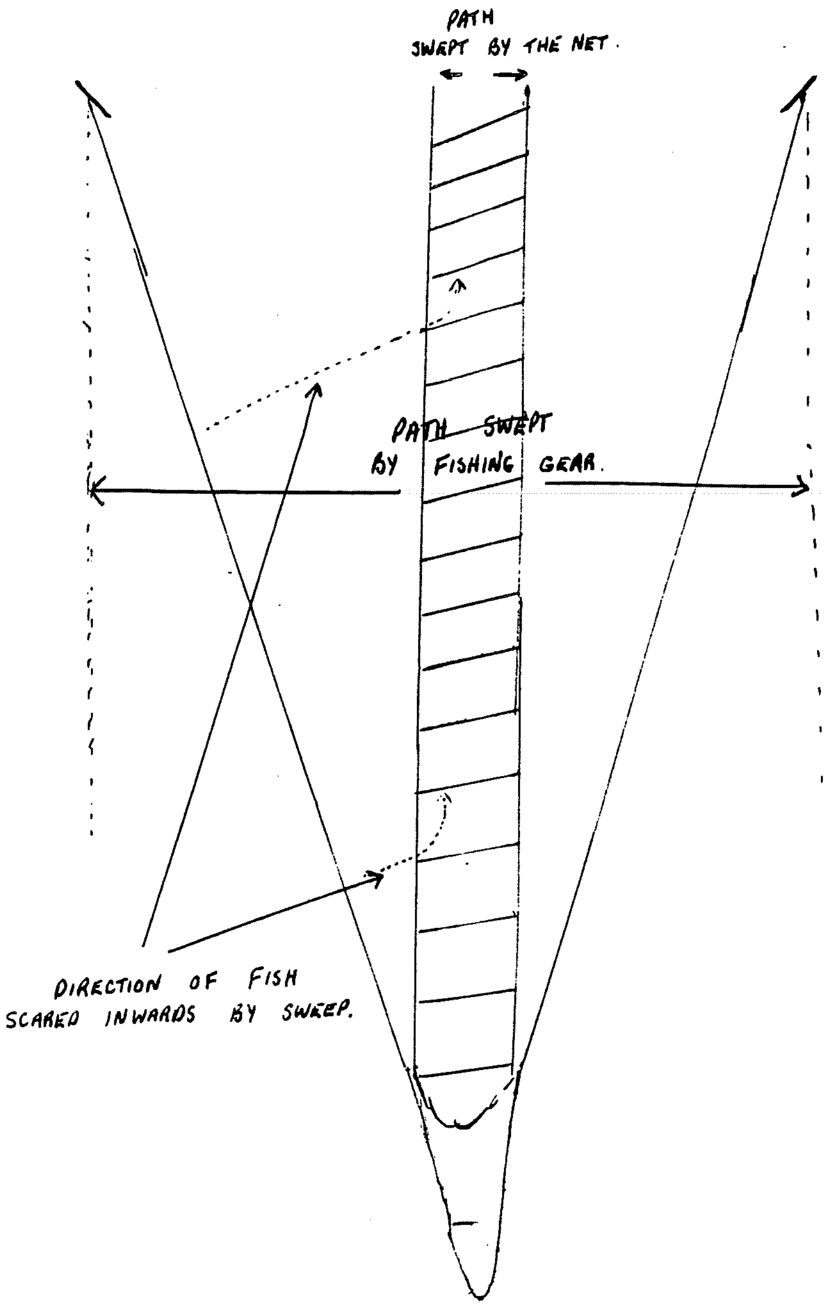


Fig. 1 FISHING AREA OF TRAWL GEAR

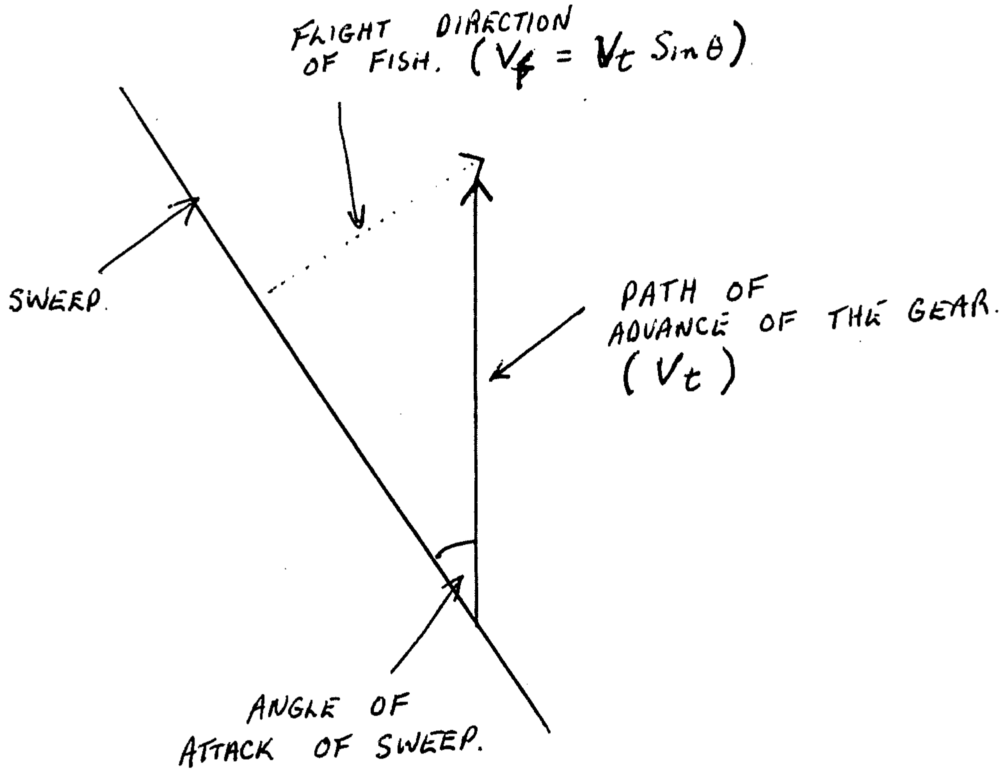


FIG2. RELATIONSHIP BETWEEN FLIGHT SPEED, ~~AND~~ SWEEP ANGLE, AND GEAR SPEED.

FISH TYPE	FLIGHT	CRUISING
PELAGIC.	10 B.Ls/sec.	8 B.Ls/sec.
DEMERSAL.	6 - 8 B.L.s/sec	4 - 5 B.L.s/sec.

SWIMMING SPEED (BODY LENGTHS/sec)

FIG 3. BROAD CATEGORIES OF SWIMMING SPEED OF PELAGIC AND DEMERSAL FISH.

In this respect we can look at four groups:

(a) Demersal fish with no red muscle which tend to rely on camouflage to escape and only have limited endurance.

(b) As above but flight speeds.

(c) Pelagic fish, with red muscle, which tend to rely on fast swimming and shoaling to escape predators and have extended endurance.

(d) As (c) above by flight speeds.

Scientists have determined relationships between fish weight/length and their approximate speeds. However, it is emphasised that these relationships are empircal and there are exceptions to the rule.

(a) Some species can swim faster than scientists' can calculate (e.g. tuna)

(b) Fish of unconventional shape (i.e. morwong and flathead) are slower than the relationship would give calculation.

The hard truth of Australian research is that this basic research has not to my knowledge been completed for the species of commercial importance, yet it is vitally important for the efficiency of the trawling operation. I would suggest that the way to get a quick answer would be to find the most successful trawler skipper and measure his speed and sweep attack angle, and work out the swimming speeds from that.

If this basic data were available what would we do with it with respect to the trawling operation?

The basic data that can be derived from experiments with fish	Vc = cruising speed of fish
	Vt = flight speed of fish

Remember the above are a function of size.

The other parameters that we can look at are:

Vt = speed of trawl

Vs - speed of sweep in a direction at right angles to sweep.

i.e. $Vs = Vt \sin O$

For a given set of gear, the skipper has several factors that he can change in order to vary Vs and Vt. These include:

(a) vessel power (hence speed)

(b) size of net

(c) otter board attack angle

(d) length of sweep

(e) length of warp

It is not the purpose of this lecture to go into how this can be achieved, merely that it is so possible

Let us look at the relationship for a specific size of fish.

If

$Vs > Vf$	then small fish will be overtaken by the warps and escape the trawl
$Vs = Vf$	then the fish will be herded into the mouth of the trawl.
$Vt > Vc$	then the fish will be overtaken by the trawl and presumably be caught.
$Vt = Vc$	the fish will swim ahead of the trawl and will not be caught.

Therefore in order to successfully capture a fish of a certain size

$Vs < Vf$ and $Vt > Vc$ where $Vs = Vt \sin \theta$

$Vt \sin \theta < Vf$ and $Vt > Vc$

hence $Vc < Vt < Vf/\sin \theta$ for the trawl to successfully catch all the fish in the path of the trawl gear.

There are still other criteria that have to be met before the fish can be successfully caught, which relate to the behaviour of the fish in the path of the net.

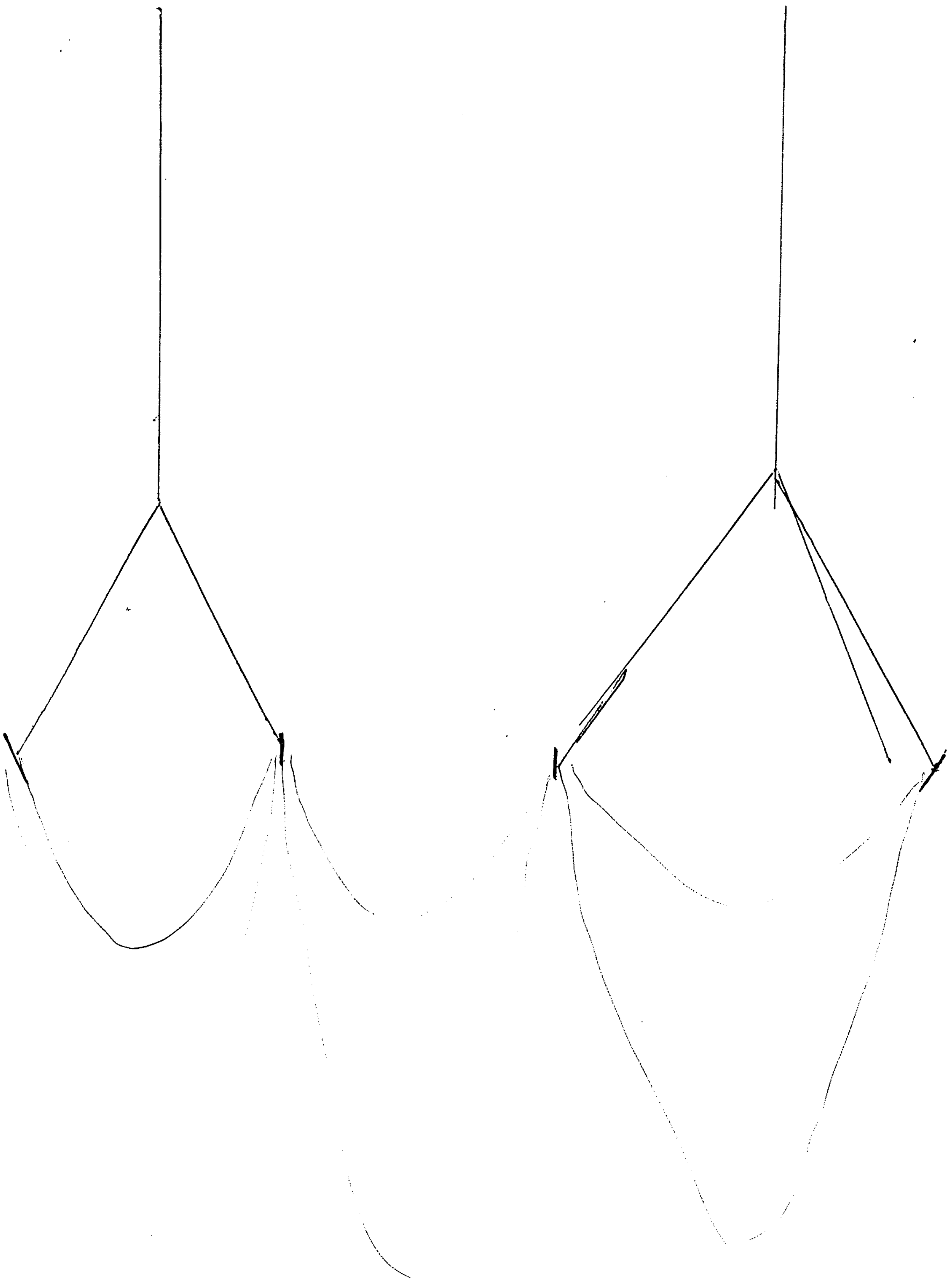
Trawl fisheries are usually carried out during the day, related to the fact that the fish have to see the trawl sweeps before they can be efficiently caught. However there are fisheries in Europe where high visibility can allow the fish to see the entire trawl and swim clear of the net, for example cod fishing on the Viking Bank in mid-summer (shallow water). There are also fish whose initial reaction is to swim upwards and over the headline of the net, thus avoiding the net in a vertical direction (i.e. saithe)

Prawn Trawling

In the preceeding section we were considering fish research most of which has been completed in Europe. However with regard to prawn trawling, I am glad to say that a great deal of research has been done in Australia. First let us look at how prawn behaviour differs from fish behaviour. Prawns are not going to have the same behaviour patterns to fish. Therefore the type of fishing gear that has evolved for fish trawls is not going to be successful for prawns. (Figure 4)

If we jump quite a bit and look at the gear used in prawn fisheries at present we see quite a different type of

FIG 4. FISHING AREA OF TWIN RIG PRAWN GEAR.



gear. This is related to the fact that the prawns do not have the same swimming capabilities as fish. The multiple rig type of gear adopted give several advantages over fish trawls such as:

(a) a greater length of footrope

(b) allowing the net to follow the bottom contours more closely

(c) less net, therefore less drag, for the same length of footrope.

Danish Seining

Although the behaviour of the fish in relation to seines are basically the same there are some basic differences with respect to swimming speeds. (Figure 5)

The areas are very much greater and far greater distances are involved with respect to the swimming speeds in front of the ropes and the net. For this reason there needs to be a very careful combination of winch speeds and vessel speeds. Probably because of this it is the method that probably requires the most skill of the skipper. (see figure 5.)

FIG 5. FISHING AREA OF DANISH SEINE.
(NOTE CHANGE IN SCALE)

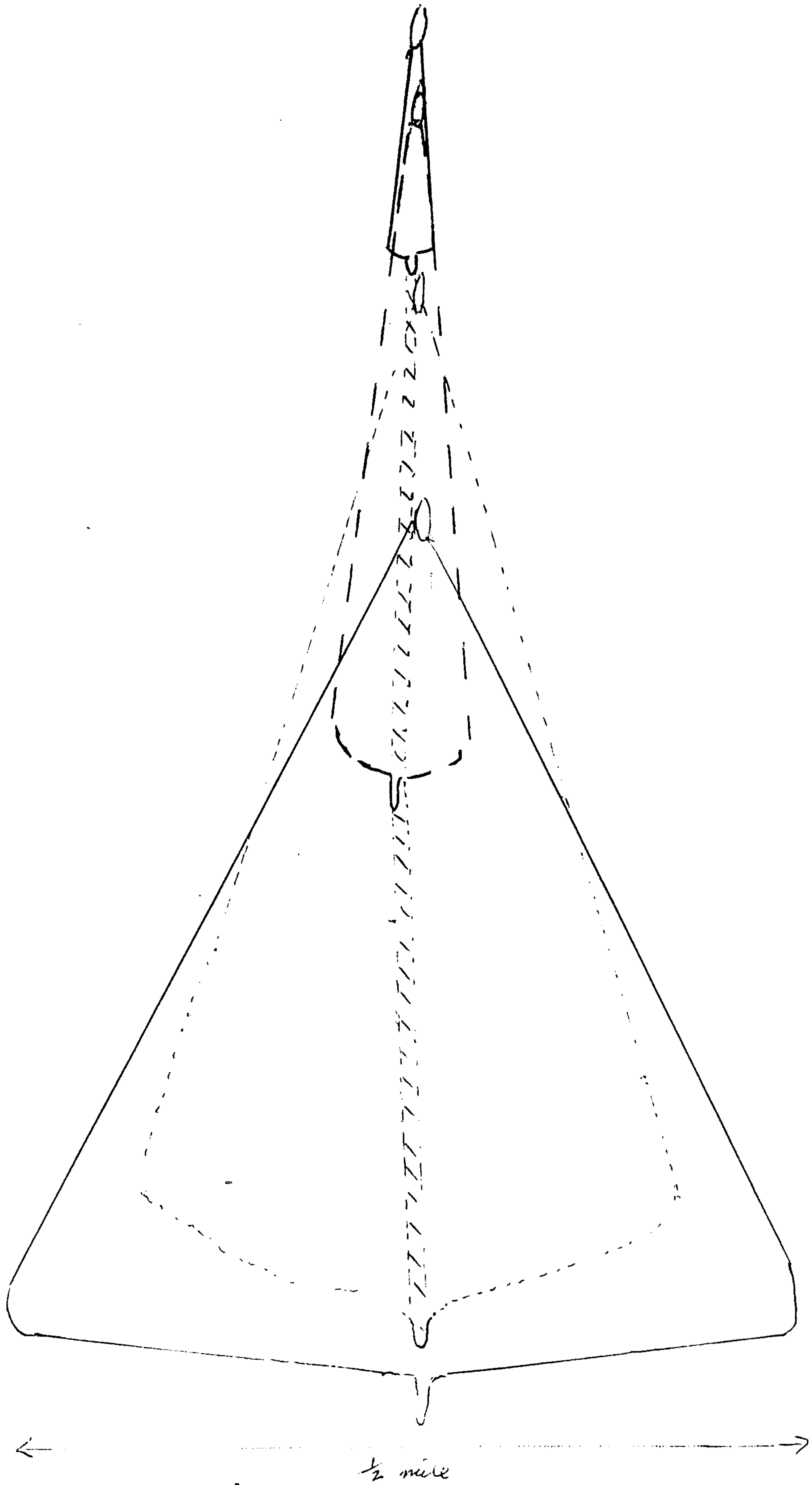


FIG 6 FISHING AREA OF DEMERSAL PAIR SEINE

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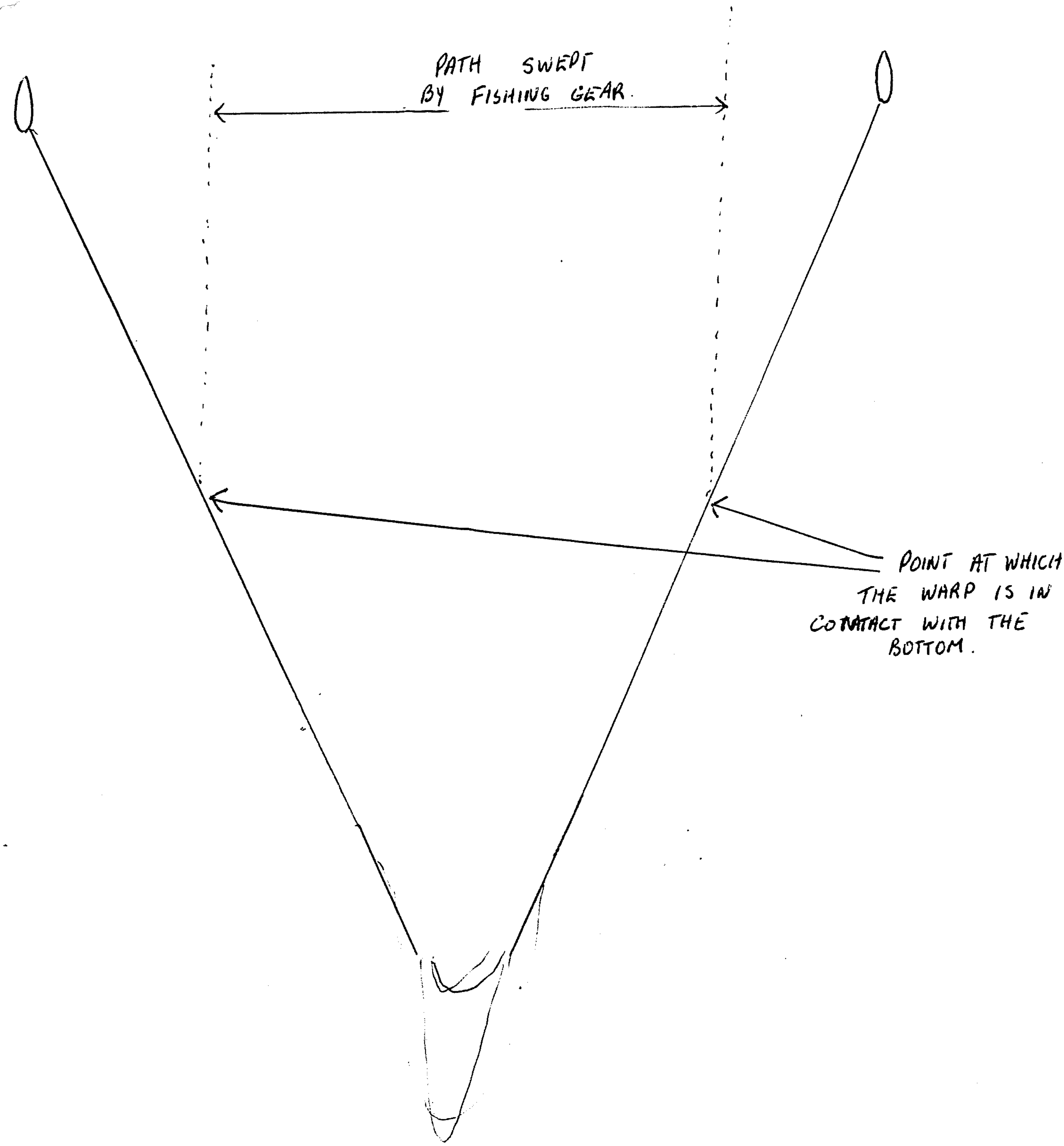

Again the time of day is critical. Normal daytime fisheries can be uneconomic in shallow water (less than 30 fathoms) with very high light intensities, yet be fairly successful in the same depth range with moonlight.

The effect of currents is detrimental to the fishery in a similar fashion to trawls, even more so because of the dependence of current on the whole operation. Do catches differ because the fish behaviour has changed or does the current have an effect on the fishing gear geometry? My own opinion is that it is a combination of both.

The Effect of Mesh Size on Fish Behaviour

The basic philosophy I have been following up till now has been that fish will swim away from an object and eventually will finish up in the mouth of the net. The fish will swim in front of the net until they become exhausted and will then pass back into the net maintaining a constant distance from the sides of the net until they finish up on the cod end. (This behaviour can be observed quite clearly in the film that you will at Beauty Point). However, there are several personal observations I have made with regard to this; some I have picked up from other fishermen.

(a) Netting greater than 4½" mesh in the square of a net has detrimental effects on the catch of haddock.

(b) A hole in the square of a net of 4½" mesh consistently gill-netted pollack around the hole.

(c) Jack mackerel have been observed to swim through the 6" mesh.

(d) With the present increase to greater mesh sizes in pelagic trawls a skipper for whom I have the greatest respect, has stated that 132" mesh for herring is too large.

From this I can only come to one conclusion - that there is not a uniform behaviour pattern for all fish, and that each individual fish has to be studied at each individual age and season before one can build up a complete picture of its behaviour in relation to fishing gear. An enormously complex task!

Purse Seining and Pelagic Trawling

These types of fishing we move involve a different type of fish. Pelagic fish. The main difference, of course, is that pelagic fish are much faster fish than demersal fish. They use a particular type of muscle (red muscles) that has a high rate of oxygen, blood supply etc., to provide continuous energy to the fish and to provide a high continuous speed.

Up until the early 1960's the catching of fish by pelagic trawls was regarded as uneconomic. The increase from a towing speed of two knots needed to catch demersal fish to a speed of four knots required to catch pelagic fish only one sixth the size, required a fourfold power increase. (This is a simplification but it is a necessary simplification in that we aren't concerned with fishing gear engineering but with fish behaviour). Not until synthetic twines became available did it become economically feasible to trawl pelagically for fish. Again we come to the behaviour of the fish. Pelagic fish such as herring pilchards, anchovies, sprats, sardines generally swim in shoals. However, they are not normally concentrated enough to be fished economically. The normal time for fishing these species is when they are in very tight schools for spawning. It always has been the source of amazement to me

(a) How the fish congregate from an apparently empty sea to a spawning ground.

(b) How tightly packed herring get in a spawning school.

Normally the behaviour of the fish has to be taken into consideration (i.e. young herring school together during the day but adult herring school together during the night with maximum densities occurring at dusk as the fish gather together to rise to the surface). At times fish are

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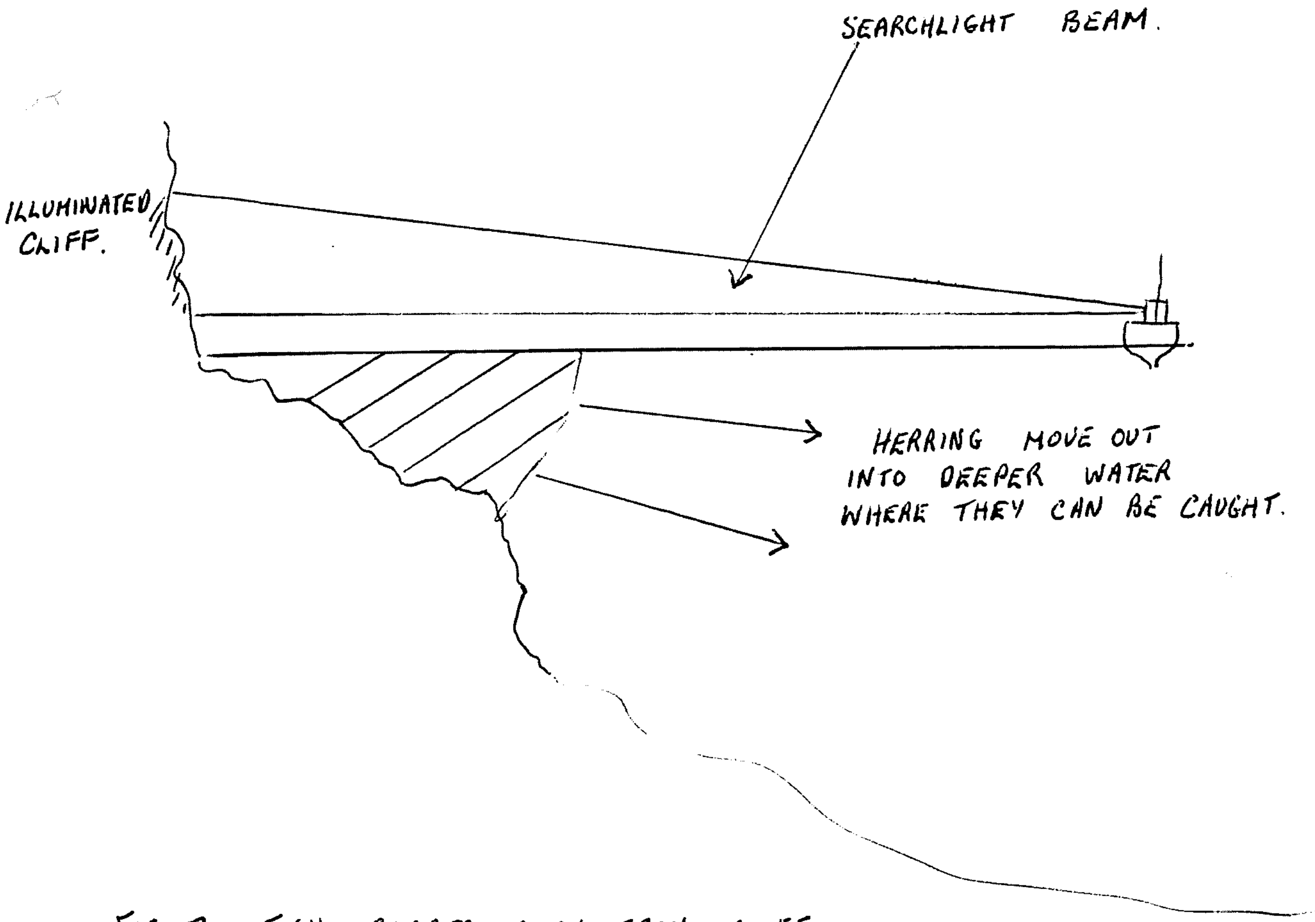


FIG. 7. FISH SCARED AWAY FROM CLIFF WITH AN INDIRECT LIGHT SOURCE BY RING-NETTERS

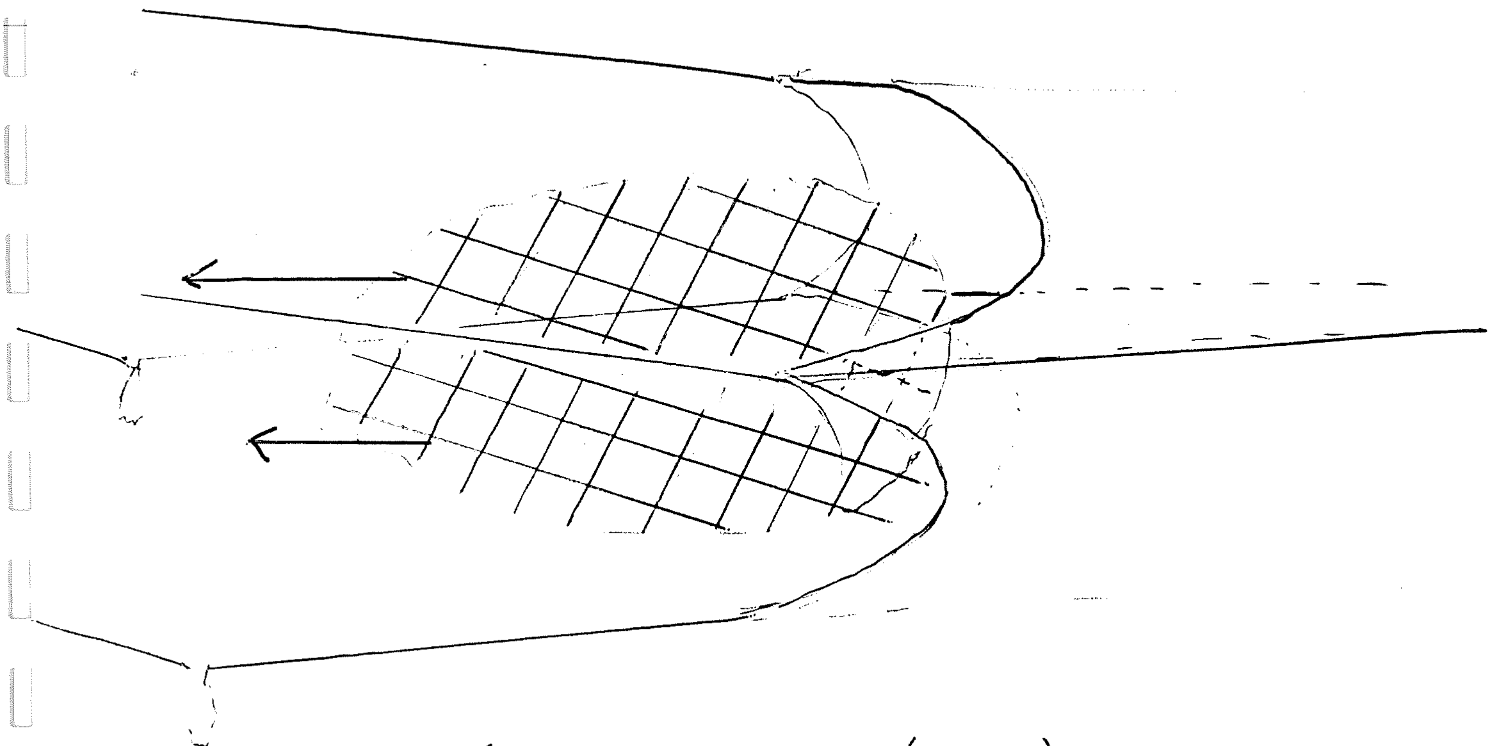


FIG 8. SCHOOLING FISH (HERRING) MOVING AHEAD OF A MID-WATER PAIR TRAWL

repelled by light (i.e. herring catches fall off during periods of moonlight. It was common practice amongst the small ring-metters to scare fish away from the cliffs by shining searchlights in them (Figure 7). It would appear to me that scientific literature is full of the attractions of fish to light, but my experience has always been the opposite (even to the extent of towing without regulation lights). Of course the cause of this is again straightforward. If fish are attracted to a light their presence is obvious, but if they are scared away there is no way of quantifying how many fish have been scared away or even that they were there in the first place.

Fish in the mouth of a trawl congregate more tightly together in the area immediately in front of the trawl and swim ahead of the trawl (Figure 8).

If the trawl is being towed faster than the Vc (i.e. cruising speed of the fish) then they will fall back gradually as a school into the net. The behaviour of fish in a shoal is now relevant. During swimming the fish will keep a regular constant distance from the fish around it in a regular lattice type configuration. (There is evidence that the fish can swim faster as a school than they can individually, due to slipstreaming; also that the position of fish within the school is constantly changing so that each fish is given an opportunity to be at the leading edge of the school where the best feeding is).

Netsounders are used to monitor the behaviour of the fish in the mouth of the trawl to see whether they are moving vertically upwards or downwards in the mouth of the mix-water trawl. The net depth altered accordingly. Generally at dusk they are relatively stable (apparently their instinct of upward vertical migration counteracted by the vessel noise above) but at dawn the schools are diving rapidly, both instincts acting in the same direction.

Horizontal swimming speeds are interesting. Two incidents I recall give an indication of problems associated with mid-water trawling, one of which possibly has a perfectly rational explanation the other as far as I can see defies explanation.

(a) While pair trawling for herring in the early 1967-68 vessel that had previously caught herring quite easily, found it far more difficult to catch herring, out vessel had 250hp Gardner partnered by a similar powered vessel. Vessels of 300hp were still able to fish commercially. One particular occasion we were using the netsounder and the recording between the headline and footrope was black, not unnaturally we felt that the net was going to be full, but discovered otherwise. The fish had been swimming directly in beneath the net transducer and had recorded continuously. When we hauled the net the fish just swam away. At that time fishermen believed that there was a breed of super herring being bred, but scientists pointed out that time had been too short for this to happen. A more reasonable explanation is that there was an older year class in which the fish were able to swim faster.

(b) Another incident of similar situation where a skipper I know was confronted with a similar incident, chased a shoal for three hours towing north, pulled up, commented "Now we've got them fooled", shot away, towed south and caught them!! It appears that this particular skipper did this many times.

Purse Seining

Although purse-seining and mid-water trawling are significantly different in method, the behaviour of the fish are essentially the same. The success of the fishing operation depends on the ability of the vessel to set the net around the fish to prevent escape in a horizontal direction, and to purse the seine to prevent escape in a downwards direction. Note that in this case we are not so concerned about the swimming speed of the fish as to the ability to out-think the fish and keep them from:

(a) rushing towards the gap in the setting net.

(b) swimming downwards to escape before the purse is closed.

It is therefore imperative that the operation is carried out at speed, even with relatively slow pelagic fish such as herring. For tuna with speeds in excess of 20 knots (i.e. faster than the vessel) it is even more so.

The fishing operation depends on shooting around the path of the school (if possible) so that the fish run into the net and have to turn. The relative speed of the vessel and fish can be determined by 'doppler'. Escape from the net horizontally can be prevented by:

(a) Speed

(b) High speed dories and explosives.

Downwards escape can be prevented by:

(a) Thermocline (if present)

(b) Speed

(c) Explosives.

As far as the gear is concerned, it is easily seen that the larger the net the greater the possibility of capture of the fish. In most cases the size of net is limited by the size of vessel. In America the tendency for tuna purses is to build larger vessels to carry larger nets, though there is bound to be a limit to the extent that this can go, it has not been found yet.

<u>Lines, Traps</u> (Baited, Lure)

Although these have many differences in application, they have one basic similarity. The fish have to be attracted to the bait. The most common method of attraction is by smell. In this respect we have to remember that fish have a far better sense of smell than humans. In experiments with tuna, it was found that tuna were excited just by small amounts of water from a bait tank. In tests it would appear that the activity of tuna increases with the following stimuli:

(chemosensory stimuli)

(a) Smell of water that bait has been kept in

(b) A particular amino acid from the fish (not always the chemical one)

(c) The same mixture of amino acids as the fish.

(d) Chopped up bait fish

(chemosensory stimuli + visual stimuli)

(e) Dead bait fish

(f) The real thing (i.e. live bait fish)

The preference for the last three is thought to be due to the visual stimuli that is added to the smell (i.e the two stimuli excite the fish to a "feeding frenzy"). Once the fish are at this stage where the visual stimuli is predominant, they can be kept biting. Atema reports that chopped cabbage has kept tuna striking.

The use of water sprays on poling vessels has been found to be particularly effective in keeping the school, but the effect on the fish, whether visual or vibrational is not understood. Some believe that the spray prevents the vessel from being seen by the tuna, but there is also an argument that the vibration has the same effect on the lateral line sense organs as baitfish.

The effect of an injured tuna on a school is believed by fishermen to be very detrimental to the feeding frenzy of the school. The school will suddenly stop striking. It has been postulated that this might be due to a chemical signal released by the injured fish.

Fish Traps

Again the fish or crustacae have to be attracted to the trap. The major variable after all the regulations etc. have been considered is the bait. Again numerous experiments have been carried out with regard to finding an artificial bait but have not met with higher catch rates than natural bait.

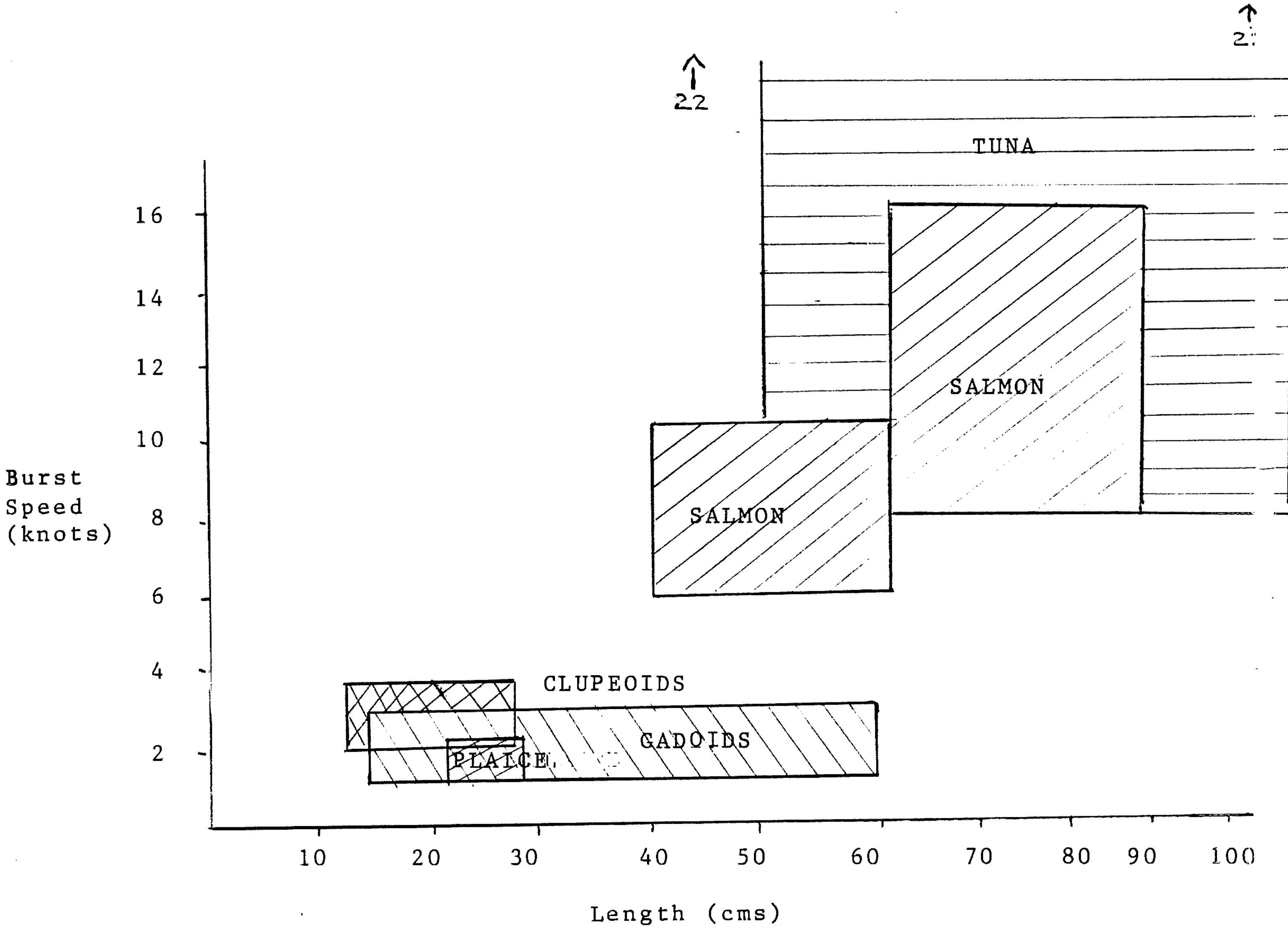
APPENDIX 1

Swimming Speeds of Fish

The swimming speed of fish is very difficult to quantify especially as different scientists have used different criteria for measuring burst and cruising speeds. Even when using the same criteria they get different results, which is not surprising. If we took a cross-section of the population and recorded their times (a) over 100 metres and (b) over the marathon we would get widely differing results.

Fish are no different. Within a species some are in good condition, some old, some pregnant, and some doggone lazy.

The results in the accompanying sheets are a broad generalization of what has occurred in the literature on the subject. I have taken the liberty of modifying the vertical scale to knots so they can be of some use to fishermen.



RELATIONSHIP BETWEEN BURST SPEED, SPECIES AND SIZE

APPENDIX 2

Search Theory

The probability of a fisherman finding a school of fish, or of a tuna finding a bait fish is essential to the whole fishing operation. There is a growing opinion in the scientific literature that schooling offers an evolutionary advantage in terms of the fact that if fish school, then the probability of a predator locating the school as a whole is reduced. If by chance the predator does locate a school then he can only consume his fill.

There is however, an adaptation that predators have evolved and that if they hunt as a school then their efficiency is increased. In terms of the fishing operation it is also true that for schooling pelagic species, fishing vessels hunting as a pack considerably increase the chance of locating a school, which, when located, is sufficient for filling a number of vessels.

The Koopman Theory of Search states that the probability of finding a given object in an area by a predator (vessel) swimming (steaming) at a constant speed V for a time t is:

$$P = 1 - \exp(-2rVt/A)$$

where A is the area to be searched, r is the radius of the school.

The equation can be extended so that the search area of the vessel can be taken into consideration

$$P = 1 - \exp(-(R + r)Vt/A)$$

where R is the radius of the search area.

Example

10 vessels are to search at random for 1000 schools of 100 metres radius. Their search speed is 16kms/hr (10 knots). The area to be covered is 400,000 sq kms (the area of the Great Australian Bight) and path of search is 800 metres. What is the probability of locating a school in 7 days?

P = .5 or in other works an even chance.

The size of school could hold 100 tons. Therefore it is possible that there is a resource of 100,000 tons just waiting to be exploited.

APPENDIX 3

Harden - Jones Theory on Fresh Water Attraction of Marine Species Attraction

Hasler's work on the migration of salmon to their home streams in North America, has been more or less accepted as fact. A more recent development has been the hypothesis of Harden-Jones that marine fish possibly locate their breeding grounds by salinity gradients formed by groundwater seepage. (A film on this concept will be shown at Beauty Point tomorrow.)

If this hypothesis is true, and it does have strong support in local fishermens' lore, then it has far reaching effects on marine fisheries and on management.

(a) If spawning grounds are located, then there is going to be a higher efficiency of fishing effort.

(b) There will be far greater danger of pollution from groundwater seepage affecting recruitment than has been accepted at present.

(c) Location of possible fishing grounds by salinity measurements.

Systems Analysis with Specific Reference to Fishing Efficiency

There is no doubt that fisheries is a complex system in that it is a additional factor imposed by man on an already complex ecological system. If a systems analysis approach is adopted then there are seven steps in the application of systems analysis.

(a) Recognition -

(b) Definition and bounding of the extend of the problem - The problem at this stage is to make the system easy enough to understand and model, and yet complex enough to give adequate results.

(c) Identification of the heirarchy of goals and objectives - These have to be rigorously set, because of the problem of someone going overboard.

(d) Generation of solutions - Looking at different ways of solving the problem and choosing the best method.

(e) Modelling - This is the crux of the matter and it is important that there is a full awareness of the inherent uncertainties in the various processes to be modelled, and of the feedback mechanisms.

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(f) Evaluation of the potential courses of action - The phase of evaluating potential courses of action investigates the sensitivity of the results of the assumptions made by the model, as it is only when the model is used that previously unsuspected weaknesses in the assumptions and in the model formulation begin to be revealed. The weaknesses can be perhaps rectified by modifications to the model, but sometimes the model has to be totally overhauled.

(g) Implementation of the results

The recent study into southern bluefin tuna is an ideal example of this kind where the system has been analysed by C.S.I.R.O. and run on a computer. At this stage it has reached a stage where there is an evaluation of potential courses of action (e.g. close the W.A. fishery?).

Types of Models Used for Analysis of Fisheries

1. Dynamic Mathematical Models - Essential for the calculation of recruitment etc.

2. Matrix Models - Of population dynamics.

3. Stochastic Models - To incorporate probabilities, and needed to simulate the variability and complexity of an ecological system.

4. Operating Models - The mathematics of these models is frequently complex, for this reason there are relatively few successful examples. Hilborn describes the use of strchastic dynamic programming for determining optimal harvesting rates for mixed stocks of fish.

5. Game Theory - To take into account the competition between fishermen, and indeed fishermen and other predators.

FISH BEHAVIOUR

Dr. Frances B. Michaelis
Lecturer
Australian Maritime College

Fish behaviour is the study of all processes by which an animal responds to changes in its environment, both internal and external. Behaviour can be studied under natural conditions in the field or in artificial conditions in the laboratory, in which case animal behaviourists or psychologists are involved. Behaviour also has a physiological or bodily component and a separate aspect of its study relates to the functioning of the nervous system of the animal. Both aspects of behaviour are involved when we consider fish behaviour in relation to fishing gear.

A higher or bony fish, such as a jack mackerel, responds to its environment through its senses and its specific sense organs, which can be summarised in Table 1.

In the invertebrates, advanced structures such as inner ears, barbels and the lateral line system are absent. However, many senses are well developed e.g. eyes in molluscs such as around the mantle of the scallop, Pecten fumata, and in Gould's calamary, Notodarus gouldi. Complex behaviour patterns have evolved. The greenlip abalone, Haliotis laevigata, feeds by trapping drifting algae or seagrasses as they are swept past by the current. It lifts the front of its shell and extends the forepart of its foot to grasp it.

Because of these senses, fish are able to develop complex patterns of behaviour, many of which are of a rhythmic nature. These include seasonal changes in growth and reproduction, migrations, and lunar tidal and circadian (daily) rhythms. All of these rhythms play a part in determining where the fish are, what they are doing and what reproductive (or nutritive) state they are in when caught. As an example, Roe's abalone, Haliotis roei, grazes only at night, an example of a circadian rhythm. A seasonal rhythm is indicated by snoek or barracouta, Leionura atun, which feeds mainly during the late spring and summer in the Bass Strait region, which is when spawning occurs.

Many questions remain not fully answered.

Is the lateral line canal organ sensitive to water displacements rather than to velocity or acceleration?

What is the interaction between aquatic pollutants, chemoreceptors and behaviour?

Answers to questions like these, particularly when related to Australia's commercial species, will greatly improve the locating and catching of fish.

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TABLE 1

Senses and their Perception in Higher Fish

SENSE	COMMENT	RECEPTOR CELLS	ORGAN
Sight	Water not very clear (20m very good but often less than 1m)	Rod and cone cell in retina	Eyes
Sound	Sound travels faster in water (hearing about same as in land animals)	Sensorary hair cells	Inner ears
Smell	Odours spread slowly in water (well developed, esp. in sharks and eels)	Nasal lamellae	Olfactory organ
Taste	Similar to smell (requires actual contact)	Taste cells (buds)	Lips, fins, barbels etc.
Touch	Important in aggressive and mating displays	Epidermal tactile cells	Epidermis (barbels in some fish)
"Distance touch" "sound"	Used to detect low frequency vibration, movements, pressure changes, temperature	Neuromasts	Lateral line system

"DOES THE FLUME TANK PROVIDE SOME ANSWERS?"

Mr. Frank Chopin
Lecturer
Australian Maritime College

1. Introduction

The session under which this paper is presented is titled 'Gear Efficiency Saves Dollars'. In order to understand how a flume tank, or circulating water tank may be used to investigate gear efficiency, it is necessary to find out what is meant by gear efficiency, secondly, describe the work that may be carried out in the flume tank and finally see how this work may be related to fishing gear efficiency.

The most significant fishing methods in Australian waters are included in table 1 (Maclenan). "Operating efficiency" may be determined by:-

1. The quantity, quality and composition of catches.

2. The cost of fishing gear.

	Column	1	2	3	4	5	6	7	8	9	10	11	12
		Catch rate (efficiency)	Income /catch ratio	Gear and equipment costs	Operating costs (per unit catch)			Suitable vessels (3)			Skill required	Catch selection (by length)	Remarks
					Fuel	Labour	Other	S	M	G			
DEMERSAL GEAR	Otter trawl	AL	AH	A	H	A	A				A	AL	
	Pair trawl	A	AH	A	AH	A	A				AH	AL	
	Seine net	AL	AH	A	AL	A	L				A	A	limited to suitable ground - not too rough
	Gill net	L	AH	A	L	A	LA				L	AH	The selectivity depth on the construction (hanging ratio)
	Trammel	L	A	A	L	A	LA				L	AL	
	Pound net	L	AH	H	-	AH	A				AH	H	fixed gears - operating from the shore
	Fyke net	L	AH	A	-	L	L				A	AH	
	Traps	L	AH	A	L	A	L				L	AH	shellfish gears
	Handlines	L	H	L	L	H	L				LA	H	
	Longlines	AL	H	AL(4)	L	H(4)	AL				AL	H	
PELAGIC GEAR	Purse seine	H	L(2)	H	A	H	L				H	L	for shoaling species
	Otter trawl	AH	A	AH	H	A	A				H	HL	
	Pair trawl	AH	A	AH	AH	A	A				H	AL	
	Drift net	L	AH	A	L	A	L				L	H	
	Handlines	L	H	L	L	H	L				LA	H	
	Longlines	L	AH	A	L	H	L				AL	H	
	Trolling	L	AH	L	AL	A	AL				L	H	

Notes: (1) Assumes motor vessels. In some cases sailing ships may be used, eliminating fuel costs.
(2) High in the case of valuable species e.g. tuna.
(3) S = small (15m), M = Medium (15-40m), G = large (40m).
(4) Labour intensive except if automatic baiting machines used, when equipment costs will be high

L = Low
A = Average
H = High

MACLENAN (1980)
Table 1

3. The running costs of vessel and labour.

4. The safety of fishing operations.

5. The skill of the skipper and crew.

Columns 1-12 in table 1 list the items of importance for each fishing method. For example, through improved selectivity, it may be possible to reduce fish by-catch in the prawn industry. The implications of this are reduced operating costs (through reduced labour to sort catch) and also a higher income/catch ratio because of improved prawn quality. Another example would be reduction of gear drag through improved hydrodynamic performance of nets and/or trawl boards in the trawl industry.

Improvements in both species selectivity and length selectivity in longline/gill/trammel net industries will result in reduced labour time and possibly higher catch rates for the species required.

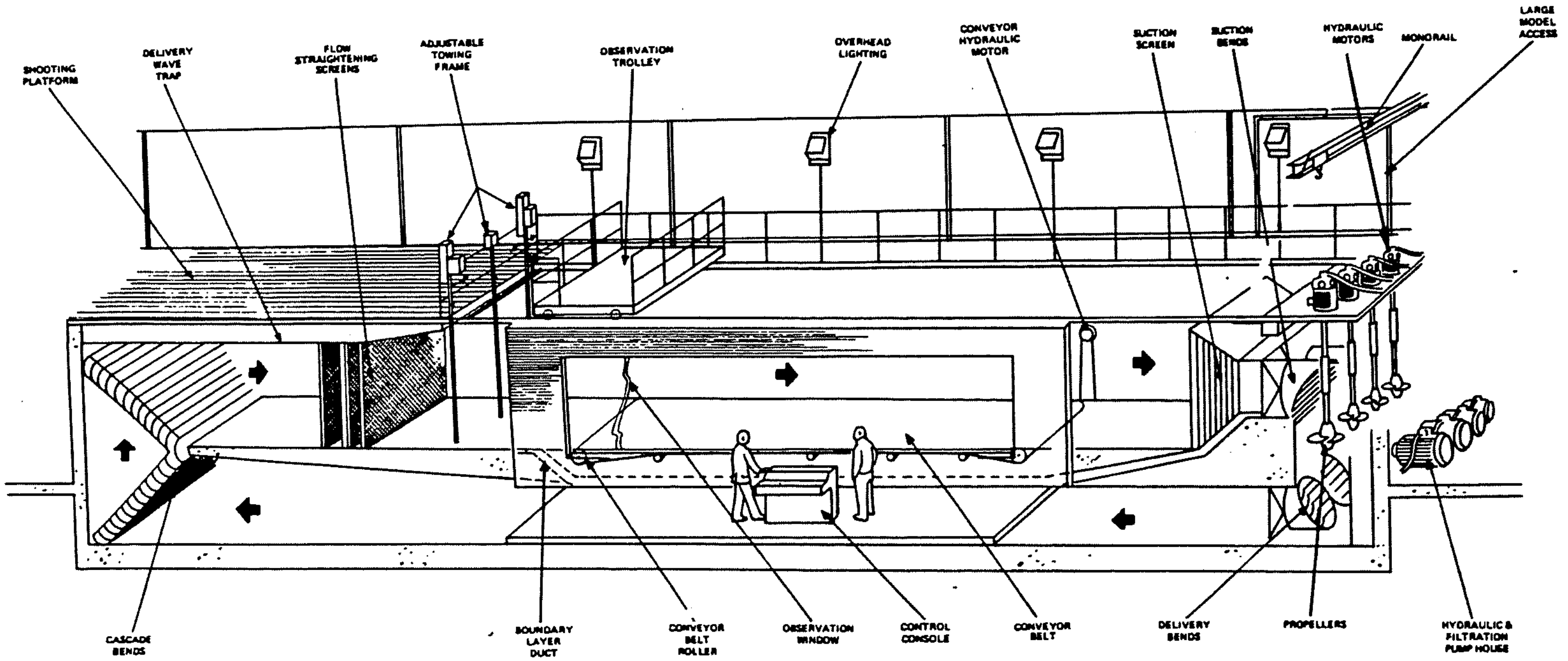
Training courses that improve the skill of skipper and crew in fishing operations (fishing tactics, fishing gear design or onboard processing) may also result in improvements in economic returns.

As we can see, the term gear efficiency includes a variety of different subjects as well as fishing methods and these must be understood if we are to determine in which areas the flume tank may be used.

2. The Flume Tank

Structurally, it is a large reinforced concrete tank 31m long and 5m wide by 5m deep built at ground level. It is divided into two chambers which are inter-connected at each end to enable the water to circulate (see diagram 1). Demonstration and testing of the model or full scale gear takes place in the centre portion of the upper tank chamber. This area, which is the tank working section, is 11m long by 5m wide by 2.4m deep. The lower chamber of the tank forms a return passage through which the water re-circulates. For testing purposes, the water speed can be varied from 0 to 1.5m per second (0-3 knots), whilst a conveyor belt (11m long x 5.0m wide in the working section) can be made to travel in forward or reverse directions at speeds up to 1.5m per second (0-3 knots). A speed of 1.5m per second is equivalent to a towing speed of about 6.5 knots at at 1:5 scale.

The water flow through the test section is fairly uniform in both horizontal and vertical sections, however, there is a boundary layer 'tail off' at the sides of the tank and a free surface section.



SPECIFICATIONS

WORKING SECTION			
	LENGTH	–	17.2m
	WIDTH	–	5.0m
	DEPTH	–	2.5m
OBSERVATION WINDOW			
	LENGTH	–	11.5m
	DEPTH	–	1.5m
	THICKNESS	–	100mm
WATER SPEED		–	0 - 1.5m/s
CONVEYOR BELT SPEED		–	0 - 1.5m/s
HYDRAULIC MOTOR POWER		–	58.5kw
PROPELLER DIAMETER		–	1.2m

Flume Tank
Australian Maritime College

DIAGRAM 1.

Several circulating water tanks are in operation, but only very few of this size are equipped with a conveyor belt. The Australian Maritime College flume tank is the second largest in the world, the largest being in Denmark.

2.1 Flume Tank Operation

Knowing how the flume tank operates will allow us to decide which fishing methods can be investigated. Whilst trolling, gill netting and purse seining models have been streamed in flume tanks, the majority of the work is concerned with the performance of demersal and pelagic single boat or pair trawls.

Since the water and the 'sea bed' move past the trawl, the flume tank model remaining in one position can be studied for any length of time. This eliminates problems associated with acceleration/deceleration of the gear which can be a problem in towing tanks. Long observation times allow precise measurements to be made on the trawl geometry and any forces in the cables through use of electronic load cells.

Because of the size of the tank, it is necessary to construct scale models of fishing gear. The scale will depend on the size of the full scale net - prawn trawls

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being constructed at 1:5 scale, demersal fish trawls at a scale of 1:10 whilst pelagic nets can be constructed at scales ranging from 1:10 to 1:30. (The problems associated with scale modelling will be discussed further on in the paper).

2.2 The Flume Tank Work Programme

The work being carried out at the flume tank falls into three main areas:-

2.21 Fisheries Training

Two types of short courses have been set up to cover both prawn trawling and fish trawling (see enclosed brochures). Each course is of one week duration, and during this time, fishermen attending the course will observe different otterboards, nets and rigging arrangements. An understanding of how the trawl and its associated hardware perform will allow the fisherman to rig his trawl to suit both the grounds being fished and the fish species sought. Thus 'gear efficiency' may be improved through acquired knowledge of how the gear operates under different conditions and by adjusting the gear to suit both the environmental conditions and behaviour of species sought.

By measuring the vertical and horizontal openings of different net, a fisherman may find that his existing gear compares unfavourably with other designs and his catches may be increased by using a more suitable design.

The flume tank may also be used to make comparisons between the drags of different nets and otterboards, thus potential fuel savings may result through using low drag trawls (see figure 1.)

2.22 Fishing Gear Development

Before new fishing gear is used commercially, it must first undergo some tests to examine its performance. The flume tank may be used in the early stages of prototype development. Once a design has been chosen, the procedure should be to carry out sea trials to measure the engineering performance of the net. These trials should be followed by further sea trials to examine the fishing performance of the net. The instrumentation being developed at the College for model-full scale correlation will allow full engineering trials to be carried out on trawl gear. (diagram 2).

2.23 Model Full Scale Correlation

Where scale models are being used to predict the performance of the full scale gear, it is necessary to know what the limitations of the model are and how well the model results correlate to those of the full scale gear.

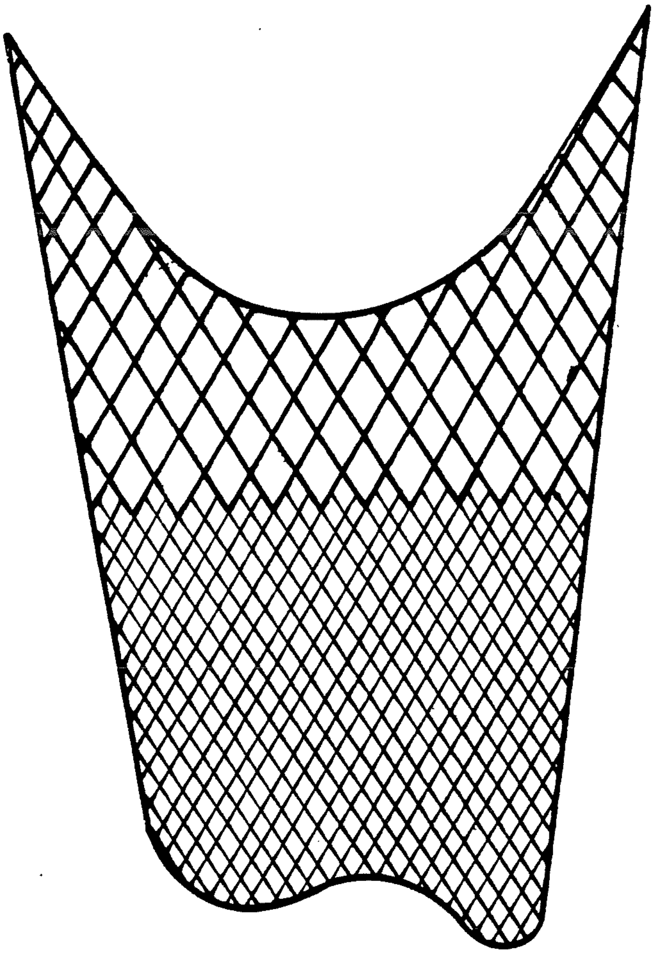
The flume tank is being equipped with instrumentation that will enable model to full scale correlation to be carried out (diagrams 2 and 3).

This work has been carried out for some years at the Sea Fish Industry Authority (Chopin 1980) and at the Department Agriculture and Fisheries marine laboratory, Scotland (Hou 1981). However, due to the variable environment in which sea trials are carried out, the results to date have been disappointing. Problems have also arisen due to poor trials technique and to errors involved with the calibration and measurement of trawl geometry using instrumentation at sea (Reid 1977).

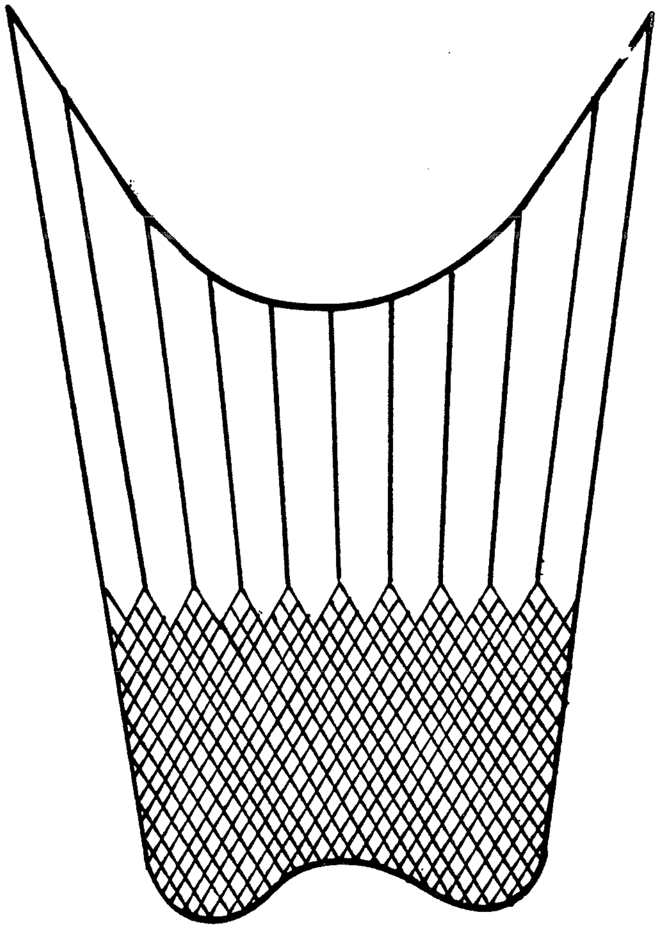
Graphs (1) and (2) show the relationship between total drag and towing speed for two full scale trawls with the model drag lines included. These are typical results and indicate the degree of scatter on full scale readings.

2.24 Fishing Gear Research

In single boat trawling, the net may contribute up to 60% of the total drag, whilst the otter boards can contribute up to 40%. Investigations have been carried out for several years into the engineering performance of trawls and otterboards. (Ferro and Lee 1977, Ferro, Robertson, Simpson 1980).

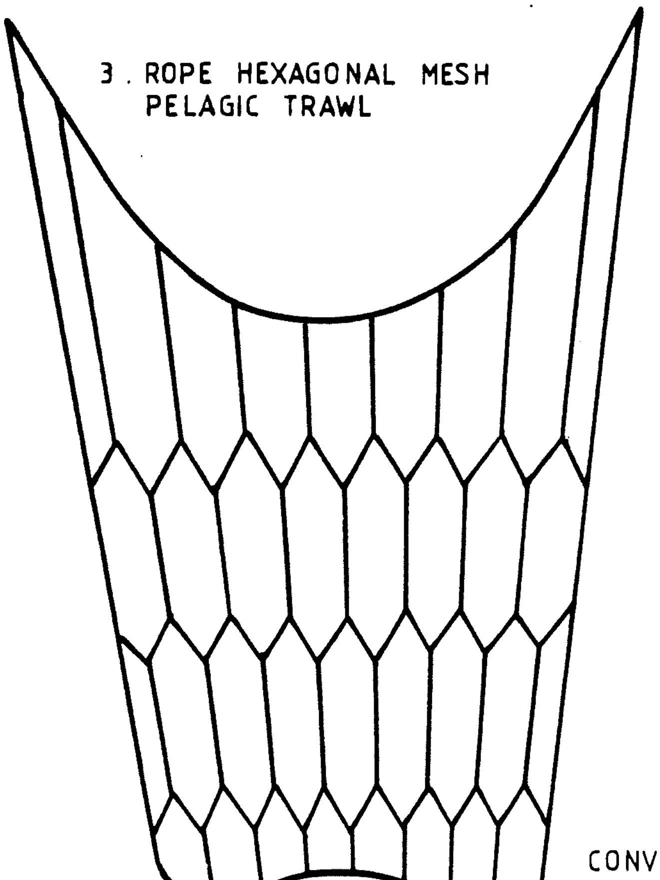


1. CONVENTIONAL PELAGIC TRAWL

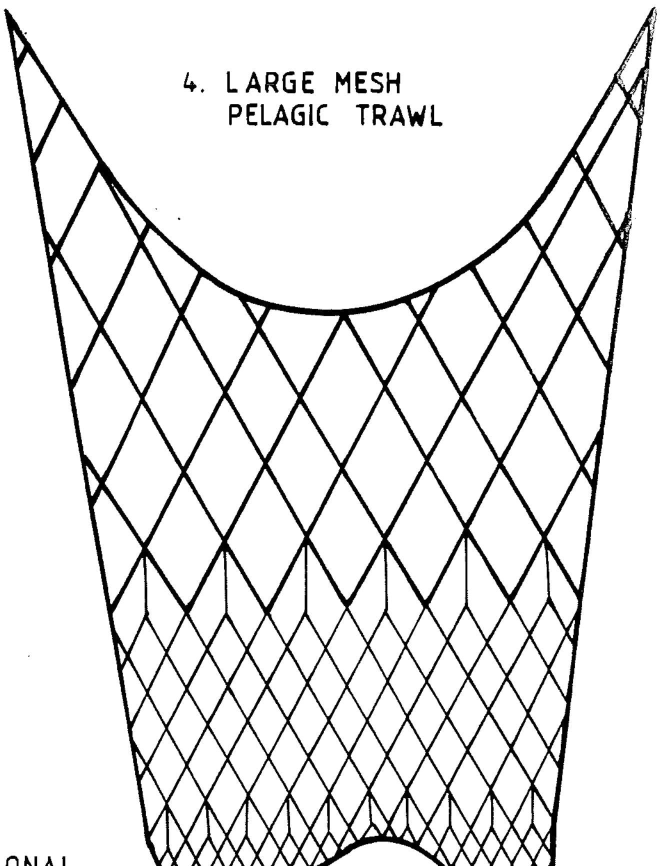


2. PELAGIC ROPE TRAWL

COMPARISON OF SINGLE PANELS OF LOW DRAG PELAGIC TRAWLS



3. ROPE HEXAGONAL MESH PELAGIC TRAWL



4. LARGE MESH PELAGIC TRAWL

CONVENTIONAL MESH SIZE MAY START AT THIS ROUND OR LOWER

FIG. 1.

ARRANGEMENT FOR MEASURING THE PERFORMANCE OF FISH TRAWLS IN THE FLUME TANK

NOTE:

TOTAL NET GEOMETRY CAN BE MEASURED USING THE FLUME TANK PHOTOGRAMMETRY SYSTEM

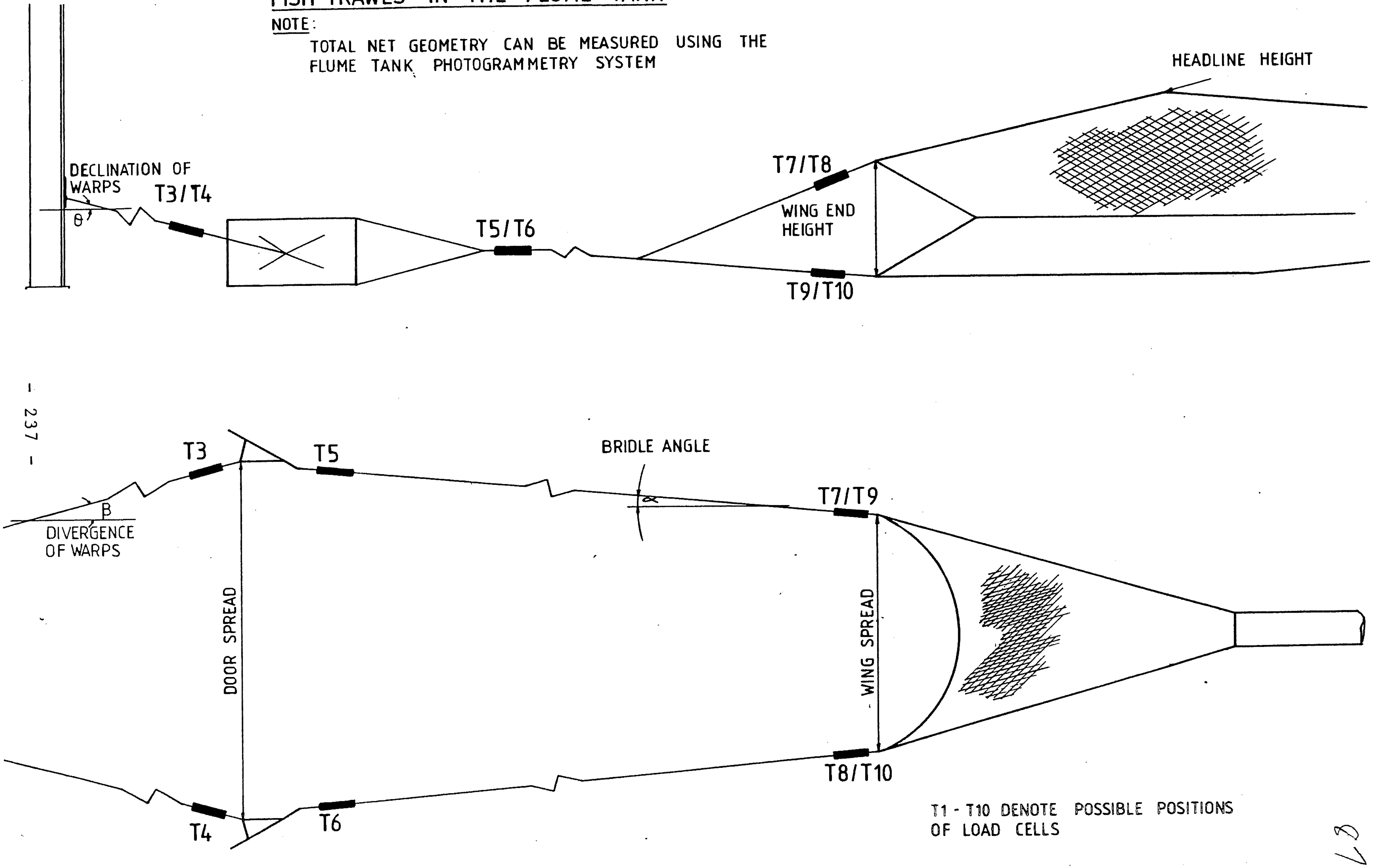
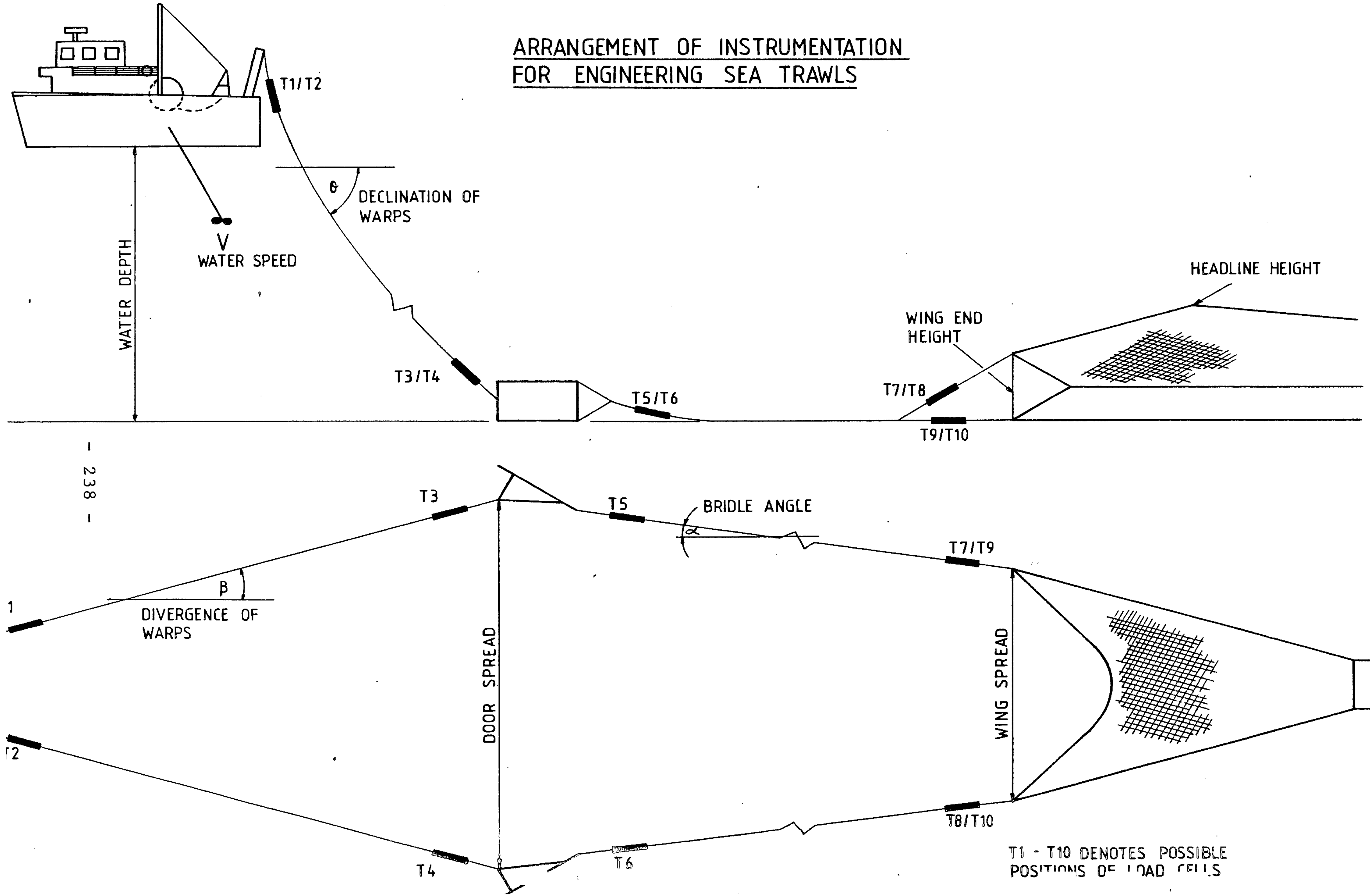


DIAGRAM 2

ARRANGEMENT OF INSTRUMENTATION FOR ENGINEERING SEA TRAWLS



At present, the flume tank could only be used as an aid to design. The determination of otterboard efficiency would best be carried out in fast flow channels or towing tanks, or in fact at sea under fully instrumented engineering trails.

Future work on model full scale correlation may show that the scaling procedures and modelling techniques are adequate or that they need to be modified if we require to use the flume tank as a full research tool in fishing gear design.

Conclusions

Can the flume tank improve fishing gear efficiency and save dollars?

1. By continuing short course programmes in fishing gear design, more fishermen will become aware of how trawls should be rigged to suit different conditions and how their performance will depend upon the net and otter board designs.

2. By carrying out full engineering trials on both model and full scale trawls, our knowledge of model to full scale correlation will be increased, allowing us to have more confidence in model trawl results. This may enable us to use the tank as a design tool in its own right.

If this is the case, then it would become a very powerful design tool for the fishing industry.

3. The requirement to carry out full scale engineering trials at sea for model/full scale correlation will be immensely valuable to the industry as it will enable different net designs to be compared in terms of net/otter board drag and also gear geometry.

4. Whilst the flume tank can investigate the engineering aspects of trawl design, it is not capable of assessing the catching performance of a particular net. This required an understanding of how crustacea or fish react in the path of towed gear and can only be carried out effectively through direct observation of fishing gear at sea.

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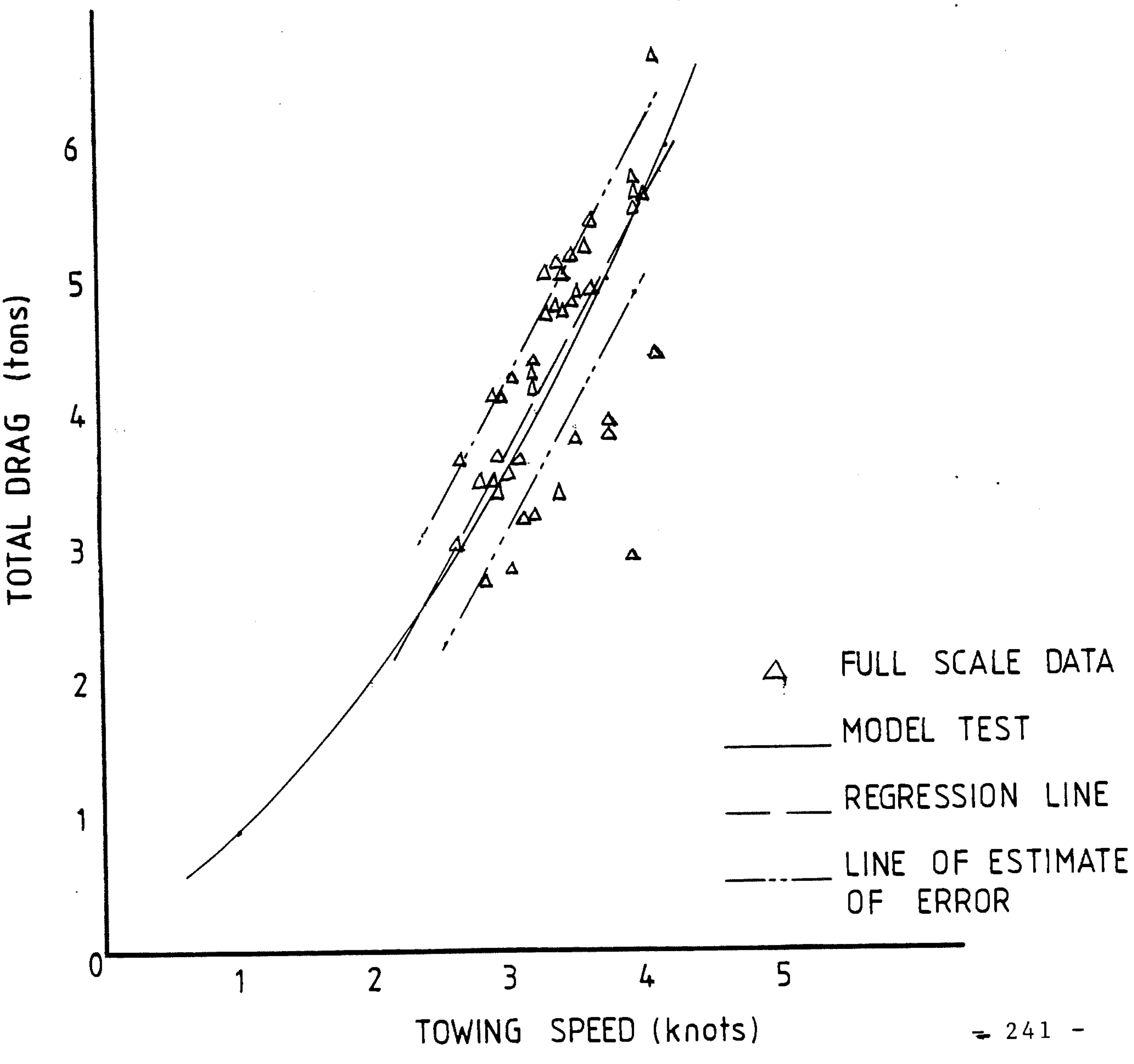
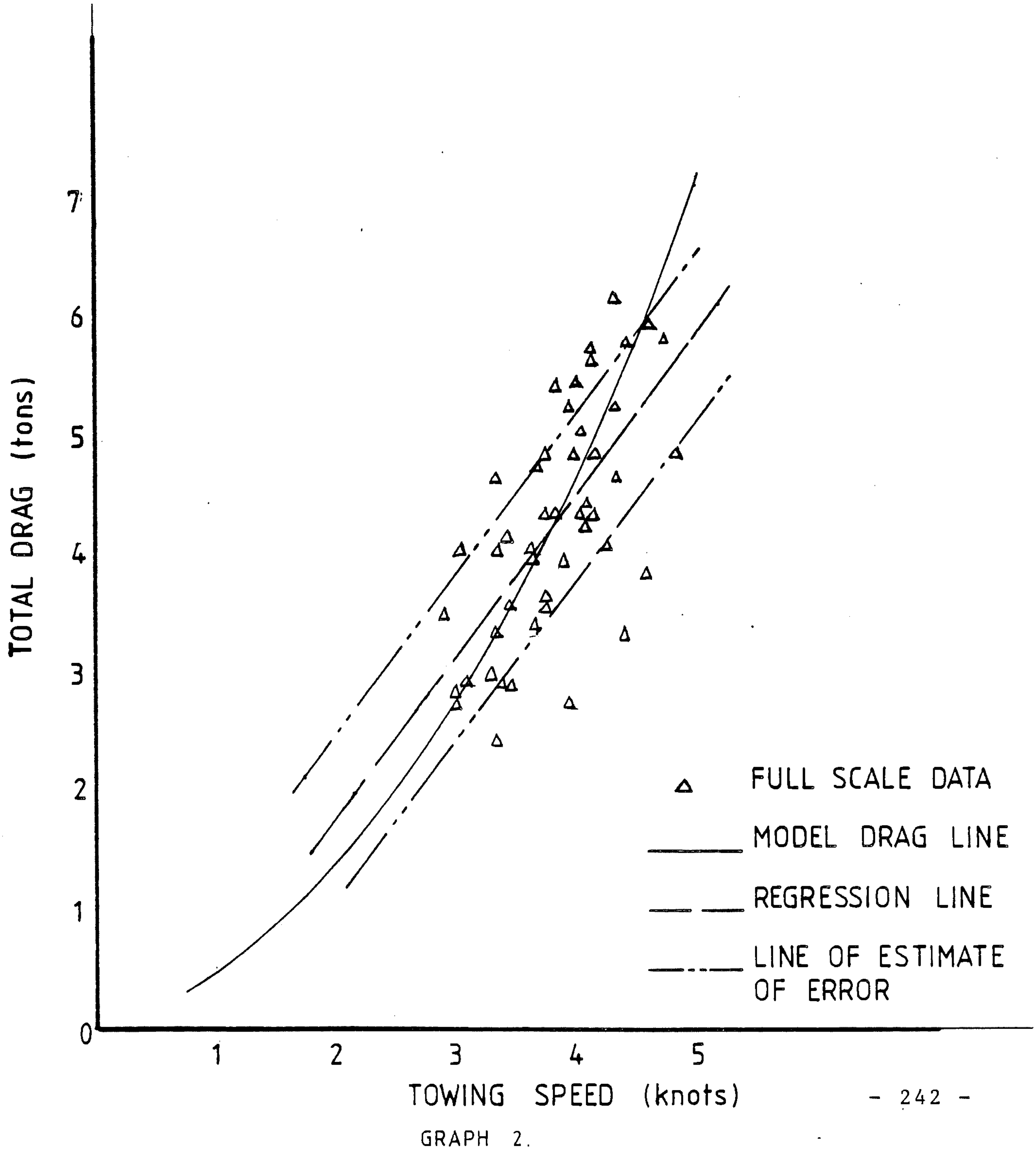
WHITE SEA TRAWL
BT 134



GRAPH 1.

(HOU and CHOPIN)

G.O.V. TRAWL WITH FULL LOWER WINGS



GRAPH 2.
(HOU and CHOPIN)

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QUALITY - AN ATTITUDE OF MIND

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What is quality?

Quality is that attitude of mind, that approach, that event, that state of being when everything is right. The ancient Greek sophists would have said that quality comes first and is the cause of events not the effect; although they used a word different to quality, the meaning was the same. Thus until a seafood is eaten its 'quality' can only be surmised indirectly; however seafoods do possess a set of properties, attributes or characteristics that for practical purposes can be related with quality. The seafood in itself does not possess an entity known as quality; this is only evident when it is eaten. It is important to make the distinction between quality (the attitude of mind) and the attributes of the product itself which will relate to quality (when the product is eaten).

Take the events where a person has just eaten some seafood that to them was perfect. That attitude of mind stays with them and, because it is pleasurable (virtually by

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definition), they wish to repeat the experience. The experience motivates them to buy the seafood again and if the experience is similar the attitude of mind is reinforced - repeat sales for the fishing industry. If however, the initial or the repeat experience did not engender the pleasurable sensation of quality then repeat sales are in doubt. The attitude of mind of the consumer sparks the profitability of the industry. Quality motivates the series of events that result in jobs for fishermen.

There is only one 'quality' but there may be many attributes and different people may lay different stress on the value of each attribute for different reasons. That seafoods are bought, sold and consumed is entirely due to attitudes of mind. Such attitudes as "it's good for your body", "it's nutritious", "it's prestigious", "it's a brainfood", "it's an aphrodisiac". "it's convenient", "it's natural", "it's moral", or "it's a luxury" or that "today is Friday", are behind many of the decisions to buy or to eat seafood. Forms of merchandising and marketing can nurture the attitudes that lead to the decision to buy and consume seafoods, but, for the attitude to be maintained or reinforced, the product must live up to the expectations placed on it. It is then up to those who have a hand in placing it before the consumer to consider their own attitudes of mind to conserving those characteristics of the product that the consumers find desirable.

Attitudes.

Fish begin to deteriorate soon after catch and the attitude that fishermen have towards their catch is of prime importance if those desirable characteristics are to be maintained. It should never be forgotten that the fate of the catch is for it to be eaten and that fishermen are food handlers and often (in part) food processors. The attitude of mind adopted by the skipper toward the catch is passed on to the crew for better or worse - if he cares, they care. Similarly the attitude of mind taken by top management in the process factory to their raw material and their product sets the tone for middle management and for the workers. The attitudes adopted by distributors, retailers and fish shops are equally important, to ensure that the best possible product reaches the consumer. Thus all the way from catch to consumption there is a linking of attitudes of mind to produce in the eater that attitude of mind known as "quality". If at any stage the attitude held is not one of conserving quality attributes, then the whole chain is affected and the desired end result not achieved. In terms of the original argument, quality is the prime mover and attitudes of mind are the causes not the effects.

Quality assurance.

When a fisherman, processor, distributor, retailer or restaurateur holds the attitude of mind that they wish to conserve the quality attributes in their products, then the steps taken to do this fall logically from existing information. In practice this amounts to the adoption of procedures and conditions that cause minimum harm to the product and which are designed to conserve its quality attributes. Most commonly these practices are known as quality assurance schemes. Large organisations and processors can, and do, initiate quality assurance programs but to the individual fisherman or seafood retailer the practices should amount to the systematic application of common sense based on reliable knowledge.

The most important consideration is one of temperature - the higher its temperature the faster the seafood will spoil and the rate at which this occurs is a known function of the square of the temperature. A simple-to-use practical expression of this relationship that holds for seagoods from - 2°C to 20°C is that

$$\text{rate of deterioration} = (\text{temperature °C} + 10)^2.$$

This means that when the temperature is 0°, 4°, 10°, 15°, or 20°, the rates are 100, 196, 400, 625, 900 respectively. Alternatively this relationship can be expressed as $\sqrt{r} = (1 + 0.1T)$, where r is the rate of deterioration and T°C is the temperature. Taking 0°C, the temperature of melting ice, as a practical reference point, this means that seafoods at either 4, 10, 15 or 20°C deteriorate respectively twice, four, six and a quarter and nine times as fast as they do at 0°C. If, for example, the temperature of a fish when caught is 15°C and it is not chilled, then after 24 hours it would deteriorate as much as it would have in over six days in ice! The relationship also holds below 0°C until about -2°C when fish start to freeze. At minus 1.8°C the rate of deterioration is given by $(10 - 1.8)^2 = 67$, that is only 67% of the rate at 0°C. So for every three days a fish is at -1.8°C it would lose the equivalent of only two days shelf life at 0°C. This represents one of the advantages of refrigerated sea water (RSW). This method of calculation can be used cumulatively when the time-temperature history of a fish is known to add up its equivalent days on ice. For convenience, tables of equivalent times spent at 0°C - called "Icetime" by the Tasmanian Food Research Unit (TRFU) - have been set out in terms of time and temperature (Appendices 1 and 2). For example, reading from Appendix 1, 14 hours at a temperature of 11°C corresponds to an icetime of 2.6 days.

Take the three examples shown in Table 1, where the three fish were handled in three different ways with the first being well looked after, the second having fair treatment and the third not being looked after much at all. The results (calculated using the Appendices 1 and 2) are that the three fishes which were consumed a mere 5.5, 5.6 and 4.4 days after catch had spent the equivalent of 8.5, 13.9 and 14.5 days on ice at that stage. Such histories are common and it is no wonder that repeat sales are often difficult. These types of charts are very useful because they can be used to pinpoint areas where temperature control should be improved i.e. the fish should be better chilled or where handling should be expedited or both. The equipment to ascertain this is simple; a watch, a thermometer and a pen. The tables are based on empirical data gleaned from years of research on fish spoilage and subsequently found to obey the rate of deterioration = $(\text{Temp } °C + 10)^2$ relationship.

After the decision to chill fish properly is taken, it is then a matter of choosing between the alternative methods. In general the most versatile and useful way of chilling the catch is to ice it adequately so that the ice is in contact with the fish. A layer of ice on the top of a box of fish is of cosmetic use only. The techniques of icing are well known and well reported although not often practised. Effective chilling by the use of ice is the best quality assurance tool that fishermen, processor and transporter can employ. If ice were correctly and consistently used, then the standard of the fish offered for sale in this country would improve enormously.

Control of temperature in the frozen product is important too. The product should be frozen as quickly as is practical and maintained at as low a temperature as practical. This temperature should not be allowed to fluctuate since higher temperatures may allow irreversible diffusion of materials which result in deleterious reactions.

Table 1 - Estimation of Equivalent Time at 0°C (Icetime) for Three Fish Handled Differently

	Fish Well iced Well looked after	Fish 2 poorly iced	Fish 3 Not iced Not well cared for
AT SEA			
Temperature when caught	15°C	15°C	15°C
Delay before icing	2h	6h	18h
Icetime	0.5d	1.6d	4.8d
Average temperature for first 2 hours	6°C	10°C	10°C
Icetime	0.2d	0.3d	0.3d
Average temperature for next 2 hours	2°C	6°C	6°C
Icetime	0.1d	0.2d	0.2d
Temperature of fish in stowage	0°C	5	-
Duration of trip	2.8d	2.0	-
Icetime	2.8d	4.4d	
Total equivalent days on ice at sea	3.6d	6.5d	5.3d
ASHORE			
Temperature during transport	4°C	5°C	6°C
Time of transport	2h	16h	24h
Icetime	0.2d	1.5d	2.5d
Holding temperature before processing	2°C	5°C	4°C
Time of holding	16h	16h	10h
Icetime	0.9d	1.5d	0.8d
Temperature during processing	5°C	5°C	6°C
Time for processing & packaging	2h	2h	6h
Icetime	0.2d	0.2d	0.6d
Temperature during holding/distribution	4°C	4°C	6°C
Holding/distribution time	30h	30h	36h
Icetime	2.4d	2.4d	3.8d
Temperature in retail display	5°C	8°C	9°C
Time product displayed	6h	6h	5h
Icetime	0.6d	0.8d	0.8d
Temperature after purchase before cooking	6°c	10°C	10°C
Time between purchase and cooking	6h	6h	4h
Icetime	0.6d	1.0d	0.7d

Total equivalent days on ice ashore	4.9d	7.4d	9.2d
Grand total equivalent days on ice at sea and ashore	8.5d	13.9d	14.5d
Actual time elapsed since catch	5.5d	5.6d	4.4d

Temperature fluctuations also allow formation of large disruptive ice crystals which result in textural changes, evident when the product is thawed.

The other major consideration is one of treating the catch gently and as though it were a foodstuff (which it is!). Whenever possible, controlled mechanical handling should be employed and men should not be treated as machines. Damage caused by rough physical handling during sorting and loading, particularly if the catch is in rigor mortis, destroys not only textural attributes of the flesh but leads also to chemical or enzymic breakdown and/or bacterial penetration, all of which cause undesirable changes in the flesh. Rough handling on the boat, in the factory and in distribution, is anathema to the quality attributes that need to be conserved. The mistaken belief that handling fish correctly and gently is somehow effeminate, should be seen as the nonsense it is.

Thus the two cardinal principles of quality assurance are temperature control and gentle handling. All that is required to initiate quality assurance is the right attitude of mind. The rest follows logically.

Qualities Control

For the fisherman quality assurance is all that is needed but for the processor quality control (as it is termed) is generally also required. In the way which quality has been discussed in this paper the term quality control is a misnomer. The term "quality attributes control" or perhaps "qualities control" would be more appropriate. The term "quality control" is, however, widely used and substitution of the acronym Q.C. (for qualities control rather than quality control) will overcome semantic and conceptual difficulties.

A quality assurance program is underwritten by Q.C., that is the facts and information on which a quality assurance program is run may be gathered initially by the Q.C. program. Furthermore Q.C. results can show if the quality assurance program is working or not. Although known as quality control, many of the tests currently employed are more to do with product standardisation or safety. In fish canneries, for example, regular checks on filling and seaming equipment are essential if the safety of the product is to be assured, not to mention meeting regulations for drained weights etc. Some of the tests have day to day uses as aids to process control but others are only useful in carefully controlled conditions such as occur in research. Such tests may measure no more than one attribute (indirectly). Tests for particular bacteria or for products of the metabolism of spoilage bacteria e.g. trimethylamine, or for endogenous breakdown of nucleotides e.g. hypoxanthine values or K values $\left(K = \frac{\text{dephosphorylated nucleotides}}{\text{total nucleotides}} \times 100\right)$ or for changes in physical properties, e.g. Torrymeter, have found some use because they change in some regular or predictable way with time of storage of the seafood. Test indicators often do not change with time and temperature in the same pattern as do the desirable characteristics associated with quality. It is also rare for the time temperature pattern of changes to have been thoroughly established. Indeed the correlation with time elapsed since catch is all that many of the indicator tests have in common with quality.

Assessment

Since seafoods are bought and sold on appearance and odour and rated for quality when they are eaten, it is logical that sensory tests be used to judge them. Sensory testing should be done on a well planned, not an ad hoc, basis.

A sensory score sheet (Appendices 3 & 4) used for judging fish has been developed at TFRU and has been found to be applicable to fish from tropical to Antarctic waters. The score sheet works on a demerit system with points being allotted in several categories for defects as they become obvious. Different fish deteriorate in different ways; in some the change in the eyes is quite marked, in others the gills change first while in others belly burn, scale loosening or loss of brightness may be indicative of change.

This scoring system is flexible enough to accommodate the range of changes and has been simplified to make decision making easier. No training is required to use these score sheets and the only equipment needed is a pencil. We have found that these score sheets give equally as useful and more reliable results for a fraction of the cost than sophisticated laboratory equipment. Recently TFRU have had developed for them the software to encode the score sheet into small pocket computers, thus giving the advantage of an immediate answer coupled with ease of use. These low cost portable units can be used on the wharf or in the market or factory. A more comprehensive program which includes data storage and retrieval has been written for an Apple IIE computer.

The results obtained for sweetlip (Plectorhynchus pictus) from the northwest shelf stored at ambient temperatures 24-26°C and in ice 0°C are shown also in figure 1 in comparison with the K value - a chemical measure of changes in the flesh with storage time. The determination of K value requires considerable technical expertise and expensive equipment, whereas the score sheets not only give a judgement on the fish but provide a description of it as well. Fish arriving at the market or at processors could be rapidly graded by this method to provide a permanent record of the catch, which can be collated in various ways such as by season, by boat or by skipper to give information to aid in management decisions.

Since the theme of this paper is that quality occurs when the food is eaten, then it is obvious that the most appropriate test of quality attributes must be the use of taste panels. Taste panel results are the closest that processors can come to an overall judgement of quality on their products. Taste panels too can be used to test for specific quality attributes that actually have relevance to the consumers' ideas. Staff with the right attitude of mind under the guidance of an experienced worker can provide quickly and cheaply much reliable useful data on a company's seafood products. Many companies small and large may already conduct taste experiments to some extent. What is required is a systematic approach where information is gathered on a formalised basis. If the answer required is some judgement on the acceptability of a product, then a simple (but subtle) scale such as the Smiley scale is very informative (Appendix 5) and easy to use. Other scoring systems (Appendix 6) are also useful when specific information on the properties of a seafood are required.

Many of the techniques can be learned from the literature but particular attention needs to be given to ensuring that the panelists do not know the identity of each sample and that they get them in a different order according to a set plan. Such plans can be found in statistical textbooks as can methods of analysis and, these days, data analysis can be done with pocket computers.

Routine taste tests on production batches can provide a continuing check on the variability of a company' products if the information is gathered systematically. The size of the company does not matter; small concerns with eight employees can do this just as effectively as much larger companies. Note also that the choice of the taste test and the personnel selected to make the tests may depend on knowledge of the market for the particular products.

Defects should be discovered by the producer, not by the customer. Few companies can afford the cost of mistakes. However, it is not easy to identify in a company's financial statements the costs of returned product, of wasted raw material or potentially good material which had to be used in cheaper products with lower profit margins because it was not looked after. Reports on wastage, product recalls, product refund claims and Q.C. systems audits should be systematically and regularly inspected and the costs and lessions learnt from them should be used to modify existing quality assurance.

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Conclusion

Quality, real quality, it the attitude of mind evoked in the consumer when a product is eaten. Up till then other tests give only an indirect indication of what the quality may be. If a product is to be of quality then the attitude of mind of all who have had a hand in producing and selling it must be one of conserving its desirable attributes. In any organisation large or small this attitude of mind must be held at the top by the manager or skipper and be established company policy. When this is done, quality assurance practices are the logical outcome underpinned by appropriate tests for quality attributes.

Acknowledgements

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The computerised sensory score sheet demonstrated at the seminar was developed by Allan C. Branch, consultant for the CSIRO Division of Food Research, Tasmanian Food Research Unit and was funded by the Fishing Industry Research Trust Account. Details of the software are the subject of a CSIRO

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<u>List of Recommended Reading</u>

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*This reference is the most readable, interesting and comprehensive approach to quality. Highly recommended.

Appendix 1 'Equivalent days on ice' corresponding to the actual number of hours of storage

Temp. C.	2h*	4h	6h	8h	10h	12h	14h	16h	18h	20h	22h	24h	Relative spoilage rate
0	.1	.2	.3	.3	.4	.5	.6	.7	.8	.8	.9	1.0	1.00
1	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.20
2	.1	.2	.4	.5	.6	.7	.8	.9	1.1	1.2	1.3	1.4	1.40
3	.1	.3	.4	.6	.7	.8	1.0	1.1	1.2	1.4	1.5	1.7	1.65
4	.2	.3	.5	.6	.8	1.0	1.1	1.3	1.4	1.6	1.7	1.9	1.90
5	.2	.4	.6	.7	.9	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.20
6	.2	.4	.6	.8	1.0	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.50
7	.2	.5	.7	.9	1.2	1.4	1.6	1.9	2.1	2.3	2.6	2.8	2.80
8	.3	.5	.8	1.1	1.3	1.6	1.9	2.1	2.4	2.7	2.9	3.2	3.20
9	.3	.6	.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.60
10	.3	.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3	3.7	4.0	4.00
11	.4	.8	1.1	1.5	1.9	2.3	2.6	3.0	3.4	3.8	4.1	4.5	4.50
12	.4	.8	1.3	1.7	2.1	2.5	2.9	3.3	3.8	4.2	4.6	5.0	5.00
13	.5	.9	1.4	1.8	2.3	2.8	3.2	3.7	4.1	4.6	5.0	5.5	5.50
14	.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.00
15	.5	1.1	1.6	2.2	2.7	3.2	3.8	4.3	4.8	5.4	5.9	6.5	6.45
16	.6	1.2	1.7	2.3	2.9	3.5	4.0	4.6	5.2	5.8	6.3	6.9	6.90
17	.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6	7.3	7.25
18	.6	1.3	1.9	2.5	3.2	2.8	4.4	5.1	5.7	6.3	7.0	7.6	7.60
19	.7	1.3	2.0	2.6	3.3	4.0	4.6	5.3	5.9	6.6	7.2	7.9	7.90
20	.7	1.4	2.0	2.7	3.4	4.1	4.7	5.4	6.1	6.8	7.4	8.1	8.10

*h refers to the number of hours storage at a given temperature

Appendix 2

'Equivalent days on ice' corresponding to the actual number of days of storage

Temp. C	1d*	2d	3d	4d	5d	6d	7d	8d	9d	10d	11d	12d	13d	14d	15d	Relative spoilage rate
0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	1.00
1	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2	14.4	15.6	16.8	18.0	1.20
2	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0	15.4	16.8	18.2	19.6	21.0	1.40
3	1.7	3.3	5.0	6.6	8.3	9.9	11.6	13.2	14.9	16.5	18.2	19.8	21.5	23.1	24.8	1.65
4	1.9	3.8	5.7	7.6	9.5	11.4	13.3	15.2	17.1	19.0	20.9	22.8	24.7	26.6	28.5	1.90
5	2.2	4.4	6.6	8.8	11.0	13.2	15.4	17.6	19.8	22.0	24.2	26.4	28.6	30.8	33.0	2.20
6	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5	30.0	32.5	35.5	37.5	2.50
7	2.8	5.6	8.4	11.2	14.0	16.8	19.6	22.4	25.2	28.0	30.8	33.6	36.4	39.2	42.0	2.80
8	3.2	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8	32.0	35.2	38.4	41.6	44.8	48.0	3.20
9	3.6	7.2	10.8	14.4	18.0	21.6	25.2	28.8	32.4	36.0	39.6	43.2	46.8	50.4	54.0	3.60
10	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0	44.0	48.0	52.0	56.0	60.0	4.00
11	4.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	40.5	45.0	49.5	54.0	58.5	63.0	67.5	4.50
12	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	5.00
13	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0	49.5	55.0	60.5	66.0	71.5	77.0	82.5	5.50
14	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0	90.0	6.00
15	6.5	12.9	19.4	25.8	32.3	38.7	45.2	51.6	58.1	64.5	71.0	77.4	83.8	90.3	96.8	6.45
16	6.9	13.8	20.7	27.6	34.5	41.4	48.3	55.2	62.1	69.0	75.9	82.8	89.7	96.6	103.5	6.90
17	7.3	14.5	21.8	29.0	36.3	43.5	50.8	58.0	65.3	72.5	79.8	87.0	94.3	101.5	108.8	7.25
18	7.6	15.2	22.8	30.4	38.0	45.6	53.2	60.8	68.4	76.0	83.6	91.2	98.8	106.4	114.0	7.60
19	7.9	15.8	23.7	31.6	39.5	47.4	55.3	63.2	71.1	79.0	86.9	94.8	102.7	110.6	118.5	7.90
20	8.1	16.2	24.3	32.4	40.5	48.6	56.7	64.8	72.9	81.0	89.1	97.2	105.3	113.4	121.5	8.10

*d refers to number of days storage at a given temperature

Appendix 3

Sweetlip stored at ambient temperature 24-26°C

Storage time (hours)

Fish Ident.	SWEETLIP P. PICTUS	0	1.75	3.5	5.5	7	9
APPEARANCE	(v.bright/bright/sl. dull/dull) 0 1 2 3	1	1	1	1	1	2
SKIN	(firm/soft) 0 1	0	0	0	0	1	1
SCALES	(firm/sl. loose/loose) 0 1 2	0	0	0	0	0	0
SLIME	(absent/sl.slimy/slimy/v.slimy) 0 1 2 3	1	1	1	1	1	1
STIFFNESS	(pre-rigor/rigor/post-rigor) 0 1 2	0	0	0-1	2	2	2
EYES Clarity	(clear/sl.cloudy/cloudy) 0 1 2	0	0	0	0	0	0
Shape	(normal/sl.sunken/sunken) 0 1 2	0	0	0	0	0	1
Iris	(visible/not visible) 0 1	0	0	0	0	0	1
Blood	(no blood/sl.bloody/v.bloody) 0 1 2	0	0	0	0	0	0
GILLS Colour	characteristic (sl.dark) (v.dark) (sl.faded) (v.faded) 0 1 2	0	0	1	1	1	2

	Mucous	(absent/moderate/excessive) 0 1 2	0	0	1	1	1	1
	Smell	(fresh oily) (metallic, seaweed) fishy/stale/spoilt 1 2 3	0	0	0	2	2	3
BELLY	Discolour-ation	(absent/detectable/moderate/excessive) 0 1 2 3	0	0	0	0	0	0
	Firmness	(firm/soft/burst) 0 1 2	0	0	0	0	0	0
VENT	Condit.	normal 0; (sl.break) (exudes) 1; (excessive) (opening) 2	0	0	0	0	0	0
	Smell	(fresh/neutral/fishy/spoilt) 0 1 2 3	0	0	0	0	0	0
BELLY CAVITY	Stains	(opalescent/greyish/yellow-brown) 0 1 2	0	0	0	0	0	0
	Blood	(red/dark red/brown) 0 1 2	0	0	0	0	0	1
	Total Demerit Points		2	2	4-5	8	9	15

Appendix 4 Sweetlip stored on ice 0°C

Storage time (days)

Fish Ident.	SWEETLIP P. PICTUS	0	5	9	12	12	20	23
APPEARANCE	(v.bright/bright/sl.dull/dull) 0 1 2 3	1	1	1	1	1	1	2
SKIN	(firm/soft) 0 1	0	0	0	0	0-1	1	1
SCALES	(firm/sl.loose/loose) 0 1 2	0	0	1	1	1	1	1
SLIME	(absent/sl.slimy/slimy/v.slimy) 0 1 2 3	1	0	0	0	0	0	0
STIFFNESS	(pre-rigor/rigor/post-rigor) 0 1 2	0	1-2	2	2	2	2	2
EYES Clarity	(clear/sl.cloudy/cloudy) 0 1 2	0	1	2	2	2	2	2
Shape	(normal/sl.sunken/sunken) 0 1 2	0	1	2	2	2	2	2
Iris	(visible/not visible) 0 1	0	1	1	1	1	1	1
Blood	(no blood/sl.bloody/v.bloody) 0 1 2	0	0	0	2	1	2	1
GILLS Colour	characteristic (sl.dark) (v.dark) (sl.faded) (v.faded) 0 1 2	0	2	2	1	2	2	2

	Mucous	(absent/moderate/excessive) 0 1 2	0	0	1	1	1	1	1
	Smell	(fresh oily) (Metallic, seaweed) fishy/stale/spoilt 1 2 3	0	0	1	1	2	2	2
BELLY	Discolouration	(absent/detectable/moderate/excessive) 0 1 2 3	0	0	0	0	0	0	0
	Firmness	(firm/soft/burst) 0 1 2	0	0	0	0	0	0	0
VENT	Condition	normal (sl.break) (exudes) (excessive) (opening) 0 1 2	0	0	0	0	0	0	0
	Smell	(fresh/neutral/fishy/spoilt) 0 1 2 3	0	0	0	0	0	0	0
BELLY CAVITY	Stains	(opalescent/greyish/yellow-brown) 0 1 2	0	0	0	0	1	1	2
	Blood	(red/dark red-brown) 0 1 2	0	0	0	1	2	1	2
	Total Demerit Points		2	7-8	13	15	18-19	19	21

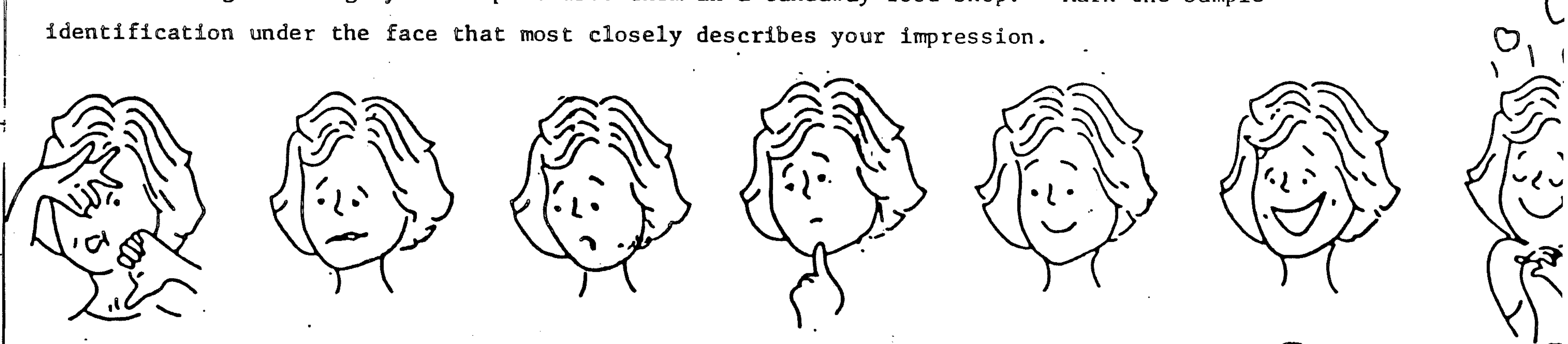
Appendix 5

Y... will .. gi... .... samp... of ...ked ...sh. ..lea.. ass.. the ...sh fla...r, ...ure ...d overall liking as though you had purchased them in a takeaway food shop. Mark the sample identification under the face that most closely describes your impression.

TASTER ____________

DATE ____________

SESSION ____________



1 2 3 4 5 6 7

FLAVOUR	
TEXTURE	
OVERALL LIKING	

Appendix 6

Date ....

Time ....

Taster ....

Taste order.............

FLAVOUR AND AROMA

AROMA Little or no characteristic aroms	1	2	3	4	5	6	7	8	9	Strong characteristic aroma
OFF AROMA Little or no off aroma	1	2	3	4	5	6	7	8	9	Strong off aroma

COMMENTS:-

FLAVOUR Little or no characteristic flavour	1	2	3	4	5	6	7	8	9	Strong characteristic flavour
OFF FLAVOUR Little or no off flavour	1	2	3	4	5	6	7	8	9	Strong off flavour

COMMENTS:-

SALTINESS Little or no salt	1	2	3	4	5	6	7	8	9	Very salty

TEXTURE ASSESSMENT

PRIMARY CHARACTERISTICS

Wetness	1	2	3	4	5	6	7	8	9	
Very Wet										Very dry
Firmness	1	2	3	4	5	6	7	8	9	
Very soft										Very firm
Springiness	1	2	3	4	5	6	7	8	9	
Plasticine										Very firm

Comments:-

SECONDARY CHARACTERISTICS

Toughness	1	2	3	4	5	6	7	8	9	
Very tender										Very tough
Succulence	1	2	3	4	5	6	7	8	9	
Reduces water in mouth										Increases water in mouth
Fibrousness	1	2	3	4	5	6	7	8	9	
No fibres										Long fibres

Comments:-

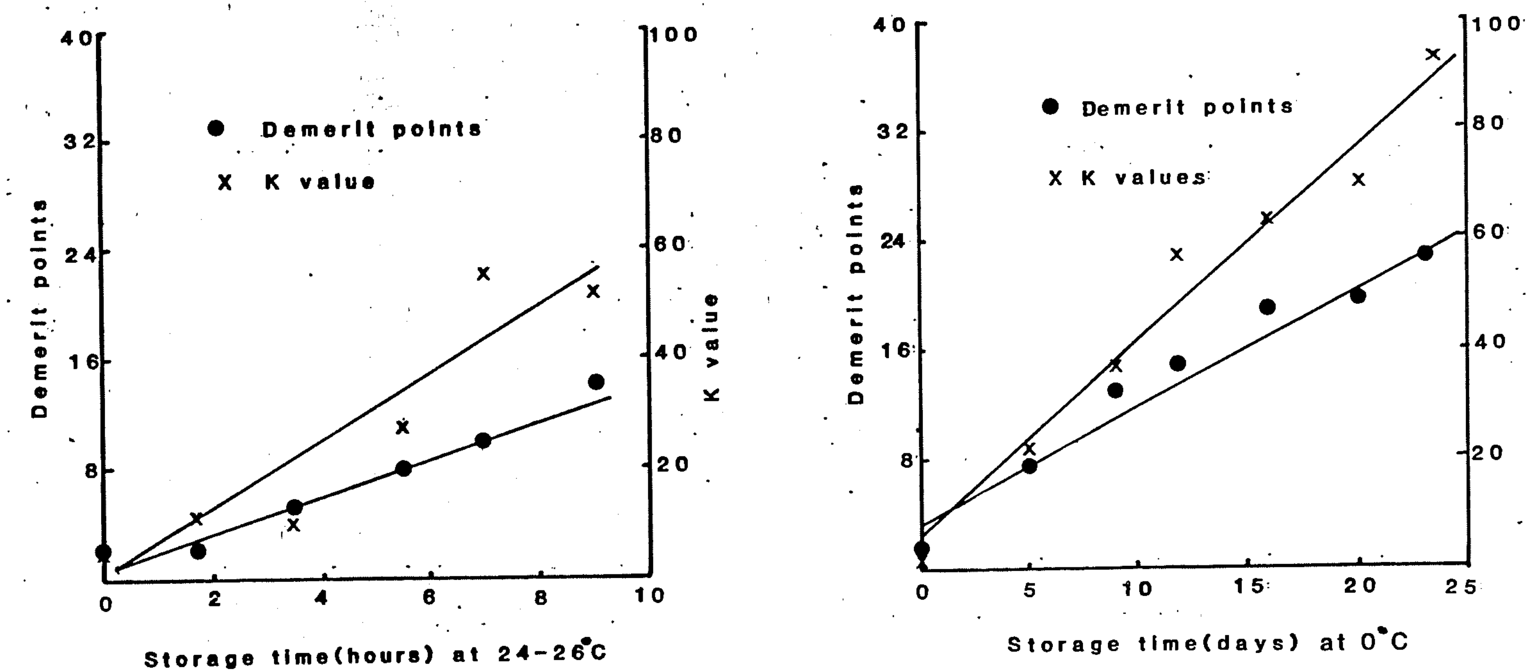


Figure 1:Sweetlip stored at ambient temperature and in ice.

Sensory demerit points and K values vs.storage time.

"THE COLDER THE BETTER"

Some aspects of engineering as applied to refrigeration in the fishing industry.

Mr. Stephen Sykes

CSIRO Food Science Laboratory

The retention of quality attributes in seafoods is related to the degree of spoilage which they have undergone. The degree of spoilage is, in turn, strongly dependent on the product's temperature history. For this reason the control of product temperature in the sequence of operations beginning with catching and stowage at sea and ending with domestic consumption is of prime importance; it is also primarily an engineering problem.

The types of spoilage to which fish products are susceptible can be classified under three general headings: bacterial, chemical and physical.

Bacteria are present on the skin, gills and in the gut of a live fish. They begin to proliferate after death and as they multiply they produce unpleasant odours and flavours, leading ultimately to putrefaction of the fish.[1]

The rate of bacterial spoilage, r, can be related to temperature by an equation:[2]

$$\sqrt{r} = b(T - T_o)$$

or, in graphical form (Fig. 1).

T_o is a notional temperature at which bacterial activity effectively ceases and T is the ambient temperature. T_o is normally about -10°C to -8°C for the cold-tolerant bacteria associated with fish from temperate waters or tropical fish which are quickly chilled after catching. To illustrate the importance of this relationship, consider spoilage processes occurring at 2°C and 0°C, for instance. If T_o in this situation is -8° the ratio of the spoilage rates will be

$$r_{2^oC} = b^2(2 - (-8))^2 = 100$$

$$r_{0^oC} \quad b^2(0 - (-8))^2 = 1.56$$

That is, bacterial spoilage proceeds more than one and a half times more quickly at 2°C than at 0°C.

Spoilage is brought about by the action of enzymes present in the gut, in the fish muscle and from the bacterial themselves. At temperatures above 0°C the bacterial component of spoilage predominates. The rate of spoilage continues to rise until the effects of heat at temperatures exceeding about 18°C cause it to fall again. The dependence of spoilage on temperature is illustrated diagrammatically in Fig. 2.

Damage to the product caused by rough handling such as trampling, throwing, crushing and gaffing is referred to as physical spoilage. It can substantially reduce the edible yield and can intensify the effects of bacterial and chemical spoilage.

Examination of Figures 1 and 2 reveals the strong temperature dependence of bacterial and chemical spoilage. However, the increase in rate of chemical spoilage between 0°C and -5°C is worthy of additional comment. This reversal in the trend exhibited at high temperatures is due to the increase in enzyme and substrate concentration as the water in the flesh begins to freeze. This effect leads to a qualification of the general premise of this paper; that is, "the colder the better". For instance, exposure to temperatures between -2°C and -10°C can cause greater spoilage than equivalent exposure at 0°C. Refrigeration processes are therefore divided into two categories:

(i) Chilling and chill storage; in which the object of the process is to bring the temperature of the product down to the lowest value practicable above -1.5°C (the temperature at which fish muscle starts to freeze) as quickly as possible, and maintain it at that temperature for the duration of storage.

(ii) Freezing and frozen storage; in which the object of the process is to bring the temperature of the product down to the intended frozen storage temperature (commonly -18°C in Australia) as quickly as possible, and maintain it for the duration of storage.

Chilling and Chill Storage

Chilling and chill storage may occur at several different stages in the chain of distribution of seafoods, both at sea and on land. Chill storage is often used as a buffer between the application of other processes. However, the first application is usually onboard the catching vessel shortly after the catch has been brought aboard. The following discussion shall be limited to this situation although the general principles apply to chilling and chill storage on land as well.

When refrigeration at sea is applied by chilling, the choice of whether to use stowage in crushed ice or in chilled sea water depends largely but not entirely on the subsequent operations such as unloading or transfer at sea; presentation for sale or temporary stowage awaiting further processing; or transport from the landing place to some remote location.[3]

Icing

Icing is the traditional, and still one of the most popular methods of chilling fish.

Ice has several advantages over other forms of refrigeration; it involves little or no complication in the design and operation of the fish room or storage space; it provides clean, moist, aerated storage and, since the temperature at which ice melts is fixed, there is some degree of control of fish temperature. Given good contact between fish and melting ice, chilling is quick; ice can also be distributed so as to cope with external heat ingress and whatever heat is generated by spoilage processes.[4]

Methods of Stowage in Ice

The most common form of iced stowage on Australian fishing vessels is boxing.

Boxing has several advantages over bulk stowage in crushed ice: discharge of the catch is made easier and lends itself to mechanisation; handling on shore can be reduced, with a consequent improvement in quality at the point of consumption; also catches can be more easily sorted. The boxes used for this purpose should be robust and easily handled, filled, emptied and cleaned. They should also stack securely, nest when empty and have no sharp corners or crevices. The high-density polymer boxes which are used widely throughout the Australian fishing industry meet all the above requirements.

Good icing practice requires that the fish and ice are packed in alternate layers so that each fish is in contact with melting ice. This will give rapid chilling and will maintain chill temperature for the longest time for a given quantity of ice. However, such practice also demands the most labour and is time consuming, thereby possibly reducing the achievable catch rate. Roach,[5] referring to the Canadian fishing industry, observed that 'well-iced fish' is an expression commonly used by technologists, but such careful icing is seldom seen today except on (vessels) which have low catch rates".

The benefits of chilling and chill storage in crushed ice are foregone if icing practice deviates markedly from the ideal. Thrower[1] compared chilling times for equal quantities of ice and fish using ideal practice and the more common method of placing all the ice in a single layer at the top of the box. In the ideal situation the loss of potential shelf life after 10 hours was 10.5 hours but 42.2 hours were lost with the poorly-iced fish.

How much ice is enough?

The amount of ice required to chill the catch and maintain it at chill temperatures depends on the temperature of the catch as it is brought aboard, the length of the voyage, the ambient sea and air temperatures and the amount of heat entering the fish hold from its surroundings. The surest way to judge whether sufficient ice has been used is to see how much is left at the end of the voyage. If there is none, insufficient ice has been applied.

Supply of Ice

Use of ice for chilling on board fishing vessels presupposes a reliable supply of ice. This may be produced on an ice-making plant at the port used by the vessel or ice-making equipment installed on the vessel. If the fisherman is to rely on a shore-based supply, he must pay the market price, which may fluctuate. He is also restricted to using ports where such a supply is available. While there are ice-making plants in many Australian fishing ports, these may not have sufficient capacity to cope with periods of high demand. The extent of Australia's coastline and the large number of isolated ports militate against the use of ice supplied from shore-based plants.

Is Icing the Method of Choice

There is much to recommend the use of ice for chilling and chill storage on board fishing vessels. However, the higher quality achieved by good icing practice must justify the extra effort required in its application. Whether use of ice is the method of choice depends on the nature of the fishery. In general it is better suited to those fisheries where catch rates are relatively low and the value of the product is high.

Chilled Sea Water

The most common alternative to chilling and chill storage of fish in crushed ice is immersion in sea water which has been cooled by the addition of ice or by mechanical refrigeration. The first method is conventionally referred to as chilled sea water (CSW), the second as refrigerated sea water (RSW).

The most important advantage of RSW/CSW over ice is the ease of handling and stowage on the fishing vessel, saving a great deal of labour.[4,6]

Temperature and Spoilage in RSW/CSW

Because sea water contains 3.5% salt, its freezing point is about -2°C. This allows ultimate storage temperatures of -1°C to be achieved which, if maintained, will give a lower rate of spoilage than for stowage in ice. However, Eddie[7] noted that for RSW/CSW to compete with storage in crushed ice, it must be capable of achieving mean temperatures of 0°C. The minimum permissible temperature is -1.5°C, at which temperature the fish begins to freeze, hence upward excursions of temperature must be limited to 1.5°C. This requires very close control of sea water temperature in the face of spasmodic additions of newly caught fish and, while not impossible, requires a fair degree of sophistication in the equipment. In particular, RSW systems, which rely purely on mechanical refrigeration, must be sized on the basis of a compromise between two conflicting requirements; if the refrigeration plant is selected so as to meet the initial chilling load, it will be grossly oversized for the task of maintaining chill temperatures in the RSW tanks; if the refrigeration plant is sized for the maintenance of chill temperatures it will not have sufficient capacity to effect rapid chilling of newly caught fish. CSW, on the other hand, provides virtually unlimited refrigeration (in the form of ice), which can be utilised immediately.[5]

Comparison of spoilage rates in RSW/CSW to those in ice is complicated by differences in the storage environment. In particular, storage in RSW/CSW can have deleterious effects on the appearance of the fish which do not necessarily reflect their state of spoilage. If the fish is sold by auction, where appearance is an important criterion for assessing quality, fish stored in RSW/CSW may not fetch prices as high as those for iced fish, even with a more favourable temperature history.

Storage limits in RSW/CSW systems are curtailed in some cases due to the uptake of excessive amounts of salt and water.[6] The amount of increase in salt depends on several factors; the size and species of fish, whether or not they have been gutted, the type of sea water storage (i.e. RSW or CSW) and the duration of storage.

A salt concentration of 1% or more which can be reached after seven days storage with many species, will be objectionable in many forms of fish products. If the fish are to be frozen and cold-stored after a period of chilled storage, the permissible increase in salt content may be relatively low, since the salt can accelerate some of the changes which take place during cold storage and hence decrease storage life. There are, however, important cases where a substantial increase in salt content can be tolerated, especially where salt is added during processing after landing.

RSW/CSW Systems

For RSW/CSW systems to effect rapid chilling and maintain chill temperatures, they must have, in addition to sufficient refrigerating capacity, the following: provision of circulation or agitation to ensure good mixing of sea water, fish and, in the case of CSW systems, ice; effective temperature control; and facility for thorough cleaning and sanitation.

Circulation or agitation are required in RSW/CSW systems in order that chilling be as quick as possible and that temperature stratification in the fish/sea water mixture be avoided. Pumped circulation is used widely but close attention must be paid to the design of the sea water circuit if it is to be effective. A common problem in such systems is inadequate suction screening in the tanks which results in excessive by-passing of sea water and hence poor chilling of the catch.[5]

Agitation has been provided in some CSW systems by sparging small quantities of low-pressure compressed air into the fish/sea-water/ice mixture. This obviates the necessity for continuous circulation so that the pumping system can be designed to perform only the charging and discharging duties, thereby reducing its complexity.

It has been found that RSW installations on board some Australian fishing vessels make no provision for circulation or agitation of the sea water, relying purely on the motion of the vessel for mixing of the fish and sea water. In such cases refrigeration is frequently applied by means of pipe coils placed around the walls of the tanks. In the absence of forced circulation or agitation, heat transfer will be slow and system performance poor. There is often a build-up of ice around these coils indicating poor heat transfer: sea water adjacent to the coils is over-chilled, then frozen, and contact between the remaining liquid and the coils is prevented by the growing layer of ice. Under these conditions chilling rates are slow and storage conditions variable.

Satisfactory operation of RSW/CSW systems is impossible if thorough cleaning and santitising practices are not used.

The initial charge of sea water should be as clean as possible, preferably being pumped aboard when the vessel is well away from port. Circulating pumps and piping networks, where used, should be designed so as to allow effective cleaning with facility for back-flushing.

Freezing and Frozen Storage

Freezing and low-temperature cold storage is at present the pre-eminent method of long-term fish preservation; it is also the method which appears to give most scope for the application of engineering science.[8,9]

Freezing Time

The time taken for a product to freeze depends on its thermal properties, its shape and the conditions at its surface. Numerous methods have been developed for estimating the freezing times of foodstuffs. These vary widely in complexity and accuracy, many requiring substantial computing resources for their implementation. One of the most useful methods of estimating freezing times is Plank's equation.[10] It is sufficiently accurate to allow the design engineer to make reliable predictions of freezing time; these provide the basis on which the choice of freezer layout and capacity is made.

Freezer Output

The output of a freezer depends on the freezing time of the product and the amount of product loaded into the freezer. The following examples illustrate the relationships between freezing time and freezer capacity.

Freezer 1 (for large items)

Product freezing time	6 hours
Amount of product	9 tonnes
Output	1½ tonnes/hour

Freezer 2 (for small items)

Product freezing time	2 hours
Amount of product	3 tonnes
Output	1½ tonnes/hour

If Freezer 2 is loaded with 3 tonnes of large items, the output will be reduced to ½ tonne/hour because the freezing time is unchanged: 6 hours. If Freezer 1 is loaded with 9 tonnes of small items, the output will not increase to 4½ tonnes/hour because there is insufficient refrigerating capacity.

Freezer output is primarily a function of refrigerating capacity. If the product to be frozen has a long freezing time, the freezing chamber must be sufficiently large to accommodate the amount of product which will give the required output. The shorter the freezing time of the product the less space is required for the freezer to achieve the required output.

Freezing Time and Quality

The quality of frozen fish is unaffected by rate of freezing for freezing times less than 10 to 12 hours. On storage, temperature rapidly becomes more important than freezing rate.[8] Slow freezing, where freezing times exceed 15 hours, is reported to have adverse effects on the texture of fish, these changes becoming apparent after three months storage at -18°C.

The commonly-held view that freezing rate has a significant effect on quality of frozen fish was perhaps supported by early experience of freezing which was so exceedingly slow that bacterial spoilage must have occurred, quite apart from excessive drip formation, pronounced dehydration and extreme toughening.[8,11] The wide commercial use of rapid freezing is due not so much to considerations of quality but to its suitability for the mass production of frozen seafoods.

Air Blast Freezers

Air blast freezers are widely used in the fishing industry because they are versatile and allow products of various shapes and sizes to be frozen.[12]

For an air blast freezer to function effectively it must maintain a stream of high-velocity cold air over the surfaces of the product in all parts of the freezer. This is done by installing sufficient fan capacity to maintain the required air flow rate and by designing the freezer in the form of a tunnel so that the air is constrained to move in a circuit over the product and through the cooler. The design of ducting and the placement of baffles and turning vanes should be such that the velocity profile in the working section is not excessively uneven, that pressure losses and flow disturbances are minimised and that there is no short-circuiting or bypassing of the air. For uniform air flow, the product to be frozen should be evenly distributed across the working section of the freezer. This avoids the problems caused by uneven freezing rates and ensures that the refrigerating capacity is being used to greatest effect.

Another important requirement in an air blast freezer is that the design air temperature should be suitable for reducing the temperature of the product to that of cold storage. Australian practice is commonly to store frozen fish at $-18^{o}C$; therefore the temperature in the freezer should be at least $5^{o}C$ lower at $-23^{o}C$.

Plate Freezers

The most common alternative to the air-blast freezer is the plate freezer: it is best suited to the freezing of regularly shpaed products having uniform thickness. Product to be frozen is placed directly in contact with refrigerated metal plates. Freezing times tend to be shorter for products in plate freezers than for the same products in air blast freezers; therefore the plate freezer can be more compact.

The plate freezer does not have the versatility of the air blast freezer and sometimes deformation caused to the fish by the plates is considered to be a disadvantage: however, plate freezer systems require substantially less power than air blast systems, mainly because of the power requirements of the fans in the air blast freezer. Also, because air acts as a secondary refrigerant in air blast systems, the temperature difference between the product and the refrigerant will be greater than in a plate freezer for a given heat load. This increased temperature difference requires that the air blast system operates with a lower compressor suction pressure: because the volumetric efficiency of the compressor falls with reduction in suction pressure, the air blast system will have a lower overall efficiency than the plate freezer.

Cold Storage

The final quality of frozen fish is largely determined by cold storage temperature in conjunction with duration of storage.[8]

The main changes that occur during cold storage are chemical spoilage and dehydration. Chemical spoilage proceeds in cold storage because, even at -30°C, there is still up to 5% of the original water content of the product remaining unfrozen. The intensity of chemical changes occurring at these temperatures depends on the availability of "free water", which falls with temperature. Water-related chemical spoilage is considered to effectively cease at temperatures below -40°C.[13] Increase in storage temperature markedly reduces the shelf-life of frozen fish, which is approximately halved by a 6°C rise. Frozen fish stored at -30°C could be expected to keep roughly four times as long as similar product stored at -18°C.

Dehydration of frozen fish in cold storage is caused by migration of moisture from the surfaces of the product to the surface of the cooler, where it is deposited as frost. Excessive drying alters the appearance of the fish, an effect known as "freezer burn". It is often accompanied by high rates of chemical spoilage and oxidation. The rate of dehydration depends on the difference between the storage temperature and the temperature of the surface of the cooler and on the velocity and relative humidity of air in contact with the surface of the product. Cold stores should be designed with adequate cooler area so that the temperature difference between the air and the surface of the cooler is kept to a minimum. Air movement should be controlled in such a way that velocities are low, consistent with maintenance of the required cold storage temperature. Glazing and packaging can also be used to protect the stored product from the effects of dehydration.

Fluctuations in temperature in the cold store can cause irreversible damage to stored product even if the average temperature is at or below the required value. Such variations in temperature are inevitable: heat gains due to presence of humans, door openings, lights and heat ingress through the insulation will cause rises in store temperature which must be counteracted by the refrigeration system. Careful design and operation of the cold store will minimise these effects. Also, the temperature of cold storage should be selected so as to reduce the effect on product quality of variations in store temperature. The lower the average store temperature the less the effect variations in temperature will have.

Summary

The purpose of this paper has been to indicate the importance of engineering science in the successful use of the cold chain from catcher to consumer. It has been shown that chilling and chill storage can be used to advantage at sea: there are a number of methods, all of which have particular strengths and weaknesses, but none can be effective if due attention is not given to the engineering details of system design and operation. It has also been shown that freezing and cold storage are essential to the viability of a modern fishing industry and that these can only fulfill their function where, again, the systems are designed and operated according to well-tested engineering principles.

Acknowledgements

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Legends to Figures

Figure 1 The $\sqrt{r}$ relationship with temperature; plotted as a rate relative to $0^{o}C$ with a T_o of $-10^{o}C$. After J. Olley, 1982.[14].

Figure 2 The rate of enzymic spoilage as influenced by temperature and enzyme concentration. After R. Harvie 1982.[15] With acknowledgement to the New Zealand Fishing Industry Board, Wellington, N.Z.

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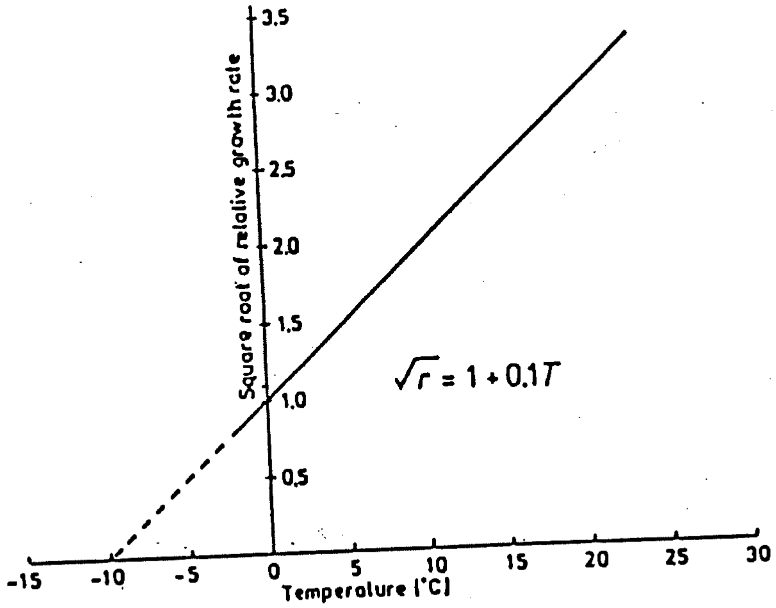

Figure 1. The $\sqrt{r}$ relationship with temperature; plotted as a rate relative to 0°C with a T_o of -10°C. After J. Olley, 1982.[14]

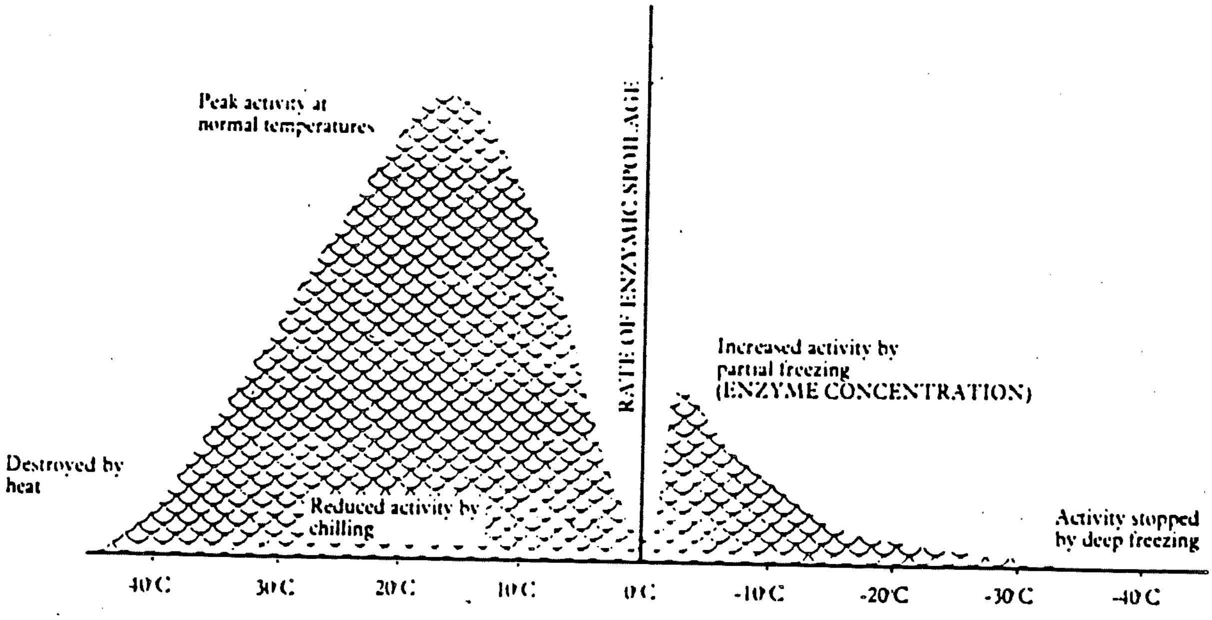

Figure 2. The rate of enzymic spoilage as influenced by temperature and enzyme concentration. After R. Harvie 1982.[15] With acknowledgement to the New Zealand Fishing Industry Board, Wellington, N.Z.

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CRYOGENIC FREEZING AND MODIFIED ATMOSPHERE PACKAGING

Mr. Ken Bishop

Commonwealth Industrial Gases Limited

The two processes which I want to discuss today are both employed to preserve foodstuffs using products manufactured and sold by Industries Gas Companies.

Firstly, let us consider cryogenic freezing.

I do not intend to go into the properties of cryogenics in any depth, but suffice to say that what we are considering is a system using either liquid nitrogen or liquid carbon dioxide as a total loss refrigerant. The refrigerant is applied through an appropriate piece of freezing equipment.

Within limits, the two cryogens are interchangeable and the choice of which to use will be governed largely by the economics of supply. In most Australian States, liquid nitrogen is the cheaper of the two to produce and so is the most widely used. In the United States the reverse is true and carbon dioxide is the most widely used cryogen for food freezing operations.

Liquid nitrogen is produced on an air separation plant while carbon dioxide is recovered from a waste gas stream of another industrial process. Where this is not practical, it may also be produced in an oil burning plant. However, this is an expensive exercise.

Why use cryogenics for freezing? Cynics and our opposition might say that we are only interested in selling gas. Having surplus nitrogen we 'flog' it to the food industry.

While there is some truth in this statement, what is also true is that gas companies have products which span many industries and the food industry is a most important sector. CIG has developed expertise in this area over many years and continues to invest money in development work on its own or in conjunction with other organisations. It employs trained food technologists and engineers to help customers in their various application areas.

When compared with mechanical refrigeration systems, cryogenics is often perceived as a high cost method of achieving the same result. If this were in fact so, we would have been out of business years ago. Instead, what we see today is cryogenics holding a minor but growing share of the freezing market. Why is this so?

There are many factors to be considered when installing a freezing plant. Some of these are:-

- What is the product life cycle?

- What is the importance of product quality?

- What percentage of the final cost of product is represented by freezing costs?

- How much capital have we got?

- What are the competing demands on that capital?

...And so on. Each individual application will have its own set of priorities.

Specifically what cryogenics can offer for food freezing applications are the following:-

1. Low capital requirement. Plant can be hired, purchased outright or bought on leasing plans. This frees funds for other purposes such as product packaging or promotion.

2. Consistently high product quality due to very rapid freezing rate. This is manifested in the thawed product which exhibits superior appearance and texture.

The ability to freeze at temperatures below -30° is the major contributing factor.

3. Because of the simplicity and reliability of the process, the probability for failure in equipment is low and hence, out-of-stock situations are less prone to occur using this process.

4. Cryogenics offers flexibility to the processor through the ability to handle widely varying throughput literally at the turn of a knob. High freezing rates can be used to maintain single shift operation.

5. Other benefits to a processor could be less space required, less labour for supervision, maintenance and operation. e.g. single shift processing vs two or three shift operation.

I would like to turn now to the selection of equipment, which is of prime importance in applying cryogenics.

Essentially there are three types of freezers used in industry today and the decision on which type to use is largely dependent on the throughput required.

The three types of freezer are:-

1. The Batch Freezer

This machine which is loaded and unloaded manually, is designed to handle up to 200kg per hour of product. Cycle times of around thirty (30) minutes are required for freezing. New developments include improved gas circulation through new fan design and programmable control system.

2. The Cryogenic Tunnel Freezer

The most commonly used piece of equipment in the market today is the cryogenic tunnel freezer. This is essentially a conveyor belt and so fits easily into a continuous processing operation. This machine can be used to cool, case harden, crust freeze or full freeze the product. Tunnels can handle up to one tonne per hour of product, but this figure is dependent upon the application.

Recent design innovations have seen developments such as lift-top or drop bottom configuration for easier cleaning and improved automatic systems for control of temperature. Better insulation, improved fan configuration for gas circulation and overall more economic operation are the likely ways the design of this equipment will progress in the future.

3. Cryogenic Spiral

The third piece of equipment in use is the cryogenic spiral. The design has received much impetus in the United States where it is widely used. There the equipment commonly handles freezing rates in the range of one to three tonnes per hour and has also been built in dual configuration for even higher throughput.

The great advantage which the spiral has is its high throughput capability combined with minimum space requirement. A special close radius design developed by our American associate company, Airco, occupies a floor area of 4m x 5m, and has a height of 4½m. With a belt length of 133m (400 ft), it can handle two tonnes per hour of product.

Cryogenic spirals are designed to operate at temperatures of -50°C and with recent advances in spray header design and circulating fan location, the efficiency of the machine is now close to that of the freezing tunnel. It should be remembered that the spiral is isothermal in operation, whereas the tunnel is a counter current heat exchange.

Another feature of the spiral is its ability to site the unit external to existing buildings. It does require regular routine maintenance to keep it in top working condition.

The other process I want to discuss today is gas packaging, especially in relation to fresh fish. Our approach to this process and that of our parent company, British Oxygen, has been to assist with promising development work in an effort to come up with commercially viable processes which would be of benefit to the industry.

In the UK, several processors are using gas packaging in the presentation of fresh or smoked fish for sale in supermarket chains. This covers shellfish as well. The criteria which they felt were important to meet were:-

1. An adequate shelf life without deterioration in quality

2. Controlling odour

3. Dry handling in distribution and store.

Closer to home, our New Zealand associate company, New Zealand Industrial Gases, has been involved in a successful venture marketing mussels as kiwi clams in a mixture of carbon dioxide and air.

Because of the high bacterial load on fresh seafood following filleting, microbial spoilage is very much the limiting factor to shelf life. This has led to extensive use of carbon dioxide, either alone or in conjunction with other gases as an inhibitor to bacterial spoilage.

The use of carbon dioxide alone has been shown to have problems such as pack collapse through absorption of the gas into the fish tissue and drip production inside the pack. Obviously both these problems lead to poor pack presentation.

The techniques have been refined so that what is now the case is to evacuate the package and fill it with a gas mixture, the composition of which will depend upon many factors:-

1. The product.

2. The shelf life required.

3. The spoilage mechanism.

Oxygen is commonly used to maintain fresh appearance and ensure that anaerobic conditions do not occur, which can support pathogenic bacteria. Used in conjunction with carbon dioxide to act as a bacteriostat, good results have been obtained. The presence of oxygen can cause problems due to oxidative rancidity with fatty or oily fish and nitrogen may be substituted for all or part of the oxygen in this case.

Thus, some typical mixtures which have been used are as follows:-

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60% CO_2 40% O_2

or 60% CO_2 40% N_2

40% CO_2 30% N_2 30% O_2

These processes offer improved shelf life for fresh foods, which in turn provides:-

1. Higher acceptance by consumers.

2. Larger geographic market.

3. Lower rejection rates.

The use of these processes does involve an added cost because of packaging, however the premium price which fresh foods can command should enable recovery of the extra cost involved.

The other point which needs to be made is that if the quality of the product is poor before packaging, then the use of gases will not improve it. What is required is top quality fresh product and good chilled storage preferably at 0°C. This then leads into a discussion of the distribution portion of the food chain, which has always tended to be a weak link and an area in need of improvement.

The growth of supermarket chains and centralised distribution have been the catalyst for development of processes such as this. Overseas experience indicates that the processes are commercially sound as they have received consumer acceptance. After all this is the ultimate test as to whether a process is a success.

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DEVELOPMENT OF VALUE ADDED PRODUCTS

Mr. Geoff McKenna

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Every day in one way or another, we hear about "convenience foods", "quick snacks", "fast foods" and of course "junk foods". The terminology tends to suggest that the amount of research and development required to produce such foods is minimal. But have you ever considered, for example, products that are available for the local take-away? Why does every seafood cocktail you buy from your take-away taste the same? and why, after days of refrigeration has there been no separation of aqueous phases in the sauces? Or why does every Chicko roll look and taste the same regardless from where you buy it? The answers are, of course, that behind every product there is some type of research and development program that decides the parameters that will be characteristics of that particular product, which in turn, delete the difference between convenience foods and fast foods because TECHNOLOGICALLY there is very little difference at all.

What are Value Added Products?

The definition of value added products (VAPs) can best be summed up as an extension or utilisation of raw materials or by-products to create and provide feasible outlets for materials that could otherwise be discarded, downgraded or too costly to produce.

An example of this definition can be clearly seen by comparing two simple filleting operations:-

FACTORY A - Achieves a fillet recovery of 70% from 1000 kgs of whole scale fish per day, with all fillets produced packaged into one standard grade. All filleting waste (300 kgs) is dumped.

FACTORY B - Achieves a fillet recovery of only 65% and trimmings are processed through a mechanical deboner. From the resultant separated mince, fish blocks, fish cakes and composite fillets are produced.

The deboner waste, heads and viscera are minced together and processed through an ensiling plant for sale as stock feed.

This is a relatively simple example but clearly emphasises the utilisation of downgraded product and raw materials that are too often destined for discard waste.

The idea of adding value to "traditionally downgraded raw material is not new with the VAPs available on the market shelves today as numerous as they are diversified.

Why are Value Added Products Developed?

There are several reasons why VAPs are developed, but within the fishing industry the following points are usually the most influential factors that govern their inception.

a) Stabilisation of fluctuating supply of raw material, especially those seasonal species of fish that are readily available during seasonal gluts.

All of us in the fishing industry know the impact that seasonal catch variations have on our production schedules.

b) Utilisation of by-products as well as low-value fish species that would otherwise be downgraded or discarded.

Downgrading some species of fish (especially into bait) because of lack of consumer acceptance, along with the enormous amount of filleting and visceral waste per year from processing plants, warrant these problems continued and specialised attention.

c) Improvement or enhancement of the organoleptic (i.e. is, the senses of odour, taste, appearance and texture) qualities of the characteristically "unattractive" fish species. For example, squid, which until recent times had received relatively low consumer preference in comparison with the more popular species.

d) To meet market demand, either naturally present or created, for different types of products.

Convenience foods such as fish in sauces, prawn cocktails and even fish fingers all fulfil a market need.

e) To establish new processing techniques which can lead to variety and diversification of standard products.

Tuna in undoubtedly the most indicative raw material that illustrates this point. In the tuna range, Safcol alone produces:-

Tuna in Brine
Tuna in Oil
Tuna in Seafood Cocktail Sauce
Tuna with Tomato
Tuna with Mayonnaise Dressing
Sweet and Sour Tuna
Sandwich Tuna

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Tuna and Beans

Tuna Mornay

Tuna Salad with Dressing

Smoked Tuna Slices

Smoked Tuna Pate

Smoked Tuna - Chunk Style

Processing techniques do not only involve plant and equipment but also freezing, canning and packaging mediums which in combination determine the eventual organoleptic and physical characteristics of a particular product.

f) Improvement of profit potential for manufacturers and retailers.

The scope of profit potential depends, of course, on the total costing structure of any particular company. However, the common view of cost related turnover is indicative of the profit potential for any VAP.

Development of Value Added Products

Once the demand for a particular product has been identified, the development can be divided into five major categories:-

1. Formulation

2. Testing Sampling / Data Retrieval

3. Final Product - In-House Sensory Evaluation

4. Quality Assurance

5. Pilot Model - Production Surveillance.

1. Formulation

Product formulation incorporates many areas. The researcher must have an intimate understanding of materials, tools, processes, food laws and the marketing objectives of the company. To understand the total scope of these techniques is arguably the prime requirement for an optimum formulation. An optimum formulation satisfies three requirements:-

1. It maximises consumer acceptance.

2. It performs at the standard manufacturing level of the company and

3. It is cost effective.

The first step in the formulation procedure is ingredient screening. This is the process by which the final list of ingredients for the finished product is drawn up and usually includes a broad range of options to cater for variations in colour, texture and taste. If comparison of competitors' products is included, the screening research also provides an early opportunity to obtain a marketing level assessment of the product under development. The second step is ingredient suitability. This process identifies "high-impact" ingredients and those whose functional characteristics have a strong influence on the organoleptic parameters of the final product. Although the type of basic raw material available generally decides the usage of such ingredients, cost factors and consumer acceptance also play an equally deciding role during the formulation process.

The third and possibly most important step is ingredient suitability design. This stage assesses the performance and functional capabilities of ingredients under processing and storage conditions and eventual home preparation by the consumer. Freeze - thaw stability of emulsions, chemical and physical changes that occur in canned products during thermal processing, and the durability of products under certain storage conditions are just a few of the fundamental research considerations assessed during the ingredient formulation process.

2. Test Sampling/Data Retrieval

Once formulation of the product has been achieved, the most critical stage of the development process takes place - consumer sample testing and data retrieval. The consumer sample should be developed with the guidance of marketing research and samples must be representative of the target market for the final product; age, gender, regionality and competitive product usage are typical considerations. The samples presented for consumer-orientated testing should allow for a discernable difference in organoleptic profiles to the extent that acceptability of the product will vary from a too-low point to a too-high point; that is, the study takes advantage of the fact that consumer acceptance is nonlinearly related to ingredient level. This is especially true for ingredients such as salt, sugar, colourants and thickners. Even for products where consumers traditionally state they want more of some ingredient, there is a level that is too high. The objective is to identify the high and low levels which will enable a more accurate estimate of the optimum level.

The method of sampling technique can vary to correspond with the appropriate data objectives. The techniques can range from randomized testing to replicated balanced block design, but the simplest method is the balanced triangle test (Figure 1).

Figure 1.

PLAN FOR BALANCED TRIANGLE TEST

JUDGE NUMBER	SAMPLE ORDER	JUDGE NUMBER	SAMPLE ORDER
1	A B B	7	B B A
2	B A B	8	B A B
3	B B A	9	A B B
4	B A A	10	A A B
5	A B A	11	A B A
6	A A B	12	B A A

NOTE: (Figure 1)

a. There are six possible orders for serving a triangle test.

b. All permutations occur an equal number of times.

c. One complete permutation block is completed before a second complete permutation block is introduced.

d. Judges receive the A or B sample as the odd sample.

There are several types of information to be gained from test sampling, but the most important information required and the most dependent variable is the acceptance rating. In fact, this is the only rating that is absolutely necessary to obtain indicative product formulation variables.

The method chosen from which an accurate acceptance rating is derived depends upon the sample testing technique employed, but all sensory and physical attributes must be accounted for to minimise acceptance error at the final development stage.

3. Final Product - In-House Sensory Evaluation

On completion of formulation, test sampling and data analysis, the evaluation and specifications for the final product can proceed. If the above stages have been correctly equated, the final product samples should only need minor adjustment within the established parameters set during the preliminary stages.

In-house panels or executive panels can be used at this stage of development with the results of the evaluations generally used to cross-reference data obtained from the original test sampling stage and also to familiarise a formal panel with the expectant sensory and physical profiles of the final product. The evaluation techniques used during this stage usually vary in format from the methods employed in a consumer-orientated evaluation.

However the results must be relative in comparison, with the objective to detect the amount of drift, if any, from the standard product profile.

Once the parameters of the final product have been identified, the specifications, process controls and production techniques are aligned in conjunction with the respective management whose responsibility it is to account for correct and proper procedures.

When final product specifications are to be established, the following criteria should be included in the standard:-

Ingredient name, grade, supplier and availability.

Raw material specifications.

Composition and batch weights.

Processing methods emphasising specific details regarding process times, temperature and any other relevant information.

Packaging - including full-in weights and packaging material specifications.

Preservation methods.

Quality assurance and microbiological specifications.

Codes and other markings.

All other relevant information including expected trouble spots, ingredient variables and specifications contact.

4. Quality Assurance

Quality assurance will be discussed later in this paper as a separate subject to be presented by my colleague, Mr. Bradley Hudson. However, there are some points that I would like to highlight prior to Mr. Hudson's presentation.

The practice of a research and development division maintaining the quality control standards for finished product should be avoided; this should be carried out as a separate function of the quality assurance department. This ensures a more balanced and impartial evaluation study of the processing, production and microbiological status of the final product.

The approach taken by the quality assurance department will vary depending upon the nature of individual products. However the fundamental considerations placed on standard production techniques are the guidelines for any "new products" and may be placed into four basic classifications:

1. Organoleptic
2. Physical
3. Chemical
4. Microbiological.

1. Organoleptic evaluation ensures that product characteristics such as colour, odour, flavour, texture and acceptance are maintained uniform and satisfactory.

2. Physical parameters require control to satisfy not only the consumer, but also legal requirements and manufacturing control efficiency. These include vacuum, fill-in weights, headspace, high-impact ingredient monitoring, drained weights etc.

3. Chemical tests measure pH, salt, soluble solids and other parameters that affect product specifications.

4. Microbiological examination ensures contaminated product is not released into the market place.

Laboratory quality standards are designed for each product and usually contain the following information:

Tests to be performed.

Frequency of sampling.

Working limits of each parameter.

Quarantine limits of each parameter.

Where the results drift from the standard range, corrective action is taken. If results fall outside the quarantine limit, those parts of production are immediately isolated and quarantined.

5. Pilot Model - Production Surveillance

Prior to mass production of any "new product", the researcher, in liaison with plant management, should monitor pilot stages and initial production runs so that potential problems and weaknesses at action level can be recognised and arrested. This is particularly important during the transition from laboratory mixtures to actual bulk preparation stages. A simple illustration of the importance of the monitoring stage is in the use of leavening agents, shortenings and some spices, where the dosage rate depends upon the actual batch size. For instance, it may take 45 grams of yeast to produce three x 500g loaves of bread (3% dosage rate), yet the production of 300 loaves of bread using the same time, temperatures and conditions may only require a dosage rate of 2%. Leavening agents, shortenings and spices are of course high-impact ingredients, and although cost and performance parameters are established at the formulation stages, the performance and resultant costs are PROVEN at the production level.

Production techniques, machinery requirements, daily throughput and cost variances (labour, ingredient and processing) should all be monitored at this stage.

The Future of Value Added Products

We in the fishing industry are extremely fortunate in that our basic raw material is a protein rich, nutritious, natural resource which possesses definite and unmistakable characteristics different from any other food source. Our raw material is one which has versatility, wholesomeness and an untapped potential.

It is this untapped potential that will determine the future of development programs. The potentials lie in many areas and no one answer will suffice the scope of available possibilities. However some of the influential factors may include:-

(a) The discovery of new or under-developed fish species

Orange roughy is one of the more recent species found in Tasmanian waters which may prove to have an influence in product development. The white, boneless and somewhat bland characteristics of this fish make it a "natural" in products that will highlight its subtle qualities.

(b) Improvement of cultivation and aquacultural techniques ensuring a more stable supple of the consumer-accepted species

The recent success with the development of cultured scallops by the Tasmanian Fisheries Development Authority should, in the long term, stabilise supply of the raw material, making such products as coquilles St. Jacques and other related products more attractive to the consumer.

(c) improvement of process and ingredient technology

Food process technology, ingredient technology, processing aids, diversification of food additives and by-product technology undergo continuous and stringent upgrading and review, which will no doubt play a decisive and integral role in the future development of "saleable" products.

(d) A more concerted effort in the development of utilisation techniques

Greater utilisation of the fish catch by improving or developing conventional methods, which involves such

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things as avoidable spoilage deterioration and waste.

The future of value added products is never in doubt. It is the success of these products that yields the greatest achievements to both research and manufacturing bodies. In the development of new or value added products, one has to expect a relatively low success rate in comparison to the actual products that are "shelved" each year for various reasons. However the continuation of development programs is a necessary pre-requisite for the stability of the future for the processing industry.

CUSTOMER ASSURANCE - HOW DO WE ACHIEVE IT?

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Consider the word assurance. By definition it is a positive declaration intended to give confidence; it is a pledge or guarantee, or a freedom of doubt. Generally food products are purchased to satisfy the sensation of hunger. Irrespective of the reasons why a person selects and purchases a particular food product, he requires certain assurances. These are that the product will contain no harmful organisms, foreign or toxic substances, and that when consumed in moderation will have no harmful effect.

These considerations are probably not exercised in the consumer's mind every time a food product is purchased. Above all consumers will require that the experience they have with a particular food product will live up to their expectations at the time of purchase. Should the expectations of taste, odour, colour or appearance of the food product not be satisfied, this may be the last occasion that a particular food type or brand of product will be purchased.

Obviously it is in the food processor's interest that customer expectations are satisfied. We can do this by achieving a specified standard of quality in the product.

Quality is conformance to specified standards which are to be achieved at the end of the chain when the product finally reaches the consumer. Non-conformance to standards may precipitate a customer complaint or a product recall situation. It is within the manufacturer's interest to have a well defined recall plan and that all personnel in key positions as set out in the plan be aware of their function.

The product specification will be a reflection of consumer acceptance, food legislation and economics of production and distribution. Achievement of product specifications has to be a total involvement requiring participation by the producer and all personnel in the processing, packaging, warehousing and distribution chain. Should one or more of these elements fail, then assurance of quality can no longer be given.

The producer or fisherman is the first person responsible in the process of assurance of quality. The quality of fish begins to deteriorate very soon after death of the animal. Bacterial and enzymic spoilage is very well documented. The aim of fishermen is to slow down the rate of deterioration to the minimum possible within the limits of economy of operation. Proper handling of fish between capture and delivery to the processor or market is crucial to final product quality. It is important to remember that any deterioration in quality cannot be compensated for. It is lost for ever.

The second area of responsibility in the assurance of quality is with the processor. This responsibility may be subdivided into the areas of:-

1. Pre-processing.
2. Processing of raw materials into specified products
3. End product analysis.

All raw materials and sundry materials used in processing and packaging should be purchased to a specified standard. This standard must be realistic and meet the capabilities of the supplier as well as the needs of the purchaser. Another function under pre-processing is environmental sanitation. Control of environmental factors contributes to ensure quality in processed food. Careful designing and monitoring of the sanitation operation is important to ensure bacteriological standards are maintained. A sanitation program should also include high standards of hygiene for food handlers.

During processing of the raw material into the specified product, physical or chemical indicators must be employed to ensure the process is in control at all times.

The attributes defining the process must be standardised and adhered to in manufacturing operations. Control points must be established and adequate control procedures maintained at these points. This approach is identified as the Hazard Analysis Critical Control Point concept. Hazard analysis is the identification of sensitive ingredients, critical process points and relevant human factors as they affect product safety. Critical control points are those processing determiners whose loss of control would result in an unacceptable food safety risk. The Hazard Analysis Critical Control Point concept is the foundation of many successful food quality and customer assurance programs.

A formal hazard analysis should be performed on all new food products that any processor prepares and should be reviewed whenever any modification in processing formulation, intended end use, or distribution of a food product may affect food safety. Hazard analysis must consider the ingredients, the processing steps and the potential for consumer abuse of the product.

To illustrate how the Hazard Analysis Critical Control Point may be applied, a general canning operation is an ideal example. The critical control points of a canning operation will vary with the product packed, the container in which it is packed and the equipment used to thermally process the filled closed containers. To find the critical control points, questions must be asked.

Consider the raw materials and sundry ingredients. Are these to the standard and specification required? What is the bacterial load on these materials? Have ingredients changed since the process was designed and, therefore, is the original process valid?

Canning operations usually require a process to prepare materials prior to filling of containers. Consider canning of scale fish. It is necessary to dehead, gut and slice the fish. We need to ask, is this being done correctly? Are the people doing the job properly trained and supervised? The preparation of raw materials may involve a chemical and or a heat process. We need to ask similar questions with respect to control of the process.

Filling of containers is the next step in the canning operation. Is the correct weight of fish and or other materials being backed into the container? Is the container being filled to the correct level? Is the head space being measured and at what frequency and at what point in the line is it being measured?

The closing operation is next to be considered. Are sample containers checked for defects and at what sampling rate? What action is to be taken when defects are detected? What are the can seam inspection procedures? How often is an inspection or seam teardown performed? Does the person performing the seam teardown have proper training and does

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this person have a procedure to follow when seaming faults are detected?

After closing, the next operation is thermal processing. Questions to be considered here are:- is the retort properly equipped? Does it have a mercury in glass thermometer? Is the thermometer readable, correctly installed and regularly calibrated? The retort should have a chart recorder. Are the correct recorder charts being used? Is the condensate drain operating? Are steam bleeders of the correct size, installed correctly and operating in continual sight of the retort operator? Are retort operators trained and qualified? Considering the process used, who designed it and when? What is the venting schedule and are these posted by the retort? Are times and temperatures of operation recorded and are these records viewed by management? What is the course of action when process deviations occur? Is the retort cooling water treated with a germicide? Is the germicide effective and what is the concentration at the retort drain outlet? Is this monitored regularly and are results recorded?

Following cooling, product containers are labelled and packaged. We need to ask, how are the cans handled in this process? Has the correct label and date of packaging been applied to the container? Is damage occurring in the labelling and packing operation? How are dented cans handled and what is the potential for container damage?

This is by no means a complete list of the critical points within a canning process. Hazard analysis is preventative in nature, attempting to highlight areas of danger in processing so that corrective action may be taken immediately should deviations occur. This approach is applicable to any food or manufacturing process.

Before distributing a product, we require certification that it conforms to the desired product specification. This will require sampling and analysis of the end product. The size and frequency of sampling will depend upon the quantity of the production lot, the unit size and the confidence to be expressed. The bacteriological, chemical, physical and organoleptic analysis performed will depend upon parameters within the specification. End product analysis is a valuable tool since it is a measure of the effectiveness of process control. The data may indicate that a process is under control or that it may need to be revised in order that it may be brought under control.

The final area of responsibility in customer assurance rests with the distributor or retailer. This involves the progress of food products from the end of the processing line through warehousing, storage, transport, handling, display and even storage and preparation in the home. Packaging must be sufficiently tolerant to enable the product to encounter foreseeable conditions and mishandling in phases outside the manufacturer's direct control and still reach the consumer in acceptable condition. The packaging must also provide the consumer with adequate information and advice on storage and preparation.

In conclusion, customer assurance is achieved through conformance to the product and process specification. This will reflect product safety, consumer acceptance, regulatory compliance and economics of operation. Consequently the people involved in all the areas of responsibility discussed will have the one objective, customer assurance. They will then become an integral part of a quality management system. This system must not be seen as a cost to production but as a profit centre. Conformance to specifications will minimise failure costs, resulting in improved profitability and product quality.

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ADDED VALUE PRODUCTS - PREPARATION OF SASHIMI TUNA

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Fish resources in Australian waters are comparatively sparse.

This precludes us from producing large quantities of fish at competitive prices.

To gain the greatest benefit from our limited resources and to compete with imports we have to move up-market and provide high quality seafood for both the local restaurant trade and export markets.

Our prawn and rock lobster industries produce export products second to none and in return receive top prices. However, it should be noted that lobsters and prawns are also sought-after luxury products at home and therefore we appreciate their value. But what of tuna? To us, it is a day to day low cost salad or sandwich material and we pay accordingly. To the Japanese, however, an Australian tuna, handled properly is something akin to heaven, and he is prepared to pay accordingly. Unfortunately, for our tuna fishermen, the disparity between prices paid on these markets is between 700% and 6000%.

Now that the southern bluefin tuna resource is considered to be overfished and prospects for the traditional industry look bleak, surely it is time to take a good look at moving up-market with the sashimi grade tuna species and to start catching more skipjack and longtail for the canneries.

Demand for sashimi grade tuna in Japan exceeds supply and our southern bluefin and bigeye are considered superior to those species from Taiwan and the Phillipines.

Between one hundred and three hundred tonnes of sashimi tuna cross the floor per day in Tokyo giving ample scope for any Australian product.

Just what is sashimi?

Sashimi is Japanese for raw fish, either served on its own as a dish called sashimi or with rice as sushi.

Sashimi comprises bite size pieces of raw fish arranged exquisitely on a plate. The most desirable parts of the fish are the outer layer of muscle and the belly flap. Sushi is a very popular way of eating raw fish, especially tuna, and consists of thin slices of fish laid on top of finger shaped servings of rice.

Many species of fish, including snapper, morwong and prawns are suitable for use in raw fish dishes, but the most highly valued are the bluefin, southern bluefin, bigeye and yellowfin tuna.

As our palates are at present unfamiliar with most raw fish cuisines we must be careful not to flippantly shun or modify Japanese guidelines for handling procedures. One fisherman told me that he had worked with tuna for twenty five years and that many of the handling procedures listed by the Japanese were gross overkill and unnecessary. He might have been right; but if anybody is prepared to give me between eight and forty dollars a kilogram on a fish for which I previously received seventy five cents, I think I would be tempted to accommodate him.

It is worthwhile mentioning that each tuna is auctioned separately and before the sale is examined closely by prospective buyers. They will very quickly pick up any sign of mishandling which of course will be reflected in the bidding. In extreme cases the fish will remain unsold.

. Suffice to say that quality must be high as the fish will be eaten raw by a discerning consumer for whom it is an expensive delicacy.

Sashimi tuna comes in two forms, fresh or frozen. Criteria which determine the suitability of tuna meat for both the fresh and frozen sashimi market are: taste, moisture content, firmness and texture, but most important are oil content and flesh colour. As fresh tuna requires more rigorous handling practices and commands greater prices, I shall treat this form primarily.

All too often a discussion about fresh sashimi tuna centres on remarks about high prices. I intend to take a different tack and start by mentioning the costs of getting fish from your boat to the Japanese buyer. Depending on market conditions and the size of fish sent to Tokyo, this currently varies between $.00 and $5.50 per kg all up, from the eastern States.

The reason for attaching such importance to these overheads is that a prospective exporter must be able to judge whether a fish is worth sending. Therefore, he must know the state of the market in Japan. (Regular contact with his agents can help here.)

He must also develop some expertise in valuing individual fish based on the criteria mentioned earlier.

Generally, an exporter will be selecting fish, of at least 15 kgs but preferably over 50 kgs. Small tuna (under 15 kgs), apart from having a lower oil content, tend to retain fat in a white thread like form. This has the appearance of parasite infestation, which is a turn-off to consumers and greatly reduces price.

To emphasise the importance of oil content to the Japanese buyer, it is worth noting that two outwardly identical fish, auctioned side by side can vary in price up to 500% due to different oil content.

Thus far we have spoken of grading fish on the basis of their natural condition (oil content, size, flesh colour etc). Natural condition is a factor we cannot control in the wild, although it is of interest that tuna ranching projects conducted in North America are allowing fish to be dispatched in peak condition.

Assuming that a fish is in a satisfactory condition when caught, it is what we do to it between the water and the fish market floor which will finally determine its suitability for sashimi.

Procedures for getting the fish on board, bleeding, gilling and gutting, chilling, holding and finally packaging are already well documented elsewhere. I have heard it said that too much emphasis is placed on the cutting and mechanical aspects of processing and not nearly enough on grading and marketing. Briefly, I shall describe the more important handling procedures, giving emphasis to trouble spots encountered by Australian exporters.

- Fish should be gaffed only in the head

- Fish should be manhandled carefully - bruising or chafed skin reduce price

- Fish should be handled on to a soft washable surface, such as some form of carpet or rubber sheet

- The skin should never be allowed to dry out

- Bleeding from behind the pectorals should be carried out immediately

- The nervous system must be rendered inactive - a hit on the head with a mallet or spike will not necessarily achieve this. Recently, use has been made of a sharp stainless steel tube (about 3 cms in diameter) hammered into the top of the head to core the brain. Having removed this core, a flexible wire is thrust down the spinal colum.

The reasoning behind this procedure comes from the warm blooded physiology of tunas. When a fish is caught, the surge of frenzied activity, causes rapid build up of muscle temperature and of lactic acid concentration. This causes the muscle to resemble half cooked meat and imparts a sour taste, mushy texture and strong after taste. This flesh condition, detected at auction by a greyish colouration of the flesh, usually results in a dismally low price and a note describing the fish as "burnt". Sending a fish in "burnt" condition will often result in a nett loss of about $3 per kg. This of course reduces profit for the balance of the consignment.

Overcoming the burnt flesh problem will depend on the fishing method used, prevailing ambient temperature and the time elapsed before getting the fish into the chilling medium.

- Long lining, generally, allows the fish to tire slowly, and dissipate heat and lactic acid naturally before being brought aboard

- When hand lining it can be worthwhile buoying off a fish for a while to allow heat dissipation to occur

- Particular care must be taken in tropical fisheries such as that off Cairns, where water and air temperatures can exceed 30^{o}C

- Long delays in processing always increase the risk of burning.

Gilling and gutting are carried out together, with the gut being extracted through the fill cavity.

- Care must be taken not to pierce the gut and release bile or enzymes into the gut cavity

- Only a small incision in the belly should be made as this will be extended just prior to auction giving a fresh appearance

- Gill and gut cavities should be thoroughly cleaned.

Processing should be completed as quickly as possible to allow early chilling in a seawater and ice slurry for between six and twelve hours. After satisfactory chilling, the water is pumped out of the slurry leaving the fish firmly encased in ice. Pumping out prevents bleaching and skin chaffing due to vessel movement. Fish may be held in ice for up to three weeks. Of course, the sooner a fish reaches auction the greater chance you have of receiving a high price.

Fish are airfreighted to Japan in cardboard coffins. Because of the dangers to aircraft of corrosion by salt water, the airline must be satisfied that no leakage from the coffin will occur, or damp coffins may be rejected.

Preventing leakage necessitates the use of heavy polythene bags and lines around the fish, and double bagging for the ice enclosed if the coffin is to spend time at ambient temperatures.

All external labelling must conform to local and international requirements. Packing must be carried out in an export registered establishment. Each fish is specified separately on the inventory. This will identify prices received for particular fish. If small, say under 30 kgs, two fish can be enclosed in one coffin.

As freight rates, per kilogram, reduce for product over 0.8 tonne in one LD3 air container coffin, dimensions are carefully designed to stack efficiently and minimise waste space.

Airline officials sometimes fail to appreciate the difference between frozen and chilled, making it a wise policy to emphasise that your product must not be placed in a freezer.

As I have no practical experience with frozen sashimi tuna, I am hesitant to address the subject. However, it would appear that fish to be frozen should be treated in the same way as those to be stored in ice. It should be noted that:

- Prechilling in an ice slurry is often carried out. Just before freezing, the tail is removed and a rope loop threaded through the spinal column. The gill covers and fins are removed

- Fish stored in ice longer than four days should not be frozen

- Holding temperature should be at least minus 65°C, necessitating the use of specialised freezing equipment based on ammonia refridgerant.

It would appear that the handling practices for fresh sashimi tuna are not applied as rigourously to frozen product.

Indications from the developing east coast fishery are promising with prices of up to $43 per kg for bigeye and $21 per kg for yellowfin having been received.

The use of all monofilament long line gear appears to be giving distinctly superior catch rates, at least when the tuna are near the surface.

Innovative co-operatives at Ulladulla and Coffs Harbour have thrown their weight behind the longliners, allowing small catches to be combined to make up the minimum economical consignment of about 1 tonne. Also, by providing the marketing infrastructure, small operators can concentrate on their fishing operations.

Other fish species, handled by the Co-ops to sashimi grade have been airfreighted to Japan - hapuku and garfish look promising.

In summary sashimi is a fledgeling industry with exciting possibilities, much to learn and of course the ever-present financial potholes through which we stagger in our search for a profit.

NOTE: The video feature: "Sashimi tuna - a guide for exporters", produced by the Department of Primary Industry, is available in VHS or U'Matic formats on receipt of a blank tape. If interested contact: Mr Jameson on (062) 725477.

ADDED VALUE PRODUCTS -
PACKAGING FISH FOR THE RETAIL TRADES

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Introductory Notes

It does not matter which area of the fishing industry that we are involved in, there is one aspect that influences the success or failure of our endeavours and this is marketing.

Previous speakers have discussed the resource and its availability; how it should be harvested, processed, packaged and shipped. But despite your best endeavours all could be lost if the financial return is inadequate or, in the worst circumstances, if a market does not exist, which means that your products have no value.

Despite the importance of marketing I feel it is neglected and sometimes totally ignored particularly at the primary level where the resource is harvested.

Some producers, and I speak as a producer, do at times consider that the market should always be available to suit their convenience.

This attitude is accentuated during periods of consumer demand when some producers develop the attitude that the demand will always exist and that prices will continue to rise. Such factors as market research, product innovation, consumer education and promotion of their products mean nothing. In fact these could spell the difference between producers' success or failure.

This paper deals with some ideas on how to maximise the return on seafood products.

New Seafood Products to Meet Changing Lifestyles

With people around the world becoming more concerned about health and nutrition, there is a noticeable swing towards seafood as a major source of protein in our diet.

However there is still a strong consumer preference towards "fresh" products, such as meat, fruit, poultry, vegetables as well as fish and other seafoods. But there are few countries that can consistently supply large quantities of suitable varieties of fresh seafoods on a regular basis at competitive prices. There are also limitations on shelf life of fresh seafoods, probably more severe than for other product groups.

For these reasons, increasing quantities of seafoods are now sold in a frozen form which if correctly processed, stored and distributed is equal to and in many cases superior to the fresh product.

With fish the basic process is to freeze it whole or to fillet it before freezing and packaging for specific markets.

Seafoods are generally frozen in blocks, layer packed or as IQF (separate portions individually quick frozen). More sophisticated IQF or layer products are graded to a precise weight, size and shape (portion control). Consumers have reacted positively to the development of these modern methods of freezing, grading and packing. The end result is greater consumption and a better return to the producer.

Distributors have been able to widen their markets by simplifying the method of handling and preparation. With the advent of individually packed quick frozen items there is no longer a need to defrost a bulk block of seafood to use one portion, or to defrost the portion before cooking. This method of freezing and packing has been a major factor in the expansion of the seafood market.

New equipment has also been developed which can cut regular geometric shapes from fish blocks and then press these into various irregular shapes and sizes to suit specific markets. So it is not unusual to see natural shapes or various shapes presented in portions to suit the buyer's requirements, thus overcoming the problem of poor acceptance of the rectangular fish portion.

So far I have discussed the primary process of taking a fresh product, preserving it in its natural form and portioning and packing it to suit particular markets. The result is a whole variety of choices to tempt distributors and consumers. The introduction of these methods and techniques has increased consumption and the value of the humble piece of fish.

Perhaps the most important development - certainly the one with the most potential - has been the development of value-added products. Adding value by coating the products with various combinations, adding flavours and sauces or preparing seafood as an ingredient in a recipe dish. Such products extend the use of the seafood and generally reduce the price to the consumer by using an additive which has less value than the seafood itself.

The development of specialised equipment reduces the labour component and this, with volume production, reduces costs.

The extension into value-added products has resulted in the development of convenience foods that are not only popular with the domestic cook, but have made inroads into new areas competing for the consumer's dollar against meat, chicken and other products in all types of catering establishments. This style of product is "ready to use" and can be prepared with minimum effort.

These developments will lead to increased per capita consumption of seafoods and increase the demand for seafood products. Breaded products were perhaps the first of the value-added seafoods presented to the market. It is interesting to note that these products did not evolve through the desire to satisfy consumer demand but were a means of extending the use of seafoods and reducing or stabilising the cost.

Initially the proportion of breadcrumbs exceeded the proportion of seafood and a 70/30 combination with a predominance of breadcrumbs was not uncommon. However a mouthful of breadcrumbs did not satisfy seafood consumers, and consumer resistance plus the intervention of regulatory bodies led to the establishment of a standard that limits the proportion of breadcrumbs in the USA to a maximum of 50%. This regulation does not apply to all countries.

However, the greatest growth in breaded and other products coated with batter has been where light coatings are used in the approximate ratio of 70% fish and 30% coating. This changed ratio increased consumption.

The development of better quality coatings was another important factor with tempura batters, oriental breadcrumbs and other ingredients resulting in nutritious and delicious products.

There has been even more interest in the development of recipe dishes which allow full rein to the imagination of gourmet chefs. There's practically no limit to the varieties of frozen dishes that can be produced.

Modern technology has allowed the most delicate of sauces and their subtle flavours to be retained when reheated for immediate use. When you consider the amount of time and effort that a housewife or professional chef has to spend to produce the simplest of sauce dishes, it is not surprising that properly prepared dishes are so popular. The problem is not only the physical effort required by the end user to create these products but the techniques and skills of the gourmet chef are not always available in the home or even in the restaurant. Nor, for that matter, are the ingredients always available.

Successful producers of recipe dishes use only the best quality ingredients, equipment and facilities and employ highly qualified, experienced professional chefs to prepare their recipes. They support the chefs with a fully equipped research facility and the latest technology to ensure consistency and high quality control of their products.

One well known European producer draws ingredients from several countries. It is not unusual to find parsley from Belgium, onions from France, mushrooms from England, potatoes from Holland all used to make a recipe dish in Denmark which will be sold in Switzerland. It goes without saying that this is all woven around seafoods which are sourced from all parts of the globe.

With today's developments in food technology, specialised equipment, establishment of research and development facilities and tight quality control systems, quality recipe dishes are making high inroads into consumer and food service areas.

There is virtually no limit to the variety of products that can be produced. Recipe dishes can be designed for a specific position in the market to suit a consumer's preference or to meet a cost requirement.

The home consumer section of the market has increased dramatically in the past few years and progress has already been made in the food service areas with specialised products being prepared for the catering and restaurant trade.

It is possible to envisage the day when a proportion of menus in restaurants at all levels will include prepared frozen seafood dishes. This is already happening with airlines which use specific frozen recipe dishes developed for use in economy and first class sections.

In Switzerland and France some restaurants are already using frozen recipe dishes as part of their menu requirements. I cannot think of any food product that has as much potential as seafoods for the recipe market. Unlike many other foods, the main ingredient - seafood - is a seasonal product. It is not always easily obtainable in peak quality condition and requires a greater skill in its preparation. This is, therefore, an area where producers should pay more attention and make a greater commitment both in time and investment.

The concept will work in any country with any cuisine, providing the technical problems are properly researched. There are few seafood dishes (providing they have been correctly prepared, frozen, packaged and stored) that would lose any of their quality, taste or flavour when reconstituted.

There are may versions of recipe dishes, some good and some bad. The latter cause many problems for those introducing quality products. There is only one way to succeed - properly research the market, recruit skilled and experienced technicians, use only the best ingredients.

The success of these frozen recipe dishes does not mean there will be an increase in the ranks of unemployed chefs, rather, there will be an increase in the variety and an improvement of the quality of dishes available.

A recent European innovation has been the development of a range of frozen seafood recipe dishes designed specifically for a restaurant chain in France.

Four entree dishes have been created that are prepared in units of 24 serves with the sauce, broth and seafood frozen and packed separately. This allows the cook to actually contribute to the preparation by combining the ingredients in accordance with a prepared sequence and to introduce his or her individual skills by adding whatever other ingredients or seasonings as required. The concept paves the way for the introduction of a sophisticated menu range prepared by a gourmet chef but requiring basic skills in its reconstitution.

The changing lifestyle in most developing countries is creating more leisure time and different eating habits. There is a strong trend towards the use of convenience foods to match changing lifestyles. The fishing industry should prepare to meet the challenge for a greater demand for tis products.

Perhaps what is most significant to the fish industry in the development of value added products is that species previously considered unusable or of less value because of unsatisfactory visual characteristics or flavour can now be utilised if combined with a specific ingredient designed to overcome any unacceptable factors.

This means that fish that is good quality, but with dark or off-white flesh, or fish that has a strong flavour or soft texture now has many uses. This development could change the economics of several known resources.

The need is for the industry to combine in promoting seafoods in all forms highlighting the varieties and individual characteristics of each product.

An example of an industry getting behind its product was the initiative taken by the USA egg industry.

They had a one type product with limited uses compared with the seafood range. With promotion they changed a declining consumption rate to an increasing rate which they continued to maintain by regular promotion.

There is still plenty of room for innovation and experimentation in presentation to attract more consumers to seafood products.

The golden rule is that whatever your skills, quality must always take first priority as you cannot make good dishes from bad ingredients.

UNDERWATER OBSERVATIONS OF TRAWL NET OPERATIONS

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Summary

This paper discusses underwater observations and filming of prawn trawl nets in operation by scuba divers using a two-man underwater sled.

A telegraph system between the sled and the surface towing vessel provided instructions to the towing vessel so the divers could position themselves.

A 16mm underwater movie camera held by the observer, was used to record the net's performance. Other relevant information was recorded on roughened perspex attached to the sled.

Diver safety was maintained by using a back-up vessel with a fully equipped standby diver on board.

Introduction

Underwater observations and filming of prawl trawl nets have provided research divers and vessel operators with information on the performance of different net design.

In some instances, underwater observations have shown that only minor adjustments are necessary to substantially increase the catch rate.

This paper documents some of the scuba (self contained underwater breathing apparatus) diving methods used to observe and film prawn nets, including those used by the surface support vessels.

Methods and Techniques

Early attempts of observations by divers did not allow them to move about the nets and otter boards without extreme difficulty as the divers simply held on to the net and moved about by crawling. With the development of a suitable underwater sled (Hold 1960), divers can position themselves in relation to any part of the net or otter boards (Fig. 1).

The sled has a crew of pilot and observer and can be operated successfully to depths up to 40 metres. A telegraph alarm from the sled to the surface towing vessel provides an adequate communication system. This system consists of a magnetic reed switch, a three core electric cable and an integrated relay switch. The reed switch is set in epoxy resin and is activated by shifting a magnet which is incorporated into the switch housing. The integrated relay provides the power necessary for the surface alarm. A set of head phones attached to the vessel operator allows the signals to be clearly heard.

The sled and surface support vessels were used on two occasions to film and observe prawn trawl nets. The first was a 7 fathom GUNDRY net towed by a 17 twin rigged vessel. The second was a QUAD rigged 9 fathom FLORIDA FLYER net towed by a 28 metre Gulf of Carpentaria vessel.

Because of the similarity of the methods and procedures, on both occasions only the FLORIDA FLYER net observations are described (Fig. 2).

Procedures

Two 7 metre shark cat vessels were used as surface support vessels one as the sled towing vessel and the other as a back-up with a fully equipped safety diver on board. The safety vessel was positioned above the trawl nets at all times. Radio contact between the trawling and other surface vessels was maintained to ensure adequate positioning and safety.

On commencing operations, the prawn trawler deployed its gear into position approximately 800 metres from the other two vessels. When approximately 400 metres away, the divers boarded the sled at the surface and descended to the sea bed where they were towed at 1.5 knots while waiting for the trawl vessel to catch up. The trawl vessel towed the nets at 2.5 knots. Towing speed in excess of this results in the divers having difficulty in maintaining their position on the sled and increases the possibility of losing equipment.

When the trawl net caught up with the divers, a signal was sent to the surface vessel to hold its position. The sled was then moved about the net where observation and filming took place. Filming and observations were made of the net's performance, opening height of the net, the distance between each net, the performance of the sled between each of the two nets and the impact of the net on the sea bed.

The otter boards and the sled between each net were positioned perfectly and required no adjustments. The net was well made and no obvious resonant waves were observed. The opening height of the net was approximately 1.3 metres. Only two faults were observed. The first was an open area of approximately 3 metres between each of the two nets. The second was the head rope adjustment frame attached to each otter board. The adjustment height was inadequate for the height which is necessary for certain species of prawns. The adjustment frame was increased by approximately 1.8 metres before the vessel commenced commercial operations.

Observations by the divers showed that the net had only a slight impact on the sea bed. The chains slung from the foot rope barely touched the sea bed, and damage to the flora and fauna growing on the sea bed was minimal. Only a few minor adjustments were recommended to the vessel operator to enable the nets to reach their full potential.

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