THE UNIVERSITY OF HULL

A METHODOLOGY FOR INVESTMENT PLANNING IN DEVELOPING FISHERIES

being a Thesis submitted for the Degree of Doctor of Philosophy in the University of Hull

by

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SUMMARY

Of all the corporate tasks facing government agencies and business enterprises, none is more challenging or has received more attention than those involving the management of capital. This is as true for fisheries as any other sector of the economy. However, a fishery is the meeting place of many disciplines and the complex interactions that result from the biological, legal, social, psychological, political, technological and engineering problems within it, intensify the difficulties in the search for ideas and solutions for the rational economic management of capital investment.

In spite of the complexities a rational approach is needed involving the location and evaluation of all the opportunities for development across the whole of a fishery now or in the future. Capital investments dictate the entire pattern of production of fish and fish products and decisions taken in this area are usually irreversible. It is therefore, undesirable to allow the situation to develop as a random process.

It is essential for work of this kind, that a theoretical study of the methodology, techniques and criteria should be developed within a realistic environment. For this reason, all the cases examined are based on actual fishery problems.

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In spite of the complexities a rational approach is needed involving the location and evaluation of all the opportunities for development across the whole of a fishery now or in the future. Capital investments dictate the entire pattern of production of fish and fish products and decisions taken in this area are usually irreversible. It is therefore, undesirable to allow the situation to develop as a random process.

No system of capital budgeting will substitute for the final judgements that have to be made regarding fishery investment decisions. They can provide systematic approaches to reducing available information into patterns that suggest particular decisions and strategies and an outstanding requirement is to determine in which sectors and to what extent they can assist with these problems.

The benefits that can be obtained from the ability to programme capital investments which will secure improvements in the utilisation of capital labour and other resources have not been investigated within a comprehensive framework. A number of theoretical studies have been published and in a few cases have been validated on actual fisheries. Some of them are well developed but have generally considered the problems of sections of the industry in isolation.

This thesis is concerned with the development of the methodology; techniques, criteria and data that will assist with management decision-making in this field and, also with an assessment of the relative contributions that result. The particular approach is to consider a completely integrated national fisheries system and investigate the overall problems that develop and then consider the independent sections of fisheries in order to investigate the specific problems that are peculiar to those sections.

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1 - INTRODUCTION

1. INTRODUCTION

One of the most important changes taking place in world fisheries today arises from the widespread acceptance that coastal states should be able to declare an extended jurisdiction over fisheries. Where feasible, Exclusive Economic Zones (EEZs) are now being established 200 miles from the shore. Once all states have taken such action, a sea area roughly equal to the entire land surface of the world will fall under national jurisdiction.

The new regime is bringing almost all of the marine living resources presently exploited under the control of coastal countries. These countries now have the opportunity to plan fisheries development for maximum benefits against a background of nationally-controlled resources.

A problem arises immediately from the need to secure maximum benefits. This, in fact, implies that a fishery has a certain value or productivity, and while this is true, there cannot be a single concept of productivity that is common for all countries in all situations of fisheries development. Each one has to be examined independently and the appropriate values determined in accordance with the nation's order of priorities. These may include the production of protein, the provision of employment, the generation of revenues or contributions to the balance of payments.

It is often the complexity and variety of these objectives that prevents a government from seriously investigating the value of a fishery, but a stark realisation of values quickly becomes apparent when a prospective foreign partner approaches the government with a proposal for a licensing agreement or presents a co-operative programme for the formation of a joint-venture company. It also becomes evident that in agreeing to develop such co-operative programmes in which objectives may be advanced - such as the improvement of revenues and contributions to foreign exchange - others may have to face sacrifices. These may include production of fish for the home market or a reduction in employment. The major problem is how to develop a fisheries policy that satisfies the ambition of government and at the same time reconciles these conflicting objectives.

There are three broad policy options:

(a) To develop the fishery with the nation's management expertise labour and financial resources only.

(b) To establish licensing agreements with a foreign partner.

(c) To enter a co-operative programme involving the promotion of joint-venture companies with foreign partners.

Most countries should benefit from a balanced contribution from each of these options, and the degree to which each makes a contribution should be governed by the nation's requirements. There should be a search for a symbiotic package in which the economic and social benefits of a local fisheries programme can co-exist and be assisted by parallel developments in a co-operative programme. This is particularly important for infrastructure and services, which are essential for the co-operative programme and produce benefits for both areas.

In addition to the need for balance in policy formulation, there is a requirement for balance in the development programme. This must apply from the seabed to the consumer and include the fishery resources, the fishing vessels, port development, processing facilities and distribution and marketing fuctions. Such a balance also has to take into consideration the location of the development, its composition and phasing.

Freedom of choice between different policies may be limited by the existing manner in which a fishery is organised and also by economic, technical and other constraints. In addition, the impact of such factors often change as development progresses.

A methodology is required for a rational approach to policy formulation and evaluation in order to identify the goals and constraints within an overall fisheries investment programme. This methodology should indicate how selected policies can be implemented through a programme of investment projects which can be appraised and evaluated.

The essential pre-requisites for a fish industry are the availability of fish resources and markets for the fish products. The investment problems lie in a chain between these two factors from the fishing vessels to the distribution activities. This thesis is concerned with that chain. Fish resources and markets are not investigated explicitly but are treated as important problem constraints.

A wide range of practical cases are included to provide a variety of material for a consideration of the themes that need to be explored for the development of a methodology.

A review of previous work has been carried out (Section 2) and examines the application of quantitative analysis from the sea to the consumer. National problems have been covered (Section 3) and show the progressive use of a single technique, i.e. a linear programming input-output model, for different countries with problems at a different level of complexity (Section 4). A company study has been used to illustrate the problems of conflicting criteria and the advantages of modern micro-computer techniques particularly with respect to communication and implementation. The problems of the individual operations within the fisheries sector (Section 5) have been considered with respect to the techniques that are appropriate and also their level of efficiency.

A further consideration of the efficiency of models is covered and considers the selection of techniques not only in terms of the need to select one from those available but also to consider when techniques might be used in conjunction with each other to good effect. (Section 6). The selection of criteria for fisheries investment decisions is also important (Section 7) and an investigation of criteria appropriate for decision-making at different levels is covered. The problems of uncertainty and implementation have been described with respect to two projects covered by models in the thesis (Section 8) enabling a comparison of predicted and actual performance in the projects. The final conclusions have been drawn with appropriate recommendations (Section 9).

2 - A REVIEW OF PREVIOUS WORK

2. A REVIEW OF PREVIOUS WORK

The need for pre-investment planning in fisheries has been widely acknowledged, particularly for investment programmes in developing countries. Engstrom (1) who presents various aspects of project formulation, states that inadequate and poor preparation of investment projects has often been responsible for the slow growth and a waste of scarce capital resources. The objectives for fishery development may be conflicting and Lawson (2) points out that increased economic efficiency may conflict with increased employment; increased foreign exchange earnings may conflict with increase of supplies of domestic food, etc. Recently the development banks have placed a greater emphasis on post project evaluation and Lawson (3) has made a contribution to this work.

Although there is no evidence of the comprehensive development of a methodology for investment decisions in fisheries, there has been a considerable effort to develop and incorporate a wide range of techniques for the solution of problems in different sectors of the fishing industry. They can be broadly described as accounting methods, operational research models and econometric and statistical techniques:-

2.1 Fishery Resources

This is a field of study that has received considerably more attention than any other section of the industry and although publications are numerous, there are few that relate the resource problem to the total industry situation. Gulland (4) makes the point that few general descriptions of the complete management system have been given. It is therefore not surprising that models of the complete system do not exist. A comprehensive modelling approach has been described by Ervik et al (5) and a multiple species model, the basis of which is an input-output model, has been proposed by Hoppensteadt and Sohn (6). The overwhelming problem appears to be the growth of models when incorporating all the sections of the industry and the subsequent difficulties in controlling them. Ervik et al make the point that if the assumptions incorporated in a model are complex and their mutual interdependencies are obscure, the model is no easier to understand than the real situation.

A comprehensive bio-economic model has been developed by Troadec (7) which examines not only the biological aspects of a fishery but also the economic and social aspects, and, the effects of innovation. The conclusion of this work is that only when the overall framework for the rational exploitation of natural fish resources have been assessed, can a coherent plan be worked out. This would include the equipment, skills to be acquired (training), the changes in institutional structure, the programmes to be initiated and possibly the needs for outside assistance. This work is complementary to the work of this thesis and provides a methodology for the estimation of resource constraints within a total management framework.

2.2 Fishing Vessels

Development of fishing vessels has been mainly a matter of gradual empirical modification, each small step being thoroughly tested by experienced operators before general adoption. This method has much to commend it and Blackett (8) states that any organisation that regularly varies its methods and observes the results will have come close to an optimal operation. If either of these elements, variation or observation, is missing it is likely that large improvements can be made by restoring it.

The major emphasis has been on identifying a technically valid combination of design parameters which represents the most profitable capital investment in a particular fishery or combination of fisheries before committing the capital.

The first comprehensive studies are reported by Bogucki (9) who has employed a method called a 'decision variable' technique. The method is flexible and is applicable to a range of vessels and also to fleeting operations. The variables are fish hold capacity, speed and throughput of processing plant for individual vessels and others are added for fleeting operations. The method is an ordered search through the decision variables using upper and lower limits for each one arriving at a design region for a vessel. The final decision being made on a subjective basis within the constraints from the study which identifies an optimal region for investment rather than a specific vessel design.

Doust (10) proposed a method of identifying the optimal vessel design by a study of existing designs using regression analysis. Techniques such as these work best in situations where there are many existing designs of known performance covering the whole likely range of each parameter but are limited when major changes are envisaged. A technique has been developed by Curr (11) for situations where data are limited and Digernes (12) has built several models with the objective of improving implementation by placing the models at the disposal of the decision-maker.

A series of studies have been carried out by Engvall and Engstrom (13) (14) (15) and by Engvall, Engstrom and Salmon (16). These take the same basic form as the other studies, investigating the economic effect of changes in vessel size and power for a variety of vessels including Mexican shrimp trawlers and Peruvian merluza trawlers and anchovy purse seiners.

The work of Hamlin (17) deals in a pragmatic way with the problems of vessel design. The principles of modelling are similar to the other methods already covered but start from a study of the gear and gear resistance.

Green and Broadhead (18) studied the costs and earnings of 113 tuna vessels based in California concentrating on vessel size, catch rate and price of fish. The technique used is regression analysis and its limitations and advantages are mentioned with respect to the work of Doust.

Nybø and Melhus (19) have analysed relevant operating costs for long liners in Northern Norway and the costs are related to physical parameters for vessels or gear. Statistical distributions for the costs are given. Using this work Dahle (20) reports on the application of a mathematical simulation model for a long line fishery. The model is general with respect to vessels but is restricted by gear consideration to a long-line situation. Dahle et al (21) have also investigated the problem of matching a fleet of fishing vessels with an on shore processing plant.

2.3 Fishing Ports

In a review, Madziar (22) states that there is no generally accepted method for pre-investment planning of harbours but the essential elements are:-

(i) The needs of the consumer (demand) including the forecast on the processing to be performed in the harbour and the storing capacities required

(ii) The fish to be handled in the harbour - quantity and kind (supply)

(iii) The fishing vessels to be allocated and serviced in the harbour (dimensions and processing equipment).

All other services to be rendered in the harbour are derivatives from these three basic assumptions based on the biological, technical and economic forecasts.

Madziar makes the point that this subdivision of the process of planning and designing of the fishing harbour is of course not the only one possible but it shows the complicated interrelations between the stages of planning where output of one phase is input for the next one for further calculations. Nearly every stage of the planning process should involve optimisation procedures, even in their simplest form (comparison of alternatives).

The first stages of the fishing harbour planning are done by the specialists in fields other than fishing harbour planning, but the influence of the harbour planner should start early.

A paper that makes use of techniques is that by Seo (23). He develops a solution to the problem of transporting fish from several fishing grounds through various harbours to several consumer regions using a linear programming formulation. Other specific problem areas such as the required number of berths are solved by queueing theory and simulation.

A further paper by Madziar (24) deals with the problem of adequate number of berths for high sea fishing vessels. In Polish conditions the fishing company operates the fishing fleet and the harbour installations and is dealing with harbour extensions. Therefore formulating the problem for decision-makers was comparatively easy. Queueing theory was applied and the assumptions were verified with statistical data.

2.4 Processing Plants

A paper relating to the evaluation of a fish meal plant at sea is that operated aboard a shrimp trawler in El Salvador (25). The study summarises the operation of a small trash-fish meal plant installed on board the shrimp trawler.

This is a simple techno-economic investigation and a practical attempt to determine the value of the fish meal plant aboard the vessel. The authors spent some time on the vessel studying plant operations and whilst the final outcome appears to be financially disappointing, the results should prove useful to operators in a similar fishery.

In principle a similar type of investigation was carried out by Sola (26). It was an attempt to evaluate the economic operation of fish meal plants on shore. The plants were of the Stord-Myren type and consideration was given to plants with or without facilities for the reduction of fatty raw material.

On the basis of data collected from different fish meal factories in Norway, theoretical calculations were made in order to determine the most profitable production under various conditions, e.g., the minimum amount of raw material which must be supplied to get a reasonable return when working with fatty or lean fish and fish offal. The calculated values apparently depend upon many different factors, and are subject to great fluctuations from place to place and from time to time. General conclusions cannot therefore be drawn in a short survey. Diagrams show how profits, among other factors, are a function of the method of processing and the amount of raw material which can be supplied. More recently a considerable effort has been spent in Norway studying the problems of over-capacity in the fish meal industry and models have been described by Mathieson (27) and Bjorndal (28). The problems of surplus capacity, in general, in the fish processing section of Norway have been studied by Mikalsen and Vassdal (29).

2.5 Marketing and Distribution

In fisheries investment appraisal studies, there is a need to establish prices for products and to understand the mechanism for price changes.

A major interest of the economist in fish marketing has been the analysis of market demand and typically the analysis has been confined to the industry or total market level. Contributions in this particular field of fish marketing are almost exclusively from the U.S.A. The technique is to start with a demand function for a typical fish product, Q,

$$Q = f\ (X_1, X_2, \ --- X_m: \ Z_1, Z_2, \ --- Z_n)$$

where X_1 represents internal economic factors under some degree of control and Z_s is a set of uncontrolled or external factors. The internal factors might include the price of fish or some fish quality specification; external factors could be consumer income, population, prices of substitute products, etc. The model invariably takes on some aspect of analysis of variance usually by means of a multiple regression model. Success depends on the data that are available. The nature of the data may affect the study in three ways:

(a) It may simply be incomplete, or not, in itself, measure what is needed.

(b) Although the data may be adequate, the range of experience exhibited by the data may be limited.

(c) The various statistical series may be too collinear to provide reliable estimates of the contribution of each factor.

The main objective of such a model by Farrell & Lampe (30) was to provide estimates of the demand for the haddock products of the New England fishing industry at the various levels between the fishermen and the national consumers. To fulfil a secondary objective, an effort was made to isolate and demonstrate seasonal changes in demand for this species. The model consisted of ten equations wherein the functional relations of the major determinants of supply and demand were formulated. The authors expressed satisfaction that tests on the equations indicated that the parameters developed were reliable enough to gauge the effects of changes in several variables on gross revenue obtained from haddock in New England fishing ports. Several hypothetical situations were posed and their effect on gross revenue from haddock were measured.

An inventory of demand equations has also been published (31). The equations were drawn together at a conference sponsored by the Division of Economic Research of the Bureau of Commercial Fisheries in 1968. Those published were selected as the most representative of all those submitted to the conference.

The editors of the inventory express the hope that the equations will be useful as background information for those that are doing further work in fishery demand analysis. Nash (32) states the advantages of such analysis to fishermen and processors. While the former hopes will already have been realised, a discussion on the introduction of such work into company information systems could prove to be useful. With the emergence of agencies proposing to provide data to the fishing industry, it is possible that the potential of this work could be realised by some processing or partial processing of data. This would involve the use of such equations developed by economic researchers but would involve some further development for incorporation into fishing and fish processing companies.

A forecasting model of the multiple regression type has been described by Pickles (33). The major factors in the model, again concerned with U.K. cod prices, were supply and demand. By using catch rate forecasts, the model was tested against actual monthly prices and a good fit was obtained.

A model has been described by Hansen (34) which analyses the demand for fish meal using a linear programming formulation.

The literature does not reveal many studies that are directly concerned with the investment appraisal of fish transport and cold storage systems but several papers are of interest.

A problem investigated by Portlock (35) concerned the daily transportation of fish from five ports in England and Wales to inland depots and wholesalers which were wholly or partly owned by a company, or who had special delivery agreements. The company had for some time been faced with rapidly increasing transport costs which made a competitive pricing policy difficult. Portlock studied this problem by means of a heuristic model.

A project was carried out by Coverdale (36) on the economics of using chilled sea water (CSW) containers on U.K. fishing vessels.

The objective of the work was to establish the most effective distribution pattern for the containers. A marginal costing technique was used to determine the change in profitability over the transportation cycle arising from the loss in capacity of the vessels with respect to the former method of stowage.

3 - NATIONAL FISHERIES PLANNING

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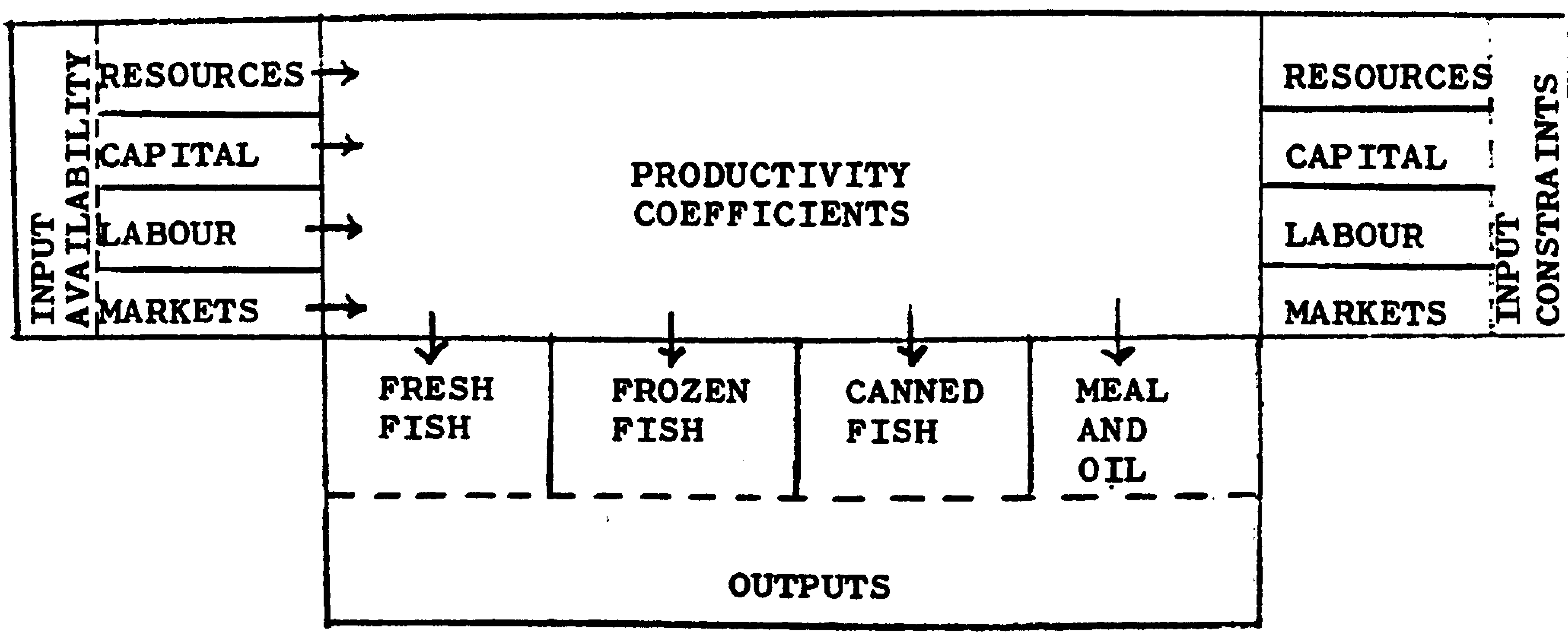
The problems for executives and administrators in national fisheries development are complicated and diverse. The solution of such problems depend upon information and analysis determined from economics, from quantitative methods, from finance and accounting and from organisational behaviour. The emphasis in this section will focus upon those aspects of decision-making which draw heavily upon the first three areas. They will be used to assist with decision-making at the national policy level.

In developing nations the problems are exacerbated by the desire to achieve conflicting objectives. Fisheries are expected to carry many burdens and are generally expected to maintain their role as a major source of protein, to generate employment for the coastal population and to earn foreign exchange (Fig. 1). There is a need to identify and evaluate potential projects and also to estimate the overall growth of output, savings investment, imports and exports arising from such projects.

An additional complication arised from the hierarchical nature of the decision-making process (Fig 2). The national objectives are intimately inter-related with company activities and the individual operations within the industry.

A LINEAR PROGRAMMING INPUT-OUTPUT MODEL FOR FISHERIES DEVELOPMENT



ECONOMIC CONTRIBUTIONS

	FRESH FISH	FROZEN FISH	CANNED FISH	MEAL AND OIL
HOME PROTEIN	HIGH	MEDIUM	LOW	NONE
LOCAL EMPLOYMENT	MEDIUM	MEDIUM	HIGH	LOW
FOREIGN EXCHANGE	NONE	HIGH	HIGH	HIGH
GROSS NATIONAL PRODUCT	MEDIUM	HIGH	HIGH	LOW

Fig. 1

National Policies and Plans

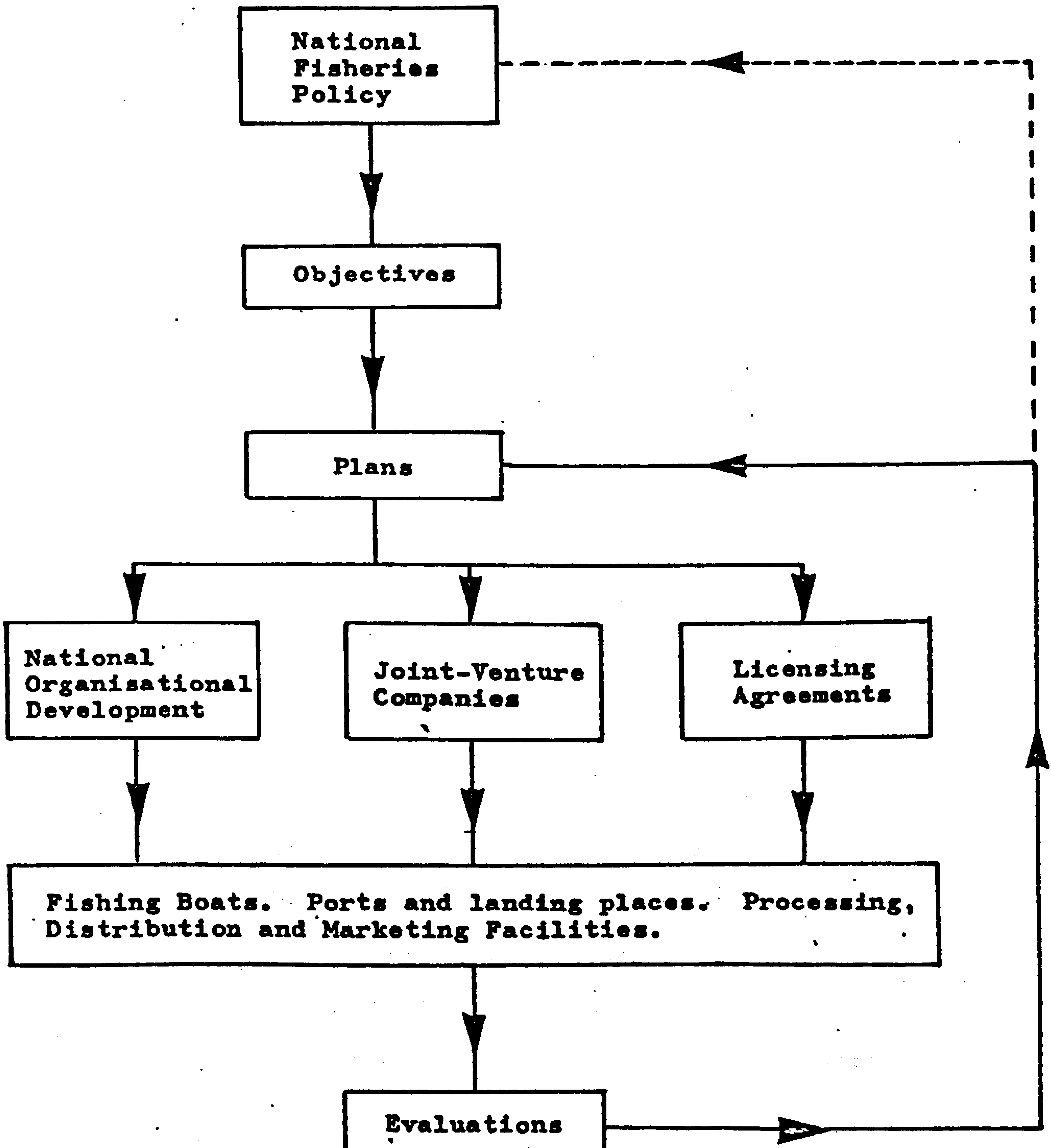


Fig. 2

Solutions to problems depend also on the specific industrial geographic and demographic characteristics of the country concerned but a general framework may be devised to provide appropriate answers.

Fishery regions within a country may be differentiated in many ways:-

a) The availability of fishery resources.

b) Endowments of immobile physical factors of fish production.

c) Population and its urban-rural distribution.

d) Consumption behaviour which is related to c) above.

e) Infrastructure and current productive capacity such as fishing vessels, transport and processing plants.

There is a requirement to devise a development strategy for the industry with respect to bottleneck resources such as fresh water, preferred locations for the development, inter-regional transportation flows, social overhead requirements and inter-regional migration.

A tool that has been developed for such investigations takes the form of a model which includes all the operations in a fishery from catching to processing.

3.1 A General Multi-regional Fisheries Model

A model for the investigation of fishery policies should be able to satisfy several requirements:-

a) It must show how outputs in terms of fish products are related to the inputs such as fish resources, labour, capital, etc., as they are utilised in the different activities of fishing, handling, processing, marketing and distribution.

b) It must be able to identify activity locations, within a regional framework, such as fish resource locations, location of fish processing facilities and inter-regional transport costs.

c) It must account for all the practical constraints affecting the fishery such as Total Allowable Catch (TAC) for different fish species, the limits on labour, capital, and also the market potential for each type of fish product.

d) It must be able to optimise the contribution of the fishery to the Gross National Product (GNP) within each alternative policy framework, that is formulated. The criteria used for this purpose is Value Added (Section 7.1.3).

A linear programming model has been chosen for the analysis of multi-regional fisheries investment choices. The objective function to be maximised is the value added and choices of activity location are determined in the model by fish resource locations, location of fish processing facilities, inter-regional transport costs and capital and labour costs.

3.1.1 Mathematical Formulation of the General Model

The equations of the model are as follows; definitions are listed after the equations.

The exploitation of the fishery resources are met or not exceeded. Alternatively this could be regarded as a quota constraint:

$$\sum_i \sum_k x_{ijk} \leq R_j \qquad (1)$$

The national constraint on labour availability:

$$\sum_i \sum_j \sum_k l_{ijk} \cdot x_{ijk} \leq L \qquad (2)$$

The use of capital does not exceed its availability:

$$\sum_i \sum_j \sum_k c_{ijk} \cdot x_{ijk} \leq C \qquad (3)$$

Regional constraints on resource use (water):

$$\sum_i \sum_j w_{ijk} \; x_{ijk} \leq Wk \qquad (4)$$

Domestic sales and exports are presented from exceeding demands by upper bounds:

$$\sum_j \sum_k x_{ijk} \leq Di \qquad (5)$$

Objective function:

$$\max \sum_i \sum_j \sum_k a_{ijk} \cdot x_{ijk}$$

where $a_{ijk} = l_{ijk} + c_{ijk}$

Definition of variables:-

x_{ijk}	output of fish product i from fish caught in region j and processed in region k.
a_{ijk}	coefficient for added value for fish product i from fish caught in region j and processed in region k.
l_{ijk}	labour coefficient for fish product i from fish caught in region j and processed in region k.
c_{ijk}	capital coefficient for fish product i from fish caught in region j and processed in region k.
w_{ijk}	coefficient for water requirement for fish product i, caught in region j, and processed in region k.
R_j	maximum of fish resources in region j.
L	national labour availability.
C	national capital availability.
W_k	water availability in processing region k.
D_i	market demand for each product i.

3.2 A National/Regional Model for the Sardine Fisheries of Morocco

A numerical example of the model may be introduced by an examination of the development of the sardine fisheries of Morocco (Fig. 3). The existence of the established industry in the north and the new potential in the south give rise to a situation that can be regarded as a closed two region economy (Fig. 4) with severe inter-regional inequalities.

The problem is concerned with the allocation of capital and labour over the two regions. Any significant investment in the south must be associated with the building of a new port and so the objective is to find the locational pattern that maximises the value added.

Theoretically sardines may be caught in any region, processed in that region or transported to any other region to be processed. For practical purposes and for historical and technological reasons some of the options have been eliminated. There are four fish products, fresh sardines, frozen sardines, canned sardines and fishmeal. The assumption has been made that there would be eight commodity outputs and the labour, capital and value added coefficients are shown (Tables 1 and 2). The outputs are listed:-

LABOUR COEFFICIENTS (NUMBERS OF PEOPLE)

VARIABLE	X211	X311	X411	X312	X412	X122	X222	X322	X422
LABOUR (NO. OF PEOPLE/TONNE)									
FISHING	0.0056	0.0056	0.0056	0.0056	0.0056	0.0167	0.0167	0.0167	0.0167
PORT	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
PROCESSING	0.0145	0.2145	0.0051	0.2145	0.0051	0.0001	0.1045	0.2145	0.0051
TRANSPORT	0.0005	0.0005	0.0005	0.0006	0.0006	0.0011	0.0005	0.0005	0.0005
TOTAL	0.1107	0.2207	0.0113	0.2208	0.0114	0.0180	0.1218	0.2318	0.0224

TABLE 1

LABOUR AND CAPITAL COEFFICIENTS (FINANCIAL)

LABOUR (Dn/Tonne)	X211	X311	X411	X312	X412	X122	X222	X322	X432
Fishing	42	42	42	42	42	126	126	126	126
Port	1	1	1	1	1	1	1	1	1
Processing	75	220	24	220	24	1	75	220	24
Transport	4	4	4	6	6	10	4	4	4
TOTAL	122	267	71	269	73	138	206	351	155
CAPITAL (Dn/Tonne)									
Fishing	28	28	28	28	28	56	56	56	56
Port	9	9	9	9	9	9	9	9	9
Processing	265	460	46	460	410	1	265	460	46
Transport	25	25	25	35	35	60	25	25	25
TOTAL	327	522	108	532	118	126	355	550	136
VALUE ADDED	449	789	179	801	191	264	561	901	291

TABLE 2

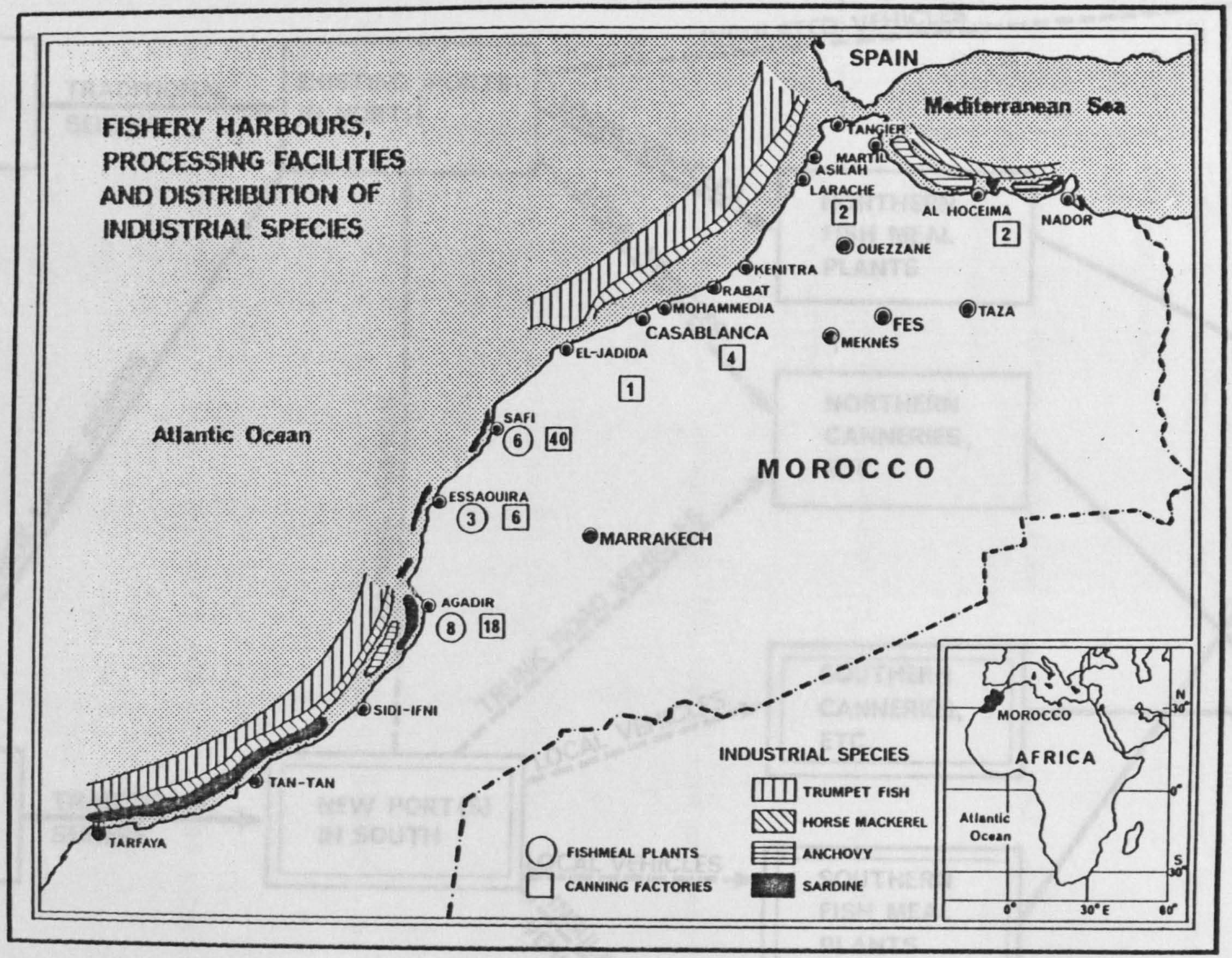

FISHERY HARBOURS, PROCESSING FACILITIES AND DISTRIBUTION OF INDUSTRIAL SPECIES
SPAIN
Mediterranean Sea
Atlantic Ocean
MOROCCO
TANGIER
MARTIL
ASILAH
LARACHE
AL HOCEIMA
NADOR
OUEZZANE
KENITRA
RABAT
MOHAMMEDIA
CASABLANCA
FES
TAZA
MEKNES
EL-JADIDA
SAFI
ESSAOUIRA
MARRAKECH
AGADIR
SIDI-IFNI
TAN-TAN
TARFAYA
2
2
4
1
6
40
3
6
8
18
INDUSTRIAL SPECIES
TRUMPET FISH
HORSE MACKEREL
ANCHOVY
SARDINE
FISHMEAL PLANTS
CANNING FACTORIES
MOROCCO
AFRICA
Atlantic Ocean
N 30°
0°
S 30°
0°
30° E
60°

Fig. 3

FIG. 4 MOROCCO SARDINE MODEL

x_{211} frozen sardines, caught in the south and processed in the south.

x_{411} fishmeal sardines, caught in the south and processed in the south.

x_{312} canned sardines, caught in the south and processed in the north.

x_{412} fishmeal sardines, caught in the south and processed in the north.

x_{122} fresh sardines, caught in the north and processed in the north.

x_{222} frozen sardines, caught in the north and processed in the north.

x_{322} canned sardines, caught in the north and processed in the north.

x_{422} fishmeal sardines, caught in the north and processed in the north.

The availability of water in the south of Morocco creates severe problems and a linear constraint may be applied, but another approach is to consider the water requirements of the products and eliminate these which require water surplus to that which is available. This is the approach taken here and has resulted in the elimination of product x_{311} - canned sardines, caught in the south and processed in the south.

The first formulation of the linear programming model places no undue pressure on the labour and capital requirements (Table 3). The total supply of 450,000 tons is sold and in this situation, the capital input is fully utilised but the available labour input is not fully utilised. The value added of this solution is in excess of 183 million dirhams and the labour requirement 34,000 people. If the value of the labour input is reduced from 80 to 40 million dirhams (Table 4), then the reduction in the quantity of fish processed is of the same order but the man-power requirement of 29,000 is not very different from the previous solution.

It can be seen that optimal solutions are consistent with the preferential use of the sardine resources off the southern coast and the processing of canned sardines in the northern canneries. The introduction of a constraint, the value of labour does not significantly alter the man-power requirement because the production of canned sardines with

LINEAR PROGRAMMING PROBLEM

VARIABLE	X_{211}	X_{411}	X_{312}	X_{412}	X_{122}	X_{222}	X_{322}	X_{422}	CONSTRAINTS
South Fish	1	1	1	1					250,000
North Fish					1	1	1	1	200,000
Labour	122	71	269	73	138	206	351	155	80,000,000
Capital	327	108	532	118	126	355	550	136	110,000,000
Fresh Demand					1				58,000
Frozen Demand	1					1			8,000
Can Demand			1				1		126,000
Meal Demand		1		1				1	274,000
Obj. Function	449	179	801	191	264	561	901	291	

TABLE 3

LINEAR PROGRAMMING SOLUTION

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF	LABOUR VALUE	L.V. COEFF	CAPITAL	CAPITAL COEFF	LABOUR (NO)	LABOUR COEFF
X_{211}	-	-	449	-	122	-	327	-	0.1107
X_{411}	19,600	3,508,400	179	1,391,600	71	2,116,800	108	222	0.0113
X_{312}	-	-	801	-	269	-	532	-	0.2208
X_{412}	230,400	44,006,400	191	16,819,200	73	27,187,200	118	2627	0.0114
X_{122}	42,000	11,088,000	264	5,796,000	138	5,292,000	126	756	0.0180
X_{222}	8,000	4,488,000	561	1,648,000	206	2,840,000	355	974	0.1218
X_{322}	126,000	113,526,000	901	44,226,000	351	69,300,000	550	29207	0.2318
X_{422}	24,000	6,984,000	291	3,720,000	155	3,264,000	136	537	0.0224
TOTALS	450,000	183,600,800	-	73,600,800	-	110,000,000	-	34323	-

TABLE 3 (CONTD.)

LINEAR PROGRAMMING PROBLEM

VARIABLE	X_{211}	X_{411}	X_{312}	X_{412}	X_{122}	X_{222}	X_{322}	X_{422}	CONSTRAINTS
South Fish	1	1	1	1					250,000
North Fish					1	1	1	1	200,000
Labour	122	71	269	73	138	206	351	155	40,000,000
Capital	327	108	532	118	126	355	550	136	110,000,000
Fresh Demand					1				58,000
Frozen Demand	1					1			8,000
Can Demand			1				1		126,000
Meal Demand		1		1				1	274,000
Obj. Function	449	179	801	191	264	561	901	291	

TABLE 4

LINEAR PROGRAMMING SOLUTION

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF	LABOUR VALUE	L.V. COEFF	CAPITAL	CAPITAL COEFF	LABOUR (NO)	LABOUR COEFF
X_{211}	8,000	3,592,000	499	976,000	122	2,616,000	327	886	0.1107
X_{411}	-	-	-	-	-	-	-	-	-
X_{312}	126,000	100,926,000	801	33,894,000	269	67,032,000	532	27,820	0.2208
X_{412}	70,274	13,422,000	191	5,130,000	73	8,292,000	118	801	0.0114
X_{122}	-	-	-	-	-	-	-	-	-
X_{222}	-	-	-	-	-	-	-	-	-
X_{322}	-	-	-	-	-	-	-	-	-
X_{422}	-	-	-	-	-	-	-	-	-
TOTALS	204,274	117,940,000	-	40,000,000	-	77,940,000	-	29,507	-

TABLE 4 (CONTD.)

a high labour requirement is maintained while the low labour processes are reduced or eliminated. The change in the labour constraint reduces the value added from approximately 183 million to 118 million dirhams.

The distribution of labour between north and south is very important. This problem is not the classical one for developing countries where one of the objectives of expansion of fisheries is to counter-balance the rural-urban drift. It is the problem of establishing a community of some kind in an area where one does not exist.

In the first LP formulation, the requirement is for a labour force of 32,873 in the north and 1,450 in the south and in the labour contrained situation 28,343 in the north and 1,164 in the south. The major concern would appear to be with the basic problem of establishing a community at all in the south rather than any difficulties that would arise from a difference in numbers of this kind.

3.3 A National Model for Mauritania

This model has been formulated in the same way as the Moroccan Model but has been extended to cope with a multi-species, multi-vessel situation (Fig. 5) which is extremely important for a methodological investigation. The question of alternative decisions about all the

TEXT BOUND INTO

THE SPINE

individual aspects of a fishery can be examined within the context of the total fisheries management requirement.

A large amount of data are required as inputs to the model covering the stocks of fish available, fishing regions (Fig. 6), vessels, ports, processing, marketing, etc. The exact requirements for the model and all the input information is described (Appendices 1, 3 and 4).

The model determines the optimal fisheries development strategy for any stated policy option or "scenario". In this case, the variable optimised is that which contributes directly to the Gross National Product, i.e. the total value added. Solutions from the model are shown (Appendix 2).

3.3.1 The Scenario Investigated and the Results

The presentation of the scenarios and the solutions for them are shown (Table 5). The constraints of each scenario and the major features of the solutions are:-

Scenario A

The specific constraints are:-

a) It is assumed that artisanal fishing villages will operate at their current level of activity.

b) The home market is supplied by fish from artisanal fishermen.

MAURITANIAN FISHING REGIONS

Fig. 6

TABLE 5

POLICY OPTIONS FOR THE MAURITANIAN FISHERY INVESTIGATED BY THE MODEL

POLICY	Resource Utilisation		Number of Vessels to be Employed				Port Unloading Capacity (Human Consumption) Fish (t/d)	Processing Plant Capacity (tonnes /day)	Cold Store (tonnes)	Number of People Employed		Value Added Million UM per Annum	COMMENTS
	Demersal and Cephalopod Species (t/yr)	Pelagic Species (t/yr)	Iced Fish Trawlers	Vedettes	Purse Seiners	Freezer Trawlers				Sea-Going Staff	Shore Staff		
Status Quo - No further investment on-shore but use current facilities to their maximum potential (Scenario A)	48,500	72,000	53	40	11	0	300	175	6,500	1200	700	700	This is the policy that could be implemented quickly with organisation of fishing vessel operations into existing on-shore facilities
Increase investment in processing plant and cold store capacity in Nouadhibou to balance port handling capacity (Scenario B)	99,000	72,000	113	40	11	0	300	280	17,200	2800	1800	1540	This policy constitutes only a marginal change from that above and a modest investment in processing plant would more than double the value added
Commit a marginal investment in new boxes and unloading equipment to improve Nouadhibou Port unloading capacity. No investment in Nouakchott (Scenario C)	115,000	104,000	137	40	11	5	500	400	25,000	3500	2200	2000	This policy would result in full exploitation of northern demersal fish. It is assumed that pelagic fish for human consumption is caught by freezer trawlers and landed ashore.

TABLE 5 (CONTD)

POLICY OPTIONS FOR THE MAURITANIAN FISHERY INVESTIGATED BY THE MODEL

POLICY	Resource Utilisation		Number of Vessels to be Employed				Port Unloading Capacity (Human Consumption) Fish (t/d)	Processing Plant Capacity (tonnes /day)	Cold Store (tonnes)	Number of People Employed		Value Added Million UM per Annum	COMMENTS
	Demersal and Cephalopod Species (t/yr)	Pelagic Species (t/yr)	Iced Fish Trawlers	Vedettes	Purse Seiners	Freezer Trawlers				Sea-Going Staff	Shore Staff		
Increase investment in Nouadhibou to exploit all the resources in its proximity and pelagic species from south. No investment in Nouakchott (Scenario D)	115,000	495,000	137	40	12	47	500+ 1900*	400	113,000	5700	3000	4350	The major change from Scenario B is that all Mauritanian Pelagic fish is caught by freezer and landed in Nouadhibou. This would require considerable investment in port handling and cold storage.*
							*This looks to be impossible although the value-added is high.						
Increase investment in Nouadhibou to exploit all the resources in its promity. Increase investment in Nouakchott in a similar way and include fishing port (Scenario E)	174,000	495,000	231	40	23	49	700+ 3000*	650	185,000	8000	4500	5060	This policy involves the construction of a fishing port at Nouakchott. The policy of landing Pelagic species appears to be unsound as before. *However this represents the new policy.
The 'best' solution	174,000	144,000+ 351,000(a)	208	100	22	50(b)	700	650	37,000	8000	3500	4940	This is the recommended policy

c) All fish produced for export can be sold.

d) There is no investment on-shore but current facilities will be fully utilised.

It can be seen from the solution (Table 5) that 48,500 tons of demersal species and cephalopods could be landed each year together with 72,000 tons of pelagic species. This represents a good policy that could be implemented quickly with the minimum investment totally committed to fishing vessels. The important aspect on shore is that all the processing plant is fully utilised but the port handling capacity is not.

Scenario B

It is obvious that the next incremental stage of development to be investigated is to increase the fish processing plant capacity to match the port capacity.

The results of this policy (Table 5) are shown and the production of valuable fish products is more than doubled with a similar increase in value-added and a considerable increase in employment.

Scenario C

This scenario is the same as scenario A but with an increase in off-loading capacity of fish at Nouadhibou from 300 tonnes per day to 500 tonnes per day. This is achieved by marginal improvements such as the introduction of fish boxes and unloading equipment.

If the throughput capacity of the port of Nouadhibou is increased to this level, then there is a requirement to increase the processing and cold store capacities by a greater amount than in the previous scenario to achieve balance. One of the objectives of this analysis is to determine this level.

Scenario D

This option examines the needs in terms of capital, labour, vessels, unloading capacity, etc., in order to catch all the fish available to the port of Nouadhibou.

In this solution, a total of 495,000 tonnes of pelagic species and 69,000 tonnes of demersal species and cephalopods could be landed at Nouadhibou (including a small amount of artisanal demersal species landing at Nouakchott).

This would require fleets of 47 freezer trawlers, 137 iced fish trawlers, 40 vedettes and 12 purse seiners needing a port extension of 6 berths for freezer trawlers.

(This is based on a 24 hour unloading basis. If 12 hours is taken then 10 berths would be required). Thus the port would consist of 6 freezer trawler berths, 8 wet fish trawler berths and 2 purse seiner berths.

The processing capacity required would be the fishmeal plant of 600 tons per day, a canning plant of 10,000 tons per year capacity and a freezing capacity of 400 tons per day. However, the cold store requirement would increase dramatically to 113,000 tons. The land based labour force required would be 3,000 men and sea-going personnel would be 5,700.

The value added of this solution totals UM 4350 million.

Scenario E

This represents a policy of exploiting all the resources of Mauritania and landing the fish in the country at the two ports of Nouadhibou and Nouakchott.

The port of Nouadhibou, in addition to the pelagic species for fishmeal and canning and the artisanal demersal species landings, the port could contend with 99,000 tonnes of demersal species and cephalopods landed by wet fish trawlers and vedettes and an additional 165,500 tonnes of pelagic species from freezer trawlers. This represents the total northern fish availability of 352,500 tonnes.

This would require fleets of 24 freezer trawlers, 137 wet fish trawlers, 40 vedettes and 12 purse seiners needing a port extension of 5 berths for freezer trawlers (based on 24 hour unloading and 9 berths based on 12 hour unloading). Thus the port would consist of 5 freezer trawler berths, 8 iced-fish trawler berths and 2 purse seiner berths.

The processing capacity required would be the fishmeal factory as previously, a canning plant of 10,000 tonnes per year and a freezing capacity of 400 tonnes per day. The cold store capacity required would total 95,000 tonnes. A land based labour force of 2,700, together with sea-going staff of 4,500 would be required.

The first requirement for Nouakchott in this scenario is the building of the fishing port. The port could contend with 64,000 tons of demersal and cephalopod species and 247,500 tons of pelagics representing the total resources of the southern region. This would require a fleet of 25 freezer trawlers, 94 iced fish trawlers and 11 purse seiners. The port would require 11 unloading berths and the labour requirement in the south would total 4,300.

With two ports in operation like this, all the vessels and plant located at each would be independant with the exception of the freezer trawlers. The possibility exists here of one fleet following the pelagic fish stock and servicing both ports. The value added of this solution equals UM 5060 million.

3.3.2 The Recommended Solution

The solutions obtained for each policy option show advantages and disadvantages. The objective has been to optimise the contribution to GNP but some sub-optimisation has already been incorporated through subjective imposition of some of the constraints. This has been carried out where solutions are known to be totally unacceptable. The final recommendations, with a value added of UM 4,940 million, arise from a composite of several of the policy options. These have been selected with respect to other constraints not covered by the models:-

Nouadhibou

a. It is recommended that Nouadhibou be developed to the level of throughput of 500 tonnes per day as investigated in scenario B. This would be associated with a development of processing capacity and cold storage on-shore to cope with that situation, 400 tonnes per day and 20,000 tonnes respectively. This would allow all the demersal species available in the Nouadhibou area to be processed on shore and also allow some marginal processing of pelagic species.

b. There is no provision for a canning factory in Nouadhibou. This was included initially to observe the effect on economic grounds. This kind of development is always highly desirable on the basis of value added but it has been rejected on financial grounds as a profit could not be achieved.

c. The problem of handling a large quantity of pelagic species for human consumption could be solved by iced-fish trawlers landing the fish into factories for processing, by factory trawlers processing them at sea or by iced-fish trawlers transferring them into a factory moored close to shore. The latter has been selected as the best option. It gives better control over the fishery and at the same time does not involve excessive investment in capital on-shore.

d. The fishmeal plant should be fully utilised.

<u>Nouakchott</u>

a. The long term requirement in fisheries for Mauritania demands further development at Nouakchott and a new fisheries port recommended. This port should be able to service a total of 94 iced-fish trawlers and 11 purse seiners.

b. On-shore, the development should include processing plant to deal with 200 tonnes per day and cold storage at a capacity of 12,000 tonnes.

c. It is recommended that a fishmeal plant of the same capacity as that in Nouadhibou be installed in Nouakchott.

3.3.3 Conclusions

Static linear programming input-out models have been used for multi-regional, multi-industry investment problems in Korea by Norton (37). The approach developed here for the fisheries sector could be criticised on the basis that the matrices for the fisheries sector form only a block in the total inter-industry structure. The fisheries sector will have an impact on other areas of the economy particularly boatbuilding, gear manufacture, etc., but the emphasis has been placed upon the primary issue of the intrinsic value of the fisheries sector. Additional financial and economic analyses have also been developed (Tables 6 and 7).

The series of solutions conducted under different sets of constraints explore the trade-off between GNP, more equitable regional development and the most suitable structure of the fish industry.

TABLE 6 **FINANCIAL ANALYSIS OF FULL FISHERIES DEVELOPMENT PROGRAMME**

	YEAR	1	2	3	4	5	6	7	8	9	10	11	12-25
	TOTAL												(SUM)
1. **NO. OF UNITS -**													
Fish Meal	2	1				1							
Fish Processing	10	3				3		1	1	1	1		
Cold Stores	10	2		1		3		1	1	1	1		
Ice Plants	7	1		1		2		1	1		1		
Purse Seiners	22	41				11							
Trawlers	208	50		26		47		16	33	8	28		
Vedettes	100	40		10			10	10		10	10	10	
Pirogues	50	55		(-5)									
2. **THROUGHPUT - (Tonnes)**							Tonnes						
Pelagic		247,500	247,500	247,500	247,500	371,250	495,000	495,000	495,000	495,000	495,000	495,000	6,930,000
Demersal & Cephalopods		46,800	46,800	67,860	67,860	89,440	104,540	117,020	141,320	147,500	150,500	174,000	2,436,000
		294,300	294,300	315,360	315,360	460,690	599,540	612,020	636,320	642,500	645,500	669,000	9,366,000
3. **ALLOCATION - (Tonnes)**													
Fish Meal		72,000	72,000	72,000	72,000	108,000	144,000	144,000	144,000	144,000	144,000	144,000	2,016,000
*Pelagic Trans-shipments		175,500	175,500	175,000	175,000	263,250	351,000	351,000	351,000	351,000	351,000	351,000	4,914,000
Demersal Freezing		45,817	45,817	66,435	66,435	86,066	99,353	111,571	132,371	138,420	141,356	161,800	2,265,200
Demersal Fresh		983	983	1,425	1,425	3,374	5,187	5,449	8,949	9,080	9,144	12,200	170,800
		294,300	294,300	315,360	315,360	460,690	599,540	612,020	636,320	642,500	645,500	669,000	9,366,000
4. **CAPITAL**							UM Million						
Nouakchott Port Devel.		7.0	1949.0	998.0	2943.0	176.0	-	1489.0			1279.0	-	
Nouadhibou & Baie du Repos Development		3693.7	1283.8	32.9	743.0	34.4	846.2	6.1	502.2	37.3	27.2	-	
TOTAL CAPITAL		3700.7	3232.8	1030.9	3686.0	210.4	846.2	1495.1	502.2	37.3	1306.2		
5. **REVENUE**													
Nouakchott		-	-	-	-	828.7	1657.3	1657.3	2852.0	2852.0	2852.0	3858.3	54,016.2
Nouadhibou & Baie du Repos		3030.6	3030.6	4183.9	4183.9	4702.9	4867.2	5550.6	5550.6	5888.9	6053.2	6204.6	86,864.4
TOTAL REVENUE		3030.6	3030.6	4183.9	4183.9	5531.6	6524.5	7207.9	8402.6	8740.9	8905.2	10,062.9	140,880.6
6. **EXPENDITURE**													
Nouakchott Port		-	-	-	-	633.3	1266.3	1266.3	2126.3	2126.3	2126.3	2848.9	39,884.6
Nouadhibou & Baie du Repos		1901.3	1901.3	2570.6	2570.6	3017.2	3042.2	3551.9	3551.9	3878.0	3903.0	3928.1	54,993.4
7. TOTAL EXP. EXC. DEP. & INTEREST		1901.3	1901.3	2570.6	2570.6	3650.5	4308.5	4818.2	5678.2	6004.3	6029.3	6777.0	94,878.0
8. GROSS INCOME (UM MILLION BEFORE DEP. & INTEREST		1129.3	1129.3	1613.3	1613.3	1881.1	2216.0	2389.7	2724.4	2736.6	2875.9	3285.9	46,002.6

TABLE 6 (CONTD) **FINANCIAL ANALYSIS**

UM MILLION

YEAR	1	2	3	4	5	6	7	8	9	10	11	12-25
9. GROSS INCOME BEFORE DEP'N & INTEREST	1129.3	1129.3	1613.3	1613.3	1881.1	2216.0	2389.7	2724.4	2736.6	2875.9	3285.9	46002.6
10. DEPRECIATION	262.5	263.4	355.8	355.8	545.3	680.5	747.4	854.8	898.9	902.8	999.2	13988.8
11. INTEREST	45.9	48.1	129.2	113.7	159.6	437.0	459.7	409.6	498.2	435.6	368.5	2724 .1
12. NETT EARNINGS	820.9	817.8	1128.3	1143.8	1176.2	1098.5	1182.6	1460.0	1339.5	1537.5	1918.2	29289.7

CASH FLOW

YEAR	1	2	3	4	5	6	7	8	9	10	11	12-25
1. OPENING CASH BALANCE	-	1052.6	2095.1	3477.4	4875.2	6449.3	7702.4	9035.3	10753.3	12279.5	14007.6	16216.7
2. SOURCES:-												
Operating Profit	1129.3	1129.3	1613.3	1613.3	1881.1	2216.0	2389.7	2724.4	2736.6	2875.9	3285.9	46002.6
Loan & Grant	863.3	3232.8	1030.9	3686.0	210.4	846.2	1495.1	502.2	37.3	1306.2	-	-
	1992.6	4362.1	2644.2	5299.3	2091.5	3062.2	3884.8	3226.6	2773.9	4182.1	3285.9	46002.6
3. USES:-												
Project Capital	863.5	3232.8	1030.9	3686.0	210.4	846.2	1495.1	502.2	37.3	1306.2	-	-
Loan Repayment	30.6	38.7	101.8	101.8	147.4	·525.9	597.1	597.1	712.2	712.2	708.3	6652.5
Loan Interest	45.9	48.1	129.2	113.7	159.6	437.0	459.7	409.6	498.2	435.6	368.5	2724.1
	940.0	3319.6	1261.9	3901.5	517.4	1809.1	2551.9	1508.6	1247.7	2454.0	1076.8	9376.6
4. CASH BALANCE C/FWD.	1052.6	2095.1	3477.4	4875.2	6449.3	7702.4	9035.3	10753.3	12279.5	14007.6	16216.7	52842.7
5. DEBT SERVICE CAPACITY RATIO	14.8	13.0	7.0	7.5	6.1	2.3	2.3	2.7	2.3	2.5	3.0	4.9

6. **FINANCIAL INTERNAL RATE OF RETURN** - 22.6%

TABLE 7 **ECONOMIC ANALYSIS - MAURITANIA FISHERY DEVELOPMENT PROJECT**

(UM Million)

YEAR	1	2	3	4	5	6	7	8	9	10	11	12-25
1. OPERATING PROFIT - FINANCIAL	1129.3	1129.3	1613.3	1613.3	1881.1	2216.0	2389.7	2724.4	2736.6	2875.9	3285.9	46,002.6
ADD ECONOMIC BENEFITS -												
2. FISH MEAL					11.4	11.4	11.4	11.4	11.4	11.4	11.4	159.6
3. COLD STORE			2.1	2.1	8.4	8.4	10.5	12.6	14.7	16.8	16.8	235.2
4. PROCESSING PLANTS					24.6	24.6	32.8	41.0	49.2	57.4	57.4	803.6
5. ICE PLANTS			1.6	1.6	4.8	4.8	6.4	8.0	8.0	9.6	9.6	134.4
6. TRAWLERS	68.0	68.0	172.0	172.0	360.0	360.0	424.0	556.0	588.0	700.0	700.0	9800.0
7. PURSERS					42.6	42.6	42.6	42.6	42.6	42.6	42.6	596.4
8. VEDETTES			5.2	5.2	5.2	10.4	15.6	15.6	20.8	26.0	31.2	436.8
9. NOUAKCHOTT - Port					1.8	3.5	3.5	16.1	16.1	16.1	17.2	240.8
10. NOUADHIBOU - Port			8.9	8.9	14.0	14.0	16.7	16.7	19.0	19.0	19.0	266.0
11. BAIE DU REPOS - Port			1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	26.6
12. BAIE DU REPOS - PROCESSING COMPLEX			4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	65.8
13. OPERATING PROFIT - ECONOMIC	1197.3	1197.3	1809.7	1809.7	2360.5	2702.3	2959.8	3451.0	3513.0	3781.4	4197.7	58767.8

14. **ECONOMIC INTERNAL RATE OF RETURN** - 27.3%

(Shadow Prices on Labour, Repairs and Maintenance only.)

GNP was selected as the maxim as it is income and employment that policy makers are trying to adjust more equitably in regional distribution.

Labour and capital are assumed to be mobile among regions and projects. Land is assumed to be available in sufficient amounts although one of the major problems might arise here from the policy of landing pelagic species with high processing plant and cold store requirements.

Investment is assumed to be a function of the terminal year output rather than that of change in output of fish products. This means that a phased programme must be investigated with several model runs for different proposed terminal years or use the results of this model as a guide to inputs to a different kind of analysis (Tables 6 & 7).

The capital cost parameters and plant lifetime are used to estimate the coefficients of the investment functions (Appendices 3 and 4).

There is a combination of eight fishing vessels, three port and landing place regions, eight processing methods and four markets giving rise to many activities (Fig. 5). Some of these are set at zero level.

The linear programming technique tends to produce extreme solutions that take advantage of any marginal gain in value added irrespective of the disadvantages when considering other desirable criteria, e.g., inefficient artisanal activities would predominate unless supressed by subjectively developed constraints. It also assumes a linear relationship between inputs and outputs and this might not be so for changing levels of activity. Changes in economies of scale can affect the situation. There are several methods that can be used to overcome or minimise the effect of this problem. Coefficients may be chosen at a level at which one expects an activity to enter the solution but this is not completely satisfactory and can be improved by iteration. Separable programming or mixed integer programming may also be used but the modelling could become complex and expensive using these techniques.

There are many problems in selecting a model structure for a problem of this kind but an input-output analysis combined with a linear programming model offers many advantages. It has the value of solving the allocation problem and at the same time combines all the aspects of the problem from fishery resources to marketing in the same model structure. The inputs may be derived from other models or simple statistical analyses of operational situations and can be carried out in a short term period.

This form of analysis gives a clear indication of the values of the different policy options and although there has been some sub-optimisation arising either from the limitations of the model or from assumptions made for each policy option, the major advantage of this approach is to be able to identify and number these individual facilities, e.g. fishing boats and processing plants, that are appropriate for solutions acceptable to government. Although final decisions on these facilities would not be made without a final analysis based on criteria conducive to entrepreneurial investment (Sections 4, 5 & 7), it is doubtful if this total analysis could be carried out in a more efficient way, i.e. by building up the incremental parts of the fishing to the total situation.

The sequential use of the model for investigation of the policy options, particularly in this case where they grow considerably in magnitude, assists in the learning process and also in the testing of the model. Additional advantages arise from using the model in one situation such as Morocco and transferring its use to another such as Mauritania. These advantages contribute to learning and also give model cost benefits.

4 - COMPANY OPERATIONS

4. COMPANY OPERATIONS

Company operations involve one or more of the individual fishery operations (Section 5) and the most complicated of these are the vertically integrated companies that include all such operations from fishing through to marketing.

A model has been developed for such an African company who wished to expand a fish catching, processing and marketing operation. The need was to reconcile conflicting objectives. The company objective was to maximise profitability and there was also a requirement for a high economic rate of return and a major contribution to employment.

The most important constraint was the limitation on the amount of capital for investment but others included limits on the timing of the investment programme and government regulations and guidelines.

4.1 The VISICALC Model

The model uses the VISICALC programming package in conjunction with the APPLE II micro-computer. The system has been described by Curr (38) where the problem is entered into the machine as a table of numbers, together with the relationships between them. Once the table is complete, any item originally presented as a number can be changed, whereupon the computer will recalculate the entire table. All this happens in full view of the user, who sees his data going in, and observes recalculations taking place on the TV screen, when numbers visible through the chosen "window" change value. The table can also contain titles and headings, both to help the user find his way, and to produce printed analyses (Table 8).

4.2 Financial Analyses

The trading activities covered by the analyses are:-

i) Acquisition

a) Fish from company fishing operations

b) Purchase of finned fish from artisanal fishermen

c) Purchase of lobsters from artisanal fishermen

d) Ice production

ii) Sales

a) Sale of fresh fish

b) Sale of smoked fish

c) Sale of smoked fish to feed mill plant

d) Sale of frozen lobsters on the home market

e) Export of frozen fish

f) Export of frozen lobsters

g) Sale of ice

TABLE 8 FINANCIAL RATE OF RETURN

VESSELS		EXISTNG	NEW BIG	NEW SMALL	
CAPITAL COST VSL	*	5	1309	340	SH 000
CAPITAL COST ENGINE	*	0	186	87	
AGE OF VSL	*	13	0	0	YEAR
DAYS FISHING/YEAR	*	192	192	192	
CATCH/DAY FISHING	*	0.46	1.54	0.78	TONNE/DAY
SPECIES SARDINES	*	60	60	60	% OF CATCH
MACKEREL	*	30	30	30	% OF CATCH
OTHERS	*	10	10	10	% OF CATCH
FUEL/TRIP	*	28.44	80	28.44	LITRE
KEROSINE/TRIP	*	13.44	20.16	13.44	LITRE
NUMBER CREW	*	16	20	16	
WAGE/MAN	*	8385	SH/YEAR		
ICE/BOAT/TRIP	*	.46	1.54	.78	
PRICE FUEL	*	11.14	SH/LITRE		
KEROSINE	*	7.01	SH/LITRE		
CATCH TREND SARDINE	*	0	%/YEAR		
" " MACKEREL	*	5	%/YEAR		
" " OTHERS	*	10	%/YEAR		

FISHING GEAR			
EXISTING	*	5000	SH 000
AGE	*	4	YEAR
NEW	*	7946	SH 000
SHORE FACILITIES GENERAL			
BUILDINGS			
PRESENT VALUE	*	493	SH 000
EQUIPMENT PRICE NEW	*	1927	SH 000
NEW EQUIPMENT	*	5093	SH 000
CHILL STORE			
CAPACITY	*	12	TONNES
AV. DWELL TIME	*	2	DAYS
MAX THROUGHPUT		2160	TONNES/YEAR
PRESENT THROUGHPUT	*	0	TONNES/YEAR
COLD STORE			
CAPACITY	*	60	TONNES
AV. DWELL TIME	*	21	DAYS
MAX THROUGHPUT		1029	TONNES/YEAR
PRESENT THROUGHPUT	*	0	TONNES/YEAR
ICE PLANT			
MAX CAPACITY	*	3750	TONNES/YEAR
PRESENT CAPACITY	*	1000	TONNES/YEAR
ICE PRICE	*	500	SH/TONNE
UTILISATION	*	75	%

PRODUCT PRICE (SH/TONNE)		SHOPS	AUCT	FRZ	SMK
SARDINE	*	5200	2600	3900	3300
MACKEREL	*	6400	3200	4800	
OTHERS	*	9000	4500	6750	
LOBSTER	*		42325	63488	
FISH ALLOCATION (%)					
SARDINE	*	60	20	10	10
MACKEREL	*	60	20	20	0
OTHERS	*	20	20	60	0

DEPRECIATION			
VESSELS	*	10	YEAR
GEAR	*	4	YEAR
ENGINES	*	5	YEAR
BUILDINGS	*	20	YEAR
EQUIPMENT	*	5	YEAR

TABLE 8 (CONTD)

YEAR	0	1	2	3	4	5	6	7	8	9	10
FLEET COMPOSITION											
EXISTING VSL *		3	3	0	0	0	0	0	0	0	0
NEW BIG VSL *		2	2	2	2	2	2	2	2	2	2
NEW SMALL *		8	8	8	8	8	8	8	8	8	8
FISH LANDINGS (TONNES)											
SARDINES		1233	1233	1074	1074	1074	1074	1074	1074	1074	1074
MACKEREL		647	678	617	644	671	698	725	752	778	805
OTHERS		226	247	233	251	268	286	304	322	340	358
TOTAL		2106	2157	1924	1968	2013	2058	2103	2147	2192	2237
FISH ALLOCATION (TONNES)											
SHOPS		1173	1196	1061	1081	1101	1120	1140	1160	1179	1199
AUCTION		421	431	385	394	403	412	421	429	438	447
FREEZING		388	407	370	387	403	419	435	451	467	483
SMOKING		123	123	107	107	107	107	107	107	107	107
TOTAL		2106	2157	1924	1968	2013	2058	2103	2147	2192	2237
PURCHASED LOBSTER (TONNES)*		4	5	6	7	8	9	10	11	12	13
FISH *		50	100	150	200	250	250	250	250	250	250
REVENUE (SH 000)											
SHOPS		6738	6893	6139	6274	6410	6545	6680	6816	6951	7086
AUCTION		1259	1297	1163	1196	1229	1263	1296	1329	1362	1396
FREEZING		2017	2130	1954	2052	2150	2248	2346	2445	2543	2641
SMOKING		407	407	354	354	354	354	354	354	354	354
SUB TOTAL		10420	10726	9610	9877	10143	10410	10677	10944	11211	11477
ICE		353	328	444	422	400	377	355	333	310	288
LOBSTER EXPORT		254	317	381	444	508	571	635	698	762	825
FROZEN FISH EXPORT		338	675	1013	1350	1688	1688	1688	1688	1688	1688
CHILLSTORE HIRE *		188	188	188	188	188	188	188	188	188	188
TOTAL REVENUE		11553	12235	11636	12281	12927	13234	13542	13850	14158	14466
OPERATING COSTS (SH 000)											
VESSELS											
DIESEL & FUEL		1012	1012	829	829	829	829	829	829	829	829
KEROSINE		253	253	199	199	199	199	199	199	199	199
WAGES		1811	1811	1409	1409	1409	1409	1409	1409	1409	1409
MAINTENANCE VESSELS		81	118	144	160	176	187	203	213	224	229
SHORE FACILITIES GENERAL											
MANAGEMENT EXPENSES *		47	47	47	47	47	47	47	47	47	47
WAGES (ALL PERS) *		535	535	535	535	535	535	535	535	535	535
MAINTEN BUILDINGS *		30	30	30	30	30	30	30	30	30	30
ELECTRICITY (TOTAL) *		50	50	50	50	50	50	50	50	50	50
TRANSPORT FUEL *		27	27	27	27	27	27	27	27	27	27
BUYING LOBSTER		169	212	254	296	339	381	423	466	508	550
FISH		225	450	675	900	1125	1125	1125	1125	1125	1125
TOTAL OPERATING COST		4015	4095	3524	3582	3640	3693	3752	3805	3858	3905
OPERATING PROFIT		7538	8140	8112	8699	9286	9541	9791	10046	10301	10561
DEPRECIATION											
BUILDINGS		25	25	25	25	25	25	25	25	25	25
VESSELS		534	534	534	534	534	534	534	534	534	534
GEAR		1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
ENGINES		213	213	213	213	213	213	213	213	213	213
EQUIPMENT		1019	1019	1019	1019	1019	1019	1019	1019	1019	1019
TOTAL		3776	3776	3776	3776	3776	3776	3776	3776	3776	3776
PROFIT BEFORE TAX		3762	4364	4336	4923	5510	5765	6014	6269	6524	6785
GOVERNM TAX		180	180	180	180	180	180	180	180	180	180
NET PROFIT		3582	4184	4156	4743	5330	5585	5834	6089	6344	6605

TABLE 8 (CONTD)

YEAR		0	1	2	3	4	5	6	7	8	9	10
CASH FLOW FORECAST												
OPENING BALANCE		0	0	7358	15318	23250	23823	26772	36133	45744	47663	57783
GRANT		20513										
OP PROF AFTER TAX		0	7358	7960	7932	8519	9106	9361	9611	9866	10121	10381
CASH AVAILABLE		20513	7358	15318	23250	31769	32929	36133	45744	55609	57783	68164
NEW INVESTMENTS		20513										
REPLACEMENT												
GEAR	*		0	0	0	7946	0	0	0	7946	0	0
ENGINES	*		0	0	0	0	1064	0	0	0	0	1064
EQUIPMENT	*		0	0	0	0	5093	0	0	0	0	5093
TOTAL INVESTMENT		20513	0	0	0	7946	6157	0	0	7946	0	6157
CLOSING BALANCE		0	7358	15318	23250	23823	26772	36133	45744	47663	57783	62007

NET PRESENT VALUE	0	1	2	3	4	5	6	7	8	9	10
CASH FLOW	-20513	7358	7960	7932	573	2949	9361	9611	1919	10121	4224

DISCOUNT RATE 28.90 %

iii) Hire

a) The renting of chill and cold storage space to artisanal fishermen.

The investment programme has been analysed over a 10 year period with an initial injection of capital. The items that need to be replaced during this period have been financed from the subsequent cash flows. The financial rate of return (Section 7.1.1) has been calculated at 28.9%. (Table 8).

It can be seen that the main contribution to revenues come from the sale of fish caught by company boats and the main contributions to costs come from wages, fuel oils and possibly taxation. Therefore, the risk associated with the rehabilitation programme and the reliability of the rate of return assessment has to be considered with respect to the following factors:

a) Total Annual Catch

The estimate of annual catch of about 2,000 tons takes into consideration not only the state of the resources but also allowances for a low level of productivity. There is a provision in the analysis for a modest increase in both the catch and its quality over the ten year period.

The only additional risk arises from the immediate availability of crews. This is not regarded as serious because of the good level of expertise of local fishermen. It is considered that this problem might cause marginal delays during the first year of operation.

b) Fish Prices

The fish prices are historical and relate to the period 1980/81. They could be regarded as slightly pessimistic since there has been no upward adjustment with respect to a start to the project in the year 1982/83.

c) Wages

The estimation of wages does not present a problem but the analysis assumes that the payment system in operation now will continue i.e. fixed wages. Changes could arise from the need to operate bonus systems.

d) Fuel Costs

The real price changes in fuel oil over the last decade have had a significant effect on fishingboat operating costs. There is not provision for a forecasted fuel price increase over the period of the project but if fuel prices were 50% higher throughout the project, the financial rate of return would be reduced to 25.5%.

e) Taxation

A recurring payment is made every year. This is reputed to be 80% of the expected net profits but in reality this appears to vary between 100,000 and 200,000 Tz shillings whatever the profit or loss.

If this payment relates to the value of interest payable on the assets then there is no logical reason why this payment should increase in the investment programme and in the analysis an annual payment of 180,000 Tz shillings has been used.

It is certain that the economy will require some transfer of funds from the fisheries sector, if it can be made profitable, to others. However, it is important that such taxation does not cripple the company by taking away cash that needs to be retained as working capital or by reducing cash flows to a point where replacement investments cannot be made throughout the 10 year period.

A sensitivity analysis relating a change in the taxation to the financial rate of return is shown below:

Taxation as a percentage of net profits	financial rate of return (%)
0	29.9
20	24.2
40	17.7
60	10.1
80	0

4.3 Economic Profitability

The same discounting cash flow technique that is used to measure financial profitability from the point of view of the company, may be used to measure the Economic Rate of Return (ERR) or the return to the national economy of the project. While the financial calculations are based on prices of goods and services in the open market, economic calculations are based on social opportunity costs (or the value to the national economy of employing a unit of a certain resource in the best alternative usage). This introduces the concept of "shadow prices" (Section 7.1.2) and in the case of this fisheries project, the economic rate of return (Table 9) has been calculated using shadow prices derived from market prices with the following adjustments:

TABLE 9 ECONOMIC RATE OF RETURN CALCULATION

VESSELS		EXISTNG	NEW BIG	NEW SMALL	
CAPITAL COST VSL	*	5	1305	340	SH 000
CAPITAL COST ENGINE	*	0	186	87	
AGE OF VSL	*	13	0	0	YEAR
DAYS FISHING/YEAR	*	192	192	192	
CATCH/DAY FISHING	*	0.46	1.54	0.78	TONNE/DAY
SPECIES SARDINES	*	60	60	60	% OF CATCH
MACKEREL	*	30	30	30	% OF CATCH
OTHERS	*	10	10	10	% OF CATCH
FUEL/TRIP	*	28.44	80	28.44	LITRE
KEROSINE/TRIP	*	13.44	20.16	13.44	LITRE
NUMBER CREW	*	16	20	16	
WAGE/MAN	*	8385	SH/YEAR		
ICE/BOAT/TRIP	*	.46	1.54	.78	
PRICE FUEL	*	11.14	SH/LITRE		
KEROSINE	*	7.01	SH/LITRE		
CATCH TREND SARDINE	*	0	%/YEAR		
" " MACKEREL	*	5	%/YEAR		
" " OTHERS	*	10	%/YEAR		

FISHING GEAR			
EXISTING	*	5000	SH 000
AGE	*	4	YEAR
NEW	*	7946	SH 000

SHORE FACILITIES GENERAL BUILDINGS			
PRESENT VALUE	*	493	SH 000
EQUIPMENT PRICE NEW	*	1927	SH 000
NEW EQUIPMENT	*	5093	SH 000

CHILL STORE			
CAPACITY	*	12	TONNES
AV. DWELL TIME	*	2	DAYS
MAX THROUGHPUT		2160	TONNES/YEAR
PRESENT THROUGHPUT	*	0	TONNES/YEAR

COLD STORE			
CAPACITY	*	60	TONNES
AV. DWELL TIME	*	21	DAYS
MAX THROUGHPUT		1029	TONNES/YEAR
PRESENT THROUGHPUT	*	0	TONNES/YEAR

ICE PLANT			
MAX CAPACITY	*	3750	TONNES/YEAR
PRESENT CAPACITY	*	1000	TONNES/YEAR
ICE PRICE	*	500	SH/TONNE
UTILISATION	*	75	%

PRODUCT PRICE (SH/TONNE)		SHOPS	AUCT	FRZ	SMK
SARDINE	*	5200	2600	3900	3300
MACKEREL	*	6400	3200	4800	
OTHERS	*	9000	4500	6750	
LOBSTER	*		42325	63488	

FISH ALLOCATION (%)					
SARDINE	*	60	20	10	10
MACKEREL	*	60	20	20	0
OTHERS	*	20	20	60	0

DEPRECIATION			
VESSELS	*	10	YEAR
GEAR	*	4	YEAR
ENGINES	*	5	YEAR
BUILDINGS	*	20	YEAR
EQUIPMENT	*	5	YEAR

TABLE 9 (CONTD)

YEAR	0	1	2	3	4	5	6	7	8	9	10
FLEET COMPOSITION											
EXISTING VSL *		3	3	0	0	0	0	0	0	0	0
NEW BIG VSL *		2	2	2	2	2	2	2	2	2	2
NEW SMALL *		8	8	8	8	8	8	8	8	8	8
FISH LANDINGS (TONNES)											
SARDINES		1233	1233	1074	1074	1074	1074	1074	1074	1074	1074
MACKEREL		647	678	617	644	671	698	725	752	778	805
OTHERS		226	247	233	251	268	286	304	322	340	358
TOTAL		2106	2157	1924	1968	2013	2058	2103	2147	2192	2237
FISH ALLOCATION (TONNES)											
SHOPS		1173	1196	1061	1081	1101	1120	1140	1160	1179	1199
AUCTION		421	431	385	394	403	412	421	429	438	447
FREEZING		388	407	370	387	403	419	435	451	467	483
SMOKING		123	123	107	107	107	107	107	107	107	107
TOTAL		2106	2157	1924	1968	2013	2058	2103	2147	2192	2237
PURCHASED LOBSTER (TONNES)*		4	5	6	7	8	9	10	11	12	13
FISH *		50	100	150	200	250	250	250	250	250	250
REVENUE (SH 000)											
SHOPS		6738	6893	6139	6274	6410	6545	6680	6816	6951	7086
AUCTION		1259	1297	1163	1196	1229	1263	1296	1329	1362	1396
FREEZING		2017	2130	1954	2052	2150	2248	2346	2445	2543	2641
SMOKING		407	407	354	354	354	354	354	354	354	354
SUB TOTAL		10420	10726	9610	9877	10143	10410	10677	10944	11211	11477
ICE		353	328	444	422	400	377	355	333	310	288
LOBSTER EXPORT		254	317	381	444	508	571	635	698	762	825
FROZEN FISH EXPORT		338	675	1013	1350	1688	1688	1688	1688	1688	1688
CHILLSTORE HIRE *		188	188	188	188	188	188	188	188	188	188
TOTAL REVENUE		11553	12235	11636	12281	12927	13234	13542	13850	14158	14466
OPERATING COSTS (SH 000)											
VESSELS											
DIESEL & FUEL		1012	1012	829	829	829	829	829	829	829	829
KEROSINE		253	253	199	199	199	199	199	199	199	199
WAGES		906	906	704	704	704	704	704	704	704	704
MAINTENANCE VESSELS		81	118	144	160	176	187	203	213	224	229
SHORE FACILITIES GENERAL											
MANAGEMENT EXPENSES *		47	47	47	47	47	47	47	47	47	47
WAGES (ALL PERS) *		268	268	268	268	268	268	268	268	268	268
MAINTEN BUILDINGS *		30	30	30	30	30	30	30	30	30	30
ELECTRICITY (TOTAL) *		50	50	50	50	50	50	50	50	50	50
TRANSPORT FUEL *		27	27	27	27	27	27	27	27	27	27
BUYING LOBSTER		169	212	254	296	339	381	423	466	508	550
FISH		225	450	675	900	1125	1125	1125	1125	1125	1125
TOTAL OPERATING COST		2842	2922	2552	2610	2669	2722	2780	2833	2886	2934
OPERATING PROFIT		8711	9313	9084	9671	10258	10513	10762	11017	11272	11533
DEPRECIATION											
BUILDINGS		25	25	25	25	25	25	25	25	25	25
VESSELS		534	534	534	534	534	534	534	534	534	534
GEAR		1987	1987	1987	1987	1987	1987	1987	1987	1987	1987
ENGINES		213	213	213	213	213	213	213	213	213	213
EQUIPMENT		1019	1019	1019	1019	1019	1019	1019	1019	1019	1019
TOTAL		3776	3776	3776	3776	3776	3776	3776	3776	3776	3776
PROFIT BEFORE TAX		4935	5537	5308	5895	6482	6737	6986	7241	7496	7756
GOVERNM TAX		0	0	0	0	0	0	0	0	0	0
NET PROFIT		4935	5537	5308	5895	6482	6737	6986	7241	7496	7756

TABLE 9 (CONTD)

YEAR		0	1	2	3	4	5	6	7	8	9	10
CASH FLOW FORECAST												
OPENING BALANCE		0	0	8711	18024	27108	28832	32934	43447	54209	57280	68552
GRANT		20513										
OP PROF AFTER TAX		0	8711	9313	9084	9671	10258	10513	10762	11017	11272	11533
CASH AVAILABLE		20513	8711	18024	27108	36779	39090	43447	54209	65226	68552	80085
NEW INVESTMENTS		20513										
REPLACEMENT												
GEAR	*		0	0	0	7946	0	0	0	7946	0	0
ENGINES	*		0	0	0	0	1064	0	0	0	0	1064
EQUIPMENT	*		0	0	0	0	5093	0	0	0	0	5093
TOTAL INVESTMENT		20513	0	0	0	7946	6157	0	0	7946	0	6157
CLOSING BALANCE		0	8711	18024	27108	28832	32934	43447	54209	57280	68552	73928
NET PRESENT VALUE												
CASH FLOW		-20513	8711	9313	9084	1725	4101	10513	10762	3071	11272	5376

DISCOUNT RATE 36.10 %

a) Taxes and duties are measures used by government to transfer resources from one sector of the economy to another and have been deducted.

b) The current national level of unemployment means that shadow prices can be used for labour, but these can only apply to unskilled personnel. In this case the shadow price is taken as 50% of the market price.

The difference between all these factors are illustrated in the financial and economic analyses. The financial and economic rates of return are 28.9% and 36.1% respectively. The latter highlights the outstanding benefit of this project to the national economy.

4.4 Employment Creation

The level of unemployment, the increase in population and the general decline in the economy places an increased responsibility upon the fisheries sector to provide employment. This is a vertically integrated project that provides employment in all of its activities from fishing through to marketing. It is estimated that the project will employ a minimum additional number of 143 staff. In addition, the expenditure of income received by these people will, in turn generate further employment, mainly in the services sector of the national economy. The contribution is difficult to estimate but even pessimistic estimates for similar situations are of the order of 30% of the employment provided directly by the project.

4.5 Foreign Exchange

The particular circumstances in the country create a situation such that foreign exchange is always a major constraint to national development. This project makes a positive contribution to the balance of payments (Table 8) by the third year of the project and ever after. The major contributions are export sales of fish and lobster and imports of fuel oils.

4.6 Other Socio-Economic Factors

Sometimes particular attributes of investment projects are identified for special attention on the grounds of their national importance. This project will make a contribution to the earnings of artisanal fishermen. This will come from the purchasing of fish and lobsters and the use of chill and cold store space.

4.7 Conclusions

The model structure is a series of inter-related mathematical formulae with the advantage that such relationships can take any form, and are not constrained to be linear as in the case of the linear programming model.

The relationships link the fish and the facilities required to process or handle them from the sea to the consumer and it can be seen that not only the individual capacities can be examined but all the interactive effects and the total balance across the company. The capital costs, operating costs and revenues are generated enabling a rapid calculation of the value of the company investment and the effect of alternative policies with respect to the phasing of investment can also be investigated.

The most important methodological aspect of this combination of model and the micro-computer equipment is that of communication with the decision-maker. In the example described the decision-maker is confronted with the conflicting requirements to maximise profit and the national requirement to increase employment. A value judgement has to be made which balances both criteria and using the model, decisions can be made to decide which type and level of activity give an adequate profit and at the same time satisfy the requirement of government.

The communication with the decision-maker raises the problem of open or closed models and in this case the open model is preferable both for the purpose of identifying and reconciling the conflicting criteria and also from the issue of selling the solution. The decision-maker tends to feel that he has been involved in the analysis in addition to making the decision. This enables him to accept solutions more readily and particularly so in a situation such as this where a range of model runs may also convince him of the model's efficiency.

5 - INVESTMENT ECONOMICS FOR INDIVIDUAL SECTIONS OF THE FISHING INDUSTRY

5. INVESTMENT ECONOMICS FOR INDIVIDUAL SECTIONS OF THE FISHING INDUSTRY

In this section, the approach is to investigate a typical investment problem in each section of the industry.

The problems are not all related to each other but allow a consideration of independent solutions to economic questions regarding the basic desirability of investment, the economies of scale, technical and engineering variables and the associated operational and locational factors.

5.1 Fishing Vessels

The advent of freezing at sea caused the investor in fishing vessels to be faced with a much more complex task than previously. The freedom of technical choice was restricted to two main characteristics, propulsive power and water line length. From the change emerged additional factors such as fuel endurance, hold capacity, throughput of processing plant and the type of product to be produced such as whole fish, fillets, etc. These are details of a technical and engineering nature and although a choice has to be made with respect to these features, the broad questions to be answered are:-

a) Why build a fishing vessel at all?

b) What kind of vessel should it be?

c) When should it be built?

These questions are inevitably linked to the further question which arises:-

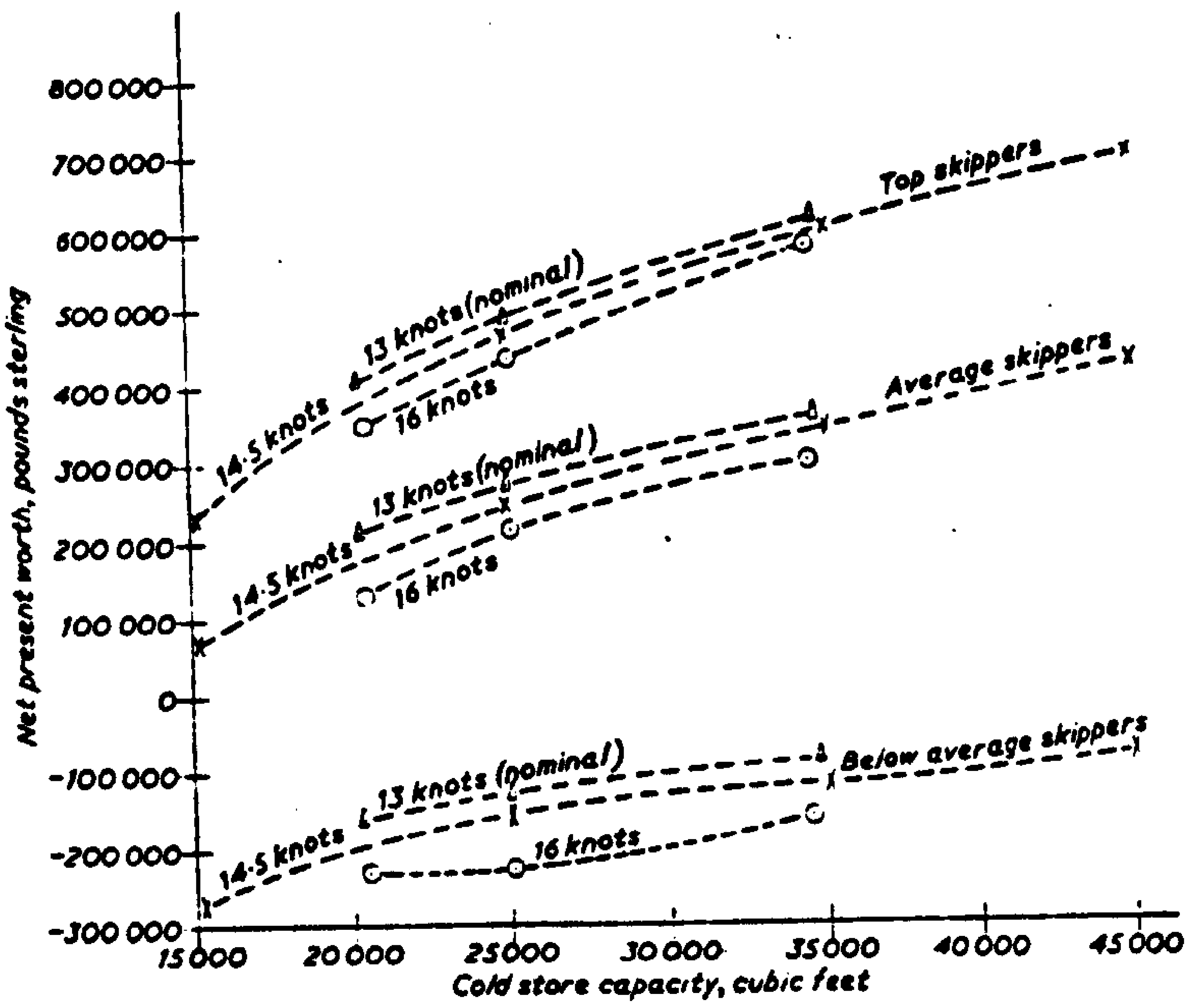
d) How should the vessel be operated?

A method of narrowing the choice when new vessels are being planned and before large capital sums are committed is desirable.

A computer simulation model has been developed for the evaluation of the economic importance of two of the principal variables in freezer trawler design, the free running speed and the capacity of the refrigerated hold. Using the simulation a study of a series of freezer trawler designs has been carried out (46).

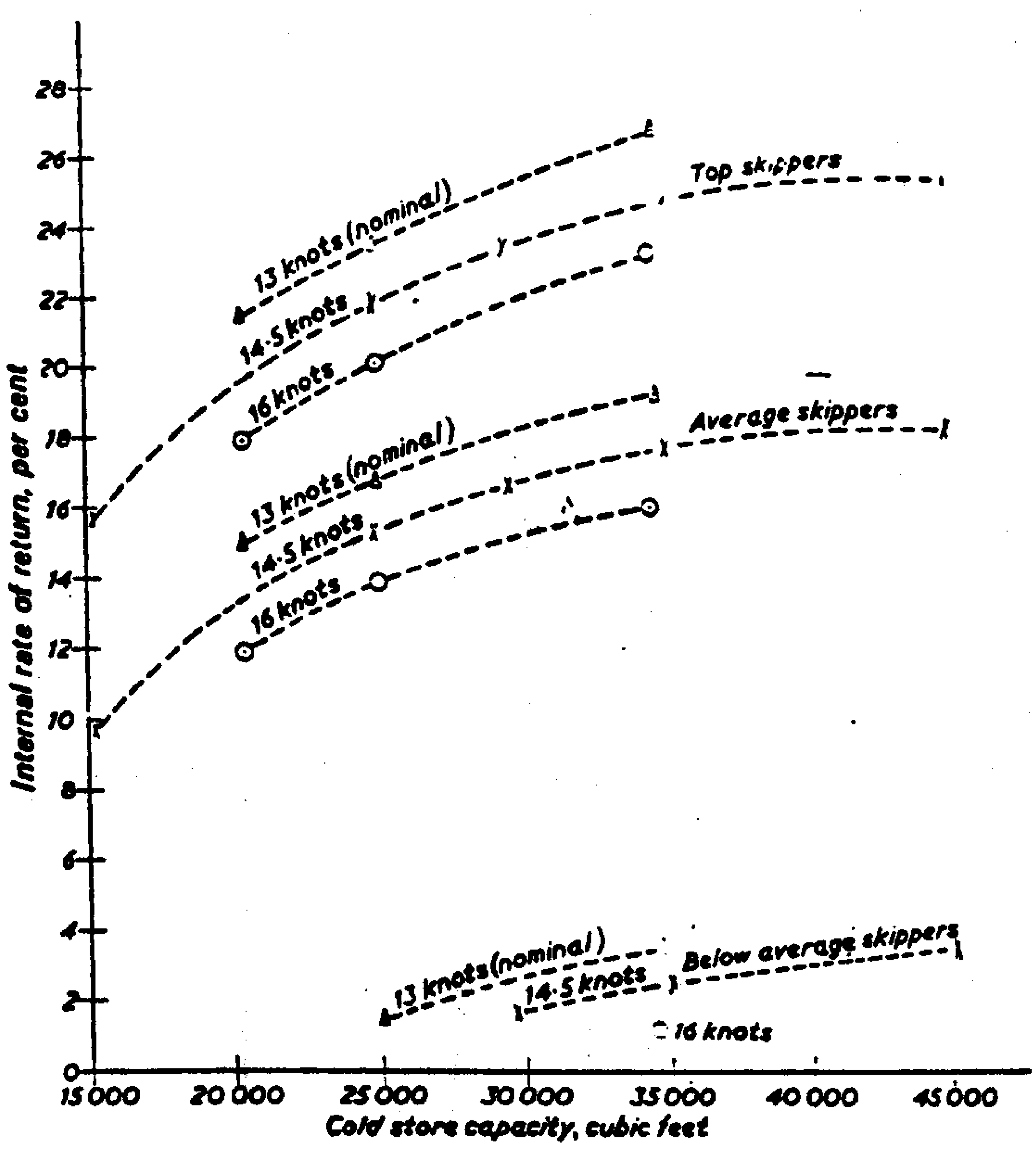
The series of trawlers were designed in conjunction with three trawler building companies and ranged from 15,000 to 45,000 cubic feet of hold capacity and free running speeds between 13.4 and 16.0 knots.

The results of this exercise are illustrated (Table 10 and Figs 7 & 8) with respect to the initial questions raised regarding the investment in a fishing vessel and immediate observations can be made. The ability of the skipper makes a greater contribution to the variation than any other factor. Of the technical factors, the economic importance of cold store capacity



Net present worth compared with cold store capacity

Fig. 7



Internal rate of return compared with cold store capacity

Fig. 8

SUMMARY OF RESULTS

Ship No.	1	2	3	4	5	6	7	8	9	10	11
Cold store capacity, ft³	15 062	20 400	20 600	25 018	25 037	25 056	29 600	34 700	35 059	34 600	45 230
Calm water speed, knots	14·5	13·8	16·0	13·6	14·5	16·0	14·5	13·4	14·5	16·0	14·5
Net present value at 7 per cent over 16 years											
Top skippers	£228 446	£406 127	£351 938	£489 935	£467 917	£439 632	£537 925	£618 345	£602 312	£582 617	£700 815
Average skippers	£63 718	£211 143	£130 094	£274 774	£249 702	£215 579	£298 239	£363 520	£343 796	£302 996	£433 538
Below average skippers	−£280 039	−£157 272	−£230 957	−£125 287	−£154 937	−£228 906	−£133 633	− £83 376	−£117 356	−£159 470	− £77 964
Internal rate of return, per cent											
Top skippers	15·41	21·46	17·96	23·44	21·80	20·08	23·36	26·66	24·70	23·19	25·29
Average skippers	9·46	14·95	11·91	16·71	15·33	13·81	16·56	19·15	17·64	15·93	18·12
Below average skippers	*	*	*	1·42	*	*	1·67	3·55	2·51	1·17	2·71
Average voyage length, days											
Top skippers	31·1	38·3	36·5	43·9	42·9	41·6	48·2	55·3	54·8	53·0	67·0
Average skippers	33·9	42·2	40·4	48·6	47·8	46·2	54·2	62·0	61·3	59·4	75·7
Below average skippers	37·1	49·2	48·1	58·2	57·3	53·2	66·3	76·3	75·3	74·2	90·8
Maximum voyage length, days											
Top skippers	37	45	43	52	51	50	57	66	65	62	77
Average skippers	39	50	46	54	54	53	64	72	72	71	87
Below average skippers	40	55	53	62	61	59	71	80	80	78	95

* Negative values

TABLE 10

is greater than that of the other variable considered, namely free-running speed. This applies particularly to the smaller ships in the series. In terms of Net Present Value the results show a steady improvement with increase in cold store size, for all classes of skipper considered. In terms of Internal Rate of Return there is also a continuous improvement with size but the curve is very flat above 35000 ft^3 capacity.

For all classes of skipper considered the slower vessels are more profitable than the faster vessels, but the difference is fairly small in relation to the difference in power of about two to one between the fastest and slowest vessels of any given cold store size.

These results imply the choice of large, slow, vessels for best economic results, with a consequent tendency towards longer voyages.

5.2 Port Operations

The basic factors to be considered in the investment planning of any port are the number and type of fishing vessels that will use it and the quantities of fish and type of processing that will take place there arising from the demand. All other considerations will depend on a detailed consideration of these factors.

Vessels landing at a port follow a simple cycle of events:-

a) arrival

b) unloading of fish

c) servicing of vessel and gear (ice, fuel, provisions, etc.)

and d) departure.

Delays may be experienced between any of these activities.

The types of fishing vessel using the port may be categorised by base and by size. They may be based at the port returning after every trip or casual visitors to the port. On completion of the port, the length of the quays will be fixed and this will provide a constraint on their availability making the size of vessel an important consideration. The arrival pattern of vessels will vary in accordance with this classification of vessels. The arrival pattern of the home based vessels will be influenced by their type, the distances of the port from the fishing grounds, the passage times to and from these grounds and the time spent fishing on them. The casual arrivals of vessels from other ports will usually vary throughout the year depending on seasonal factors. If it is possible from historical data to measure the factors associated with the different arrival patterns, then it will be possible to estimate projected patterns for the new port development.

On arrival in the port the major factors which affect the queueing and unloading of the vessels are the number of unloading bays and the rate of discharge of the fish. The optimum level of unloading facilities is a key area for investment.

In addition to queueing and unloading, the time a vessel spends in port is affected by any regulations allowing time-off for the crew and also the servicing of the vessel including the provision of ice, fuel, gear requirements and any time allowed for repairs, replacements and re-fittings.

A further delay might be experienced by the vessels depending on the availability of processing plant within the port. It is, therefore, extremely important that the balance in investment between the unloading facilities, the processing facilities and any intermediate storage facilities is correct.

5.2.1 Vessel Unloading Facilities

There are three possibilities for alleviating congestion of vessels at a fishing port. The first is to avoid irregulaties in the arrival pattern of fishing vessels at the port. This has been attempted by some fishing companies with limited success who have tried to smooth the distribution of landings in order to obtain an improved price for fish in an auction situation and also to achieve an increase in efficiency of their maintenance facilities. However, there are many situations where the arrival of fishing vessels at the port cannot be controlled to any extent. The other two methods involve changes in the unloading system. One of the simplest methods is to increase the number of unloading points to deal with the fishing vessels. The second is to change the unloading times and this is usually more difficult since this means an alteration in the present system or a fundamental change in the method of unloading usually involving mechanisation. The main methods of unloading fishing vessels:-

a) The vessels own crew manually land the fish that they have caught themselves
b) Shore-based unloading gangs unload the fish manually
c) Some form of mechanisation with an appropriate labour input.

The problem is one which can be investigated by the application of Queueing Theory.

The system can be considered as one in which vessels arrive in a Poisson stream and the unloading times for the vessels are exponentially distributed. There are several unloading bays with no interruption of unloading. There are no restrictions on queue size (sufficient aquatory for all the vessels in the harbour), and the system obeys a first come first served discipline. The general case has been developed by Page (39) and results are shown (Tables 11, 12, 13).

The first option is the simplest where the crew members unload the fish from the vessel themselves. The problem is to provide sufficient length of quay for the vessels to lie alongside for the unloading operation to take place. If in the steady state a fleet of about 50 fishing vessels land an average catch of 16 tonnes daily over a 16 hour period in the day, then the number of unloading points or in this case, the length of quay can be estimated by the approach described above. It is assumed that the average unloading time for each vessel is 90 minutes (Fig. 9). From the point of view of the average waiting time of the vessels, the provision of 10 unloading points gives a waiting time that is not significantly different from 50 unloading points which is zero. However, the economic solution is more complex as with 10 unloading points, there is the additional cost of moving the vessels after unloading and they may have to be moved again for servicing before departure. It is possible that these costs would outweigh the marginal increase in the capital cost of providing the additional cost of quayside even to accommodate 50 fishing vessels.

TABLE 11 **50 FISHING VESSELS LANDING ON AVERAGE 16 TONNES OF FISH PER TRIP WITH AN AVERAGE UNLOADING TIME OF 90 MINUTES AND INTER-ARRIVAL TIME OF 20 MINUTES**

NO. OF UNLOADING POINTS (n)	UTILISATION $\left(\frac{\text{UNLOADING TIME}}{\text{n x INTER-ARRIVAL TIME}}\right)$	WAITING TIME FACTOR (W.T.F.)	AVERAGE WAITING TIME (MINS) (W.T.F. x UNLOADING TIME)
5	0.9000	1.5250	137.25
6	0.7500	0.2838	24.54
7	0.6429	0.0862	7.76
8	0.5625	0.0291	2.62
9	0.5000	0.0102	0.92
10	0.4500	0.0033	0.30

TABLE 12 **50 FISHING VESSELS LANDING ON AVERAGE 16 TONNES OF FISH PER TRIP WITH AN AVERAGE UNLOADING TIME OF 60 MINUTES AND INTER-ARRIVAL TIME OF 20 MINUTES**

NO. OF UNLOADING POINTS (n)	UTILISATION (UNLOADING TIME / (n x INTER ARRIVAL TIME))	WAITING TIME FACTOR (W.T.F.)	AVERAGE WAITING TIME (MINS) (WTF x UNLOADING TIME)
4	0.7500	0.5160	30.96
5	0.6000	0.1181	7.09
6	0.5000	0.0330	1.98
7	0.4286	0.0091	0.55
8	0.3750	0.0014	0.09

TABLE 13 **50 FISHING VESSELS LANDING ON AVERAGE 16 TONNES OF FISH PER TRIP**

WITH AN AVERAGE UNLOADING TIME OF 30 MINUTES AND INTER-ARRIVAL TIME 20 MINUTES

NO. OF UNLOADING POINTS (n)	UTILISATION $\left(\frac{\text{UNLOADING TIME}}{n \times \text{INTER-ARRIVAL TIME}}\right)$	WAITING TIME FACTOR (W.T.F.)	AVERAGE WAITING TIME (MINS) (W.T.F. x UNLOADING TIME)
2	0.7500	1.3069	39.21
3	0.5000	0.1579	4.74
4	0.3750	0.0291	0.87
5	0.3000	0.0058	0.17
6	0.2500	0.0009	0.03

AVERAGE WAITING TIMES FOR VESSELS WITH AN AVERAGE INTER-ARRIVAL TIME OF 20 MINUTES UNLOADING AN AVERAGE DAILY (TRIP) CATCH OF 16 TONNES

Fig. 9

The second option is to have a shore-based gang unloading the vessels manually. It has been assumed that the unloading time is quicker than the previous option at an average of 60 minutes. In this option, the average waiting time for the vessels is not significantly different from zero when the number of unloading gangs and points equals 8. However, it may be from a quality control consideration that the minimum number of unloading gangs and points of 4 is acceptable. If there is no significant financial loss on this account then this will almost certainly be the case. There is the further alternative that if the provision of adequate quay for 50 vessels is economically sound for the reasons stated in the previous option, then the optimum combination could be a quay for 50 vessels with 4 unloading gangs.

The third option is the most complex where shore-based gangs would operate unloading equipment to speed up the unloading operation and achieve an average unloading time of 30 minutes. This would obviously incur a greater cost than the other two options. The average waiting time for the fishing vessels is reduced to a negligible level if there is an investment in 4 unloading bays but the interesting comparison here is that with the minimum number of 2 bays, the average waiting time is similar to the second option with 4 gangs unloading the vessels manually. It is difficult to make consistent statements about the return on investment because each case will depend on the revenues and costs appropriate to the location of the harbour but it is certain that this technique is extremely useful for the determination of the economic viability of such options.

5.2.2 Fish Processing Facilities

Within a port complex, fish passes from the vessel unloading point by a variety of transport devices to the fish processing facilities. All these processing facilities have common problems. There is the basic problem of choosing the size of plant. The nature of the fishing industry is that the raw material supply will vary considerably and a fish processing plant that will cope on all practical occasions will be larger and more expensive in terms of capital and probably labour than that at the optimum level of production. The choice is further complicated by the limitations on handling and the duration of buffer storage set by quality and possibly environmental requirements. For the purposes of this work, a fish meal plant has been selected as this type of equipment exhibits the problems of all fish processing plant and is also relevant to many fisheries throughout the world.

The process commences by the fish, which is to be used as raw material, passing to a storage facility, usually a hopper or bin arrangement. This would usually be subdivided to provide a first in first out arranagement as far as possible thus keeping the quality as high as possible. The raw material passes from storage to the continuous cooker where it is heated indirectly by steam. The drainage of the cooked material takes place in the strainer screw conveyor, the link between the cooker and the press. In the screw press, the oil and water is pressed out. The presscake is disintegrated, dried and passes to the grinding plant and the meal is then bagged or stored in silos. The presswater is passed to separators for de-sludging and oil extraction. The oil-free presswater is called stickwater and contains up to 20 per cent of the total dry matter from the raw fish treated. The stickwater is concentrated in a multistage evaporator and by returning the concentrate to the drier, the output from the same amount of raw material is increased by up to 20 per cent. Fish meal containing this concentrate is called whole meal.

A study of fish processing facilities could be carried out by using a system similar to that described previously.

In this case it would be a system in which fish arrived in a Poisson stream, the distribution of fish processing times exponentially distributed and several processing facilities. The average waiting times and the weight of fish in the queue (buffer storage) could be estimated.

However, the design and operation of a fishmeal plant is such that the fish processing time would take place at a constant rate rather than an exponential rate, which might be more appropriate for a manual processing function. This general case has also been developed by Page (39) who has also presented tables for both cases, i.e. deterministic service times and exponential for a range of values for the number of servers and utilisation of facilities giving average waiting times in the relevant queueing systems.

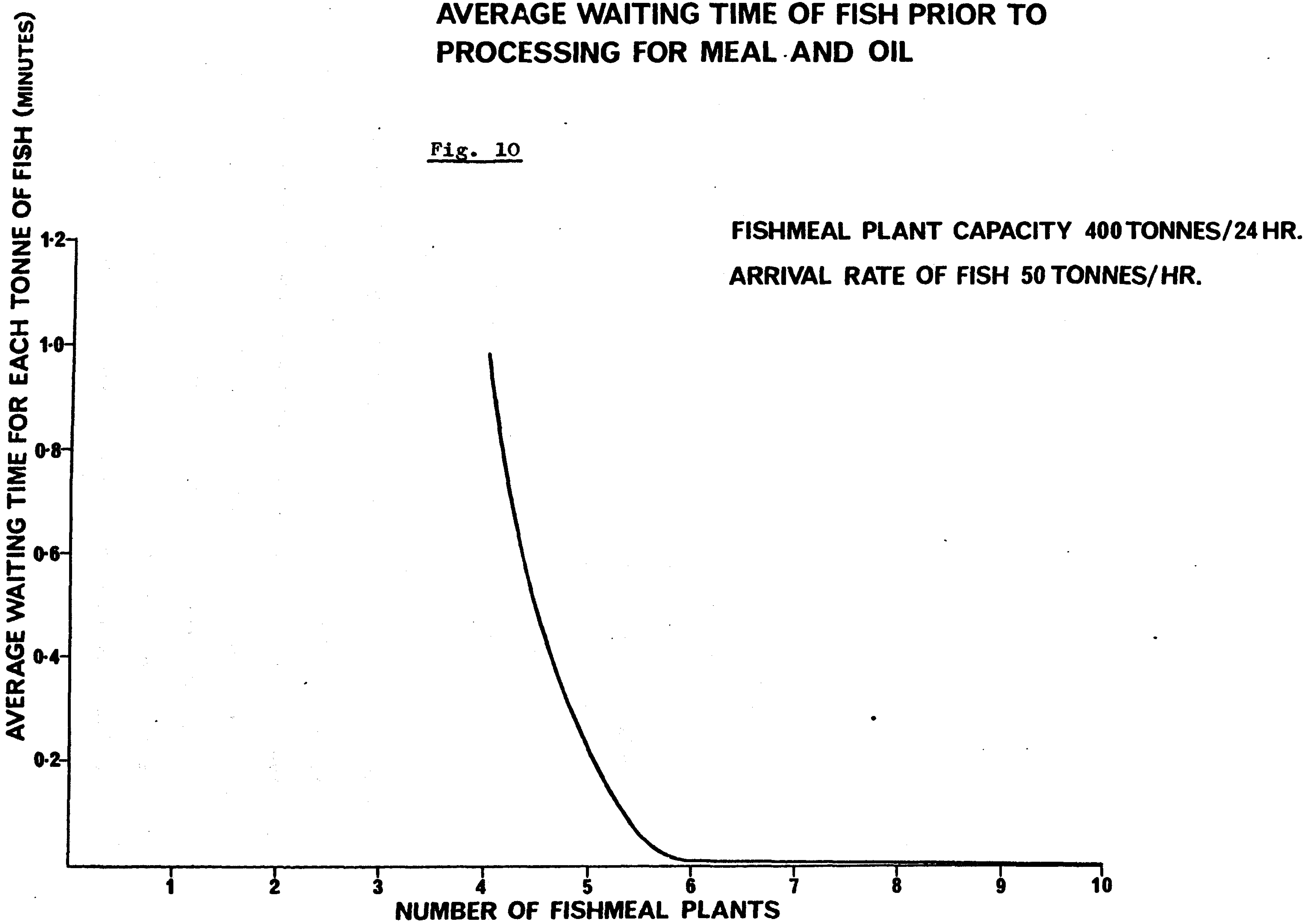
This problem is similar in principle to the previous one of determining the number of unloading bays in the harbour. The problem is to determine the capacity and number of fishmeal plants required in the environs of the port with respect to their economic viability. It is assumed that a fleet of about 50 fishing vessels land an average catch of 16 tonnes daily over a 16 hour period in the day and the whole of this supply is fed to the fishmeal plants. Initially it is assumed that plants which operate at a production capacity of 400 tonnes of raw fish every 24 hours are available for installation but are limited to working a two-shift system of 16 hours each day. The fishmeal plant requirement can then be calculated (Table 14 and Fig. 10).

TABLE 14 **FISHMEAL PLANTS HANDLING 400 TONNES PER DAY WITH AN AVERAGE PROCESSING TIME 3.6 MINUTES PER TONNE AND INTER-ARRIVAL TIME OF 1.2 MINUTES PER TONNE**

NO. OF FISHMEAL PLANTS (n)	UTILISATION $\left(\frac{\text{PROCESSING TIME}}{n \times \text{INTER-ARRIVAL TIME}}\right)$	WAITING TIME FACTOR (W.T.F.)	AVERAGE WAITING TIME (MINS) (W.T.F. x UNLOADING TIME)
4	0.7500	0.2706	0.97
5	0.6000	0.0661	0.24
6	0.5000	0.0199	0.07
7	0.4286	0.0060	0.02
8	0.3750	0.0017	0.01
9	0.3333	0.0004	0.00

AVERAGE WAITING TIME OF FISH PRIOR TO PROCESSING FOR MEAL AND OIL

Fig. 10



The minimum number of plants that can handle the supply is 4 and the average waiting time for each ton of fish is negligible. The reduction in waiting time for an increase of fishmeal plants to 5 is not significant but even if it were, then, at a capital cost of 2 million pounds for each plant, fixed costs of 0.5 million pounds and 40 pounds for each ton, it is not a viable proposition.

5.3 Transport and Distribution

The growth and development of the fishing industry in the United Kingdom was based on the transport of wet fish from the ports to the main centres of population by rail. Up to the end of 1964 some seven fish trains left Grimsby daily delivering fish to no less than 1,400 railway stations, and with very few exceptions, it was available for retail sale the morning following despatch. There was considerable apprehension when in 1964 it was announced that there was to be a phased with-drawal of these trains. Other ports were also affected.

A rapid transition to road transport was essential and because of the special nature of the operation, the fish trade had to tackle the problem with its own resources. The larger fish companies formed their own transport sections and the smaller port wholesale merchants joined together to form their own transport groups. These transportation systems are characterised by their complexity and by the day-to-day variation of quantities to be delivered and of destinations. There is very short time between receiving details of quantities and destinations and the loading of vehicles, and this does not allow a deliberate and complete examination of all possible alternatives as regards loading of vehicles, trans-shipment points, routing and so on, with a view to minimising costs or effecting the most rapid delivery.

Choice is limited, and the problem complicated, because the number of vehicles available is limited and also because of legal and union requirements which make manpower an important factor.

The particular problem is that of delivering wet fish from several ports to several depots scattered around the country. Each port delivers to several of the depots and each depot may require deliveries from more than one port. The depots are so far from the ports and from each other that it is not feasible for one vehicle to deliver to more than one depot unless one depot is en route to another (Fig. 11).

PORT	DELIVERING TO DEPOTS
1	A, C and F
2	D and E
3	A, B, F and G
4	A and F

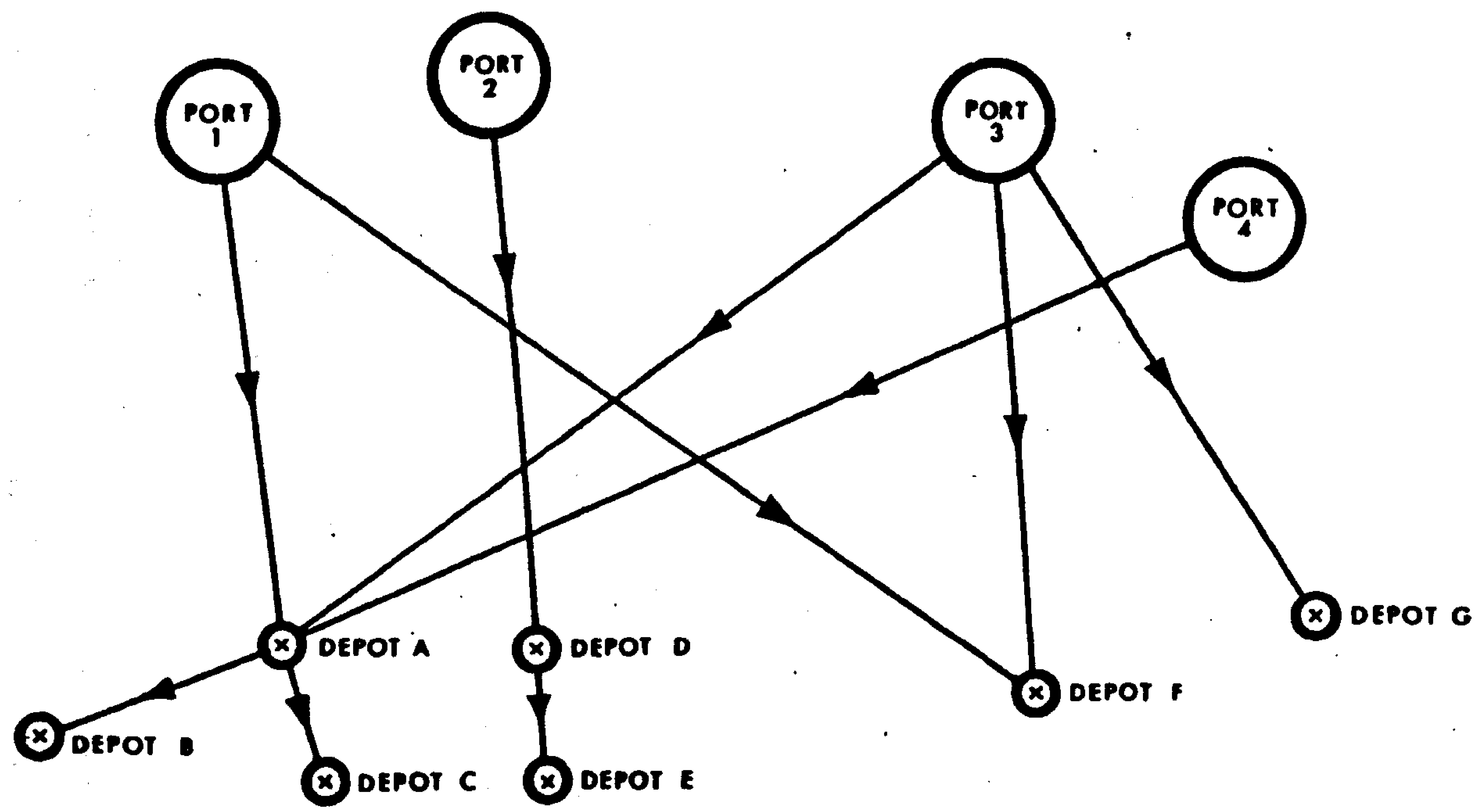


Fig. 11 A DIAGRAMMATIC REPRESENTATION OF THE PROBLEM

If Port 1, for example, had to deliver to Depot B, then, lorry capacities permitting, the consignment might be sent to Depot A and there trans-shipped on to the lorry from Port 3 which is going to Depot B. Even allowing for such occurrences, there is still a great multiplicity of vehicles from various ports to depots. If the normal consignment is nearly a full lorry load then all is well but if consignments are small compared to the capacity of the lorry then utilisation could well be poor, as in the example already quoted, making transport expensive.

There is a minimum number of lorries which must leave each port simply to be able to move the total quantity of fish: when all the consignments are destined for the same place the number of lorries necessary to carry them is the minimum number that can possibly be used for that amount of fish. For example, to move 35 tonnes will need at least six lorries if each lorry can carry 6 tonnes even if all the fish is going to the same place. It may need more if it is going to different places. Six is the minimum figure.

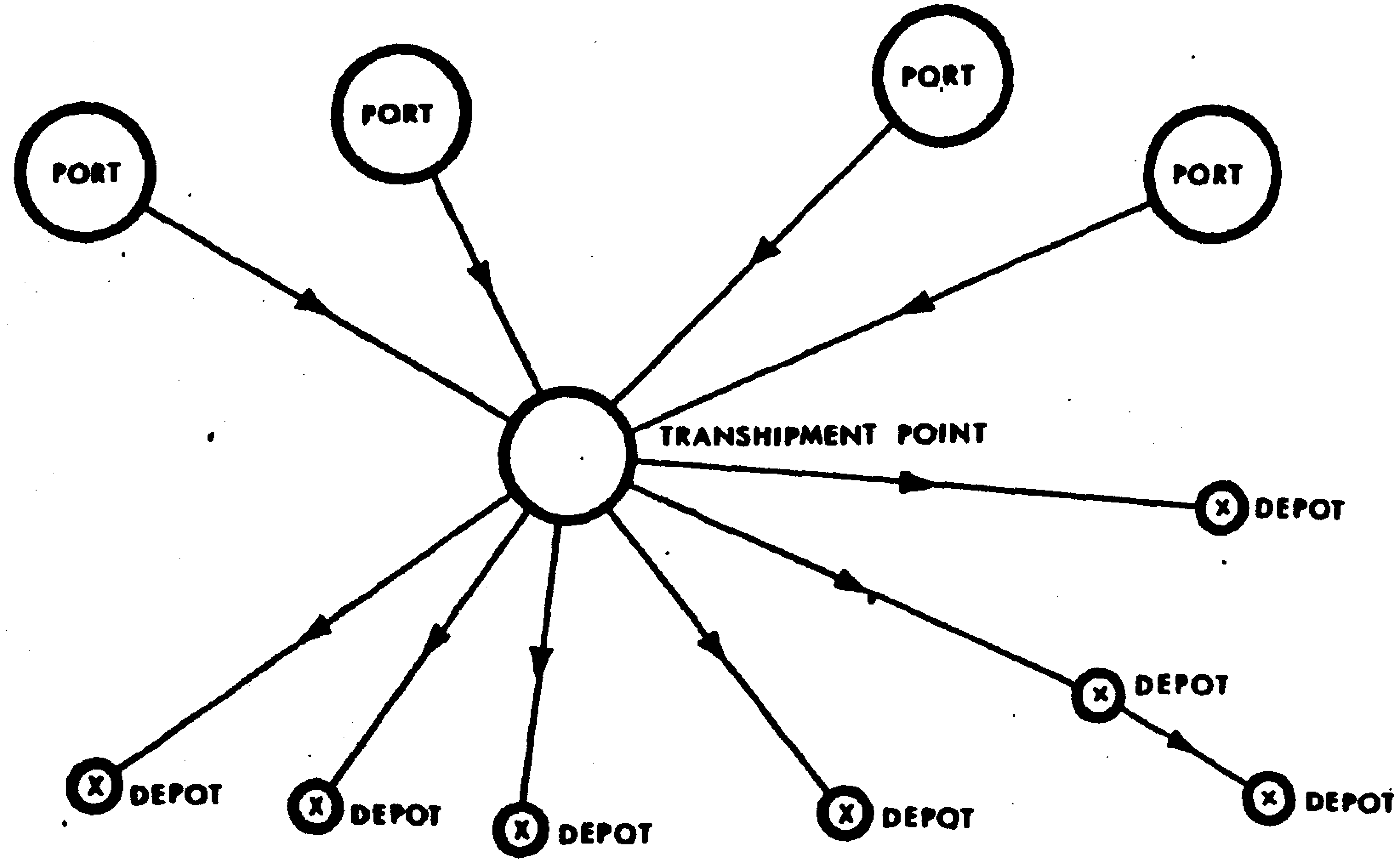
Similarly there is a minimum number of vehicles needed out of one port to bring a given quantity of fish to each depot, (or chain of depots, where two or more are on the same route). Continuing the example, if a depot is receiving 15 tonnes, then at least three lorries must arrive, even if all fish comes from the same port. If it comes from more than one port then more than three lorries may be needed. Three is the minimum. If the minimum numbers of lorries required to arrive at each depot (or chain of depots where there is more than one on each route) are added together, then the total gives the minimum total numbers of arrivals at all depots. Similarly the minimum numbers of departures from each port can be added to give a minimum total number of departures from all the ports taken together.

Under no circumstances is it possible to deliver the fish using fewer lorries than the greater of these two figures, if each lorry makes only one run.

If the loads are sent from each port to a single trans-shipment point and then to each depot, the number of lorries required, will be indicated by the line of reasoning just described, and will therefore be a minimum (Fig. 12).

Mileage may not be at a minimum but the costs saved by having the smallest possible number of vehicles will, generally speaking, far outweigh the additional costs incurred in mileage and trans-shipment. Studies of practical situations bear this out.

All that remains therefore is to find all the possible allocations of consignments that lead to the smallest possible number of lorries as outlined earlier and, once that has been achieved, to identify the particular allocation which minimises the number of trans-shipments



<u>Fig. 12</u> THE USE OF A SINGLE TRANS-SHIPMENT POINT

without increasing the number of vehicles involved.

The actual choice of the size of lorry does not present too difficult a problem. The economies of scale for a range of loads over typical distances can be easily estimated (Table 15, Figs. 13 and 14).

5.4 Conclusions

Models of individual operations in a fishery are often required in order to investigate these investment problems that arise within these operations and also to provide data for more complex investigations within companies or at a national level.

5.4.1 Fishing Vessels

The model structure is a simulation (Fig. 15).

In using the simulation model, the problem or system under study is first described as the sequence of individual operations to be performed. It is then necessary to provide data indicating how the individual operations are interrelated and the frequency distributions of elapsed time for each individual operation for the different conditions to be explored.

The quantities under investigation are systematically varied in an attempt to find an optimum solution, usually in economic terms. In this case the cold store capacity and

TABLE 15 **UNIT COST OF DELIVERY (1973/4 DATA) OF FISH FOR TYPICAL TRIPS USING DIFFERENT VEHICLES**

7 TONNE RIGID VEHICLE	WEIGHT CARRIED (TONNES)	2	4	6	7				
OVERHEAD COSTS PER JOURNEY = £7.00	500 MILE JOURNEY COST (£/TONNE)	22.25	11.12	7.42	6.36				
DIRECT COSTS = 7.5p/MILE	600 MILE JOURNEY COST (£/TONNE)	26.00	13.00	8.67	7.43				
24 TONNE ARTICULATED VEHICLE	WEIGHT CARRIED (TONNES)	4	8	12	16	20	24		
OVERHEAD COSTS PER JOURNEY = £22.00	500 MILE JOURNEY COST (£/TONNE)	18.00	9.00	6.00	4.50	3.60	3.00		
DIRECT COSTS = 10.0p/MILE	600 MILE JOURNEY COST (£/TONNE)	20.50	10.25	6.83	5.13	4.10	3.42		
32 TONNE ARTICULATED VEHICLE	WEIGHT CARRIED (TONNES)	4	8	12	16	20	24	28	32
OVERHEAD COSTS PER JOURNEY = £30.00	500 MILE JOURNEY COST (£/TONNE)	23.13	11.56	7.71	5.78	4.63	3.85	3.30	2.89
DIRECT COSTS = 12.5p/MILE	600 MILE JOURNEY COST (£/TONNE)	26.25	13.13	8.75	6.56	5.25	4.38	3.75	3.28

Fig. 13

UNIT COST OF FISH DELIVERIES, ROUND TRIP 500 MILES

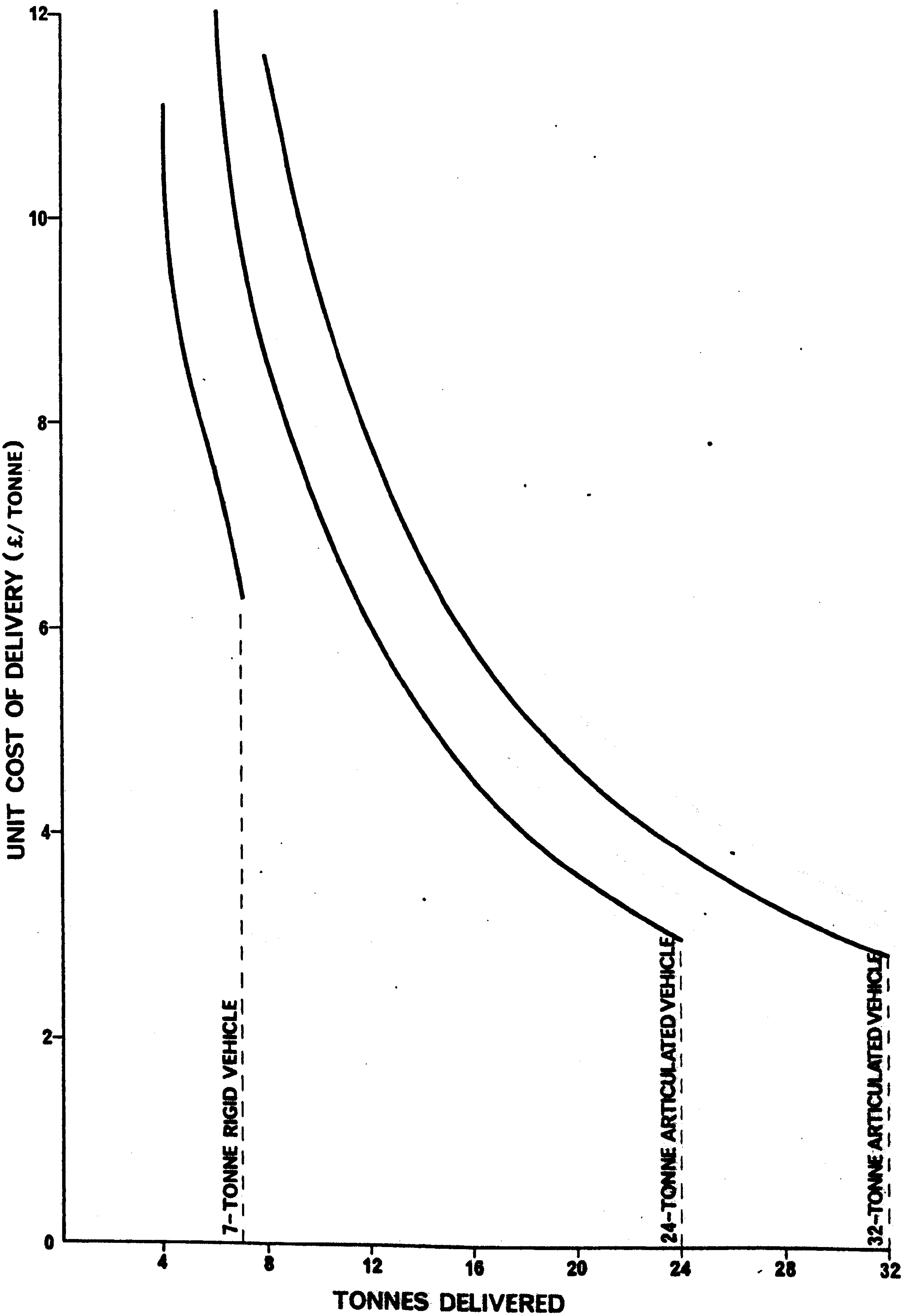
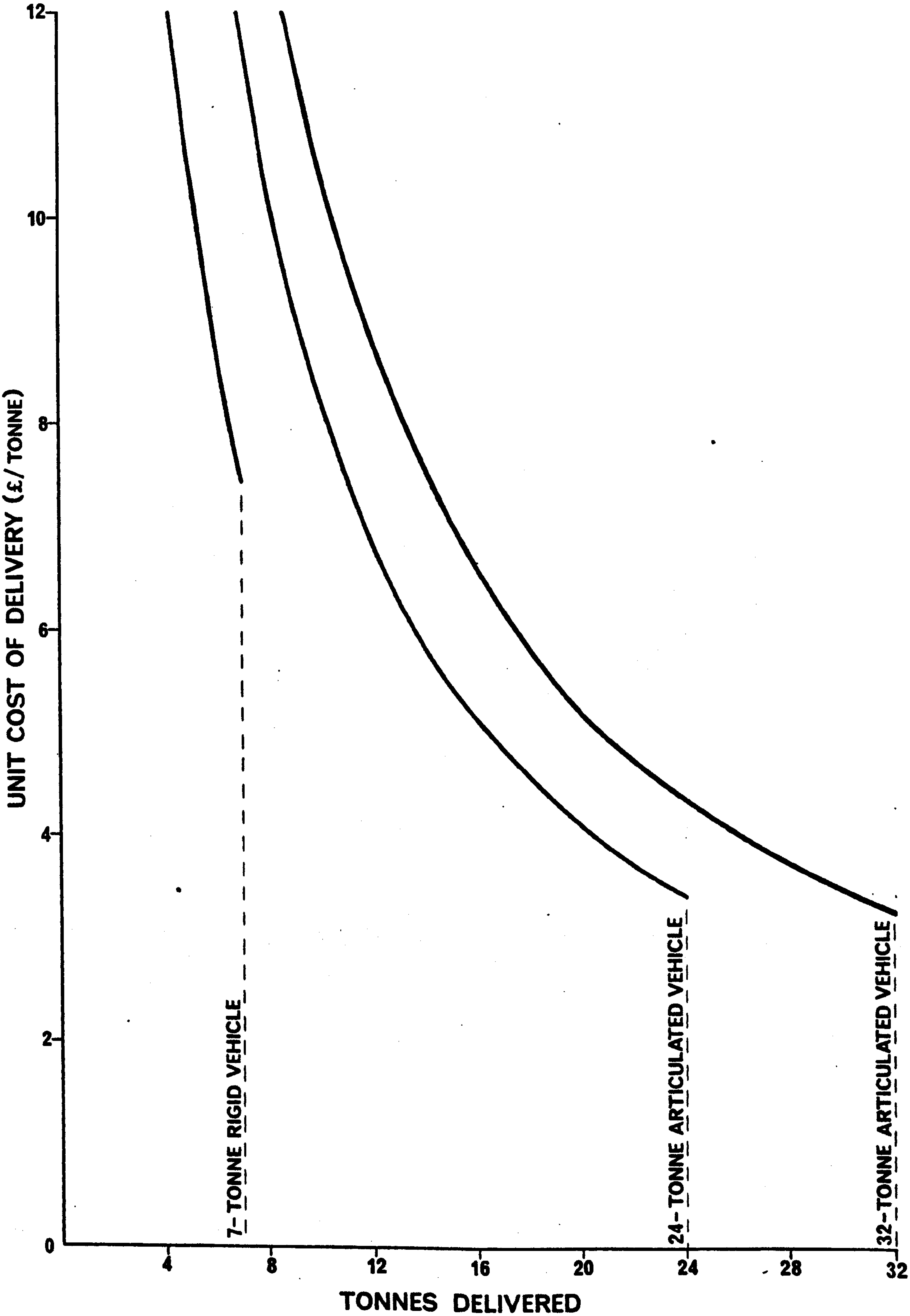
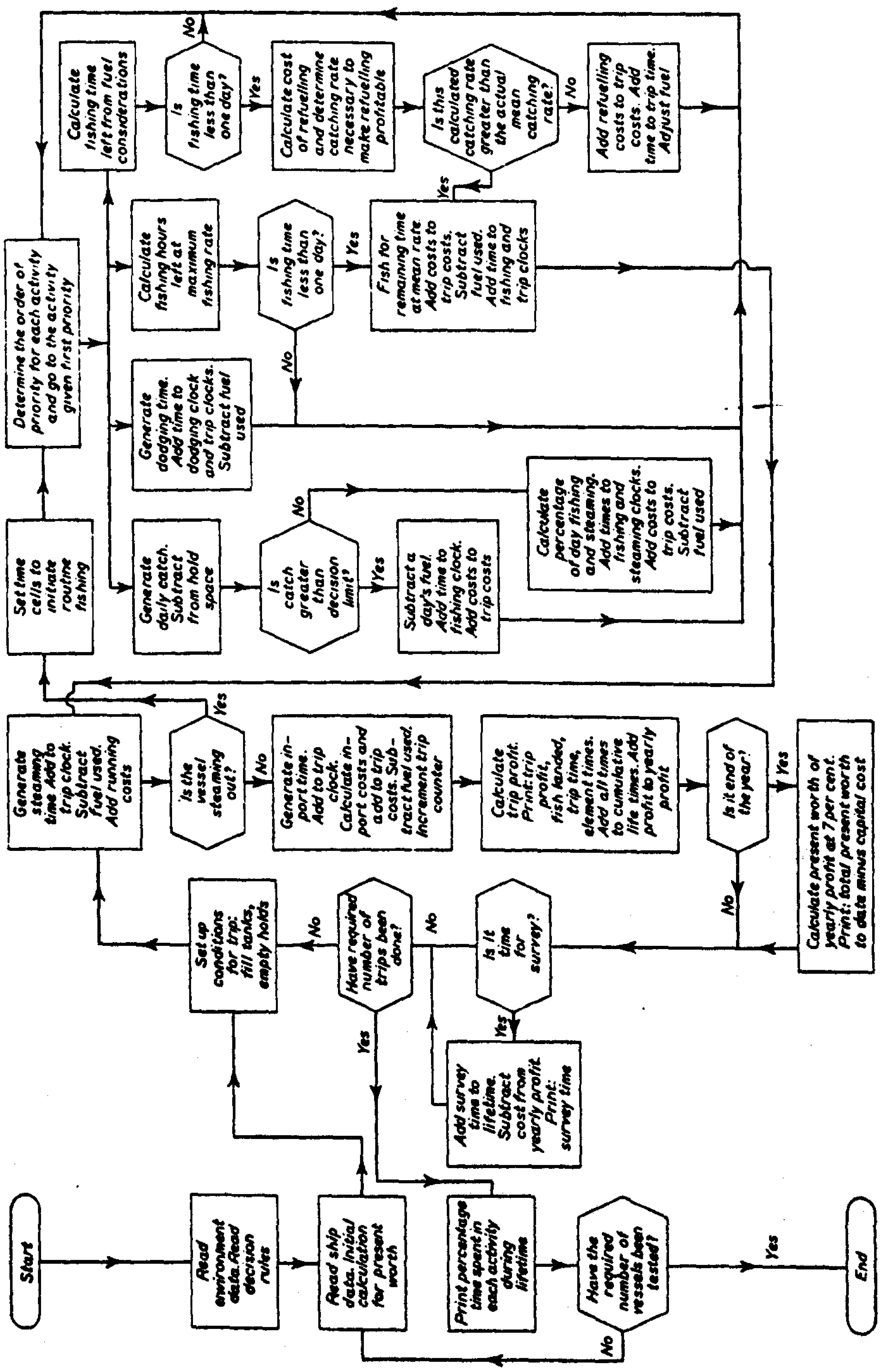


Fig. 14

UNIT COST OF FISH DELIVERIES, ROUND TRIP 600 MILES





Computer simulation flow diagram

Fig. 15

boat speed are varied to define the best choice of these two variables. By consulting the operational data mentioned above in a random manner, actual trips can be simulated and the overall time and costs for the sequence of operations can be determined. This process, performed repeatedly, permits the accumulation of such total system data as quantity of fish landed, running costs, net present worth of the investment and the internal rate of return. These outputs are then used to evaluate the desirability of the given input under test and in effect a comparison of the operations of several different designs has thus been simulated.

The use of simulation is usually restricted to situations where it is not practicable to carry out an analytical analysis to determine the optimal solution of the problem in terms of its parameters or a numerical evaluation by producing computational routines. The question of an analytic approach to this problem is considered (Section 6.1) but the technique chosen, i.e. simulation, was regarded as appropriate on several counts:-

a) the variability created by the fishing environment
b) the communication with the decision-makers
c) the cost of developing a previous analysis of the same kind by Branch (40) to cover this problem was low.

The results arising from this analysis are discussed (Section 8) in the light of operating experiences of the vessels.

Port Operations

The model structures for both the problems involving unloading facilities and fish processing facilities are based upon standard queueing theory. There is no need to comment further on this as it is covered in the literature other than to comment on the assumptions underlying the queue systems used here in relation to the real situation.

The major assumptions relate to the randomness of arrival times and service times and the development of a steady-state situation. There is some evidence to suggest arrival of fishing vessels in a Poisson stream during specific periods of the day in the case examined. The approach was to apply queueing theory first to determine the outcome for the unloading facilities. The interesting point and an important one with respect to the methodological aspect is that whether a model is adequate in treating uncertainty in a manner considered adequate. It can be seen from a discussion of the solutions that queueing theory is consistent with the decision-makers requirement to discriminate between alternative choices and the difference in their values.

Transport and Distribution

The techniques considered here could be regarded as trivial but the basic decisions required for the investment decision relate to the number of lorries and their size. The subsequent routing of them has an important bearing on the former but these techniques have not been considered here.

In the cases examined in the United Kingdom, the reduction of the fleet by one lorry proved to be far greater than a marginal reduction in mileage but this could be a function of size of organisation which in these cases was small.

6 - SELECTION OF TECHNIQUES

6. SELECTION OF TECHNIQUES

It is always expected that the models used will be efficient and effective in achieving the diverse goals within the decision-making process but from the point of view of methodology, there are many other problems to overcome even if a reliable model can be constructed.

There is the fundamental requirement that an essential element in the operations studied is the existence of alternative courses of action with a choice to be made among them. These alternatives may take various forms but one of the important observations is that there is not a continuous choice of options in fisheries development. Engines for fishing vessels are manufactured in discrete sizes and so are fishmeal plants, lorries and many other facilities. The techniques and criteria used within this model approach should be sufficiently sensitive to discriminate between the alternatives available.

The choice of technique is particularly important. Certain techniques are irrevocably tied to specific problem situations e.g., queueing theory to the problems of congestion and others may be used freely for a wide range of problem situations e.g. computer simulation. This means that any specific problem could be solved by the use of more than one technique and the choice of technique will be affected by many important factors.

It is therefore important to review techniques in the light of these factors:-

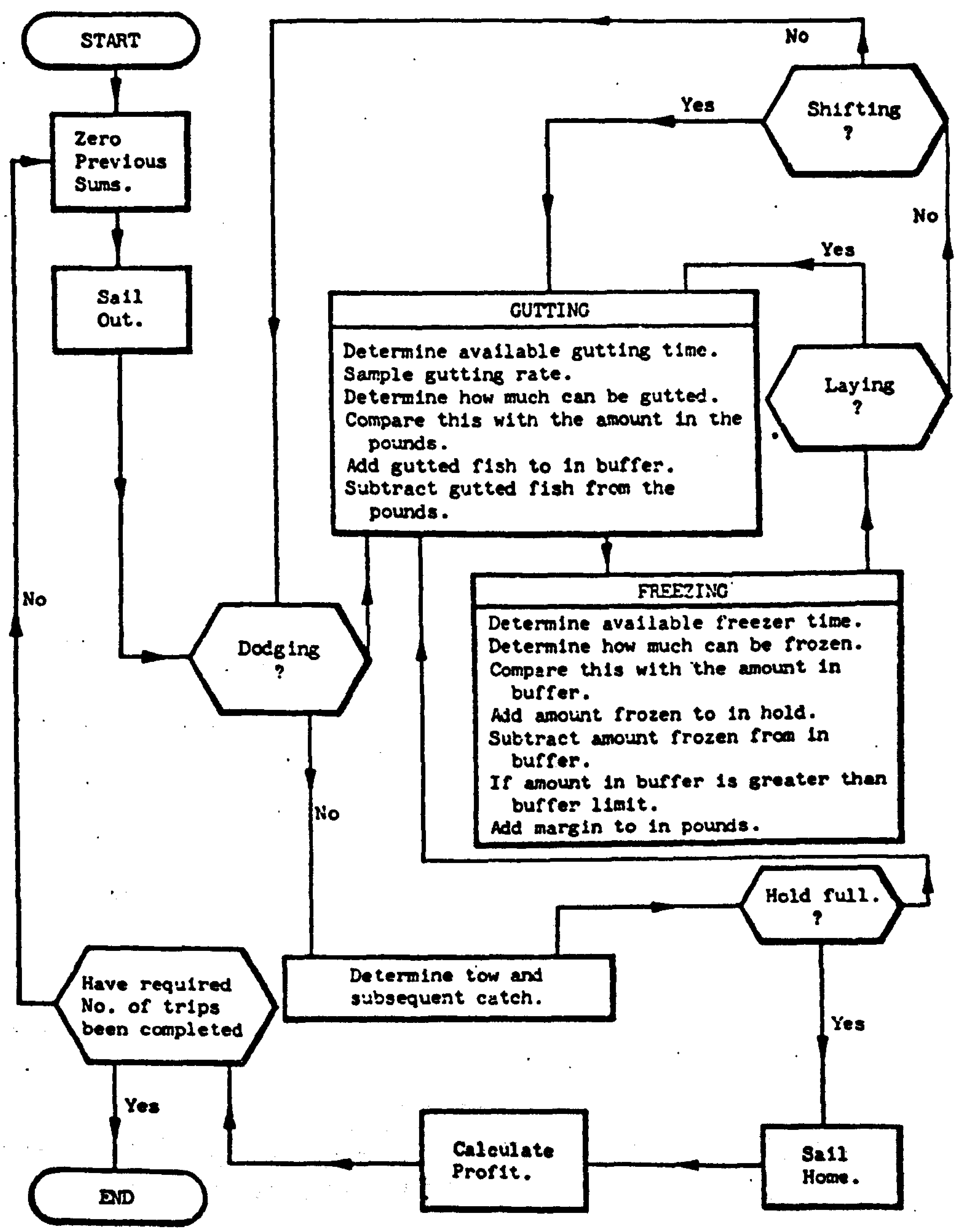
6.1 Fishing Vessels

The project on the design features of freezer trawlers was carried out by computer simulation technique (Section 5). In many cases, of this kind, it is not unusual for projects to borrow from previous experience and this is the case here. One of the first projects (40) (47) attempted in this manner was to determine the level of investment in freezing equipment on board freezer trawlers (Figs. 16 & 17). Outside the method of reviewing operational experience across a wide range of options, it is possible that this problem with its unique complexities could only be solved by computer simulation. Many of the ideas from this study have found their way into this higher level problem of determining the design parameters of freezer trawlers. However, for this problem a simple analytical approach is possible:-

If the average daily catch is C tonnes per day and the hold capacity of the trawler is H tonnes then the average number of days fishing on the ground for each trip $= \frac{H}{C}$.

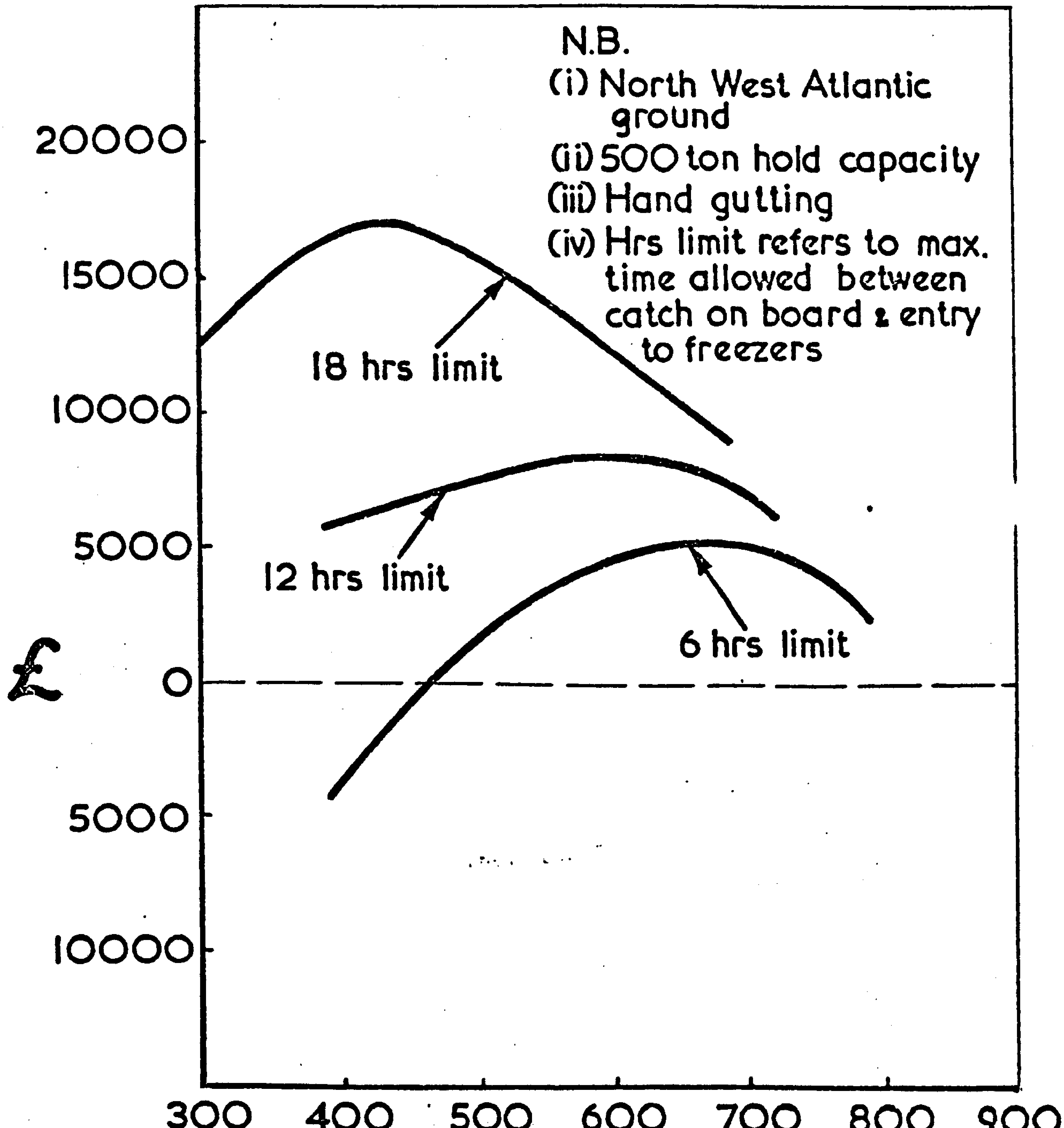
If S is the total travelling time of the trawler to and from the grounds and P is the proportion of time off in between trips then:

FREEZER THROUGHPUT SIMULATION FLOW DIAGRAM



Flow diagram of the computer simulation of the operations of a freezer trawler, which can be used to assist the choice of the freezing plant with the optimum throughput.

Fig. 16



Annual profit V freezer thro'put V time limit

Fig. 17

the number of days in port $= p\left(\frac{H}{C} + S\right)$

and the trawler cycle time from leaving port for one fishing trip to leaving again for the next $= (1+p)\left(\frac{H}{C} + S\right)$

If x is the number of days lost each year for overhauls and other outages then:

the number of trips each year $= \dfrac{365 - x}{(1+p)\left(\frac{H}{C} + S\right)} = N,$

the annual number of days fishing $= \dfrac{N.H}{C},$

the annual number of days travelling $= N.S.,$

the annual number of days in dock (crews leave) $= N.p\left(\frac{H}{C} + S\right),$

and the annual weight of fish landed $= N.H.$ tonnes

If the price realised for each tonne (£) = D, then the total annual revenue (£) $= N.H.D.$

The costs incurred may be related to fishing vessel activities and to the quantity of fish caught. If Q are the costs per day, Qd in dock, Qs for travelling, Qg for fishing, Qx for the outage period and K are the tonnage costs associated with handling, etc., then the annual profit (£)

$$= N.H.D. - N.p \left(\frac{H}{C} + S\right) Qd - SNQs - \frac{N.H.Qg}{C} - N.H.K - x\ Qx$$

$$= A_i, \text{ for any year } i.$$

The capital cost of a freezer trawler is related to its size and could be regarded as a function of its hold capacity and speed. The latter being inversely proportional to S, the travelling time of the vessel for a particular ground. These variables are not entirely independant but they are constant for a particular design.

If the capital cost of the vessel, $B = f(H,S)$ then the net present value of the investment:-

$$NPV = -B + \sum_{i=1}^{n} \frac{Ai}{(1+r)^{i}}$$

where r is the discounting rate.

6.1.1 Conclusions

The final judgement with respect to choice between alternative models would be related to the efficiency with which they can predict outcomes and in the case of this analytical model, the outcome is highly optimistic relative to the simulation model. The predicted performance of the top skipper in the simulation (Fig. 17) approximates to that of the medium skipper using the analytical model. If the role of the model is to give information on the relative profitability of the different vessel sizes, then both models will give the same information. It is a general case that in studies of this kind, the relative value of alternatives can be predicted more accurately than the absolute value. In terms of absolute value, the simulation will predict the vessel performance more accurately than the analytical model and it is not difficult to see why this is so.

The simulation by its sequential nature takes into consideration the delays, breakdowns and indirectly any dynamic queueing delays that take place in the system and so gets nearer to actual performance. The analytical method does not take these into consideration and it can be seen that with a hold capacity of 25,000 cubic feet or 500 tons and the catch rate of 15 tons per day for the medium skipper, the fishing time would be 33.3 days and with 10 days steaming the voyage length for a full hold is the same as that for a top skipper within the simulation.

There is a point in all studies where further analysis cannot be justified in terms of solution improvement but in this case, there were two additional points that had to be taken into consideration:-

a) Communications with the decision-maker. It is considered that a simulation provided a better vehicle for communications with the decision-maker showing how the technique follows the sequences of events as they happen in practice.

b) Availability of an existing model. The model was adopted from a previous model used to investigate freezing capacity and so minimised cost and used staff expertise and knowledge to its limit.

It is obvious from the considerations above that the choice of model will be selected on the basis of 'judgement' of the model-builder in a subjective manner and that the choice will depend upon his skill and knowledge of the working environment. This environment includes the decision-maker and there must be a consideration of his understanding and expectations of analysis.

6.2 National Fisheries Planning

The establishment of a national fisheries programme based on a dis-aggregation into regional plans has been developed (Section 3) using a linear programming technique. For the particular example, the sardine fishery of the Kingdom of Morocco, an alternative technique has been developed by Haywood (56) in association with Curr, Farstad and Page (41). This is based on a simulation of the sardine fishery from the seabed to the consumer (Fig. 4).

The computer simulation model was designed to reproduce the operations of the Moroccan sardine fishery as realistically as possible. The data collected (size, type and number of fishing vessels, catch rates, markets and so on) was used to represent the individual operations of the industry and the inter-relationships between them.

Fishing vessels arrive at the ports in accordance with specified arrival times. These were derived in the same way as the catch rates; that is either from actual data or projections based on that data, but representing a new operation.

On arrival of a vessel, the catch is unloaded at the appropriate unloading rate. For example, in the case of the traditional sardine fleet it is the measured rate of the current basket chain method operated by the crews.

The simulation also highlights delays which occur through queueing at fishmeal plants and canneries. This is important with respect to both product quality and yield.

The marketing information has been based on readily available data from the countries importing products from the Moroccan sardine industry. However, a certain amount of flexibility has been built into the simulation so that any detailed marketing study of the fishery in the future can be incorporated.

A market or range of markets may be specified for each product. These are categorised by product type, quantity, price and marketing cost. The integrated nature of the model ensures that the quantity scheduled for each market will be produced by the processing plants.

The computer simulation is also concerned with the financial information required for the economic evaluation of the alternative proposals for the structure and organisation of the sardine fishery. The whole range of revenues, capital and operating costs used in the simulation have been based on available data.

Several options have been evaluated and, although the list is not exhaustive, one option which promises good profitability is that of developing a fish meal and oil industry in Tan Tan, with transportation of fish by truck to canneries and freezing plants in the north. The fleet, under this option, contains a mixture of traditional vessels exploiting the stocks near to the port and larger steel purse seiners exploiting the stocks in the extreme south.

This option appears not only to be the best of those investigated, but in absolute terms, it appears to be a sound proposition with excellent potential. The solution is also compatible with two of the other requirements outlined by the Bureau National des Peches: that is a gradual build-up of labour and resources in the south and increasing the use of canneries in the north.

6.2.1 Conclusions

Simulation techniques can be extremely useful particularly in situations where key factors are subject to a high degree of variation such as in fishing activities and they may also be used to evaluate decision and logistic rules that might occur in practise. To some extent they also overcome some of the problems that arise through assumptions of linearity in techniques such as linear programming. However, one of the problems with the use of simulation techniques for solving problems at a national level is that the models become large and expensive to build and operate. This cost can be particularly high when the number of policy options to be investigated, perhaps in order to find an optimum, are numerous. The advantages of the simulation have to be considered with the cost and compared with the linear programming approach. Both techniques indicate the same direction for the development of the industry, i.e. the preferential exploitation of the southern stocks and the utilisation of processing plant in the north.

The relatively low level of complexity of the Morocco problem allowed a comparative investigation by both models but in the case of Mauritania (Section 3), a choice between techniques had to be taken.

The choice was to select the linear programming input-output model which deals only with the national problem in a relatively simple way to optimise the contribution to Gross National Product and use supplementary techniques such as queueing theory and VISICALC models to determine the capacity of individual facilities and evaluate the phasing of the investment programme. This was considered to be better than aggragating all the individual operations to form a national simulation model for the reasons stated above.

This emphasis, as in the previous comparison, that a standardised procedure for model selection is difficult and again subjective judgement, all depending upon circumstances, is exercised by the model builder.

6.3 Fleeting Operations

The comparison of techniques as considered for fishing vessels and national models is of importance but a further situation that is extremely important is the use of two techniques in conjunction with each other (48).

The difficulties in scheduling a fleet of trawlers arise from the extreme variability experienced in the environment in which they operate. The variation in catch rates and time delays in port, due to repair and maintenance, the effect of adverse weather on the actual transfer operation and on voyage times to and from the grounds, all contribute to the difficulties. In providing a practical method of managing the operation, the effects of all these variables must be estimated. The approach was to investigate the system using a linear programming model to obtain quickly such information as the optimum number of trawlers for a given set of restrictions together with the best possible schedule; this was followed by a simulation in which the effect of all the variables mentioned above was assessed. This second model was also used to evaluate the decision and logistic rules which would be applied in practice.

6.3.1 The Linear Programming Model

One complete cycle of operations for a trawler working in the fleet consisted of:

(1) Steaming time to and from the fishing grounds, 2s.

(2) Fishing time before transferring boxes of fish to a home-bound trawler, x.

(3) Further fishing time before receiving boxes of fish from a more recently arrived trawler or trawlers, y.

(4) Remaining fishing time until departure for home, z.

(5) Port turn round time, p.

According to working regulations, crews were allowed one tide in port for every eight tides at sea. The port time, p, was taken as $\frac{1}{8}(x + y + z + 2s)$. There were three basic time restrictions which determined the schedule. The age of the fish landed should not exceed a particular limit, Q. It then becomes obvious that

$$x+z \doteq Q-s \qquad (1)$$

$$y+z \doteq Q-s \qquad (2)$$

For the schedule to be maintained during successive voyages of all the boats, the cycle time must be an exact multiple of the interval between transfer operations. This multiple is simply the number of boats, N, and the relationship becomes

$$x+y+z+2s+p = Ny,$$

$$\text{or } 9(x+y+z+2s) = 8Ny.... \qquad (3)$$

The objective function to maximise is the total fishing time, x+y+z. This is now a mathematical model of the system and gives the general solutions.

$$Y = \frac{9(Q+s)}{8N-9}, \quad x+z=Q-s,$$

$$\text{for } N \geq \frac{9Q}{4(Q-s)}, \quad 0 \leq z \leq Q-s-y.$$

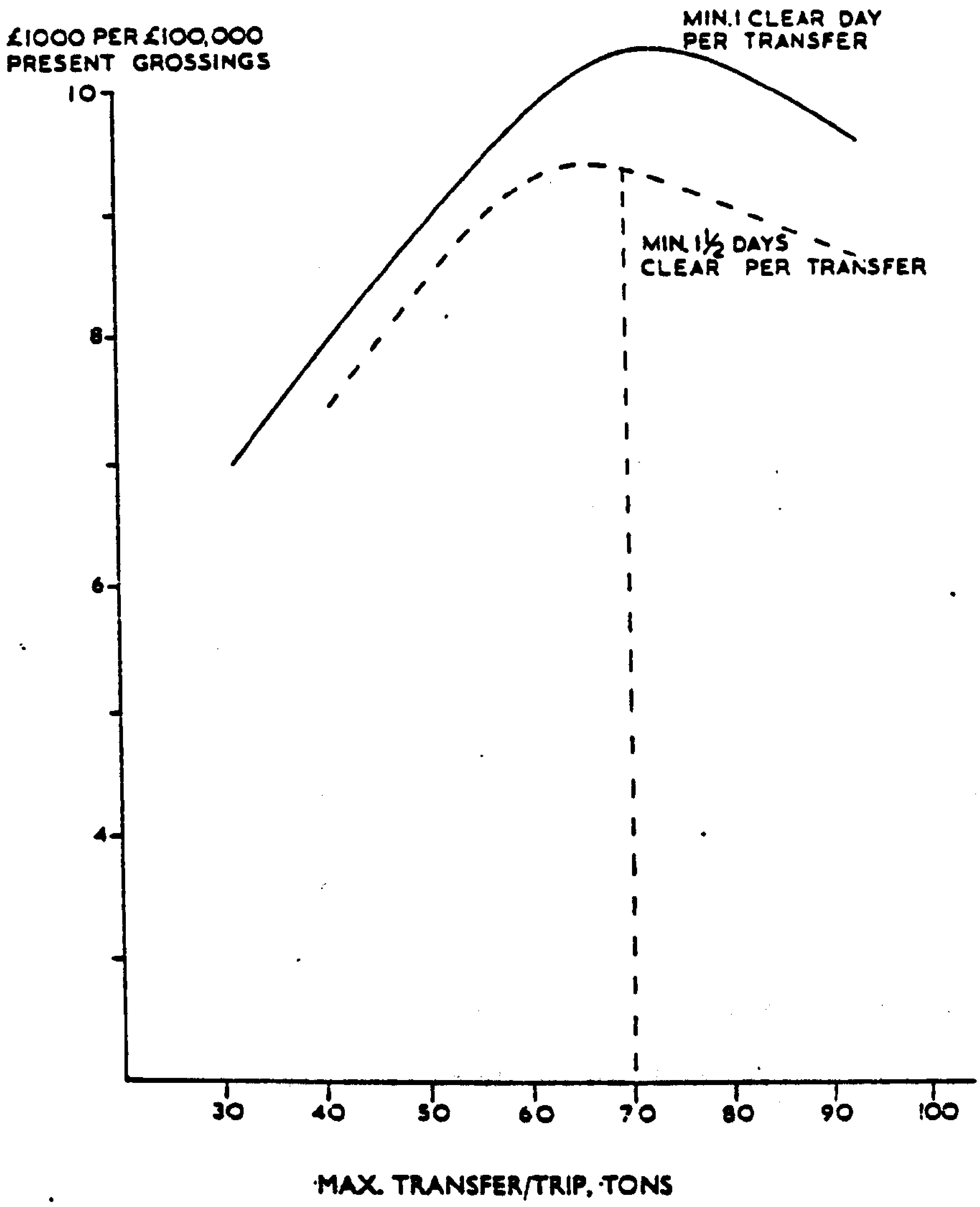
The initial task was to study the increase in fishing time that can be achieved. In one case the fish age limitation was retained at a level of 17 days on ice and the steaming time to the grounds 3.5 days. For this system the optimum fleet was three vessels and the fishing time maximised at 25.8 days for each trawler trip. This approximately doubled the fishing time for a conventional trip under the same conditions.

The linear programming model is extremely useful in the initial stages of solving the problem, but although the scheduling solutions obtained are optimal, they could never be achieved in practice because of the variations previously noted. The problem is not merely one of optimising fishing time but increasing the quantity of fish caught within set restrictions and solving logistic problems which arise in practice. A simulation model was constructed to investigate these using the minimal size of fleet of three trawlers.

6.3.2. The Simulation Model

The fleeting system was studied using a computer simulation. Account was taken of variability in steaming and port time and in the catch rate, factors likely to have a significant effect on the smooth operation of the system. The input to the programme gives all the essential numerical details, such as the size of vessel and maximum number of boxes available for transfer.

In the simulation each ship steams to the fishing grounds carrying empty boxes, the number of which determines the maximum amount of fish that can be transferred to another vessel during the voyage. The boxing capacity is assumed to be the same for all three boats, but the actual level is important, and has been studied in detail (Fig. 18).



Three ship fleet—estimated change in net profit per ship per year.

Fig. 18

On arrival at the fishing grounds, a boat will normally start fishing near another member of the fleet, which has already transferred part of its own catch. A boat which has previously transferred some of its own catch has first priority to become a 'receiver' boat, which must, if possible, collect fish from another boat before leaving the grounds.

In this case, the newly-arrived boat will start to fill its boxes, and will transfer to the receiver vessel,

either (a) when a time limit on the receiving vessel's voyage is imminent (i.e. storage limit of its own catch, or a previously agreed maximum voyage limit),

or (b) when the receiving vessel would be full up if all fish were transferred,

or (c) when the transferring vessel has filled all the boxes available for transfer.

Conditions (a) and (b) clearly carry top priority, but in case (c) transfer must still take place as soon as possible, so that a new receiver vessel is made available, enabling the chain of operations to continue smoothly.

It may be necessary to shorten the receiver's voyage to satisfy the storage limit of fish transferred on board, but in no case is a voyage cut below the duration of a conventional trip to the same fishing ground.

When the transfer is governed by time restrictions as in (a) above the actual operation is scheduled to take place a day before this time limit is reached, in order to allow for bad weather. The effect of allowing an extra half-day has also been studied.

When the most recently arrived boat finds it impossible to transfer any of its own boxes of fish, this may be for two reasons,

(a) no receiver available, or

(b) the only available receiver would have to cut its voyage by an unacceptable amount in order to land the transferred fish in a fresh condition.

With only three boats, (a) would be the most likely reason.

In this case, the boat would continue fishing. A transfer might then take place if another vessel arrived before its own departure. However, the receiving vessel would still have all of its own boxes on board, and might find it difficult to accommodate an equal number of extra boxes in present circumstances, because the trawlers' holds are not equipped to carry a full cargo of boxed fish.

In the rare case of two boats arriving simultaneously at the fishing grounds, with the third vessel elsewhere, a transfer operation would be arranged by agreement between the skippers concerned, enabling one of them to remain as a receiver.

Other situations may develop, which are unlikely for a fleet of three boats but may become important for four or more.

(c) Two or more boats competing to transfer to one or more receiver vessels. The rule here is that the receiver due to leave the grounds earliest is paired with the transferring vessel that has been longest on the grounds.

(d) Two or more receiver vessels competing to receive fish from a single boat, the receiver first due to leave has priority, any remaining boxes being transferred to the second receiver. (In a fleet of three boats fishing Iceland, a member rarely has the opportunity of transferring to both the other boats during a trip.)

It will be seen that the system will adapt to any situation, in order to make the most of opportunities for transfer.

There is a shortage of precise data on the occurrence of bad weather on the fishing grounds considered, and for these reasons it was not possible to simulate weather conditions in the model, but an examination of data covering 100 fishing voyages to Iceland during the months April to September showed that the proportion of time when either bad weather or breakdowns lasted for more than 24 hours was only 1.2%. It was therefore considered that a reasonable approach in the model, erring on the pessimistic side, would be to schedule all transfer operations to take place at least 24 hours before the receiving ship is due to leave for home. Although this allowance will be exceeded on occasion it will nearly always suffice and in practice, when the weather had obviously set fine, the skippers would time the transfer for minimum interference with fishing.

This problem was extremely interesting as it was known from the outset that the probability of implementation was high particularly in terms of operating a fleet of vessels for a short period off the coast of Iceland.

The objectives are stated above but the important point with respect to techniques arises from the conjoint use of two of them as distinct from a selection of one.

The scheduling depended heavily on queueing problems which might arise from trawlers having to wait to transfer fish at sea. However, to consider the dynamic queueing aspects immediately within the total problem area presented complications that in the first instance were suppressed. The optimal solution was then found and with regard to implementation, the important combination to discover was the minimum number of trawlers required. The problem for the model is to discriminate between the discrete options thus enabling a choice to be made and in this case, it was possible. The simulation was then used to estimate interference of queueing in the schedule and while the number of vessels required did not change, it was shown that the increase in productivity was not the 100% indicated by the linear programming model but closer to 10% forecast by the simulation.

This is a classic case of a situation where a compromise between analytic and simulation approaches are useful. The analytic solution cuts the problem down to an area that is easier to contend with and the simulation supports the analytical model in the area of the optimal solution.

7 - CRITERIA FOR INVESTMENT

7. CRITERIA FOR INVESTMENT

It has been stated previously (Section 6) that the essence of management decision-making arises from the existance of alternative courses of action with a choice to be made from them. The selection of criteria presents the problem of identifying the consequences of management decisions in terms of which, the alternative actions may be evaluated.

The basic problems arise from the following:

a) The need to reconcile conflicting objectives arising from different decision makers to produce a solution acceptable to all of them. A clear example of this is where the decision-makers are entrepreneural and governmental (Section 4).

b) The need to incorporate all the conflicting consequences of the investment decisions for a single decision-maker into an acceptable criterion (Section 5).

c) The need to take into consideration all the risk factors.

The hierarchical nature of decision-making in fisheries development has been identified on three levels i.e., national level, company or equivalent level and the individual operations level.

7.1 National Level

The objectives of government have been stressed throughout this work (Fig. 1) but may be expanded to include all the following:

a) Contribution to Gross National Product

This can be measured by the total Value Added contributed by the fisheries.

b) Contribution to Total Employment

This includes both direct and indirect employment. In order to resolve the conflict arising for competing skills, discrimination between the levels of labour must be identified.

c) Protein Contribution.

Where a fishery is primarily intended to supply the internal market, its impact on the nutritional status of the country or region should be shown, with proper emphasis on the special significance of the contribution of fish protein to diets. In some instances it may be possible to make comparisons of relative costs of protein from other sources.

d) Foreign Exchange

Fisheries development will necessitate foreign exchange costs in the form of vessels, engines, plant, fuel, synthetic yarns, etc. The foreign exchange earnings of the project will depend upon the extent of fish and fish products exported plus savings of foreign exchange from import substitution. In most cases estimates of all the costs and revenues in this area may be made without too much difficulty and a foreign exchange balance presented.

e) Regional Development

One of the most important features of small-scale fisheries in the potential contribution to regional development. The locations of these fisheries are often in coastal areas of relatively low economic development, and governments look to the fisheries sector for opportunities to develop such backward regions. Where this is the case the impact, including indirect effects on regional employment and incomes, can be extremely important.

f) Re-distribution of Income

Given the marked income disparities in many developing countries, and the tendency for these to increase rather than diminish, many governments prefer to promote public sector projects which tend to improve incomes of marginal elements rather than create opportunities for entrepreneurs in industrial-scale operations. Small-scale fisheries would certainly qualify for such projects.

g) Indirect, Secondary and Other Benefits and Costs

Indirect effects are costs and benefits deriving from the existence and operation of fisheries which accrue to other sectors or enterprises. They are generally known as 'spillover effects' or backward-and-forward linkages and must be considered as a contribution. Typical examples are opportunities in boat-building and repairing, gear manufacture, processing industries and equipment supplies.

Development of a fishery will directly or indirectly generate income and employment. This will have a beneficial effect upon national income and growth, both through its immediate effects, and through the spending and savings patterns of the primary recipients, which generate further growth and employment through the rest of the economy. These multiplier effects are very difficult to ascertain but must be regarded as important in generally improving the economy, particularly of the marine coastal population.

The criteria arising from these objectives are mainly self-evident but it is important to examine the concepts of value added, its relationship with Gross National Product and also economic and financial rates of return. These issues have been considered by Engstrom (1) and Campleman (41).

7.1.1 Financial Rate of Return

The cash flow estimates, apart from expressing the financial liquidity of the project, form the basis for the calculation of the financial profitability. This, in turn , is used to measure the absolute (whether to reject or accept a project), as well as the relative (whether Project A is better than Project B, etc.) profitability of a project. The most commonly used indicator of financial profitability used by international development banks is the financial rate of return. This is the rate at which the present value (this calculation implies use of a discounting technique which takes into account that a unit of money earned in the future is worth less than a unit of money earned today) of future operational cash surpluses equals the cost of the investment. When a project is said to have a return of, for example, 20 per cent, it usually means that the average earning power of the money used over the project's life period is 20 per cent. This is the same as saying that the project could afford to pay up to 20 per cent interest on capital (if all capital required were borrowed) and still break even.

7.1.2 Economic Rate of Return

The same discounting cash flow technique that is used for the financial rate of return can also be used to calculate the return to the national economy of a project. While the financial calculations are based on prices of goods and services on the open market, economic calculations are (at least in principle) based on social opportunity costs (or the value to the economy of employing a unit of a certain resource in the best alternative usage). In developed and diversified economies with almost perfect competition, market prices usually do not differ much from the social opportunity costs. In developing economies, however, "imperfections" in the market (price controls, monopoly elements, import restrictions, minimum wage laws, subsidies in credit systems, etc.) tend to make market prices less suitable as guides for resource allocation. This tendency is also aggravated by the custom of levying taxes on certain goods. These taxes are measures used by the governments to transfer resources from one sector of the economy to another. To overcome the deficiencies of market prices in relation to allocation of capital resources for development purposes, some central planning agencies and development banks have introduced the concept of "shadow prices" in project evaluation.

The calculation of shadow prices is a cumbersome and costly undertaking. Therefore, for typical fisheries projects it is hardly worthwhile going into the process of producing shadow prices of most of the goods and services employed. For the calculation of Economic Rate of Return it is usually sufficient to use market prices and make the following adjustments:

a) Deduct government taxes and duties included in market prices for major cost items (vessels, gear, plant machinery, fuel, electricity, etc.);

b) Add subsidies paid by the government to promote fish consumption (consumer price subsidies, subsidies for ice production, subsidies for inland transportation, etc.);

c) Recalculate the cost of imported goods and revenues of exported goods;

d) Recalculate the cost of capital;

e) While it is often maintained that shadow prices should be employed for labour used in fishery projects, there seem to be widely differing opinions on how to construct these prices. The argument that the labour costs should be zero, which implies that the value of the alternative production is nil, does not seem to coincide well with the conditions of such projects, which are dependent upon the availability of trained personnel (skippers, engineers, service staff, accountants, etc.). It appears that from the comparatively few cases where shadow prices for labour have been employed in fisheries projects, these shadow prices have been applied only for the unskilled personnel and at rates somewhat lower than the going wage rate.

7.1.3 Value Added

As a complementary measure to Economic Rate of Return, "Value Added" is particularly useful for comparing the impact on the national economy of alternative projects. For each enterprise,value added is defined as the sales value of its produced goods and services less the cost of material and services purchased from outside domestic or foreign sources. Value added may also be defined as what is left over in the production process for the payment of taxes, wages, salaries, interest and dividends. When the value added calculations are extended to include value added created in an enterprise other than the enterprise or project under study, it will embrace the secondary and tertiary effects mentioned above. A fish canning project which has considerable backward linkages (e.g. local construction of fishing vessels and gear) and forward linkages (e.g. distributing and marketing of canned fish) will thus have a large value added component in comparison with an alternative project (e.g. a fish meal industry) which relies heavily on imported equipment and which offers few opportunities for employment of labour in marketing.

For calculation of the national value added of a project (and this principle also applies to the costs and benefits included in the calculation of Economic Rate of Return), care should be taken to include only those net incremental values that are created. Thus, for example, if the effects of a new fishery harbour project at A are evaluated, care should be taken not to attribute to this project the value added that is being created already in another project at B (assuming that project A aims at attracting some of the catches that are landed at B). As another example, when considering the expansion of fishing effort in a fishery which is close to being fully exploited biologically (the introduction of new vessels is thus likely to reduce average catches of existing vessels), care should be taken to deduct the loss in value added incurred by the existing fishery from the value added created by the new project.

7.2 Criteria Relating to Companies or Individuals

The criterion of interest to individuals and companies are much the same. The main difference is that companies are usually involved in a wider range of operations than individuals and these may extend to include vertically integrated operations ranging from fishing through processing to marketing.

The use of Discounted Cash Flow (DCF) techniques are often alien to this area of business, but because of aid programmes involving grants and subsidies, there is a need to develop this kind of analysis in these situations. The accounts of an enterprise are prepared by different principles to those of DCF, trying to match income and expenditure, and writing off the original cost of the fixed assets by means of depreciation changes. Both methods have considerable importance with respect to determining the productivity of entrepreneurial enterprise.

Another popular criterion is pay-back period.

This indicator measures the number of years required for the project to recover, from net annual revenues, the capital invested in the project, Strictly speaking therefore it does not measure the profitability or attractiveness of the project, since it takes no account of revenues arising after the capital recovery period, nor of the time pattern of revenues.

However, it is quite widely used in business, and many investment decisions are based upon it. Risk and uncertainty have to be taken into account and the longer the period, the greater the risk. In these circumstances, a knowledge of the time span that the original investment is at risk will be a significant factor in the decision, even though it has to be supplemented with other measures of project worth. The method is widely used by firms in potentially risky situations, particularly in cases of investment overseas where political uncertainties tend to be large, where technological progress makes the risk of obsolescence rather large, or where other competitors' reactions, say to the introduction of a new product, will much reduce the early profitability of a project.

It clearly falls into the category of risk analysis rather than as a measure of project worth, but provided its limitations are understood, it is a useful piece of information to appear in a project formulation report, particularly if modified as suggested in the next section.

Having regard to the high risk nature of fisheries projects, it is felt to be particularly appropriate to those situations where the future of the resource is in some doubt, or for instance, in a relatively new international fishery where the size and speed of foreign intervention is hard to forecast. In such a situation it is of great assistance to know whether, on present yields per vessel, the project will recover its capital quickly before competitors can appear in force or not.

7.3 Conclusions

It is inconceivable that a decision-maker would consider a single criterion adequate for his needs whether he operated at government or company level as none are valid under all circumstances and in addition, it is unlikely that one would give all the information that was required. There will be lists of criteria and these will be ranked in a particular order of importance for each decision-maker.

It can be seen in earlier sections of the thesis that the lists of criteria will not be different for governmental or entrepreneurial decision-makers although the ranking will change. The reasons for this are clear:-

a) At government level the main pre-occupation will be with contribution to GNP, provision of protein and employment but in addition the government must seriously consider those aspects of the project that contribute to profitability in order to attract capital and support from entrepreneurs or development banks.

b) Conversely, the entrepreneurial emphasis will be on profit but in order to make a proposal that is attractive to a government, they will have to consider how far they are prepared to go in providing employment, protein and the level of contribution to GNP.

The reconciliation of conflicting objectives arising from the requirement of different decision-makers with respect to the same problem has been considered in depth (Section 4) and the interesting point is that hardware, models and criteria can be organised to satisfy this complicated situation. The important additional aspect is that the model builder and decision-makers can meet in this situation and come to a decision that is acceptable to all.

The conflicting consequences for a single decision-maker present just as difficult a problem as the previous example and requires a clear understanding of the relationship between criteria and constraints. Constraints operate to reduce the decision-making area to a point where a criteria can be used to make a choice and one aspect of this is that they can be interchanged. This can be seen in the case of the linear programming input-output model.

In view of the requirement for an almost identical list of criteria for all decision-makers in the hierarchical structure, an ordered standard procedure can be recommended:-

a) Calculate the labour and capital productivity of a project, its value added and hence its contribution to GNP.

b) Calculate the financial rate of return.

c) Calculate the economic rate of return.

d) Determine the additional economic advantages and spin-offs.

Some control procedure should form part of this sequence allowing a review of the list with possible changes in the data or assumptions made and subsequent re-calculations.

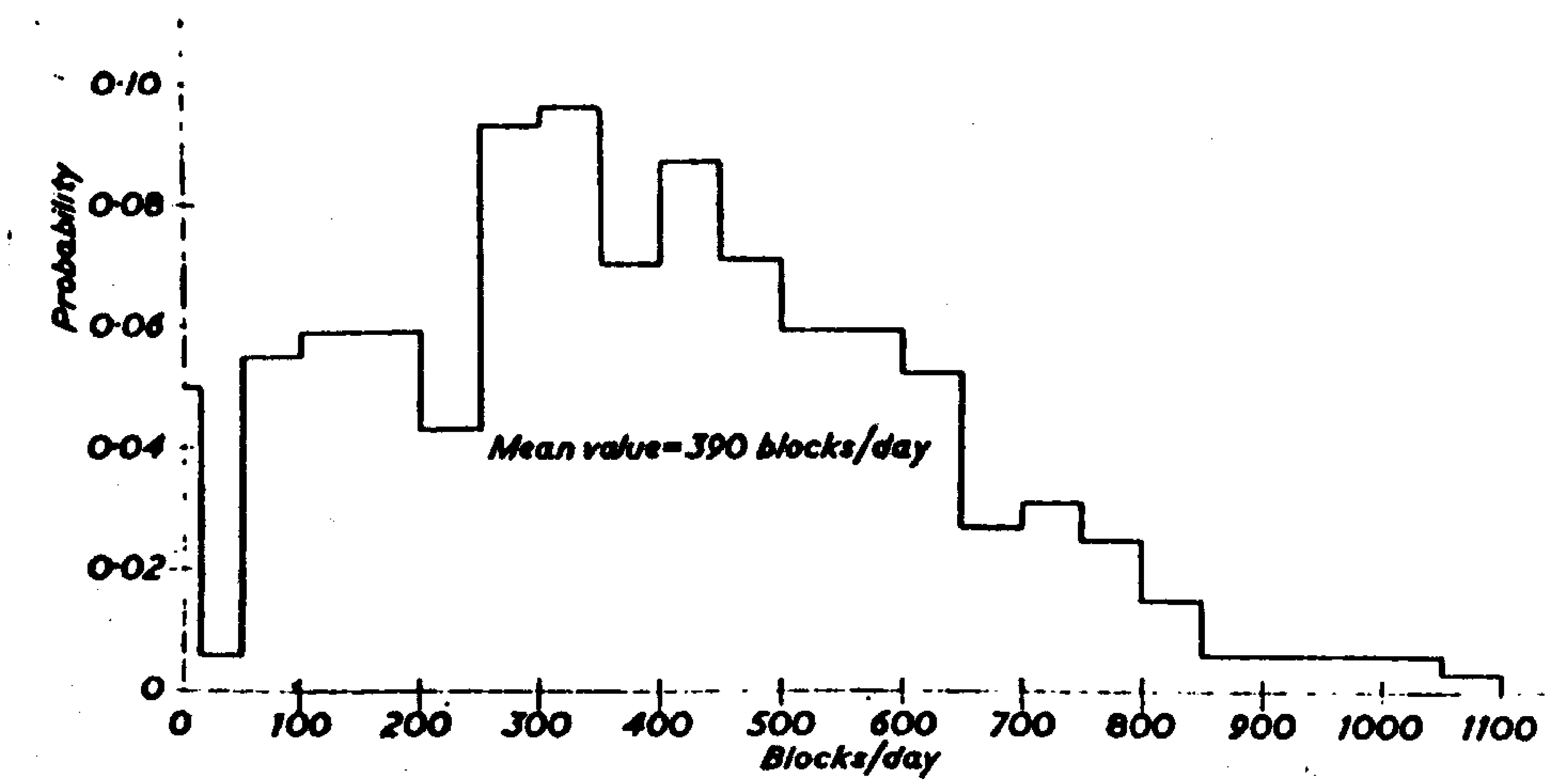
8 - UNCERTAINTY AND IMPLEMENTATION

8. UNCERTAINTY AND IMPLEMENTATION

It is incongruous to deal only with outcomes of deterministic situations in fisheries. Assumptions have been made, in the previous sections, regarding certain features of fisheries but most of these have a degree, often a high degree, of uncertainty associated with them. Combinations of these may give rise to aggregated uncertainties which if disregarded could invalidate the conclusions drawn.

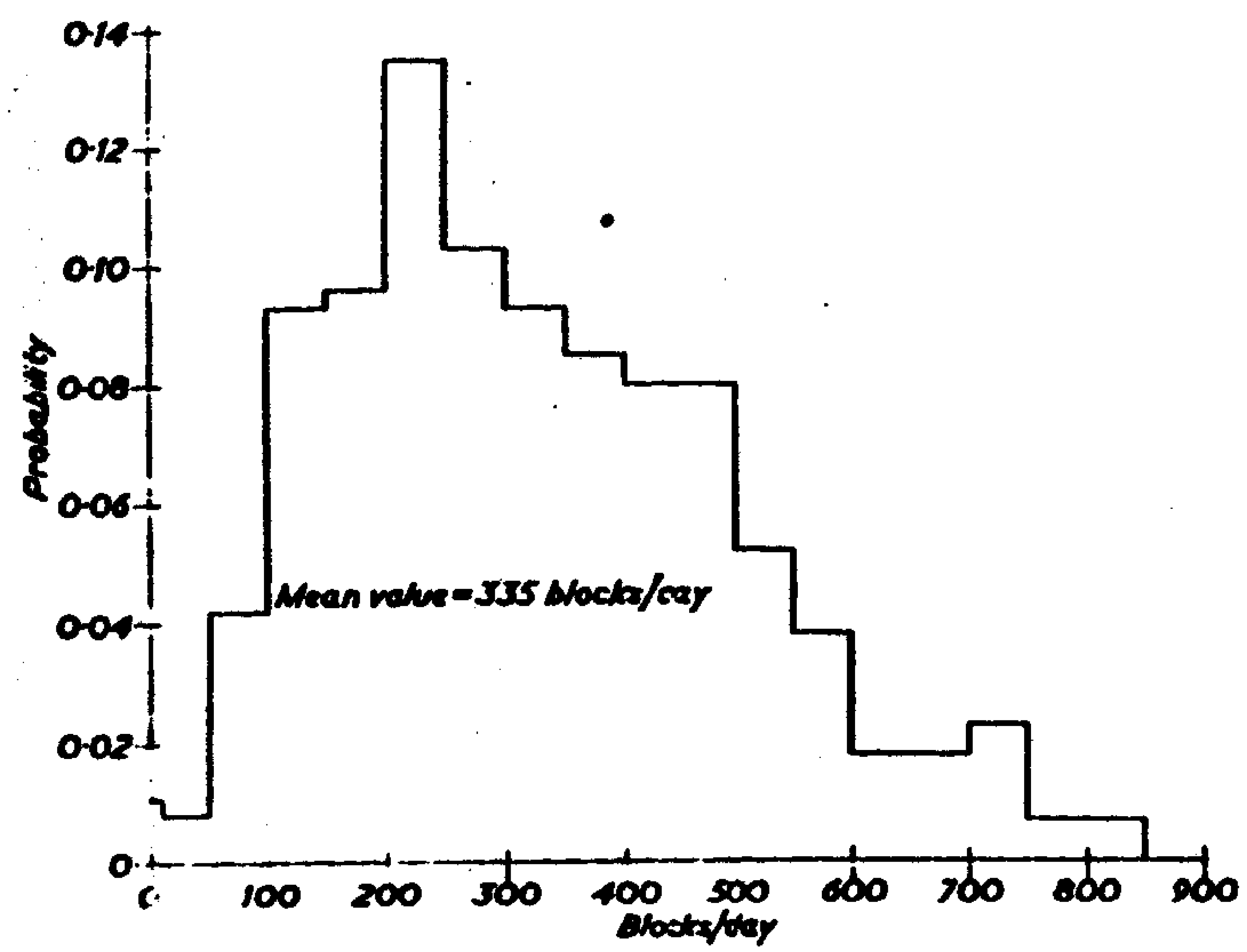
8.1 Freezer Trawler Study

There are two forms of uncertainty (42), strict uncertainty where the value of a variable is probabalistic and the distribution is unkown, this form was evident when the freezer trawler study (Section 5) was required to predict a five-fold increase in the price of oil in 1973/74 or the exclusion of these vessels from their traditional fishing grounds in 1976/77, and, risk where the value of a variable is also probabalistic but known. Risk distributions may be devised from historical records. Histograms (Figs. 19, 20 & 21) of catch rates can be constructed from the logs of fishing vessels although there is still the problem of relating these catches to future distributions.



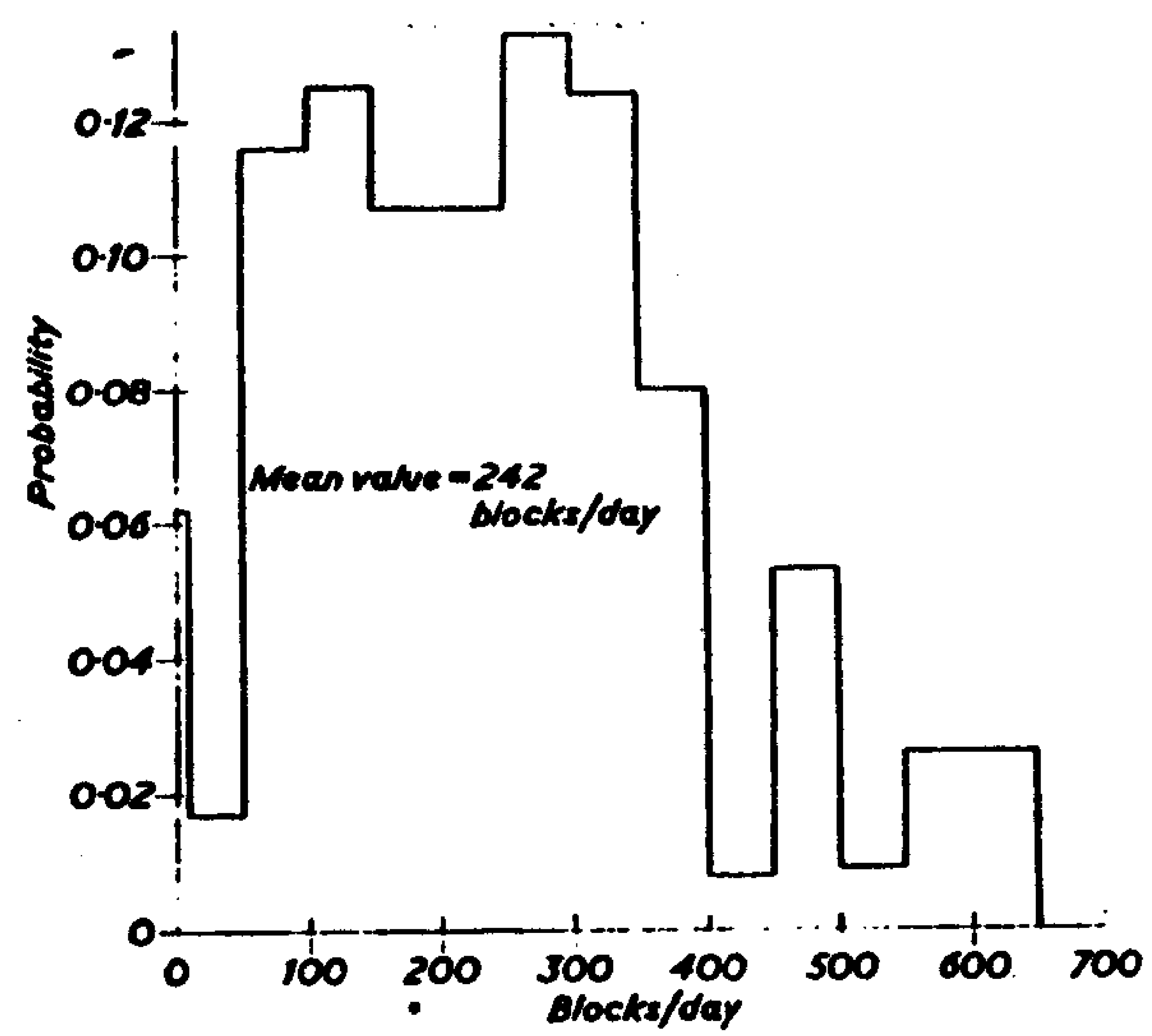
Catch rate distribution for top skippers

Fig. 19



Catch rate distribution for average skippers

Fig. 20



Catch rate distribution for below average skipper

Fig. 21

There is a need to examine the difficulties of representing this uncertainty in some formal manner and the determination of relevant criteria for assessing alternatives under different conditions. The work on the freezer trawler (Section 5) is ideal for this purpose for the following reasons:

a) It exhibits most of the facets of uncertainty that are inherent in fisheries.

b) It raises the question of closed or open models. A closed model where a prescriptive solution would result in a particular vessel specification being declared as the optimum or an open model where the decision-maker, in this case the trawler owner, would choose from a range of options provided by the model.

c) It attempts a study of human performance in terms of the effect of the management efficiency (skipper ability) and the technological parameters of design which constitute the investment decision.

d) The study was completed in 1969 giving the opportunity to examine the problems of prior and posterior validation of alternative investment decisions.

Within this problem area, the decision-maker, i.e. the trawler owner, faces a complex task when deciding the main characteristics of a new vessel. He has a choice of propulsive power, (speed), fuel endurance, hold capacity, throughput capacity of freezing plant and also certain product and processing plant considerations. Some method of reducing risk at the time when new vessels are being planned and before large capital sums are committed is obviously desirable. Risk has been treated (Section 5) by drawing up a multivariate distribution of cash flows emanating in future time periods from all the alternatives and reducing his multivariate distribution to a univariate distribution of net present value (NPV) and internal rate of return (IRR) by the use of simulation.

Some ranking has taken place and the problem has been reduced to a three-dimensional one involving skipper ability, hold capacity and speed.

Of these three variables, it is clear (Fig. 7) that the most important is the ability of the skipper. This fact is well known and traditionally, there is a relationship between a skipper's performance, his tenure of command and the vessel that he is given. This study provides additional information on the magnitude of the differences, in NPV and IRR, for different vessel designs. If a vessel is considered as a single investment opportunity, the risk can be reduced by securing the services of an appropriate skipper. However, the problem is more complex at a multiple vessel investment or company level where the transfer of a skipper or skippers from other vessel or vessels could adversely affect the productivity of other operations. There remains the alternatives of securing the services of top skippers either from a competing company or investigating the advantages of a training scheme. Studies of this kind do allow a consideration of the finance that might become available for these alternative policies.

With regard to the vessel parameters, it would appear that a low speed vessel is desirable. The differences in NPV, particularly for the better skippers (Table 10) are small indicating that the increase in gross earnings due to an increase in speed is balanced by the increased fuel costs. The difference in NPV can be closely related to the difference in capital costs of the respective vessels for the average skipper performance.

It is obvious from the results (Fig. 7) that from a consideration of vessel parameters alone, the size or hold capacity of the vessel makes the greatest contribution to the variation in NPV. It appears that within the framework of assumptions made, particularly the one regarding the acquisition of a skipper of average or greater ability that the vessels will be profitable. The difference between the means is significant within the context of a variance created by repeated runs of the simulation model but there are many other factors to be taken into consideration including the whole question of the relationship of the model with the real world. Certain operational activities have been deliberately excluded from the model such as occasional salvage operations and breakdowns. The probability of the occurrence of these events is not known, would not affect the magnitude of the results significantly but do contribute to the difference between the model and the real world.

The model contains no formalised approach to fish population dynamics as this is outside the scope of this thesis but the catch rates of the vessels and their potential variability over a 16 year period are extremely important and constitute one of the major contributions to risk. It could be argued that the three levels of catch attributed to the skippers constitute a simplistic approach to this problem, i.e., the use of optimistic but credible series of estimates are represented by the top skippers and the other end of the scale credible but pessimistic are represented by the below average skippers with the average skippers in between.

However, a decline in catch rate for say the top skippers down to the lowest level in the early years of the investment then the prospects are poor. It is unfortunate that in these circumstances the likelihood function of future catch rates is not known and this is perhaps the major reason why this particular model in this situation must remain an open one and be advisory in character rather than prescriptive.

A lack of knowledge in other areas also emphasise this conclusion.

8.1.1 Implementation

It has been proposed that implementation is the only real test of the validity of solutions, i.e. the actual performance can be compared with predicted results. However this is not always the case:-

a) Testing for optimality falls down when only one solution is actually implemented. This was almost the case with the freezer trawler model as they generally fell into only two size categories. Initially a few were designed with hold capacities of 20,000 cu. ft. but the majority were designed with capacities of 27,000 cu. ft.

The annual average profit for the sample of the larger vessels over a period of six years from 1968 to 1974 was £53,000 and the model predictions ranged from £24,295 for the poor skipper to £91,289 for the good skipper. For the vessels at 20,000 cu. ft. the annual average profit was £2,000 and the model predictions ranged between £20,000 and £79,000.

It was generally expected that the simulation would be optimistic in its predictions mainly due to the assumption that vessels would fill their holds or fish to the limit of their endurance before returning to the home port. The relative performance of vessels was predicted correctly and it is remarkable that the absolute predictions of performance were so close for the 27,000 cu. ft. vessel. The prediction for the 20,000 cu. ft. vessel were optimistic and the reason for this was the decline in catch over two bad years, 1973 and 1974 when hold capacity utilisation was about 50%. This obviously had a greater effect on the smallest vessels.

b) There is always the possibility that implementation will not be carried out as the model approach might suggest or recommend and in the case of the freezer trawler, engineering and technological development is a continuous process and capital improvements take place all the time.

It is obvious from the comparison above that this has not had a great effect.

c) Other factors might change to invalidate the computer simulation predictions and mention has been made previously of exclusion from fishing grounds and massive increase in fuel costs. A decision to invest immediately before these events could be ruinous.

8.1.2 Conclusions

The conclusions must be that fishing companies in the United Kingdom made investment decisions in a way that could be regarded as sound and rational. After the initial investment in the smaller vessels which added to their experience and knowhow, they took advantage of the economies of scale but settled mainly for a hold capacity of 27,000 cu. ft. There were few exceptions in excess of this because of the problem of declining catch rates and a desirability to hold voyages to a particular limit. This limit was linked with availability of crews.

The decision-makers, i.e. trawler owners were able to cope very well with risk of the first kind but neither the model nor they could be expected to handle the problems of strict uncertainty that later arose from the massive problems that changes in government policy placed upon them.

8.2 The Scheduling of Trawlers in a Fleeting System

The problems of this project (Section 6) were associated with risk rather than strict uncertainty but the factors contributing to the risk were numerous and included:-

a) catch rates
b) cycle times arising from fishing time, travelling time and time in port
c) queueing times arising from problems in transferring fish and also scheduling
d) marketing problems affecting the auction prices and in turn the schedule plans.

It is important to consider how these factors affected the model predictions and also the actual performance.

8.2.1. Implementation

On the basis of the results from the simulation, it was decided to test the fleeting system on the fishing grounds off Iceland.

The fleet consisted of the three vessels, the details of which are given (Table 16).

Table 16

TRANSFER AT SEA VESSELS

	Length Overall Ft.	Gross Tonnage	Year Built	Fishroom Capacity Ft^3	Crew	Endurance Days
St. Andronicus	170	576	1951	12640	19	27
St. Achilleus	170	576	1951	12640	19	27
St. Apollo	182	658	1948	15270	19	27

All the vessels were traditional side trawlers making 21 day voyages from Hull to the distant water grounds and normally bringing back between 60 and 120 tons of fish stowed in melting ice.

It was shown that the optimum quantity of fish for transfer was about 70 ton (Fig.18) but because the rates of transfer could only be estimated and the crews were unfamiliar with the technique, it was decided to reduce the quantity initially to a maximum of 35 ton and increase it only as experience was gained.

In the summer of 1968 there was a glut of fish on almost every day of landing. Consequently, only top quality fish was being sold at the auctions and large quantities of fish were being sent for reduction to fishmeal. In these circumstances the decision was taken to operate the fleeting system so as to bring back fresher fish on voyages of the same total duration as before.

A single trial was carried out first off North Cape, Iceland using the St. Andronicus and St. Achilleus and transferring 200 boxes. The full fleeting plan started operating the following month, and terminated in September (Table 17 and Fig.22). During this period nine out of a possible eleven transfers were successfully accomplished. Of the two missed transfers one was caused by mechanical breakdown and the other by one vessel filling up her hold before the other had time to catch a significant quantity of fish.

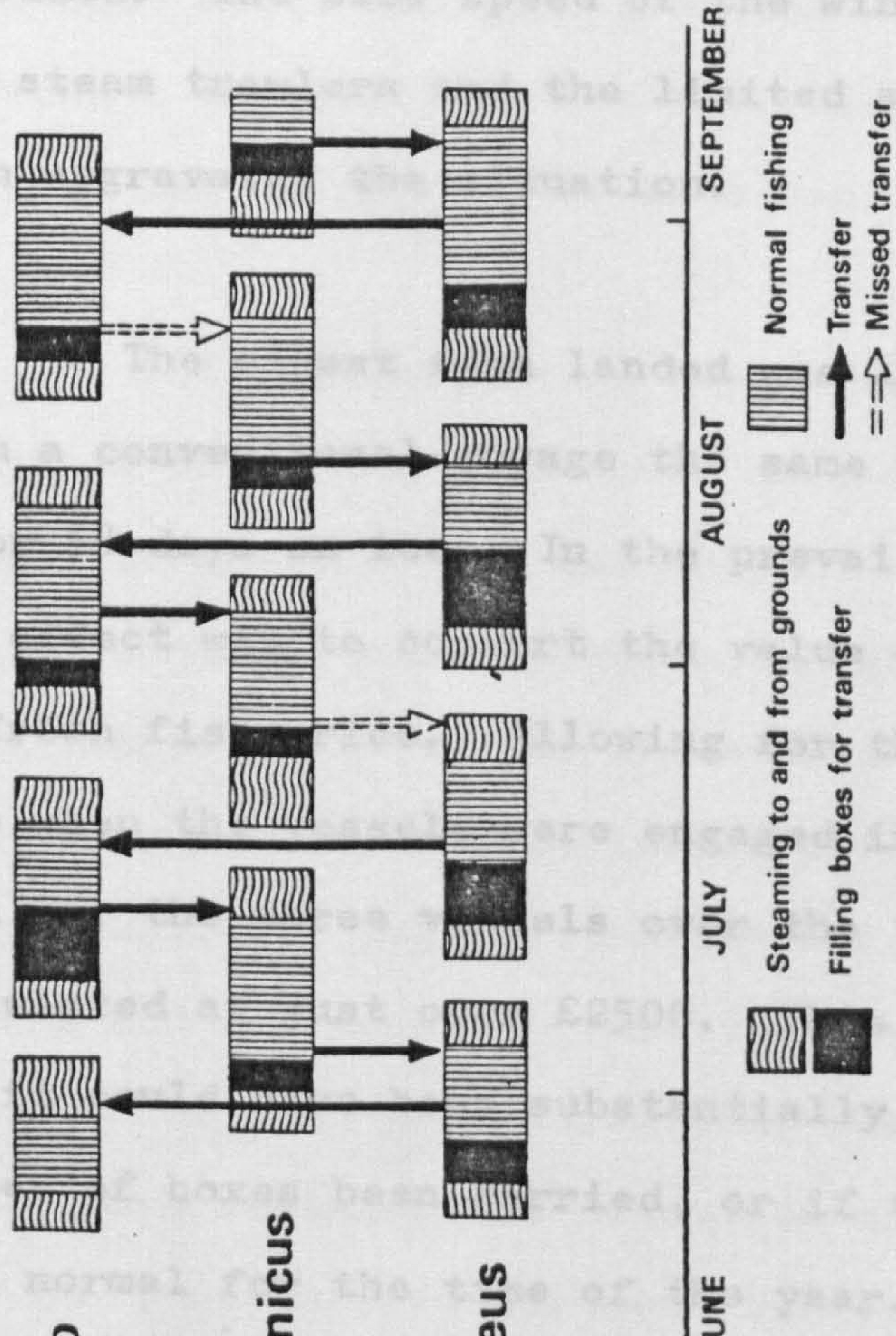
The vessels transferred fish on ten occasions, including the first trial, in open water off Iceland and in a range of weather conditions from Beaufort forces 0 to 7. The worst condition for berthing, however, was Beaufort Force 5, and it is suggested that this is the upper safe limit. Under these conditions, with due caution on the part of the skippers, the chance of severe damage occurring is extremely remote, but some risk of superficial damage to the ship's superstructure, rails and bulwarks will always remain. Some minor damage to the forecastle occurred on thre occasions. In many cases the skippers and crews were performing the operation for the first time.

A disappointing feature of the trials was the poor rate of transfer. This was a maximum of 138 boxes/hour (5.5 ton/hour) and an average of 98 boxes/hour (4.0 ton/hour) which was well below the rate predicted from earlier trials

Details of transfers

Transfer	Vessel	Date of transfer 1968	Location	Weather	Wind force Beaufort scale	Total time alongside hours	Boxes transferred (each containing approx. 100 lb of fish)	Average transfer rate (boxes/hour) discounting stoppages
1	*St. Achilleus* *St. Apollo*	29·6	S.E. Iceland	Heavy rain moderate swell	3/7	11·0	395	65–80
2	*St. Andronicus* *St. Achilleus*	3/4·7	S.E. Iceland	Low swell	3	10·7	500	50–90
3	*St. Appollo* *St. Andronicus*	13·7	S.E. Iceland	Low swell	1	10·3	587	70–90
4	*St. Achilleus* *St. Apollo*	18·7	S.E. Iceland	Calm	2	7·0	587	98
5	*St. Apollo* *St. Andronicus*	3/4·8	S.E. Iceland	Heavy swell	3/5	4·3	314	80
6	*St. Achilleus* *St. Apollo*	8·8	S.E. Iceland	Low swell	2/3	9·8	650	88
7	*St. Andronicus* *St. Achilleus*	15·8	N.W. Iceland	Heavy swell	2/3	6·0	226	No data
8	*St. Achilleus* *St. Apollo*	1·9	N.W. Iceland	No data	No data	5·0	310	90–100
9	*St. Andronicus* *St. Achilleus*	8·9	N.W. Iceland	Very heavy swell	5	5·0	370	No data

TABLE 17



SCHEDULE OF TRANSFER OPERATIONS

Fig. 22

and used in the computer programme viz. 10 ton/hour. The poor rate of transfer was largely caused by difficulties of stowage in the fishroom; the boxes were too heavy for manual handling and either a small box of about 100 lb total weight should have been used, or mechanical assistance provided. The slow speed of the winches on these rather old steam trawlers and the limited size of load (600 lb) both aggravated the situation.

The oldest fish landed was 12 days on ice, whereas from a conventional voyage the same fish would have been 17 or 18 days on ice. In the prevailing market conditions the effect was to convert the value of the fish from fishmeal to fresh fish price. Allowing for the costs of lost fishing time when the vessels were engaged in transfer, the net gain for the three vessels over the three months was calculated at just over £2500. This gain was not insignificant but it could have been substantially higher had the optimum number of boxes been carried, or if the market situation had been normal for the time of the year.

8.2.2 Conclusions

The difference in the prediction of outcomes by two different models for this operation has already been covered (Section 6). The best of the models i.e. the simulation, predicted an increase in productivity of 10% per vessel per annum but if the actual operations results were extrapolated from three months to one year, then the actual increase in productivity was one third of that predicted.

The reasons for the difference are easy to identify and arise partially from the risk factors mentioned above and also from the fact that for most personnel involved, it was the first time they had carried out operations of this kind.

The implementation stage described here was expected to be the forerunner of a continous fleeting operation but this did not happen. This reflects the decision-makers utility and although there would have been improvements in the system with the passage of time and accumulation of experience; possibly upto the level of productivity predicted by the simulation, the decision-makers did not consider that there was sufficient potential to continue with the operations. The system, as operated, would have assisted the extension of life to old vessels but the long-term requirement was for an investment in a fleeting system designed specifically for the operations and the capital for this was not forthcoming.

9 - CONCLUSIONS AND RECOMMENDATIONS

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Basic Models

The investment decision areas have been identified on three levels, i.e. the national level, the company or equivalent level and the level at which individual operations take place. The levels are not exhaustive as there may be intermediate levels in some countries but in relation to models, techniques and data, any intermediate stages could be incorporated into these three levels.

The basis for the investment appraisal work has been the model which has been used extensively throughout this work. The approach to modelling, that has been used, has already been well formulated by Ackoff (42). The process is divided into six phases:-

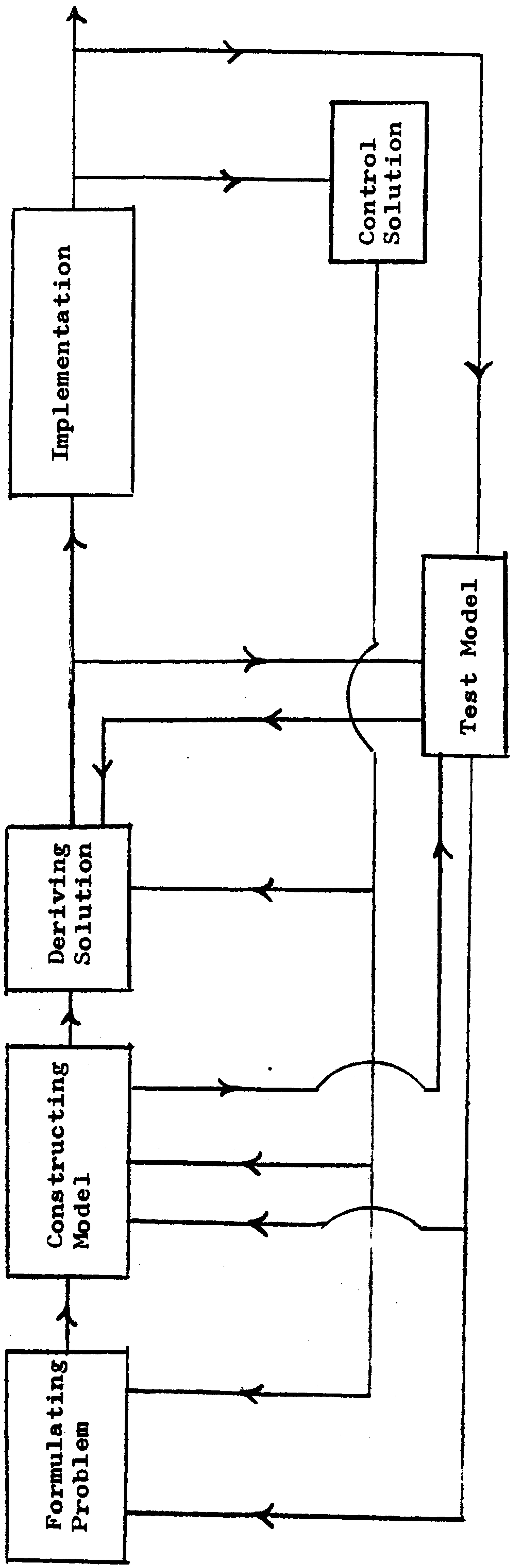
a) Formulating the problem
b) Constructing the model
c) Testing the model
d) Deriving a solution from the model
e) Testing and controlling the solution
f) Implementing the solution.

The process is cyclical, e.g. when testing a model, it may be difficient and the formulation of the problem and the model may be re-examined and modified. This leads to new testing and, in some cases, to further revision in the formulation of the problem and the model. This has also been covered by White (42) and the directional effects are shown (Fig. 23).

All the models described in this work have been good models within the context of providing balanced comparisons and the ranking of alternative outcomes in the same way as they would emerge in real life but there is always the problem of predictions of absolute performance which depends upon the effects of risk and uncertainty (Section 8). It has been shown that the problems lie more with strict uncertainty than risk.

Further research using game theory might prove to be useful for handling strict uncertainty.

The characteristic of a good model is that it often has a few key variables and obviously the cumulative effects of errors in few variables give a greater accuracy that a model with a high number of variables. It is not a general case but it is often true that Pareto's Law is in evidence and say, the contribution to 90% of the variation can be explained by 10% of the variables. In the case of the freezer trawler, it can be seen that the vessel parameters, hold capacity and speed, i.e. horse power together with the environmental parameter, catch rate or skipper effect contribute most of the variation.



Decision Analysis Feedback Format

Fig. 23

If all the complexities of reality were included in the model, then it means that little has been learned by the research into the situation and the possibility of learning anything from the model is limited. The problem for the model is not to describe reality but to form a basis for decision-making. It is also important, from the point of view of time and cost, to be able to select the key variables without the waste of incorporating any others. This is a matter for model testing.

9.2 Interrelationship of Models

Two of the major points considered were related to the sophistication of models and the problems of whether models should initially be simple and advance to be more complex by integration or be comprehensive models initially with some dis-aggragation later. This has been investigated by attempting to build models by both methods and review the consequences (Sections 3, 4 and 5).

If an investment plan is required at the national level then the recommendation is for a model of the matrix type as covered by the linear programming input-output model (Section 5). This allows the development of a framework within which models of a more detailed kind can be incorporated. It has been shown that such a model can be dis-aggragated to give some considerable detail of output sufficient for models at the lower levels to operate.

There is then a need for iterative procedures using the models in conjunction with each other to arrive at final solutions.

This would militate against the first approach in the Morocco study where effectively, the lower level models were aggragated to form the national model (56). In this case and perhaps in general, this leads to a situation where numerous detailed activities are integrated in a simulation to form the national model. This is costly and time consuming and as the real situation expands, as in the Mauritanian requirement, becomes impossible to contemplate (Section 3).

At the company or lower level the recommendation is the opposite that elemental models be combined to form the total model. Model in this context is not defined only as linear programming or simulation, etc., but as any form of procedural analysis to include computing or statistical analysis. This has been shown to be particularly appropriate in the case of the fishing company (Section 4).

Even if the recommendations for model building are not consistent then the development of data through the system must be consistent as the data from individual operations at the lower levels must be carried forward in a form that allows their use at the company and national levels (Fig. 24 and Appendices 3 and 4).

9.3 Sub-Optimisation

This has already been covered marginally above but there are some aspects of sub-optimisation that require special consideration. Sub-optimisation can arise for several reasons:-

a) lack of information
b) model limitations
c) resource limitations, e.g. time and money
d) failure to appreciate the total system and the background into which the problem fits.

If the case of investment in fishing vessels is taken as an example and the number and types have to be determined then the model may be simple under one set of conditions (Fig. 25) where a decision maker only has to consider the vessel in association with these factors that immediately affect its economic performance (Section 5). The model may be more complex where the selection of vessels may have to be considered in the context of company operations (Fig. 26) and the compatibility of vessel operations with the on-shore processing operations have to be considered (Section 4). The final and most complex model situation is that where the vessel has to be

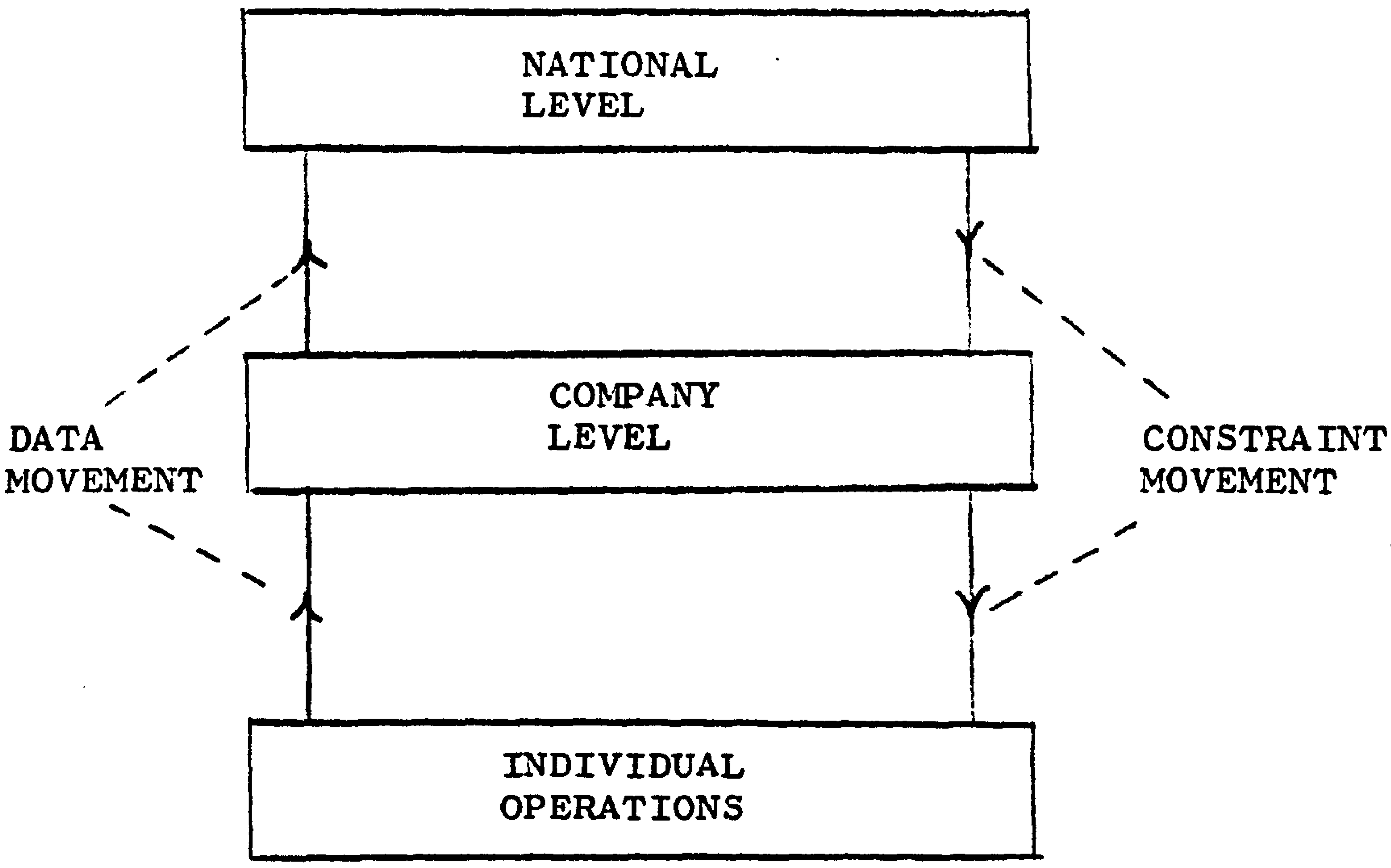


Fig. 24

MOVEMENT OF DATA AND CONSTRAINTS

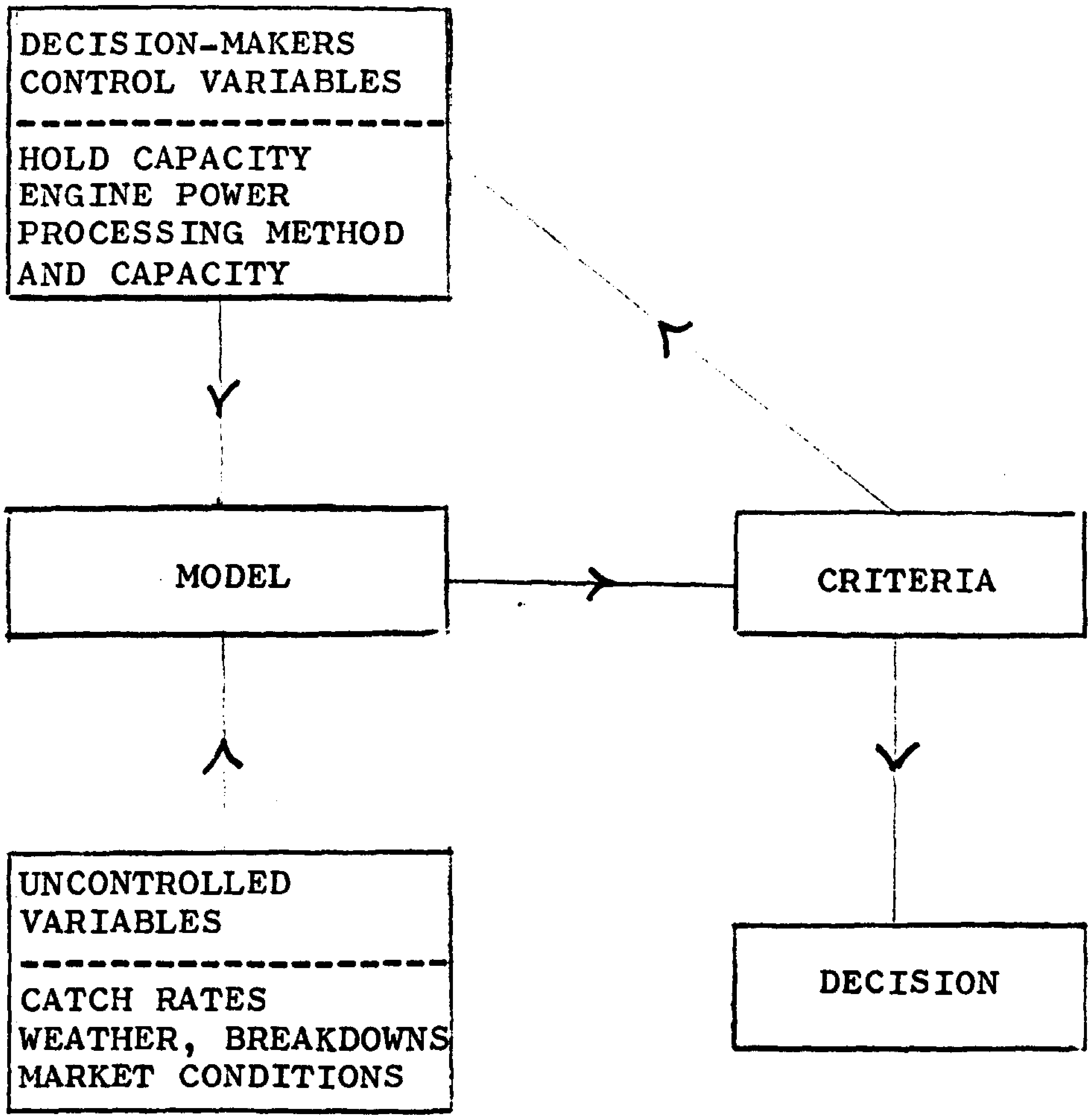
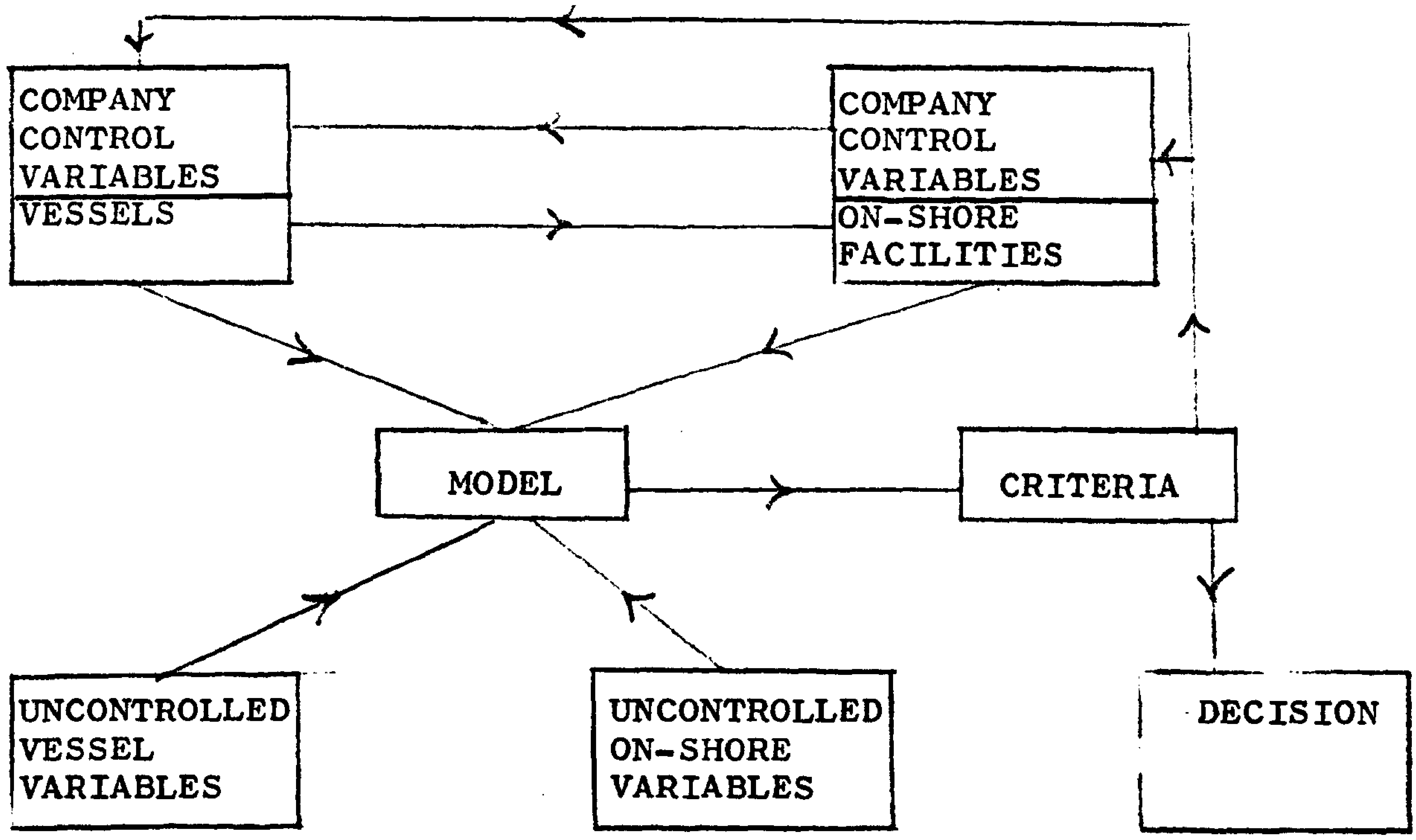


Fig. 25 FISHING VESSEL MODEL



<u>Fig. 26</u> <u>COMPANY MODEL</u>

considered within the national context which in addition to company complexities includes infrastructural requirement (Fig. 27). This has been covered in the case of Mauritania (Section 3).

It is not suggested that the last study has to be carried out before the design parameters of a fishing vessel can be determined as the cost would be prohibitive. However, the constraints that are important from the higher levels of decision making should pass down through the system to be incorporated in the models at the lower levels (Fig. 26). This has been done, in conjunction with the decision-maker in the company example (Section 4). and helps to prevent severe sub-optimisation.

9.4 Criteria

The availability, relevance and efficiency of criteria have been examined within the context of hierarchical decision-making on three levels (Section 3). In each case, it is obvious that there is no universally valid criterion for selection of the best solution to a fisheries investment problem. One of the basic reasons is that with the increase of management control at the national level through the establishment of a 200 miles EEZ and the development of regional policies, e.g. EEC, the concept of the single-decision maker is theoretical and the recommendation here is to generate the same vector

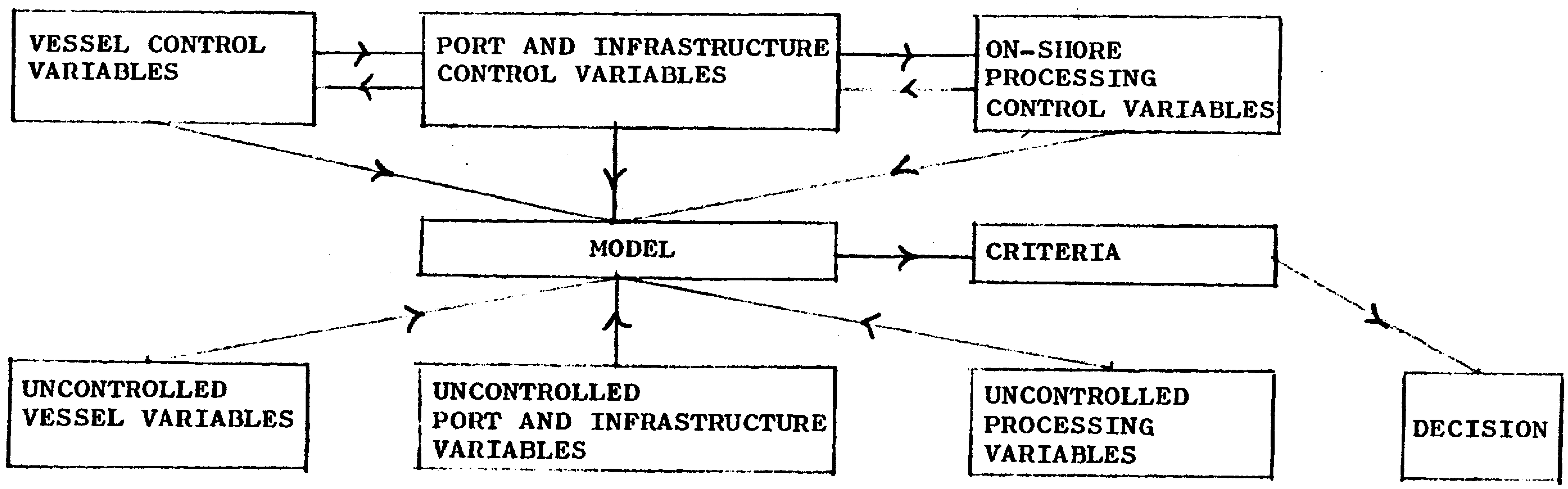


Fig. 27 NATIONAL MODEL

of criteria for each level of decision-maker but obviously with the emphasis in different areas according to the level in the hierarchy.

In developing fisheries, the main sources of investment are the aid agencies and the regional development banks who place a great emphasis on financial and economic rates of return calculated by the DCF methods described in this work. This might not be regarded as entirely satisfactory from a methodological stand point but it is a vast improvement from only a short time ago when little or no recommendations on criteria were given for investment project preparation. There is also the practical aspect from the potential recipients position that these donors do have the money for development and the motivation for adequate project preparation, with some consideration of efficient criteria, must bring benefits.

The use of DCF systems has led to considerable controversy with attendant supporters and detractors. The main problems in fisheries investment are the uncertainty and the long-term nature of decisions, e.g. fifty years for the 'life' of a port and under these conditions any criteria presents problems but the DCF systems add generally to the efficiency of investment appraisal.

9.5 Procedures

The correct procedure for preparation of fisheries investment projects has been recommended by Engstrom (1):-

9.5.1 Pre-feasibility and Identification

The process of identification results from the search for an idea with development potential and the process of gradual build-up of a project can be very expensive in terms of money and time. It can be seen, that such a process can only benefit (Section 3) by building the model or appropriate selection of models e.g. input-output, financial and economic analyses as early as possible in the life of the project, i.e. the pre-feasibility stage.

9.5.2. Project Formulation

Once the main alternatives for a project have been analysed the next stage is the formulation of the selected proposals and to examine systematically and in greater depth its essential features. The major purpose of this stage is to cover the aspects which are necessary to assist decision-making on the provision of funds. The advantages of the power of the methodology presented in this thesis can be seen in terms of time and money-saving through repeated use of the models for this purpose.

9.5.3 Appraisal

This last step in the project preparation process precedes the final decision of whether to implement the project or not. The magnitude of work required in this stage is directly related to the project formulation as it consists of data-checking and again evaluation in greater depth. Again a repeat run of the models assist greatly in this phase.

9.6 Communications and Implementation

The subject of communication is extensive with a large body of literature but this thesis is only concerned with the fundamental observations that have arisen during the course of the cases investigated. The greatest step forward in the communication of solutions from this work has resulted from the development of the micro-computer and its peripheral hardware, in particular, the TV monitor. The advantages are numerous:-

a) Feedback is an integral part of the communication system. Question and answer situations can develop freely.

b) Mistakes and misinterpretations can be rectified as questions can be re-stated and re-answered without embarassment.

c) The analyst can develop an empathy with the decision-maker over the communication time period as he has an opportunity to assess his sensitivity to him.

d) Sequential model runs with a variation of inputs, arising either from alternative proposals or just sensitivity analyses, can generate confidence in the decision-maker who can immediately see the efforts of the changes. If he takes full part in this operation, he can also consider that he has a knowledge of the model and has played some part in its development rather than just be on the receiving end of the solutions.

e) The problem of reconciling conflicting criteria (Section 4) such as company and government can be resolved very quickly.

The choice of technique might also greatly influence implementation. If the decision maker requires an explanation of how the technique will assist him, he is perhaps more likely to be persuaded by the logical flow of sequences in a computer simulation, representing an operation that he knows intimately, rather than a technique of a more complex nature not having this characteristic, but clearly more efficient.

The implementation of two projects has been covered (Section 8) and this is one of the most important stages of the work. A high level of implementation is obviously desirable as this can often be the only test of validity of the model predictions. It is not always the case as implementation may not go ahead for many reasons other than model validity. This tends to frustrate a general theory of implementation but several useful guidelines emerge:-

f) Plans for implementation should be envisaged at the commencement of the project not at the end. The training of skippers, fishermen and processing operatives might be a dominant factor of the solution and affect many issues in the project, e.g. time horizon.

g) The sources of finance for implementation should be considered at the beginning together with the availability of people, fish resources, vessels and machinery.

h) Cooperation with all levels of management throughout the investment appraisal stage is necessary. This is one aspect of persuasion.

i) Plans should be logical, feasible and practically operational.

j) The model builder should be intimately concerned with implementation.

9.7 Final Comments

There are two areas of research identified for further work. One is the problem of strict uncertainty which has been mentioned previously and the other is the dis-aggregation of national models into specific company models. The latter is difficult but if it can be done then decision-makers within national fisheries administration would benefit. Solving the problem of identifying the company or equivalent structures that would make up the national industry would allow governments in developing fisheries to place the companies on the market for auction, or bidding proposals. This would alleviate the chaotic growth of joint-venture companies that takes place in some developing countries.

This thesis has attempted to identify and develop techniques, criteria and data within a general methodological framework in order to improve investment planning in developing fisheries. It has been estimated that US $ 30,000 million (43) are required to increase the world production of fish by 60 million metric tons. This emphasises the need for improved investment planning and it is difficult to envisage how improvements will be achieved without the assistance of a methodology of this kind.

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APPENDIX 1

MATHEMATICAL FORMULATION OF MAURITANIA PLANNING MODEL

Appendix 1 Table 1

Mathematical Formulation of the Planning Model

The general equations of the model are as follows:-

Objection function:

$$\text{Maximise} \sum_{i}\sum_{j}\sum_{k}\sum_{l}\sum_{m}\sum_{n} aijklmn. \; x\,ijklmn$$

where aijklmn = lijklmn + cijklmn

Maximises value added with the following constraints:-

$$\sum_{i}\sum_{j}\sum_{k}\sum_{l}\sum_{m}\sum_{n} lijklmn. \; xijklmn \leq L$$

The national labour constraint is not exceeded

$$\sum_{i}\sum_{j}\sum_{k}\sum_{l}\sum_{m}\sum_{n} cijklmn.. \; xijklmn \leq C$$

The use of capital is not exceeded

$$\sum_{j}\sum_{l}\sum_{m}\sum_{n} xijklmn \leq Rik \quad \text{for all } i,k$$

The fishery resources are not exceeded

$$\sum_{i}\sum_{j}\sum_{k}\sum_{m}\sum_{n} xijklmn \leq H_L \quad \text{for all } L$$

Port handling capacities are not exceeded

$$\sum_{i}\sum_{j}\sum_{k}\sum_{n} xijklmn \leq Plm \quad \text{for all } l,m$$

Processing capacities are not exceeded

$$\sum_{i}\sum_{j}\sum_{k}\sum_{l} xijklmn \leq Dmn \quad \text{for all } m,n$$

Demand limitations are not exceeded.

The variables are defined as follows:-

xijklmn	The output of fish product species i caught by vessel j on fishing ground k and landed at port l for processing by method m for sale to market n.
aijklmn	The coefficient for added value for fish product species i caught by vessel j on fishing ground k and landed at port l for processing by method m for sale to market n.
lijklmn	The labour coefficient for fish product species i caught by vessel j on fishing ground k and landed at port l for processing by method m for sale to market n.
cijklmn	The capital coefficient for fish product species i caught by vessel j on fishing ground k and landed at port l for processing by method m for sale to market n.
Rik	The maximum fish resource of species i on ground k.
Hl	The maximum handling capacity at port l.
Plm	The maximum processing capacity at port l of method m.
Dmn	The maximum demand of product processed by method m in market n.

L	**The maximum labour availability.**
C	**The maximum capital availability.**

Appendix 1 Table 2

Model Suffices — **Xijklmn.**

Species (i)	**Vessel (j)**	**Ground (k)**
1 Pelagic	1 Licensed	1 Nouadhibou
2 Demersal	2 Transhipment	2 Nouakchott
3 Cephalopods	3 Pelagic Mothership	
	4 Freezer Trawler	
	5 Iced Fish Trawler	
	6 Purse Seiner	
	7 Yamaha & Canaries (Vedettes)	
	8 Imraguen Lanches	
	9 Canoe	

Port (l)	**Processing (m)**	**Market (n)**
1 Nouadhibou	1 Fresh	1 Nouadhibou
2 Nouakchott	2 Cured	2 Nouakchott
3 Villages	3 Cold Store	3 Villages
	4 Freezing	4 Fleuve
	5 Canning	5 Export
	6 Reduction	

Appendix 1

Input Resources Data for Mathematical Model RIM - Pelagic Species

Species (Group)	Potential Catch (X 1000 tonnes) Between 21°-16°N	Fishing Season				Type of Fishing
		Area	Depth (m)	Age Group	Period	
Sardinella spp.	210-260/350	North RIM 19°-21°N	10-30 50-200 50-200	Juveniles Adults Adults	Whole year June-December Whole year	Local purse seiners Offshore purse seiners Offshore trawlers
		South RIM 16°-19°N	20-50 50-200 50-200	Juveniles Adults Adults	November January-June/July December-April June-July	Offshore purse seiners Offshore purse seiners Offshore trawlers
Chinchards (jacks)	225-295	North RIM 19°-21°N			July-December/January	Offshore fleet, mainly pelagi[c] trawl, some purse seiners Trachurus trachurus: more vulnerable for bottom and sem[i] pelagic trawl
		South RIM 16°-19°N			December-May	
Scomber japonicus	60-100	North RIM 19°-21°N			Whole year round, peak in November/December and July/May	Offshore fleet, mainly pelagi[c] trawl, some purse seine
		South RIM 16°-19°N			December-July	
Total	495-655/745					

Appendix 1

Input Resource Data for Mathematical Model RIM - Demersal Fish Species

Depth (m)	Potential Catch (X 1000 tonnes) Between 16^o-21^oN Total	North of 19^oN	South of 19^oN	Dominant Species	Type of Fishing
0-40 (including B.d'Arguin, B.d'Levrier)	45-67	28-41	17-26	Sea breams Shark/Rai Courbine Flatfish Sea trout Grouper Grunt	Gillnets Lines Bottom trawlers
40-75	21-30	11-16	10-14	Sea breams (Pagellus) Grunts Flatfish	Bottom trawl
75-200	39-53	21-28	18-25	Sea bream (Dentex) Hake John Dory Flatfish	Bottom trawl
Total	105-150	60-85	45-65		

Appendix 1

Input Resource Data for Mathematical Model RIM - Cephalopods

pecies	Potential Catch (X1000 tonnes) between $16^{o}-21^{o}N$			Fishing Season	Depth (m)	Type of Fishing
	Total	North of $19^{o}N$	South of $19^{o}N$			
ctopus	50	35	15	October-June	0-170	Trawl/Pots
quid	9	6	3	October-December February-March	0-250	Trawl
uttlefish	10	4	6	All year round	0-170	Trawl Lines
otal	69	45	24			

Appendix 1

Maximum estimated allowable catch (in tons) by species group by month for the fishing grounds off Nouadibhou (above 19° Latitude)

Month	Pelagic Species	Cephalopod Species	Demersal Species
January	56,250	4,230	5,000
February	26,250	5,420	5,000
March	7,500	5,420	5,000
April	-	4,230	5,000
May	-	4,230	5,000
June	-	4,230	5,000
July	-	320	5,000
August	7,500	330	5,000
September	18,750	330	5,000
October	37,500	5,420	5,000
November	37,500	5,420	5,000
December	56,250	5,420	5,000
Total	247,500	45,000	60,000

Appendix 1

Maximum estimated allowable catch (in tons) by species group by month for the fishing grounds off Nouakchott (below 19° Latitude)

Month	Pelagic Species	Cephalopod Species	Demersal Species
January	-	2,100	3,750
February	7,500	2,800	3,750
March	18,750	2,800	3,750
April	37,500	2,100	3,750
May	37,500	2,100	3,750
June	56,250	2,100	3,750
July	56,250	500	3,750
August	26,250	500	3,750
September	7,500	600	3,750
October	-	2,800	3,750
November	-	2,800	3,750
December	-	2,800	3,750
Total	247,500	24,000	45,000

MAURITANIA PLANNING MODEL

Appendix 1
Pelagic Species

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF.	LABOUR VALUE	L.V. COEFF.	CAPITAL	CAPITAL COEFF.	LABOUR (NO.)	LABOUR COEFF.
X141135			5,924		2,037		3,887		0.0079
X142135			6,188		2,146		4,042		0.0083
X142235			6,164		2,037		4,127		0.0079
X151111			14,351		6,777		7,574		0.0321
X151145			17,522		8,073		9,449		0.0537
X152212			14,718		6,772		7,946		0.0320
X152214			15,202		6,851		8,351		0.0331
X152245			17,889		8,068		9,821		0.0536
X161145			4,689		2,056		2,633		0.0261
X161155			2,924		1,030		1,894		0.0090
X161165			1,558		732		826		0.0038
X162245			4,864		2,051		2,633		0.0260
X 162265			1,558		732		826		0.0038

MAURITANIA PLANNING MODEL

Demersal Species

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF.	LABOUR VALUE	L.V. COEFF.	CAPITAL	CAPITAL COEFF.	LABOUR (NO.)	LABOUR COEFF.
X251145			17,205		7,665		9,540		0.0469
X252245			17,572		7,660		9,912		0.0468
X271141			6,558		2,977		3,581		0.0394
X271145			6,558		2,977		3,581		0.0394
X272242			6,927		2,973		3,954		0.0393
X272245			6,927		2,973		3,954		0.0393
X281125			9,949		5,187		4,762		0.1620
X281311			8,228		3,466		4,762		0.1333
X281313			8,228		3,466		4,762		0.1333
X281323			8,228		3,466		4,762		0.1334
X282312			8,228		3,466		4,762		0.1333

MAURITANIA PLANNING MODEL **Demersal Species Cont'd.**

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF.	LABOUR VALUE	L.V. COEFF.	CAPITAL	CAPITAL COEFF.	LABOUR (NO.)	LABOUR COEFF.
X282313			8,228		3,466		4,762		0.1333
X282323			8,228		3,466		4,762		0.1334
X291111			7,544		7,137		407		0.0667
X291125			7,545		7,138		407		0.0668
X292212			6,611		6,000		611		0.1250
X292214			7,094		6,079		1,015		0.1261
X292222			6,612		6,001		611		0.1251
X292224			6,699		6,027		676		0.1254

Appendix 1 Table 9

MAURITANIA PLANNING MODEL

Cephalopods

VARIABLE	TONNAGE	VALUE ADDED	V.A. COEFF.	LABOUR VALUE	L.V. COEFF.	CAPITAL	CAPITAL COEFF.	LABOUR (NO.)	LABOUR COEFF.
X351145			17,386		7,869		9,517		0.0503
X352245			17,754		7,864		9,890		0.0502
X371145			7,805		3,747		4,058		0.0493

APPENDIX 2

MAURITANIA MODEL RESULTS

Appendix 2

MAURITANIA PLANNING MODEL

SPECIES	VESSEL	TONNAGE	VALUE ADDED(m)	V.A. COEFF	LABOUR VALUE(m)	L.V. COEFF	CAPITAL (m)	CAPITAL COEFF	LABOUR (No)	LABOUR COEFF
RUN A										
PELAGIC	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	26,000	447.3	17,205	199.3	7665	248.0	9540	1219	0.0469
	Vedettes	12,500	82.0	6,558	37.2	2977	44.8	3581	493	0.0394
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		171,000	1541.7		739.3		802.4		6076	
RUN B										
PELAGIC	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	4,145	71.2	17,205	31.7	7665	39.5	9540	194	0.0469
	Vedettes	12,500	82.0	6,558	37.2	2977	44.8	3581	493	0.0394
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	16,355	284.3	17,386	128.7	7869	155.6	9517	823	0.0503
TOTAL		120,500	667.5		346.3		321.2		3610	
RUN C										
PELAGIC	Freezer Trawler	31,700	187.8	5,924	64.6	2037	123.2	3887	250	0.0079
	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	41,800	719.2	17,205	320.4	7665	398.8	9540	1960	0.0469
	Vedettes	12,500	82.0	6,558	37.2	2977	44.8	3581	493	0.0394
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		218,500	2001.4		925.0		1076.4		7067	

Appendix 2 Table 2

SPECIES	VESSEL	TONNAGE	VALUE ADDED(m)	V.A. COEFF	LABOUR VALUE(m)	L.V. COEFF	CAPITAL (M)	CAPITAL COEFF	LABOUR (No)	LABOUR COEFF
RUN D										
PELAGIC	Freezer Trawler	413,000	2511.9	6,082	868.1	2102	1643.8	3980	3345	0.0081
	Purse * Seiner	10,000	29.2	2,924	10.3	1020	18.9	1894	90	0.0090
	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	41,800	719.2	17,205	320.4	7665	398.8	9540	1960	0.0469
	Vedettes	12,500	82.0	6,558	37.2	2977	44.8	3581	493	0.0394
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		609,800	4354.7		1738.8		2615.9		10252	
RUN E										
PELAGIC	Freezer Trawler	341,000	2062.4	6,048	694.6	2037	1367.8	4011	2694	0.0079
	Purse * Seiner	10,000	29.2	2,924	10.3	1030	18.9	1894	90	0.0090
	Purse Seiner	144,000	224.4	1,558	105.4	732	119.0	826	548	0.0038
DEMERSAL	Fresher Trawler	77,000	1337.7	17,373	590.1	7663	747.6	9710	3611	0.0469
	Vedettes	12,500	82.0	6,558	37.2	2977	44.8	3581	493	0.0394
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	69,000	1208.5	17,514	542.8	7867	665.7	9647	3471	0.0503
TOTAL		669,000	5062.0		2076.4		2985.6		12733	

* FOR CANNING FACTORY

Appendix 2 Table 3

Scenario A

Details of the results from Solution A showing the annual catches by species group and the implications in terms of vessels, berths, processing and labour.

Pelagic Species

Nouadibhou	
Catch	72,000 tons/year by purse seiners
Product	72,000 tons/year of fish meal
Vessels Required:	11 purse seiners
Nouakchott	No port

Demersal Species

Nouadibhou	
Catch	26,000 tons/year by iced fish trawlers
	12,500 tons/year by vedettes
	2,200*tons/year by lanches
	13,300*tons/year by canoes
Total	54,000 tons/year
Product	12,000*tons/year of fresh fish
	3,500 tons/year of cured fish
	38,500 tons/year of frozen fish for export
Total	54,000 tons/year

* including artisanal landings at Nouakchott

Processing capacity required:- 130 tons/day
Cold store capacity required:- 6,400 tons

Nouakchott No port

Cephalopod Species

Nouadibhou	
Catch	45,000 tons/year by iced fish trawlers
Product	45,000 tons/year of frozen product for export

Processing capacity required:- 150 tons/day (peak 217)
Cold store capacity required:- 10,800 tons

Nouakchott No port

Appendix 2 Table 4

Scenario B

Details of the results from Solution B showing the annual catches by species group and the implications in terms of vessels, berths, processing and labour.

Pelagic Species

Nouadibhou	
Catch	72,000 tons/year by purse seiners
Product	72,000 tons/year by fish meal
Vessels Required:	11 purse seiners
Nouakchott	No port

Demersal Species

Nouadibhou	
Catch	4,145 tons/year by iced fish trawlers
	12,500 tons/year by vedettes
	2,200* tons/year by lanches
	13,300* tons/year by canoes
Total	32,145 tons/year
Product	12,000* tons/year of fresh fish
	3,500 tons/year of cured fish
	16,645 tons/year of frozen fish for export
Total	32,145 tons/year

* including artisanal landings at Nouakchott

Processing capacity required:- 107 tons/day
Cold store capacity required:- 4,850 tons

Nouakchott No port

Cephalopod Species

Nouadibhou	
Catch	16,355 tons/year by iced fish trawlers
Product	16,355 tons/year of frozen product for export

Processing capacity required:- 55 tons/day (peak 68)
Cold store capacity required:- 3,400 tons

Nouakchott No port

Summary

Nouadibhou

Iced fish trawlers required:-		33	(plus 40 vedettes)
Purse seiners required:-		11	
Berths required:	Discharging	8	
	Fish meal	2	
	Total	10	(excluding service berths)
Processing capacity required:-		162	tons/day (peak 175)
Cold store capacity required:-		5,500	tons
Labour required:-	Trawlers	660	
	Purse seiners	231	
	Port	48	
	Processing	600	
	Cold store	33	

Nouakchott — No port

Appendix 2 Table 5

Scenario C

Details of the results from Solution C showing the annual catches by species group and the implications in terms of vessels, berths, processing and labour.

Pelagic Species

Nouadibhou Catch	31,665 tons/year by freezer trawlers 72,000 tons/year by purse seiners
Total	103,665 tons/year
Product	31,665 tons/year of frozen fish for export 72,000 tons/year of fish meal
Total	103,665 tons/year
Vessels Required:	5 freezer trawlers 11 purse seiners

Cold store capacity required:- 15,000 tons

Nouakchott No port

Demersal Species

Nouadibhou Catch	41,800 tons/year by iced fish trawlers 12,500 tons/year by vedettes 2,200* tons/year by lanches 13,300* tons/year by canoes
Total	69,800 tons/year
Product	12,000* tons/year of fresh fish 3,500 tons/year of cured fish 54,300 tons/year of frozen fish for export
Total	69,800 tons/year

* including artisanal landings at Nouakchott

Processing capacity required:- 181 tons/day
Cold store capacity required:- 9,050 tonnes

Nouakchott No port

Cephalopod Species

Nouadibhou		
Catch	45,000 tons/year by iced fish trawlers	
Product	45,000 tons/year of frozen product for export	
Processing capacity required:-		150 tons/day (peak 217)
Cold store capacity required:-		10,800 tons
Nouakchott	No port	

Summary

Nouadibhou			
Freezer trawlers required:		5	
Iced fish trawlers required:		137	(plus 40 vedettes)
Purse seiners required:		11	
Berths required:-	Discharging	8	
	Fish meal	2	
	Total	10	(excluding service berths)
Processing capacity required:-		331	tons/day (peak 398)
Cold store capacity required:-		25,000	tons
Labour required:-	Freezer trawlers	260	
	Iced fish trawlers	2,740	
	Purse seiners	231	
	Port	135	
	Processing	1,841	
	Cold store	150	
Nouakchott	No port		

Appendix 2 Table 6

Scenario D

Details of the results from Solution D showing the annual catches by species group and the implications in terms of vessels, berths, processing and labour.

Pelagic Species

Nouadibhou	
Catch	413,000 tons/year by freezer trawlers
	82,000 tons/year by purse seiners
Total	495,000 tons/year
Product	413,000 tons/year of frozen fish for export
	10,000 tons/year of canned fish
	72,000 tons/year of fish meal
Total	495,000 tons/year
Vessels Required:-	47 freezer trawlers
	12 purse seiners

Canning capacity required:- 10,000 tons/year
Cold store capacity required:94,000 tons

Nouakchott No port

Demersal Species

Nouadibhou	
Catch	41,800 tons/year by iced fish trawlers
	12,500 tons/year by vedettes
	2,200* tons/year by lanches
	13,300* tons/year by canoes
Total	69,800 tons/year
Product	12,000* tons/year of fresh fish
	3,500 tons/year of cured fish
	54,300 tons/year of frozen fish for export
Total	69,800 tons/year

* including artisanal landings at Nouakchott

Processing capacity required:- 181 tons/day
Cold store capacity required:- 9,050 tons

Nouakchott No port

Cephalopod Species

Nouadibhou

Catch	45,000 tons/year by iced fish trawlers
Product	45,000 tons/year of frozen product for export

Processing capacity required:- 150 tons/day (peak 217)
Cold store capacity required:- 10,800 tons

Nouakchott No port

Summary

Nouadibhou

Freezer trawlers required:		47
Iced fish trawlers required:		137 (plus 40 vedettes)
Purse seiners required:-		12
Berths required:	Frozen fish discharging	6
	Iced fish discharging	8
	Fish meal	2
	Total	16 (excluding service berths)

Processing capacity required:-		331 tons/day (peak 398)
Canning capacity required:-		10,000 tons/year
Cold store capacity required:-		113,000 tons
Labour required:	Freezer trawlers	2,444
	Iced fish trawlers	2,740
	Purse seiners	252
	Port	353
	Processing	1,881
	Cold store	678

Nouakchott No port

Appendix 2 Table 7

Scenario E

Details of the results from Solution E showing the annual catches by species group and the implications in terms of vessels, berths, processing and labour.

Pelagic Species

	Nouadibhou	(tons/year) Nouakchott
Catch:		
By freezer trawlers	165,500	175,500
By purse seiners	82,000	72,000
Total	247,500	247,500
Product:		
Frozen fish for export	165,500	175,500
Canned fish	10,000	-
Fish meal	72,000	72,000
Total	247,500	247,500
Vessels Required:		
Freezer trawlers	24	25
Purse seiners	12	11
Canning Capacity Required:	10,000 tons/year	
Cold store capacity required:	75,200 tons	79,800 tons

Demersal Species

	Nouadibhou	(tons/year) Nouakchott
Catch:		
By iced fish trawlers	41,800	35,200
By vedettes	12,500	-
By lanches	2,200	-
By canoes	3,500	9,800
Total	60,000	45,000
Product:		
Fresh fish	2,200	9,800
Cured fish	3,500	-
Frozen fish for export	54,300	35,200
Total	60,000	45,000
Processing capacity required:	181 tons/day	117 tons/day
Cold store capacity required:	9,050 tons	5,900 tons

Cephalopod Species

	Nouadibhou	(tons/year) Nouakchott
Catch:		
By iced fish trawlers	45,000	24,000
Product:		
Frozen product for export	45,000	24,000
Processing capacity required:	150 tons/day (peak 217)	80 tons/day (peak 112)
Cold store capacity required:	10,800 tons	5,600 tons

Summary

	Nouadibhou	Nouakchott
Freezer trawlers required:	24	25
Iced fish trawlers required:	137 (plus 40 vedettes)	94
Purse seiners required:	12	11
Berths required:		
Frozen fish discharging	5	5
Iced fish discharging	8	4
Fish meal	2	2
Total (excluding service berths)	15	11
Processing capacity required:	331 tons/day (peak 398)	197 tons/day (peak 229)
Canning capacity required:	10,000 tons/year	-
Cold store capacity required:	95,000 tons	90,000 tons
Labour required:		
Freezer trawlers	1,248	1,300
Iced fish trawlers	2,740	1,880
Purse seiners	252	231
Port	222	166
Processing	1,881	1,111
Cold store	570	540

Appendix 2 Table 9

MAURITANIA PLANNING MODEL - OPTIMAL SOLUTIONS

SPECIES	VESSEL	TONNAGE	VALUE ADDED(m)	V.A. COEFF	LABOUR VALUE(m)	L.V. COEFF	CAPITAL (m)	CAPITAL COEFF	LABOUR (No)	LABOUR COEFF
RUN B										
PELAGIC	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	38,500	662.4	17,205	295.1	7665	367.3	9540	1806	0.0469
	Lanches	2,200	21.9	9,949	11.4	5187	10.5	4762	356	0.1620
	Canoes	13,300	95.9	7,213	84.6	6358	11.3	855	1470	0.1105
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		171,000	1674.8		797.9		876.9		6170	
RUN C										
PELAGIC	Fresher Trawler	28,010	490.8	17,522	226.1	8073	264.7	9449	1504	0.0537
	Purse Seiner	72,000	112.2	1,558	52.7	732	59.5	826	274	0.0038
DEMERSAL	Fresher Trawler	60,000	1032.3	17,205	459.9	7665	572.4	9540	2814	0.0469
	Lanches	2,200	18.1	8,228	7.6	3466	10.5	4762	293	0.1334
	Canoes	9,800	69.5	7,094	59.6	6079	9.9	1015	1236	0.1261
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		217,010	2505.3		1160.0		1345.3		8385	
RUN D										
PELAGIC	Freezer Trawler	247,500	1531.5	6,188	531.1	2146	1000.4	4042	2054	0.0083
	Fresher Trawler	247,500	4336.7	17,522	1998.1	8073	2338.6	9449	13291	0.0537
DEMERSAL	Fresher Trawler	60,000	1032.3	17,205	459.9	7665	572.4	9540	2814	0.0469
	Lanches	2,200	18.1	8,228	7.6	3466	10.5	4762	293	0.1334
	Canoes	9,800	69.5	7,094	59.6	6079	9.9	1015	1236	0.1261
CEPHALOPODS	Fresher Trawler	45,000	782.4	17,386	354.1	7869	428.3	9517	2264	0.0503
TOTAL		612,000	7770.5		3410.4		4360.1		21952	

SPECIES	VESSEL	TONNAGE	VALUE ADDED(m)	V.A. COEFF	LABOUR VALUE(m)	L.V. COEFF	CAPITAL (m)	CAPITAL COEFF	LABOUR (No)	LABOUR COEFF
RUN E										
PELAGIC	Fresher Trawler	495,000	8764.5	17,706	3995.1	8071	4769.4	9635	26581	0.0537
DEMERSAL	Fresher Trawler	105,00	1823.0	17,362	804.6	7663	1018.4	9699	4925	0.0469
CEPHALOPODS	Fresher Trawler	69,000	1208.5	17,514	542.8	7867	665.7	9647	3471	0.0503
TOTAL		669,000	11796.0		5342.5		6453.5		34977	

APPENDIX 3

MAURITANIA MODEL DATA

APPENDIX 3

INPUT PORT AND PROCESSING DATA

The following notes relate to the capital cost, throughput and labour involvement in the unloading and fish-meal operations. No capital overhead costs are included, no running costs and no costs of other service facilities that might be required by an expansion.

The unloading costs will be catagorised for ;

a) wet fish discharge of boxed and iced fish.

b) frozen fish discharge of frozen blocks.

c) industrial fish discharge of bulked fish.

Taking a simplified view the capital cost of equipment is the capital cost contribution of the quayside and the capital cost of the discharge equipment. For the purposes of the model it is assumed that the cost of the quayside per unit length is the same for each type of discharge although in practice there might be differences in bollard arrangements, draft requirements etc. to suit the various classes of vessels. Boxed and iced fish refers to both fish and cephalopods.

COST OF UNLOADING

1.1 Nouadhibou

The capital cost per unit of the quay to be provided will depend on the scale of expansion and the following assumes an extension of the existing quay for a distance of 600m. The cost includes for the quayside itself, dock roads, provision of services, breakwater and dredging

Capital cost for 600m .... UM 775m

Capital cost of quay per metre length = UM 1.3m/metre

1.2 Wet Fish Discharge

Of the 600m expansion of quayside we can assume say 350m available for unloading of wet fish the other being used for additional ice supply, fuel and water and other service requirements. 10 berths of 35m will be assumed each equipped with a mechanical discharge unloader consisting of a cantilevered roller conveyor with integral winch.

		UM
Installed capital cost of each unit	=	900,000
Total cost for ten units	=	9 m

Handling of wet fish discharge

Each discharge unit will be assumed to be serviced by a single tractor trailer unit for delivery to the factory.

Capital cost per unit	=	600,000
Total cost of ten units	=	6 m

Total unloading capital cost, excluding the capital cost of the quay itself = 15 m

Capital cost of 350m quay at UM1.3m/metre = 455 m

Total capital cost of discharge and handling equipment plus required quay = 470 m

Throughput

Throughput of the ten discharge berths assuming a 12 hr working day = 400 tons/day

Annual throughput = 400 x 230 = 92,000 t/yr

Appendix 3

Labour involvement

Labour involvement per discharge facility including handling up to factory door as follows :

below deck	6 men
catcher	1 man
dockside	4 men
driver	1 man
	12 men
Total for 10 units	120 men for 12 hr day

1.3 Frozen Fish Discharge

The forgoing analysis of wet fish discharge assumed an expansion of 600m of quayside which will again be used as a basis for costing the quayside for frozen discharge. Only two berths will be costed however for frozen discharge and it will be assumed that the additional would be used for wet fish discharge and other service requirements. Two berths of 80m each are considered each fitted with a 'banana-type' block unloader.

		UM
The capital cost per unit including the ship and shore conveyors (adjustable to ship size without requirement of shore crane) also includes for overhead cover of discharge line.	....	4,000,000
Capital cost of 2 units	....	8 m

Handling

Each unit serviced by two flatbed lorries and two fork lift trucks.

Cost/unit = 2 x 1,800,000 + 2 x 1, 200,000	=	6 m
Capital cost of handling for 2 units	=	12 m
Capital cost of flat pallets	=	1.5 m
Total capital cost of discharge and handling excluding cost of quay		21.5 m

Capital cost of quay 2 x 80m UM 1.3/m .... UM 208 m

Total capital cost of discharge, handling and associated quay .... UM229.5 m

Throughput

Based on the 'banana type' frozen block unloader the throughput per 8 hr shift is in the order of 200 ton ignoring setting up time. Accounting for setting up by a reduction in overall throughput we can assume 150 tons per day. (8 hr shift)

Throughput of both units	....	300 tons/day
Annual throughput of both units	.....	230 x 300 tons/yr

Assuming fish is gutted this relating to wholefish is;

1.1 x 230 x 300 tons/yr = 75,900 tons/yr

Labour involvement

Labour involvement per unit;

below deck	8 men
unloading from belt conveyor	5 men
transfer point	1 man
supervisor	1 man
engineer	1 man
drivers	4 men
total/unit	20 men
Total labour for 2 units	40 men

1.4 Industrial Fish Discharge

The following relates to industrial fish discharge for meal and oil production assuming a new installation and not historical costs of the existing plant and equipment.

Appendix 3

The quayside is again costed as previously. Two berths are considered each 35m in length.

Capital cost of pump, pump house and associated gear per unit (including ducting to the factory).

		UM
	....	1,400,000
Capital cost of 2 units	....	2,800,000
Capital cost of quay		
2 x 35m x UM1.3m /m	....	91,000,000
Total capital cost of discharge equipment and associated quay	....	93,800,000
	....	93.8 m

Throughput

Daily throughput per pump	....	325 tons/day
Annual " " "	230 x 325	74,750 t/yr
Annual throughput for 2 pumps	....	149,500 t/yr

Labour Requirements

Labour requirements per pump ;

puddling and cleaning up	4 men
pump house	1 man
	5 men

Total labour requirement for 2 pumps 10 men

FISH MEAL AND OIL PRODUCTION

Based on 500t of raw fish input/day.
Capital costs (1980) as follows :

	1,000 UM
Fish meal line	50,205
Fish oil line	13,286
Concentrator	13,882
Deodoriser & sea water pump	4,177
Boiler	15,152
Installation of plant items	14,431
Freight & insurance	12,285
Plant building	6,552
Office, workshop & lab.	4,914

Appendix 3

	1,000 UM
Storage	9,828
Miscellaneous	10,647
	155,359

Total capital cost of 500 t/24 hr fish meal and oil plant .... 155.4 m

Throughput

Although costing of plant is for 500 t/day take actual throughput at 80%

Throughput = 500 x 0.8 x 230
= 92,000 tons/yr

Labour Required

Production staff per shift ;

Supervisor	1 man
Technical	2 men
Boiler	1 man
Raw fish bins	3 men
Production lines	3 men
Bagging and meal store	5 men
Production staff / shift	15 men
Total production staff/24 hrs =	45 men

Administration, Marketing and Lab.

Works Manager	1 man
Marketing Manager	1 man
Tel/Clerk	1 man
Clerical assistant/Sec.	3 men
Lab. assistants	2 men
	8 men

Total Admin and Marketing and Lab on day shift operation 8 men

Above excludes, labour on dockside and any labour for delivery.

COST OF UNLOADING

The following capital costs, throughputs and labour requirements relate to the proposed Nouakchott fishing port in the same manner as that given for Nouadhibou previously.

3.1 Nouakchott

The capital cost per unit of quay to be provided will again be dependent upon the scale of expansion but the provision of 315m quayside will be in the order of: .... UM 2,200m

This includes the quayside itself, dredging, breakwater, services and dock roads.

Capital cost of quay per metre: .... UM 7.0m/metre

3.2 Wet Fish Discharge

Of the 315m of quay provided assume 5 wet fish berths x 35m, 2 meal berths x 35m and 2 service berths x 35m

Capital cost of 5 berths = 5 x 35 x UM 7.0m ....UM 1,225 m

Capital cost of discharge equipment will be assumed as Nouadhibou

5 units x UM 0.9m = UM 4.5 m

Capital cost of handling to factory again same = 5 units x UM 0.6m = UM 3.0 m

Total capital cost of discharge and handling equipment plus required quay = ...UM 1,232.5 m

Throughput

Throughput of five discharge berths assuming a 12 hr working day .... 225 tons/day

Annual throughput .... 225 x 20 = 51,750 tons/yr

Labour Involvement

Labour involvement per discharge facility including handling up to factory door as follows :-

below deck	6 men
catcher	1 man
dockside	4 men
driver	1 man
total per unit	12 men
total for 5 units	60 men

3.3 Frozen Fish Discharge

For purposes of costing for the planning model the same cost per unit metre of quayside will be assumed for frozen fish discharge using equipment as specified for Nouadhibou. One quay for frozen discharge will be assumed of 80m.-

Capital cost of discharge equipment	UM 4 m
Capital cost of handling equipment (including pallets as for Nouadhibou)	UM 6.75 m
Capital cost of quay 80 x UM 7.0m/Metre	UM 560 m
Total capital cost frozen unloading inlcuding discharge, handling and associated quay	UM 570.75 m

Throughput

Throughput of the unit based on 8 hour shift	150 ton/day
Annual throughput gutted	230 x 150 tons = 34,500 tons
Annual throughput related to whole fish = 1.1 x 34,500	37,950 tons/yr

Labour Involvement

Labour involvement of the unit

below deck	8 men
unloading from belt conveyor	5 men
transfer point	1 man
supervisor	1 man
engineer	1 man
drivers	4 men

Total 20 Men

3.4 Industrial Fish Discharge

Two berths x 35m assumed for Industrial Fish Discharge each fitted with pump discharge to factory. Capital cost of quay per metre assumed as before.

Capital cost of pump, pumphouse and associated gear per unit (including ducting to factory)			UM	1,700,000
Capital cost of 2 units			UM	3.4m
Capital cost of quay	2 x 35 x 7	=	UM	490 m

Total capital cost of discharge equipment and associated quay UM 493.4m

Throughput

Daily throughput per pump =		375 tons/day
Annual " " " =	375 x 230 =	86,250 tons/yr
Annual throughput for 2 pumps		172,500 tons/yr

Labour Requirements

Labour requirements per pump

Puddling and cleaning up	4 men
Pump house	1 man
Total per pump	5 men
Total labour for 2 pumps	10 men

Appendix 3

The following notes relate to the capital cost and throughput for various processing operations.

4. Demersal   Headed and gutted frozen 20kg blocks.

Process :	Equipment
Reception of fish	Fork lift
Sorting and re-icing	Sorting bench, ice store
Into chill store	Pallet truck, chill store
To gutting benches	" "
Gutting and Heading	Benches & knives, aprons etc.
Washing	Drum washer
Packing into trays	Conveyor, bench & trays
Blast freezing	Freezer & trolleys
Knocking out	Spray unit
Glazing	Glazing conveyor
Packing	Bench
To Cold Store	Fork lift, cold store

Throughput

Based on 2 shifts (16 hours) day ...... 50 tons/day

(25 tons per 8 hr shift)

Equipment

Chill Store - 50t capacity (fish)

50 ton x 6 m^3/t = $300m^3$

Assuming 3m high, floor area = $100m^2$

Say store of dimensions 3m x 10m x 10m

Capital cost of store erected including refrigeration machinery .. .. .. UM 3.6m

Cold Store - 50 tons production x 30 days = capacity of 1,500 tons

1,500 tons x 4 m^3/t = $6,000m^3$

Assuming 5m high, floor area = $1,200m^2$

Say store of dimensions 5m x 40m x 30m

Capital cost of store erected including refrigeration machinery .. .. .. UM 78m

Blast Freezing

Rate of freezing = 25t x 0.65 yield x ⅛ hrs = 2 tons/hr

Capital cost of 2t/hr blast freezer including trolleys, freezer and refrigeration only .. .. .. UM 17.9m

Site preparation, freight and ins., services, erection and commissioning .. .. .. UM 9.0m

Total Capital cost blast freezer .. UM 26.9m

Handling equipment (Portable)

	Cap. cost m
3 - Electrical fork lift trucks 2500kg	4.5
5 - Pedestrian op powered pallet trucks	1.8
1,500 - Post, Box, Flat pallets	7.5
1 - Fish offal drive unit +	
2 - 15 ton cap. tipping offal containers	2.4
Total Cap. cost of portable Handling Eq't.	UM16.2 m

Appendix 3

Processing Equipment	UM Cap. cost m
Continuous fish washer (rotary)	1.0
Heading, gutting line with tipper unit infeed, controlled delivery to 12 station manual heading and gutting line with continuous delivery to fish washer and discharge to offal skip	1.0
Sorting benches (depending on degree of mixing, size and sepcies) per capita sum	0.2
Knives, aprons, boots etc	0.3
Glazing conveyor and spray unit for knocking out, packing line and washing of trays	1.2
Total of processing equipment specified above	UM 3.7 m

Building Costs	m^2
Reception of fish & offal despatch 20m x 20m	400
Chill store 10m x 10m	100
Cold store 40m x 30m	1200
Processing 40m x 40m	1600
Machine room & Maintenance 20m x 12m ..	240
Total floor area (excluding offices, washrooms, parking, access, roads etc).	3540 m^2

Capital cost at 12,500 UM/m^2 = UM 44.25 m

TOTAL CAPITAL COST OF FREEZING DEMERSAL

Total Capital cost = UM 173 m

5. Pelagic : Frozen whole 10kg blocks.

Process. As for demersal, excluding gutting and heading, and freezing process by plate not blast.

Throughput. Based on 2 shift (16 hrs) per day .. .. 50 tons/day

(25 tons per 8 hr shift)

Equipment. As before but with deletion of heading and gutting benches and freezing by plate process not blast.

Capital cost : As before except ;

	m UM
- offal line	- 0.2
- offal transport	- 2.4
- Heading/gutting unit	- 1.0
- Blast freezer	- 26.9
+ Plate freezer	+ 22.4
Difference	UM 8.1 m

Total capital cost Pelagic 173-8

.. .. UM165 m

6. Cephalopods. Graded frozen whole blocks.

Process. As for demersal but with rigorous size, species grading, and with no gutting/heading process.

Throughput. Based on 2 shift (16 hr) per day .. .. 50 tons/day

Equipment. As for demersal with deletion of heading and gutting, offal lines but with addition of size grading machines.

Capital cost

Total capital cost .. .. UM 171. m

APPENDIX 4

CALCULATION OF MAURITANIA MODEL COEFFICIENTS

APPENDIX 4

CALCULATION OF COEFFICIENTS

FISHING

Freezer Trawlers

Vessel considered is as follows:-

Length:	65 metres
Power:	3000 hp
Catch:	40 tons/day
Capacity:	800 tons
Cost:	363.6m UM.
Crew:	52 men
Species:	Pelagic

The coefficients are calculated as follows:-

Capital Cost: 363.6m UM.

Over 15 years: 24.24m UM/year

Throughput: 7000 tons/year (for vessels fishing Nouakchott grounds and delivery to Nouadhibou - 6,700 tons/year)

Labour: 52 men

Average Wage: 272,000 UM/Year

Labour Coefficient: $\frac{52}{7,000} = 0.0074$;

$\frac{52}{6,700} = 0.0078$

Labour Cost Coefficient: 0.0074 x 272,000 = 2,012.8 UM;

0.0078 x 272,000 = 2,121.6 UM

Capital Coefficient: $\frac{24.24\text{m UM}}{7,000} = 3462.9$ UM

$\frac{24.24\text{m UM}}{6,700} = 3,617.9$ UM

Fresher Trawlers

Vessel considered is as follows:-

Length:	24-30 metres
Power:	850 hp.
Capacity:	60 tons (inc. ice storage)
Cost:	72.72m UM
Crew:	20 men

Appendix 4

The coefficients are calculated as follows:-

Catch breakdown:

	Demersal	Cephalopods	Pelagic	Total
Off Nouadhibou	360	270	20	650
Off Nouakchott	410	220	20	650

Capital Cost:	72.72 m UM
Over 15 years:	4.848 m UM
Throughput:	650 tons/year
Labour:	20 men
Average wage:	218,000 UM/year
Labour coefficient:	$\frac{20}{650} = 0.0308$
Labour cost coefficient:	0.0308 x 218,000 = 6714.4 UM
Capital coefficient:	$\frac{4.848 \text{ m UM}}{650} = 7458.5$ UM

Purse Seiners

Vessel considered is as follows:-

Length:	20-25 metres
Power:	600 hp.
Capacity:	120 tons (tanked)
Cost:	63.63m UM
Crew:	21 men
Species:	Pelagic

The coefficients are calculated as follows:-

Capital Cost:	63.63m UM
Over 15 years:	4.242 m UM
Throughput:	6,600 tons/year
Labour:	21 men
Average wage:	218,000 UM/year
Labour coefficient:	$\frac{21}{6,600} = 0.0032$
Labour Cost Coefficient:	0.0032 x 218,000 = 697.6 UM
Capital Coefficient:	4.242m UM = 642.7 UM

Appendix 4

Yamaha and Canaries

See Artisanal fleet section.

Lanchos

See Artisanal fleet section.

Pirogues

See Artisanal fleet section.

Appendix 4

Artisanal Fleet

- Labour Coefficients

(i) Yamaha and Canaries - Demersal

Catch Rate: 1,500 kg/day
= 300 tons/year (200 days fishing/year)

Crew: 7 men

Labour Coefficient: $\frac{7}{300} = 0.0233$

Yamaha and Canaries - Cephalopods and Demersal

Catch Rate: Cephalopods 200 kg/day
(500 pots) = 10 tons/year (50 days)

Demersal 1,500 kg/day
= 225 tons/year (150 days)

Crew: 7 men

Labour Coefficient: $\frac{7}{235} = 0.0298$

(ii) Lanches - Demersal

Catch Rate: ~~20~~ 30 tons/year

Crew: 4 men

Labour Coefficient: $\frac{4}{30}$ (~~20~~) = ~~0.2000~~ 0.1333

(iii) Pirogues - Demersal

Off Nouadhibou

Catch Rate: 300 kg/day
= 60 tons/year (200 days)

Crew: 4 men

Labour Coefficient: $\frac{4}{60} = 0.0667$

Off Nouakchott

Catch Rate: 200 kg/day
= 40 tons/year (200 days)

Crew: 5 men

Labour Coefficient: $\frac{5}{40} = 0.1250$

Appendix 4

Labour Cost Coefficients

(i) Yamaha and Canaries - Demersal

Average Wage:	87,000 UM/year
Labour Cost Coefficient:	0.0233 x 87,000
	= 2,027.1 UM

Yamaha and Canaries - Cephalopods and Demersal

Average Wage:	87,000 UM/year
Labour Cost Coefficient:	0.0298 x 87,000
	= 2,592.6 UM

(ii) Lanches - Demersal

Sales:	30 tons @ 6 UM/kg
	= 180,000 UM/year
Expenses & Maintenance:	76,000 UM/year
Revenue:	104,000 UM/year
Per Crew Member:	26,000 UM/year
Labour Cost Coefficient:	0.1333 x 11,000
	= 3465.8 UM/year

(iii) Pirogues

Off Nouadhibou

Sales:	60 tons @ 15 UM/Kg
	= 900,000 UM

Expenses:

Petrol: 36 litres x 200 days x 30 UM
= 216,000 UM

Food: 4 crew x 200 days x 30 UM
= 24,000 UM

Repair:	12,000 UM
Liner, hooks, etc.:	6,000 UM
Total:	258,000 UM
Revenue:	642,000 UM
Share System:	4 crew
	1 vessel
	1 Engine
	6 Parts

Appendix 4

1 Share =	$\frac{642,000 \text{ UM}}{6}$ = 107,000 UM
Labour Cost Coefficient:	0.0667 x 107,000
	= 7,137.0 UM

Off Nouakchott

Sales:	40 tons @ 15 UM/kg
	= 600,000 UM

Expenses:

Petrol: 36 litres x 200 days x 30 UM
= 216,000 UM

Food: 5 crew x 200 days x 30 UM
= 30,000 UM

Repairs:	12,000 UM
Lines, hooks, etc.:	6,000 UM
Total:	264,000 UM

Revenue:	336,000 UM
Share System:	5 crew
	1 vessel
	1 engine
	7 parts

1 Share =	$\frac{336.000 \text{ UM}}{7}$ = 48,000 UM
Labour Cost Coefficient:	0.125 x 48,000
	= 6,000.0 UM

Capital Coefficients

(i) Yamaha and Canaries - Demersal

Capital Cost:	Vessel & Engine	3,500,000 UM
	Gear	1,000,000 UM
		4.500,000 UM
	Over 10 yrs	450,000 UM
Capital Coefficient:	$\frac{450,000 \text{ UM}}{300}$	
	= 1,500.0 UM	

Appendix 4

Yamaha and Canaries - Cephalopods and Demersal

Capital Cost:

Vessel and Engine	3,500,000 UM
Gear:	1,200,000 UM
	4,700,000 UM
Over 10 years:	470,000 UM
Capital Coefficient:	$\frac{470,000 \text{ UM}}{235}$ = 2000.0 UM

(ii) Lanches - Demersal

Capital Cost:

Vessel	500,000 UM
Gear	500,000 UM
	1,000,000 UM
Over 7 years:	142,857 UM
Capital Coefficient:	$\frac{142,857 \text{ UM}}{30}$ = 4761.9 UM

(iii) Pirogues - Demersal

Capital Cost:

Vessel	100,000 UM
Engine	65,000 UM
Gear	6,000 UM
	171,000 UM
Over 7 years	24,429 UM
Capital Coefficient:	
Off Nouadhibou:	$\frac{24.429 \text{ UM}}{60}$ = 407.2 UM
Off Nouakchott:	$\frac{24.429 \text{ UM}}{40}$ = 610.7 UM

Appendix 4

PORT

Wet Fish

Species: Pelagic, Demersal, Cephalopods.

	Nouadhibou	Nouakchott
Capital Cost: Quay	1.3m UM/metre x 350 metres = 455m UM	7.0m UM/metre x 175 metres 1225m UM
Over 50 years:	9.1m UM	24.5m UM
Discharge Equipment:	15m UM	7.5m UM
Over 10 years:	1.5m UM	0.75m UM
Total:	10.6m UM	25.25m UM
Throughput:	92,000 tons/yr	51,750 tons/yr
Labour:	120 men	60 men
Average wage:	48,000 UM/yr	48,000 UM/yr
Labour Coefficient:	$\frac{120}{92,000}$ = 0.0013	$\frac{60}{51,750}$ = 0.0012
Labour Cost Coefficient:	0.0013 x 48,000 UM = 62.4 UM	0.0012 x 48,000 UM 57.6 UM
Capital Coefficient:	$\frac{10.6m\ UM}{92,000}$ = 115.2 UM	$\frac{25.25m\ UM}{51,750}$ = 487.9 UM

Appendix 4

PROCESSING

Pelagic

Capital Cost: Plant	165m UM
Over 10 years:	16.5m UM
Throughput:	8,800 tons/year
Labour:	190 men
Average Wage:	60,000 UM/year
Labour Coefficient:	$\frac{190}{8,800}$ = 0.0216
Labour Cost Coefficient:	0.0216 x 60,000 UM = 1296.0 UM
Capital Coefficient:	$\frac{16.5m\ UM}{8,800}$ = 1,875.0 UM

Demersal

Capital Cost: Plant	173m UM
Over 10 years:	17.3m UM
Throughput:	8,800 tons/year
Labour:	130 men
Average Wage:	60,000 UM/year
Labour Coefficient:	$\frac{130}{8,800}$ = 0.0148
Labour Cost Coefficient:	0.0148 x 60,000 UM = 888.0 UM
Capital Coefficient:	$\frac{17.3m\ UM}{8,800}$ = 1,965.9 UM

Appendix 4

Industrial Fish

Species:	Pelagic	
	Nouadhibou	Nouakchott
Capital Cost: Quay	1.3m UM/metre x 70 metres = 91m UM	7.0m UM/metre x 70 metres 490m UM
Over 50 years:	1.82m UM	9.8m UM
Discharge Equipment:	2.8m UM	3.4m UM
Over 10 years:	0.28m UM	0.34m UM
Total:	2.1m UM	10.14m UM
Throughput:	149,500 tons/yr	172,500 tons/yr
Labour:	10 men	10 men
Average Wage:	48,000 UM/yr	48,000 UM/yr
Labour Coefficient:	$\frac{10}{149,500}$ = 0.0001	$\frac{10}{172,500}$ = 0.0001
Labour Cost Coefficient:	0.0001 x 48,000 UM = 4.8 UM	0.0001 x 48,000 UM = 4.8 UM
Capital Coefficient:	$\frac{2.1m\ UM}{149,500}$ = 14.0 UM	$\frac{10.14m\ UM}{172,500}$ = 58.8 UM

Appendix 4

Cephalopods

Capital Cost: Plant	171m UM
Over 10 years:	17.1m UM
Throughput:	8,800 tons/year
Labour:	160 men
Average wage:	60,000 UM/year
Labour Coefficient:	$\frac{160}{8,800}$
	= 0.0182
Labour Cost Coefficient:	0.0182 x 60,000 UM
	= 1092.0 UM
Capital Coefficient:	$\frac{17.1\text{m UM}}{8,800}$
	= 1943.2 UM

Fish Meal

Capital Cost: Plant	155.4m UM
Over 10 years:	15.54 m UM
Throughput:	92,000 tons/year
Labour:	45 men
Average Wage:	60,000 UM/year
Labour Coefficient:	$\frac{45}{92,000}$
	= 0.0005
Labour Cost Coefficient:	0.0005 x 60,000 UM
	= 30.0 UM
Capital Coefficient:	$\frac{15.54\text{ m UM}}{92,000}$
	= 168.9 UM

Canning

Capital Cost: Plant	102.0m UM
Over 10 years:	10.2m UM
Throughput:	8,976 tons/year
Labour:	40 men
Average Wage:	60,000 UM/year
Labour Coefficient:	$\frac{40}{8976}$
	= 0.0045
Labour Cost Coefficient:	0.0045 x 60,000

Appendix 4

Capital Coefficient:	$\frac{10.2 \text{ m UM}}{8,976}$
	= 1136.4 UM

Curing

Throughput:	3,500 tons/year
Labour:	100 men
Average Wage:	60,000 UM/year
Labour Coefficient:	$\frac{100}{3,500}$
	= 0.0286
Labour Cost Coefficient:	0.0286 x 60,000 UM
	= 1,716.0 UM

Cold Store

Capital Cost: (1,000 ton capacity)	13.635 m UM
Over 10 years:	1.3635m UM
Throughput:	4,000 tons/year
Capital Coefficient:	$\frac{1.3635\text{m UM}}{4,000}$
	= 340.9 UM

Miscellaneous

Imraguen fish curers	
Average Wage:	2,500 UM/year
Senegalese fish curers	
Average Wage:	10,000 UM/year

Appendix 4

TRANSPORT

Cured Fish

Capital Cost: Lorry	2.2725 m UM
Over 10 years:	0.22725 m UM
Capacity:	18 tons
Throughput:	3,460 tons/year
Labour:	1 man
Average Wage:	72,000 UM/year
Labour Coefficient:	$\frac{1}{3460}$ = 0.0003
Labour Cost Coefficient:	0.0003 x 72,000 UM = 21.6 UM
Capital Coefficient:	$\frac{0.22725 \text{ m UM}}{3,460}$ = 65.7 UM

Fresh Fish

Capital Cost: Lorry	3.636 m UM
Over 10 years:	0.3636 m UM
Capacity:	18 tons
Throughput:	900 tons
Labour:	1 man
Average Wage:	72,000 UM/year
Labour Coefficient:	$\frac{1}{900}$ = 0.0011
Labour Cost Coefficient:	0.0011 x 72,000 UM = 79.2 UM
Capital Coefficient:	$\frac{0.3636\text{m UM}}{900}$ = 404.0 UM