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Analysis of methods used to [illegible] fishing capacity, and establisment of a [illegible] for community needs

ANALYSIS OF METHODS USED TO DETERMINE FISHING CAPACITY, AND ESTABLISHMENT OF A METHOD SUITABLE FOR COMMUNITY NEEDS

by

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FANGKAPAZITÄTSUNTERSUCHUNG

Zusammenfassung

Nach einer Einführung in den Begriff eines "Fischerzeugungsmodells" werden in Teil I der Untersuchung die in der Gemeinschaft für den Bau solcher Modelle zur Verfügung stehenden statistischen Daten geprüft und die im Vereinigten Königreich, Norwegen und den Vereinigten Staaten angewandten Methoden zur Messung der Fangkapazität untersucht.

Teil II enthält eine Prüfung des besonderen Problems der gemischten Fischerei innerhalb der Gemeinschaft sowie Vorschläge für Methoden zur Messung der Fangkapazität in zwei Gruppen von EG-Mitgliedstaaten anhand der zur Verfügung stehenden Daten.

Die Fangkapazität einer Flotte wird definiert als die Fischmenge, die die Flotte von einem bestimmten Fischbestand anlanden würde, wenn die Flottenkapazität voll genutzt würde. Die Messung der Fangkapazität setz bei einer gemischten Fischerei voraus, dass andere Ziele als das der Erreichung der zulässigen Fangmengen definiert werden, damit ein Weg für die Wahl der bestmöglichen Flottenstruktur gefunden wird.

Durch die Unzulänglichkeit der Systeme zur Sammlung von Fischereidaten in einigen Mitgliedstaaten, insbesondere hinsichtlich des Fischereiaufwands, wird die Ausarbeitung eines besonderen Modells des Fischerzeugungssystems schwierig. Verbesserungen werden erwartet, es werden jedoch ein bis zwei Jahre vergehen, bevor ausreichende Daten für die genaue Messung der Fangkapazität in jedem Mitgliedstaat vorliegen werden.

Eine Reihe von Methoden zur Lösung des Problems der Anpassung der Flotte an die Quoten stehen zur Verfügung. Die Aufteilung der Fänge bei einer gemischten Fischerei kann durch die Verwendung einer "mathematischen Programmierung" erreicht werden, wofür das Betriebsmodell der Flotte des Vereinigten Königreichs ein gutes Beispiel darstellt. Bei einer durch Verarbeitungsanlagen gebundenen Fischerei, bei der nur eine einzige Art gefangen wird, stellen möglicherweise EDV-Simulator-Techniken nach der Art der für die norwegische Industriefischerei entwickelten Verfahren die beste Lösung dar.

STUDIO DELLA CAPACITA' DI PESCA

Sommario

Dopo un'introduzione sul concetto di "modello di produzione della pesca", la Parte I dello studio esamina i dati disponibili nella Comunità per la costruzione di tali modelli, nonché i metodi per la misurazione della capacità di pesca applicati nel Regno Unito, in Norvegia e negli Stati Uniti.

La Parte II tratta del problema specifico della pesca mista nella Comu.. e propone metodi di misurazione della capacità di pesca per due gruppi di Stati membri, a seconda dei dati disponibili.

La capacità di pesca di una flotta è definita come quantità di pesce che questa potrebbe sbarcare a partire da un determinato livello di popolazione qualora fosse utilizzata pienamente. Per la misurazione della capacità nella pesca mista occorre definire obiettivi, diversi da quello della realizzazione della cattura ammessa, onde rendere possibile la scelta di una struttura ottimale della flotta.

L'insufficienza dei metodi di raccolta dei dati sulla pesca, riscontrata in taluni Stati membri soprattutto per quanto riguarda lo sforzo di pesca, rende difficile la costruzione di un modello specifico del sistema di produzione. Si prevedono miglioramenti, ma occorreranno uno o due anni prima che siano disponibili dati sufficienti per la misurazione accurata della capacità di pesca nei diversi Stati membri.

Vari sono i metodi per risolvere il problema di un adeguamento delle flotte alle quote. L'assegnazione delle quote di cattura nella pesca mista può essere realizzata con una "programmazione matematica", della quale il modello operativo della flotta del Regno Unito costituisce un buon esempio.
Nella pesca condizionata da impianti di trasformazione, nella quale le catture sono costituite da un'unica specie, la migliore soluzione è forse data dalle tecniche computerizzate di simulazione quali quelle sviluppate per la pesca industriale norvegese.

FISHING CAPACITY STUDY

Summary

Following an introduction to the concept of a "fishery production model", Part I of the study reviews the statistical data available within the Community for the construction of such models, and examines methods of measuring fishing capacity employed in the United Kingdom, Norway, and the United States.

Part II examines the particular problem of mixed fisheries within the Community, and proposes methods of measuring fishing capacity within groups of EEC Member States, according to the data available.

The fishing capacity of a fleet is defined as the quantity of fish which the fleet would land from a given level of stock if the fleet were used to its fullest extent. Measurement of fishing capacity in a mixed fishery requires that objectives, other than that of achieving the allowable catch, be defined in order to provide a way of selecting the optimal fleet structure.

The deficiency of the fisheries data collection systems of some Member States, particularly regarding fishing effort, make it difficult to construct a specific model of the fish production system.
Improvements are expected, but it will be one or two years before sufficient data becomes available for the accurate measurement of fishing capacity in each Member State.

A number of methods of solving the problem of matching the fleet to quotas are available. Catch allocation in mixed fisheries can be achieved by the use of "mathematical programming", of which the United Kingdom fleet operation model is a good example.
In fisheries constrained by processing facilities, in which catches are of a single species, cumputer simulation techniques such as those developed for the Norwegian industrial fishery may provide the best solution.

ETUDE PORTANT SUR LA CAPACITE DE PECHE

Résumé

Faisant suite à l'introduction au concept de "modèle de production des produits de la pêche", la partie I de l'étude examine d'une part les données statistiques disponibles dans la Communauté pour la construction de modèles de ce type et, d'autre part, les méthodes permettant de mesurer la capacité de pêche qui sont appliquées au Royaume-Uni, en Norvège et aux Etats-Unis.

La partie II étudie le problème particulier des pêches mixtes dans la Communauté et propose des méthodes permettant de mesurer la capacité de pêche dans deux groupes d'Etats membres de la CEE en fonction des données disponibles.

La capacité de pêche d'une flotte est définie comme étant la quantité de poisson que cette flotte pourrait débarquer à partir d'un niveau de stock donné si elle était utilisée à son maximum. Pour pouvoir mesurer cette capacité dans le cadre d'une pêche mixte, des objectifs autres que ceux qu'impliquent des captures permeses doivent être définis de manière à permettre la sélection d'une structure optimale de la flotte.

Les lacunes que présentent les systèmes de collecte des données relatives à la pêche de certains Etats membres, notamment en ce qui concerne l'effort de pêche, rendent problématique la construction d'un modèle spécifique du système de production des produits de la pêche. Des améliorations sont prévues, mais il faut compter entre un et deux ans avant de pouvoir disposer d'un nombre suffisant de données permettant une mesure précise de la capacité de pêche dans chaque Etat membre.

Un certain nombre de méthodes permettant de résoudre le problème de l'adaptation de la flotte aux quotas sont d'ores et déjà disponibles. L'attribution des quotas de capture dans le cas des pêches mixtes peut s'effectuer en utilisant une "programmation mathématique" pour laquelle le modèle d'activité de la flotte britannique fournit un bon exemple. Dans le cas des pêches tributaires d'installations de transformation, où les prises ne portent que sur une seule espèce, des techniques de simulation par ordinateur analogues à celles développées pour la pêche industrielle norvégienne constituent peut-être la meilleure solution.

STUDIE OVER DE VANGSTCAPACITEIT

Samenvatting

Na een inleiding over het begrip visvangstmodel (fish production model) wordt in deel I van de studie nagegaan welke statistieken in de Gemeenschap beschikbaar zijn voor de opbouw van dergelijke modellen en worden de methoden bestudeerd die in het Verenigd Koninkrijk, Noorwegen en de Verenigde Staten worden gebruikt voor de berekening van de vangstcapaciteit.

In deel II wordt het speciale probleem van de gemengde visserij in de Gemeenschap besproken en worden methoden voorgesteld voor de berekening van de vangstcapaciteit in twee groepen van lid-staten van [illegible] basis van de beschikbare gegevens.

De vangstcapaciteit van een vloot wordt gedefinieerd als de hoeveelheid vis die een vloot bij een bepaald bestandsniveau zou aanvoeren indien de vloot maximaal werd ingezet. Voor de berekening van de vangstcapaciteit bij een gemengde visserij moeten andere doeleinden dan het bereiken van het toegestane vangstcijfer worden aangegeven met het oog op de keuze van een optimale vlootstructuur.

Gezien de tekortkomingen van de in sommige lid-staten toegepaste systemen voor het verzamelen van gegevens over de visserij en vooral over de visserijinspanning, kan moeilijk een gedetailleerd en precies model voor het visvangstsysteem worden opgebouwd. Verwacht wordt dat een en ander zal verbeteren, maar dat het nog een jaar of twee zal duren voor dat voldoende gegevens beschikbaar zijn voor de nauwkeurige berekening van de vangstcapaciteit in elke lid-staat.

Er zijn een aantal methoden om de vloot af te stemmen op de quota. Bij de gemengde visserij is vangsttoewijzing mogelijk via wiskundige programmering (mathematical programming); een goed voorbeeld hiervan is het model voor de activiteit van de vloot van het Verenigd Koninkrijk. Bij de visserij die afhankelijk is van verwerkingsinstallaties en waarbij slechts één soort wordt gevangen, kan computersimulatie zoals die voor de Noorse industrievisserij is uitgewerkt, de beste oplossing zijn.

UNDERSØGELSE OVER FISKERIKAPACITET

Resumé

Efter en introduktion til begrebet "fiskeproduktionsmodel" gennemgås i undersøgelsens del I de statistiske data, der foreligger i Fællesskabet til udarbejdelse af sådanne modeller, og de metoder til måling af fangstkapaciteten, som anvendes i Det forenede Kongerige, Norge og USA, gennemgås.

I del II gennemgås det særlige problem vedrørende blandet fiskeri i Fællesskabet, og der foreslås metoder til måling af fangstkapaciteten i to grupper EF-medlemsstater i overensstemmelse med de foreliggende data.

En flådes fangstkapacitet defineres som den mængde fisk, flåden ville lande fra et givet bestandsniveau, hvis den blev udnyttet i fuldt omfang. Måling af fangstkapaciteten i et blandet fiskeri kræver, at andre målsætninger end opnåelse af den tilladte fangstmængde defineres, således at der kan anvises en metode til udvælgelse af den optimale flådestruktur.

Mangelfuldhederne ved nogle medlemsstaters systemer til indsamling af fiskeridata, navnlig vedrørende fiskeriindsatsen, gør det vanskeligt at udarbejde en specifik model for fiskeproduktionssystemet. Der ventes forbedringer, men det vil vare et eller to år, før der foreligger tilstrækkelige data til præcis måling af fangstkapaciteten i hver medlemsstat.

Der findes et antal metoder til løsning af problemet vedrørende tilpasning af flåden til kvoterne. Fangsttildeling i blandede fiskerier kan ske ved hjælp af "matematisk programmering"; Det forenede Kongeriges flådeoperationsmodel er et godt eksempel herpå. I fiskerier, der begrænses af forarbejdningsfaciliteter, og hvor der fanges en enkelt art, kan computersimulering, som den er udviklet for det norske industrifiskeri, være den bedste løsning.

C O N T E N T S

INTRODUCTION

1. Context of the Study

The Commission, in its recent proposal for a common action for the re-structuring of the European fishing industry (COM (80)420) asks Member States to prepare 'multi-annual development or guidance programmes' for their national fleets. The aim of this proposal is to assist Member States and the Commission to consider how to re-structure the fishing industry so that the fleet is adjusted to the available fishery resources in EC waters. The explanatory notes attached to the proposal say:

> 'In order to avoid any increase in production capacity in excess of requirements, provision is made for the Member States to draw up a multi-annual outline plan, to be brought up to date each year on the basis of the resources available' (page 3)

and, from the proposal itself:

> 'a multi-annual guidance programme ... shall mean a set of objectives, together with a statement of the means for achieving them, designed to re-structure, modernise and develop the fishing industry ... in a Member State' (page 64)

The content of the multi-annual guidance is defined as follows:

> 'the programmes must specify the method, measures and facilities or resources that will be used to attain the following objectives in the long-term:
>
> (a) in respect of the fishing sector, a satisfactory balance between the fishing capacity to be deployed ... and the stocks which are expected to be available during the period of validity of the programme' (page 63)

and further that:

> 'Programmes shall give at least the following information:

In respect of the fishing industry

(1) The initial situation and discernible trends, in particular as regards the various categories of vessels making up the fleet.

(2) An overall estimate of the fishing capacity of the categories of vessels referred to under 1, on the basis of a list of fishing vessels in use, and an indication of the method used for determining that capacity.

(3) An estimate of the future capacity of the fleet, worked out as follows:

- an estimate of the number of vessels to be withdrawn from fishing, with an indication of their fishing capacity,
- an estimate of the number of vessels to be laid up periodically,
- an estimate of the number, tonnage and fishing capacity of vessels to be commissioned during the period within which the programme is to be implemented, and an indication of the expected schedule of commissioning, taking into account the number of vessels on order by Community shipowners.

(4) The laws, regulations and administrative provisions designed to facilitate the re-structuring or expansion of the fleet.' (page 65).

Since it was not immediately clear how these programmes should be prepared, Member States asked the Commission for clarification of the method by which 'fishing capacity' should be measured. The Commission appointed the present study group to answer this question, and to report on the feasibility of applying the methods it had found to the fishing fleets of EEC Member States, bearing in mind the existence, or otherwise, of suitable data.

2. Scope of the Problem

The problem of matching fleets to resources has to be approached with a broad view of the fishery system. The abundance of a fish resource is intimately linked to the size and structure of the exploiting fleet and to the technical details of its operation (types of gear used, mesh sizes, bycatch controls, discard practices and the areas and seasons in which it operates). This dependence of the resource on the fleet is a direct result of the fact that a fish stock is naturally renewable and that fishing directly influences the dynamic processes within it. Equally the fleet is dependent upon the resource for its continued existence. These interdependences indicate that the various components of a fishery policy (structural, resource and technical measures) have to be well coordinated and compatible. Taking an even wider view, the abundance of a fish resource, through its interaction with the fleet, is indirectly influenced by the economic and social factors which determine whether new ships are built and the conditions under which they will continue to operate. The economic and social benefits of exploiting a resource are, in turn, dependent on the resource. In an uncontrolled competitive fishery (the open access condition) these interactions are known to lead to overcapitalisation, with a poor or nil return on capital and a strong potential for resource destruction in some circumstances (Clark, 1976). Control is therefore needed in, perhaps, most fisheries, and the benefits of control need to be evaluated in economic and social terms.

This wide view of the fishery system is certainly difficult, if not impossible, to quantify in a single model (see Curr, 1981). It is, however, the real framework within which fleet restructuring must take place and, if important factors or interactions are ignored then the conclusions reached will be less than optimal (see Gulland, 1981). Practical considerations (urgent need for advice, for example) often dictate that simplifications should be made in quantifying and evaluating different policy measures. Simple models may be useful in specifying the required direction of change and the approximate region of optimal exploitation.

Much of the theoretical and technical framework for solving the problem of matching fleets to resources already exists and little of what we have to say is new in this respect. We have, however, attempted to formulate our analysis to be relevant to the particular case of the EEC fisheries. There exists an established institutional framework of management advice (from ICES and the Commission's Scientific and Technical Committee) and control measures (quotas and technical measures set by the Community). However the advice and measures which emanate from the existing advisory bodies is conceived in a particular conceptual framework which may not be ideal and which does not explicitly include the consideration of economic and social factors. Since the objectives and control measures have already been determined, there is limited freedom to fully explore the full range of solutions to the problem of EEC fisheries management. This would require that all important aspects of the system should be considered simultaneously.

In the main we have concentrated upon what might be done within the existing institutional framework. In doing so we have felt it important to emphasise the dangers associated with a limited approach and to identify the areas in which a wider view of the fishery system may be necessary.

There are three main elements to the problem of matching fishing capacity to the resources available:

1. the definition and measurement of fishing capacity,

2. the identification of that which constitutes the 'available resources',

and 3. the estimation of over- or undercapacity.

We have been asked to advise on the first of these elements but, since it is our view that the measurement of capacity is of little use in isolation, we have extended our terms of reference to include the second two elements of the problem. Fishing capacity has to be defined within the context of the fishery production system and this is dealt with first. A general discussion of the other two elements follows the definition.

3. The Fishery Production System

'Fishing capacity' is a term which is derived from the concept of the 'production capacity' of an industrial production system; for example, the capacity of a factory to produce manufactured goods measured as a rate of production per day. In any production system the capacity is defined as the output which can be achieved for a given set of inputs. In the example of a factory, the rate of production of manufactured goods will depend upon the rate of input of raw materials and also upon the volume of material which the manpower and machinery can process in a given time. In this formulation both the manpower and the machines which are used are regarded as inputs.

A fishery production system can be thought of in the same way by specifying the inputs and outputs involved and also the time units used to measure the rates. In a fishery the output is the quantity of fish landed (loosely referred to as the 'catch') and the inputs are the activity deployed by a given fleet and the stock abundances upon which the fleet operates.

3.1 Inputs

In a fishery production system there are two types of input; one concerning the supply of raw materials to the system, i.e. the fish stock, and the second concerning the activities of the manpower and machinery, i.e. the fleet.

(i) The fish stock

A fish stock is a naturally renewable resource. Its size depends upon the balance between factors which cause it to increase (recruitment and growth) and those which cause it to decrease (natural deaths and deaths due to fishing). Stock size varies considerably as a result of fluctuations in the level of recruitment from year to year. In addition, the general level of stock size is strongly influenced by the amount of fishing activity directed at the stock. The important point is that stock size is variable and cannot be regarded as a constant input to the fish production system.

The interaction between the two main inputs to the system is clearly important when considering the long-term behaviour of the fishery. However, for the present purpose of defining and measuring fishing capacity in production terms the interaction is of less significance, since we only require that the level of stock should be known at a particular point in time.

Stock abundances which have occurred in the past can be measured using common stock assessment techniques such as cohort analysis. Future stock abundances can be predicted by numerical simulations. The stock abundance or stock size can be measured either in terms of the number of fish ('stock numbers') or as the weight of fish in the sea ('stock biomass'). Only weight and biomass will be considered here.

The stock is composed of a number of age-groups; the biomass of each is identified by the common stock assessment techniques. The age-structure becomes important when one considers the relationship between stock abundance and catch-rates. Different categories of vessel may concentrate upon fish of different ages. One has, therefore, to recognise that a change in total stock abundance will not be equally reflected in the changes in the catch-rates of different fleets. This effect can be allowed for by defining that part of the stock biomass which is exploited by each fleet in terms of age-structure. This measure of stock size is known as the 'partial exploited biomass'. In practice this is difficult to calculate because it demands biological data on the age composition of the catch for each component of the fleet and this is not usually available. 'Total exploited biomass' is easier to calculate and represents the stock which is 'seen' by the whole exploiting fleet. However the use of this measure or plain total stock biomass will be an approximation to the real requirement which is the 'partial exploited biomass'. These matters are discussed in more detail in Anon (1981). (Full references to documents cited in the text are given at the end of the study).

For the moment it is only necessary to emphasise that stock size is a variable input which it is necessary to define and measure for a particular point in time, and that it has to be expressed in terms relevant to the various categories of vessel which are exploiting it, taking into account the difference in age structure between the stock and the catch.

(ii) The fleet

The activities of the fleet are the second main input to the fishery production system. The fleet consists of vessels which do not necessarily fish for the same period of time each year, and which are not, in general, equally efficient producers of fish, either with respect to the time spent fishing or to the costs of catching. These circumstances result from differences in vessel type, equipment and manpower utilisation and also upon the decisions made by the skipper. The differences in the time spent fishing and technical efficiency are particularly important because the total catch of the fleet is dependent upon them. These aspects of the fleet input are well understood in the theory of exploited fish populations by the terms 'fishing time' and 'fishing power' which are defined as follows:

(a) Fishing time - this may be the easiest fishing input to measure and can be defined as the time spent fishing in terms of hours, days or the number of vessels operating in the time unit selected. In each case the actual time spent fishing may be a variable proportion of the available time in the time period. The proportion would be expected to increase with vessel size and would be influenced by constraints on the catch due to quota enforcement or processing capacity. Fishing time becomes difficult to measure realistically in fisheries directed at shoaling species (such as mackerel). The time spent with the gear in the water is often very short (as low as 5 minutes per day for freezer trawlers in the Cornish mackerel fishery), and since this measure of fishing time is not useful as a fishing input, time may (in this instance) be best represented by days at sea.

(b) Fishing power - this component of the fishing input is difficult to measure, as it should reflect the way in which the catch-rate varies with vessel characteristics. It is only exactly defined by reference to the catch-rate of a standard vessel or vessel group, and is calculated as the ratio of the particular vessel's catch-rate to the catch-rate of the standard vessel(s) when they are fishing on the same stock density.

The product of fishing time and fishing power is called 'fishing effort' and this measure could be used to summarise the level of the fishing inputs and, thereby, derive the catch.

In a mixed fishery, however, consisting of several types of vessel fishing on the same stock, it is usually impractical to measure the relative fishing power for each type of vessel because of a lack of data. One would need comprehensive catch-rate data for each vessel group and one would need to allow for the differences in age composition of the catch between vessels. This complexity is the main reason why it is often said that regulation of a fishery by controlling fishing effort is not possible.

Measurement of the fishing input can be handled, however, by expressing the inputs in terms of the fishing time deployed by vessel categories. The vessel categories are defined by vessel size and fishing gear such that fishing power can be regarded as having a single value within each category. This 'disaggregation' of the fleet in a model avoids the need to compare the efficiency of individual vessels by measuring their fishing power. A further advantage of disaggregation is that it allows the investigation of a variety of objectives when one is attempting to estimate over- or under-capacity. The disaggregation can be used to specify differences in costs of catching or manpower utilisation within the fleet and hence allow the consequences of a variety of socio-economic objectives to be explored. This is achieved by allocating more or less of the catch to particular categories and by examining the benefits, or otherwise, of these allocations.

3.2 Output

The output of the fish production system is the quantity of fish landed. This may be expressed in numbers of fish but here we will refer only to the weight of fish landed.

The total catch from a fishery is the total weight of the fish taken from the sea and therefore includes both landings and discards. The term 'catch' is often loosely used to refer to the landed fish and this practice will be continued here, since the discards are usually irrelevant to our problem. Equally the term 'catch-rate' is loosely used to refer to the weight of fish landed per unit of fishing time.

Discards are, of course, relevant to stock assessments and to forecasting, since they represent fish which are removed from the sea and which are not usually returned alive. They are usually irrelevant to the measurement of fishing capacity because the intention is to measure over- or under-capacity in relation to the quantity of fish which it is possible to land. However, if discarding occupies a large proportion of the time at sea, then discard practices will influence fishing capacity. Total allowable catches (TACs) specifically exclude discards (even though discards may be included in the assessment) and so the definition of 'output' as the quantity of fish landed is appropriate.

Quantity landed, which we loosely refer to as the 'catch', is the main output of the fish production system. For the purpose of measuring over- or under-capacity in relation to socio-economic objectives, however, the output may also need to be measured as value, part of which is related to catch through prices, but which may also consist of the value placed on other factors such as the number of men employed.

3.3 Time units

The choice of time unit depends upon the problem which is being investigated and upon the nature of the fishery. Short time intervals (days) are appropriate to fisheries which are constrained by processing facilities. Analysing production in terms of annual catches is inappropriate if the catch-rates per day are unequal and if there is a likelihood of the fleet exceeding the capacity of the processing facilities. Medium time intervals (months or quarters) are appropriate if there are seasonal variations in the apparent abundance of the resource or if the fleet activity is seasonally variable due to the weather, as will usually be the case. Production over periods longer than this will be important (for example, the year is important for exploring the effects of TACs) but we should emphasise that the selection of appropriate time units will be governed by the consideration of all factors in the problem.

3.4 Relationships within the system

We have defined two types of input (stock abundance and fleet activity) and also the output (catch). The fundamental relationship between them is very simple. The catch per unit of fishing time ('catch-rate' or 'catch per unit effort') is expected to be proportional to stock abundance. The total catch obtained by a fleet depends upon the catch-rate and the fishing time and is given by their product.

In some fisheries the catch per unit of time will be linearly proportional to stock size. In this case one would expect the catch-rate to double if the stock size doubles. In other words, the coefficient of proportionality between catch-rate and stock size (the 'catchability') is constant with stock size. (In fact catchability will fluctuate according to season and also from year to year according to the general environmental conditions. There are, therefore, both random and seasonal components to catchability. The seasonal variations will affect our choice of time unit and the random components may be ignored or incorporated into the system model as error terms.)

In other fisheries the level of catchability is not 'constant' with stock size. This occurs mainly in schooling species and has been observed in both cod and herring. As the stock size decreases, the schools become fewer but have a similar density. If the schools are located by fishermen (modern communication between ships ensures that they are) each unit of fishing time will take a greater proportion of the total stock and the catch-rate will not be proportional to stock size. This implies that catchability is not constant but is related to stock size. Given suitable data, the relationship between them can be estimated and it will be possible to predict the catch-rate from stock size. The effect may become so extreme, in tightly schooling species such as herring, that the catch-rate is effectively constant. In this particular case the catch becomes simply a function of fishing time for a given vessel category.

In general terms one may distinguish between demersal fisheries in which the catch-rate is approximately proportional to stock size and pelagic fisheries in which the catch-rate is approximately constant and can therefore be regarded as independent of stock size. There are, in fact, a whole range of possibilities for these relationships, and it would be appropriate to investigate the actual relationship for each fishery.

3.5 Definition of fishing capacity

The definition of the production capacity of a factory is the rate at which manufactured goods can be produced for a given set of inputs. An equivalent definition can be adopted for a fishery production system:

> "Fishing capacity is defined as the quantity of fish which could be landed by the fleet in a given time interval for a given set of inputs in terms of the activity of the fleet and the level of stock abundance".

To measure fishing capacity we need a specific model of the fishery production system (i.e. catchabilities for each species and vessel category) and the given inputs of fishing activity and stock size. Fishing capacity is therefore different for different inputs. To calculate the capacity of a fleet for a future year, one must specify the level of activity of the fleet in that year. One option is to calculate the capacity when the fleet is fishing to its fullest extent. This will ensure that the fishing capacity of a fleet, which may currently be under-utilised, is not under-estimated. This specification of fleet activity will be the most useful one in the majority of applications.

One could define 'technical' or 'physical' capacity uniquely, by calculating the quantity of fish which could be landed by a fleet (used to its fullest extent) assuming unlimited stocks. This figure would be a measure of the maximum capacity of the fleet to bring fish on board and land it. This would be of no practical use in most circumstances because it is based upon such an unrealistic assumption. However, in trawl and purse-seine fisheries for pelagic fish in which we have said that catch-rates are effectively constant, the fishing capacity and the physical capacity would indeed be equivalent.

Other definitions of fishing capacity based on economic theory have been offered by Prochaska (1978) and Siegel _et al_. (1979). Prochaska (1978) draws a parallel with the economic theory of the firm where, with an existing stock of capital (production factors), the firm will produce goods at a rate at which the average costs are at a minimum. In this context the firm has a physical capacity, but the utilized capacity depends upon the costs of production. Regarding fishing vessels as individual firms, the total utilized capacity of the fleet would be the sum of the utilized capacities of the individual vessels. This leads to a definition of utilized capacity which depends upon prices and upon the market conditions to which skippers react.

Siegel _et al_. (1979) define the above concept as economic capacity: 'capacity is the amount of fish that the fleet is expected to harvest during a specified period with the existing stock of capital (vessels and gear) and technology, given the catch quotas, processing capabilities, and market conditions'. We have chosen instead to define the capacity of a fleet as the production for a given set of inputs (fleet activity and stock biomass). The approach of the two American papers is to incorporate in the definition an interaction between prices and utilized capacity.

The reason why we have not taken this approach is that the relation between prices and utilization of capacity is not known. That is, we do not know to what extent fishermen react to the prices of landed fish. It is therefore impossible to incorporate this interaction in the production model.

We prefer to define capacity in relation to a technical production model, and let prices influence the production through activity (inputs). We think this provides a more workable solution because, in a specific capacity calculation, one has to make a technical production model to predict the catches for a given activity. When it becomes possible to predict the acivity levels from prices and costs, this might be incorporated in the model and thereby make it more realistsic.

To sum up, we recognize the validity of the concept of utilized capacity, but as long as the relations behind it are unknown we see no way to incorporate it in a model, and tend to believe it to be of minor importance at present. (This subject is closely related to multispecies fishery problems discussed in Section II.1.)

3.6 Data requirements

Following the above definition of fishing capacity it should be possible to calculate the catch for a given set of inputs. The minimum requirements are for data on the inputs and data to support the construction of the specific model as, follows:

(1) biomass in recent years,

(2) catch and effort statistics by vessel categories in recent years,

(3) biomass in future years.

In the case of 'constant catch-rate' fisheries only item (2) will be required. The biomasses will normally be available in age composition terms if they are available at all, and improvements to the model could be sought by obtaining biological data on the age composition of the catch of each vessel category to facilitate the calculation of 'partial exploited biomasses' and so improve the accuracy of predicting catch-rates from stock biomass. Data on catch and effort might be obtained by a sampling system covering all parts of the fleet. Moreover it should be possible to have information on the total possible fishing time (days fishing, for example) for the different categories of vessels.

It should be noted that the above data would only allow the calculation of the fishing capacity defined as the catch for a given input. To judge whether this corresponds to an under- or over-capacity, it would be necessary to define objectives for the fishing fleet. Calculation of the way to achieve these objectives may require more information on social and economic factors.

4. Definition of 'available resources'

In the previous section we have defined fishing capacity as the catch which the fleet would obtain from a particular stock abundance if it operates in a given way and to a given extent. To be of use, fishing capacity (measured as a potential catch) must be compared with the allowable catch associated with this stock abundance in order to establish the extent of the over- or under-capacity. The stocks and the catch possibilities associated with them constitute the 'available resources' and it is necessary to define these to identify over- or under-capacity.

In considering the re-structuring of a fishing fleet one is interested in matching capacity to the resources which will be available at some time in the future. Fishing vessels have a relatively long physical and economic life (of the order of 10 years or more) and it is important to define the 'available resources' on an equivalent time scale or in such a way that the direction and magnitude of the change in capacity, indicated by the analysis, is correctly identified. The need for a long-term view of capacity is recognised in the Commission's proposals for 'multi-annual guidance programmes' which are expected to cover 5-year periods of restructuring.

There is no theoretical difficulty in measuring fishing capacity for any year in the future or even for a period of years so long as predictions of the 'available resources', in terms of stock sizes and allowable catches, are available. There are, however, practical difficulties of obtaining accurate long-term prediction of this sort. The amount of fishing which takes place between the base year of a forecast (usually the most recent year) and the target year, will have a major effect on the stock. A stock forecast must include the predicted levels of fishing in these intervening years, which will be determined by the objectives which one has for the stock and the extent to which the resultant control measures are obeyed by the fleet. Whilst the objectives should be known, the effectiveness of enforcement will not be known and this will introduce an important error into the forecasts.

A further important source of error in a stock forecast is the prediction of year-class strengths in the future. Simulations show that the error on a forecast due to doubts about future recruitments reaches a maximum within 3 to 5 years and, when recruitment can be assumed to be independent of stock size, the error increases only slightly as the forecast is extended in time. Greater problems arise when recruitment is influenced by stock size; errors in the forecast are likely to increase rapidly with time as a result of recruitment variability and lack of knowledge of future fleet activity. These problems can, however, be handled using 'stochastic' models of the fishery which will provide estimates of the probability of obtaining certain stock sizes in the future. Such models are infequently used by ICES Working Groups because there is no need for them to be used in setting short-term TACs. They have however, been used for North Sea sole, to establish the probability of obtaining a particular yield or stock biomass in the long-term. Their use could easily and profitably be extended to the majority of stocks in EEC waters by incorporating recruitment as a stochastic (or random) variable, the mean and variance of which can be determined from virtual population analysis (VPA) results. In short, until there is an incentive or instruction to use stochastic forecast models, the Working Groups are unlikely to adopt them as a matter of routine even though it is possible to construct them for the majority of stocks.

Capacity analyses could attempt to examine the longer-term requirements for the fishery based on forecasts up to, say, 10 years ahead. Beyond 10 years one would expect the reliability of stock forecasts to break down principally because of the inadequacy of present-day population models in representing environmentally induced changes in population behaviour and the biological interactions within the ecosystem.

At present, forecasts of stock size and recommendations on allowable catches are prepared only for the year ahead and it is useful to consider whether the 'available resources' so defined for the TAC year will provide estimates of over- or under-capacity which can be used to re-structure the fleet towards that required in the long term. Two distinct management strategies are currently proposed by the Commission for EEC fisheries. The first, which is applied principally to the 'constant catchability' demersal species, aims to bring fishing mortality in phased steps from present levels towards an optimum, defined as that which will produce the maximum yield per recruit in the long-term ('F_{max}'). The second strategy, which is being applied to those of the 'constant catch-rate' pelagic species under threat of collapse (herring and mackerel) is to ban fishing altogether until the stock recovers to an adequate level; once achieved it is anticipated that the quota will be annually adjusted to maintain the optimum level of stock.

In the case of demersal species, in which the strategy is to reduce fishing mortality in steps towards F_{max}, we can anticipate that adjustment of the fleet to the resources in the TAC year will achieve an appropriate adjustment towards the capacity required in the long term. In the case of the pelagic species, however, in which the TAC may be zero for a period, it is clear that adjustment to the available resources in the TAC year will not be appropriate to the long-term availability of the resources. It is essential, in these cases, to consider longer-term forecasts and to define the available resources on a time scale which is appropriate to the life of the fleet.

A further aspect of the definition of 'available resources' is the need to ensure that the objectives for each stock, which are used to determine the level of catch allowed for the stock, are compatible between stocks. Fishing vessels are capable of simultaneously catching a number of species in the same area and there is a limit to their ability to switch their attention from one species to another as dictated by the current catch quotas. The 'technical interactions' between the fisheries have been roughly quantified for the UK fleet (Shepherd and Pope, 1980) for which it was concluded that directed fisheries (i.e. those aimed primarily at one species) comprise 65% of the value of UK fish landings. Fisheries for industrial, pelagic and shellfish species were usually directed at one species with little by-catch, whereas in the demersal fisheries the by-catch proportions were greater. There was, however, a distinct separation into roundfish and flatfish fisheries with only a moderate degree of overlap. One may conclude that it is necessary to ensure the TACs are compatible within broad species groups (industrial, pelagic, shellfish, roundfish and flatfish) but that compatibility between groups, in the sense of technical interactions, is not required since the fisheries can be independent of each other.

For short-term forecasts, relatively simple single-species models are adequate to predict stock sizes and the catches which may be taken from them. As the forecast is extended into the future the model needs to be capable of handling density-dependent effects on recruitment, growth and natural mortality (if these occur in the stock) because it is more likely that the forecast will be dealing with stock sizes different from those which have existed in the recent past. Such effects are being incoporated into ICES assessments as the evidence for their existence becomes apparent (e.g. stock-recruitment relationship in North Sea herring, density-dependent growth in North Sea sole). Realistic forecasts, particularly those for the long term which are used to explore objectives, may need also to include the major features of the biological interactions between species (e.g. predation) and the economics of the fishery.

5. Estimation of over- or under-capacity

According to the definitions which have been made, over- or under-capacity can be measured as the quantity of fish which the present fleet could land in excess or deficit of the quota in a future year.

It is important to specify in the calculation of capacity that the present fleet should be used to its fullest extent. This is the maximum amount of fishing time which it could employ rather than the amount of time which it presently employs. There may be minor problems associated with defining full utilisation of the fleet since this may be influenced, in small vessels, by the preferences of the skipper who may not wish to fish on every day which is available.

To be of any practical use for re-structuring, the over- or under-capacity, measured as the difference between the potential catch and the quota, needs to be converted into a surplus or deficit of fishing time by vessel categories. This conversion can be simply achieved by dividing the catch of each vessel category by the catch-rate of that category. It should be noted that, depending upon the way the specific production model is formulated, the potential catch is likely to be a notional figure which could never actually be achieved.

A simple formulation (Type I) would postulate a proportional relationship between catch and fishing effort; this formulation would be necessary for the calculation of fishing capacity within a section of the fleet exploiting the stock (that is, for one Member State). In this case the potential fishing capacity would be a notional figure which could not be achieved. The ratio of potential capacity to the TAC would be equal to the ratio between the activity of the present fleet and that which was required to take the quota.

A more complex formulation (Type II) would, more realistically, postulate a non-linear relationship between catch and fishing effort; this could only be done if the production model included the activities of the entire exploiting fleet. In this case the potential capacity would be the catch which would actually be obtained but the ratio between the potential capacity and the TAC would not be the same as the ratio between the present fleet activity and that which was required to take the TAC. The required fleet activity would be calculated using the non-linear relationship between yield and fishing effort built into the model.

Type I models, which are the primary concern of the present study, would exaggerate the fishing capacity of a fleet to some extent; this disadvantage would be removed by the use of Type II models which, unfortunately, are much more difficult to establish.

It is possible that the size of the excess or deficit of catch (in percentage terms) will be different for different species within the same resource area. There may, for example, be over-capacity for cod but not for haddock. Ideally, this should not occur if the TACs have been arranged to be compatible, by taking account of the 'technical interactions' in the fisheries or, alternatively, by ensuring that the change in fishing mortality which the TAC aims to produce is the same for each stock.

Some flexibility exists within a fleet and there are, potentially, many ways of taking a particular set of quotas. Additional information on the economic and social objectives which the Member States have for their fleets (as opposed to the overall biological objectives) is required to make the choice. To take a simple example, one could imagine that the fleet in a particular fishery consists of two categories of vessel - large and small. The quota might be taken by allowing all of the large vessels to operate for the whole season and by making the small ones in-active. Alternatively, all vessels could operate for three-quarters of the season. The choice between these alternatives is determined by the objectives which one has for the fleet. These objectives could take several forms, for example:

- least change from the present use of the fleet
- maximum use of labour
- maximum profit.

In reality, the overall objective might be a combination of several objectives which are individually conflicting and the final fleet structure chosen would have to be a compromise between them.

<u>The fixing of an economic or social objective is essential in order to estimate the fishing inputs which would be required to take the quotas.</u>

Even if this objective is simple - e.g. one wishes only to utilize the fleet in such a way that there is equal sacrifice between vessel categories, this itself is an objective which is essential for a solution and should be stated. In this particular case, the problems posed by allocating the quota amongst different sections of the fleet, according to the objective, are relatively minor. One could envisage a relatively simple calculation which sought to determine the effort required to take the quotas, such that the effort in each vessel category should be changed equally. There would be inconsistencies between the effort required for flatfish and roundfish and certainly between demersal and pelagic species, but it is likely that these differences would be unimportant since the fisheries on different species groups are largely carried out by different categories of vessel.

More complex objectives, and, possibly, more reliable solutions in the case of the 'least fleet change' objectives for mixed fisheries, require a more sophisticated type of analysis, which allocates the quota to the different vessel categories in order to achieve the objectives. Additional data would be required on manpower, costs of catching and price of fish for the allocation under social and economic objectives. The main technique which has been developed for this type of analysis is 'linear programming', the application of which to fisheries is further discussed in Part I.2 and explained in detail in Annex 2.

P A R T I

D E S C R I P T I O N

PART I - DESCRIPTION

I.1 REVIEW OF THE AVAILABLE DATA

The aim of this section is to provide a summary of the data which are available and which are likely to be relevant to the problem of measuring fishing capacity. We also give an indication of the new data collection procedures which are being adopted, through the introduction of EEC log-books, for example. Since these new systems are not yet operating and are unproved, the main objective is to provide a summary of the data which are available now and to give an evaluation of their usefulness to analyses of fishing capacity as generally defined in the Introduction.

Broadly speaking, 4 types of data are relevant to the measurement of fishing capacity and to the estimation of the extent of the surplus or deficit of vessels in relation to available resources. These are as follows:

(i) Details of the number of vessels and their characteristics.

(ii) Details of the landed weight of each species and the effort which was expended in catching them, by vessels or vessel groups.

(iii) Information on the costs of catching, prices and manpower employed.

(iv) Information on processing capacity and marketing facilities.

These data are not equally useful; for example it is essential that comprehensive catch and effort data (ii) be available for any reasonable analysis of fishing capacity, and these may be sufficient on their own. Vessel file data (i), whilst important for ascribing landings to vessel categories, are not sufficient for any analysis without landings data or without some indication of the catch-rates obtained for particular stocks or the amount of fishing time involved. Economic data (iii) are not absolutely essential to an analysis unless the re-structuring seeks to optimise an economic or social objective. Similarly, information on processing capacities and market facilities (iv) is not required unless these are real constraints on fishing activity.

We can anticipate that few countries systematically collect data on the costs of catching fish and that information on processing and marketing facilities is not amenable to routine collection. These aspects of data availability will not be dealt with in the following descriptions in detail, but their availability is indicated in our summaries for each country.

Data on fish stocks will also be needed. In particular it will be necessary to have estimates of stock abundance for one or more recent years and forecasts of the stock abundances which are expected to occur in the future, at least for quota species. If economic objectives are to be explored similar data will be required for non-quota species. Accurate estimates will be crucial to the measurement of fishing capacity, and it should be emphasised that many assessments could be improved significantly by the collection of more accurate data on landings and fishing effort by many Member States and by the provision of more comprehensive age composition data for both landed and discarded fish.

In this review we have concentrated on the data collection systems of Denmark, France and the United Kingdom, but we have also included brief reviews of the system in other Member States. These have been obtained largely from the ICES Cooperative Research Report on the subject (Anon, 1978a) and Reports of the Statistics Liaison Committee of ICES (Anon, 1978b).

I.1.1 Data available in Denmark

(i) Organisation

The body responsible for fisheries data collection in Denmark is the Ministry of Fisheries which is assisted in this by Fisheries Control officials located in the major ports. The Danish Institute of Fishery and Marine Research initiates catch and effort data collection for specific purposes on occasion and carries out the biological sampling on Danish landings.

(ii) <u>The vessel file</u>

Between 1952 and 1976 a vessel file was kept by the Ministry of Fisheries. In 1977 the vessel file was enlarged considerably. The data collection was managed by the Fisheries Control, who mailed data sheets to every owner of a fishing vessel which exceeded 5 gross registered tonnes (GRT). The following types of data were recorded and stored on magnetic tape:

(1) Vessel characteristics:

Type of vessel, GRT, length, hold capacity (m^3), freezing capacity, insurance value.

(2) Engine:

Type, year of fabrication, year of installation, brake horsepower (BHP).

(3) Electronic equipment:

Radio, Decca, Loran, sonar, satellite navigation.

(4) Gears:

Type of gear (trawl, hooks, seines) in numbers.

The file was partly updated in 1980 correcting the information on GRT and horsepower.

A decision to create a new file has been taken and this is being constructed at the end of 1981. The data collection will be managed by the Ministry of Fisheries and it is the responsibility of the owners of the fishing vessels to supply the information to them. If a vessel is bought or sold, or if the construction or the equipment are changed, then this information must be supplied to the Ministry of Fisheries. The information is of the same type as in the 1977 vessel file, but is more detailed. The data sheets are enclosed in Annex 1.

(iii) Catch and effort data

(a) Consumption landings - The vast majority of the catch is sold through auction-sales and every merchant must supply the Ministry of Fisheries with a copy of the bill of sale. This contains information on:

Registration number of the vessel

ICES area (of capture)

Species/size category

Quantity/price.

Until 1981, the bills of sale were processed manually, giving the accumulated catch by area, species and size category. In parallel with this system the Danish Institute of Fishery and Marine Research collects samples in selected harbours. The samples consist of boxes of fish and are stratified on size category. The fish are aged and their lengths measured by the Institute. On this basis catch data are calculated and submitted to ICES.

(b) Industrial landings - The total landings are compiled in the same way as those for consumption purposes. Every merchant must supply information to the Ministry of Fisheries on:

Registration number

ICES area (of capture)

Species

Quantity/price.

The catch is split into species by sampling the catch, and biological data of age and length are collected by the Danish Institute of Fishery and Marine Research.

(c) Catch/effort statistics - In the years 1973-78 a catch/effort sampling programme was run by the Danish Institute of Fishery and Marine

Research. Data on catch and corresponding effort were collected for individual landings by sampling in selected harbours. The following data were recorded: (1) Vessel registration number, date, harbour.

(2) The international statistical square where the main fishery had taken place, and type of gear and mesh size used.

(3) Trawling time (or number of nets, hooks), days at sea.

(4) Catch by species and size category and processing purpose (industrial/consumption).

These data were gathered by interviewing the skipper of the vessel, or partly by interviews and by obtaining catch data from auction receipts.

The level of sampling varied throughout the years in the different harbours. The sampling intensity is shown in the tables below.

Table 1 Percentage sampled landings of total landings in weight

Harbour	Industrial landings				
	1973	1974	1975	1976	1977
Gilleleje	-	-	-	-	7
Nexø	-	3	1	7	18
Grenå	6	3	7	4	3
Esbjerg	95	94	96	1	51
Tyborøn	26	27	23	14	9
Hirtshals	-	-	11	78	55
Skagen	68	75	54	3	47
Hanstholm	-	-	9	40	51
Frederikshavn	-	-	-	1	2
Sampling of total Danish landings	49	49	48	18	39

Table 2 Percentage sampled landings of total landings in weight

Harbour	Consumption landings				
	1973	1974	1975	1976	1977
Gilleleje	-	-	-	-	2
Nexø	10	12	5	16	11
Grenå	6	6	6	9	5
Esbjerg	20	13	12	13	26
Tyborøn	14	16	12	8	4
Hirtshals	1	-	6	36	23
Skagen	70	66	45	2	12
Hanstholm	-	-	7	22	22
% Sampling of total Danish landings	9	9	8	10	9

(d) Future plans for catch/effort data collection - A new system of fishery statistics has been developed since 1980, and the start of the system began in September 1981. The three main elements of the system are:

Log-books

Bills of sale

A vessel file.

(Plans for the vessel file have been described earlier.) A Danish log-book will be introduced, to be replaced by the EEC log-book when agreement upon this is achieved. The Danish log-book is very similar to the planned EEC log-book. It requires that details of fishing in different ICES statistical rectangles within the same day are listed on different lines on the data sheet.

A standardized bill of sale is planned. This will contain information on:

Vessel registration number, date

ICES area

Species quantity, quality and price

Processing purpose.

In parallel a similar system will operate at the fish meal processing plants. Every landing is at present recorded and sampled because the price of the landing depends on the quality. In connection with these analyses the species composition by landing will be submitted to the Ministry of Fisheries and will be processed by computer.

(iv) Summary

The number and type of vessels in the Danish fleet is recorded in the vessel lists which are available on computer file for the years following 1977. However, only landings data (not effort) are routinely recorded on a day to day basis and they are not routinely accessible by computer at present. A limited quantity of catch per effort data are available for the period 1973-78 which arose from a special sampling excercise mounted by the Danish Institute of Fishery and Marine Research. This sampling programme covered about 50% of the industrial and 10% of the consumption landings. The new system of data collection, which is scheduled to begin in late 1981, is expected to provide detailed catch and effort data for the entire fleet and this will be accessible by computer.

Economic data on costs exist in the records of fishing companies and it is possible to quantify the capacity of fish meal processing facilities as the need arises.

It appears that, for Denmark, it is not possible to carry out a detailed analysis of fishing capacity with the data available at the moment, principally because of the lack of comprehensive catch-rate and fishing effort data. It may be possible, however, to give a rough indication of under or over-capacity utilising the data collected between 1973 and 1978 and the vessel file. It is likely that processing facilities will have to be considered in the analysis since these are likely to be a major constraint on the activities of the large fleet fishing for industrial species.

I.1.2 Data available in France

(i) Organisation

Special attention has been paid to this country as there are two separate statistical systems. The old one, organized along classical lines, is the responsibility of the 'Affaires Maritimes'. The second, more recent, is expected to replace the first from 1981 onwards and is the responsibility of the 'Institute Scientifique et Technique des Pêches Maritimes' (ISTPM).

(a) The old system -

Under the 'Affaires Maritimes' system the coast of France is divided into 37 areas ('Quartiers'), each subdivided into zones centred upon a station. Officials of 'Affaires maritimes' at the stations are responsible for the collection of various types of data concerning the fisheries including landings data and they also collect details of the vessels and men employed for social security and tax purposes. Most of their work takes place at minor ports at which there is no public auction service.

Most fishery products (80%) are landed direct to fish markets. The fish market officials are responsible for providing 'Affaires Maritimes' with statistical information on landings and transactions. Unfortunately they rarely meet their responsibilities and the documents sent to the 'Affaires Maritimes' are generally unsuitable and often inexact.

The 'Centre Administrative des Affaires Maritimes' (CAAM) centralises all the data sent to it from the 37 'Quartiers'. In theory it uses these data to satisfy the statistical requirements of the various government departments. A large number of standard tables are produced covering periods of a month, quarter and year. There is no program for handling the files other than for routine processing and it is thus very difficult to do any work or research in the information contained in them.

(b) The new system -

As a result of the shortcomings of the 'Affaires Maritimes' system and the need for better data, the 'Marine Marchande' gave new computer facilities to ISTPM in 1976 so that it could develop a new statistical system. In 1980 and 1981 the project was fully approved and equipment purchases and staff recruitment plans were authorised. The aims of the new system are to satisfy all requirements for fishery statistics by administrative departments and scientific institutes at both national and international level and to incorporate into the system all organisations which can make a useful contribution to prevent duplication and facilitate data availability.

All data will be centralised into the ISTPM system using the data sheets designed by ISTPM.

(ii) Vessel files

(a) Under the old system operated by 'Affaires Maritimes', details of each vessel are recorded on 'Roles d'Equipage' (or ship's records) which are held by 'Affaires Maritimes' and these documents contain a variety of information about the vessels and the men employed on them. The data are centralised on computer (by CAAM) but unfortunately it has not proved possible to access these files for scientific purposes.

(b) Under the new system operated by ISTPM, a set of reference files will be set up to check the landings information which is entered and to supply supplementary information. This vessel list will include information on:

Vessel registration number

Vessel name

Engine power

Length between perpendiculars

Tonnage

Year of building.

(iii) Catch and effort statistics

The majority of landings by French vessels (80%) are landed direct to fish markets at which there is a public auction. The remainder (20%) is landed at small ports at which there is no public auction. This distinction characterises the main feature of both the old and new French statistics systems.

(a) The old system of 'Affaires Maritimes' -

For minor ports without a public auction service, officials of 'Affaires Maritimes' ('Syndics') make a monthly return to the 'Quartier' office for each port on the form shown at Annex 1 which lists the total quantity and value of each species landed for the month. Information from all vessels is aggregated and the return gives no information on gear, on time spent fishing or on the location of capture. The accuracy of these data is variable depending upon the ability of each 'Syndic' and also on the volume of landings which he has to cover which varies considerably between stations.

At ports where there is a public auction service the fish market officials are responsible for providing the 'Quartier' offices of 'Affaires Maritimes' with statistical information on landings and transactions. Unfortunately, however, the documents sent to 'Affaires Maritimes' are generally unsuitable and often inexact in that the weights are simply estimated rather than measured and species are often sold together which tends to inflate the 'miscellaneous' category.

In theory all vessels fishing the open sea must complete a fishing return ('Fiche de Pêche' - see Annex 1) which should give details of time spent fishing, the gear used and location of capture. In practice the staff of 'Affaires Maritimes' are unable to collect the returns and the 'Quartiers' receive very few of them and make practically no use of those which are received.

The 'Quartier' offices of 'Affaires Maritimes' collect together the landings records from the stations and fish markets and complete a form entitled 'Statistiques mensuelles des produits debarques' which lists the species landed and gives details of total quantity and value and a breakdown of the means of disposal (auction, non auction etc).

These forms are entered into a computer file at the 'Centre Administrative d'Affairs Maritimes' in St Malo. Formal checks are applied to the data and standard tabulations of the aggregated information are produced 4 months later. There is no program for handling the files other than for routine processing and it is, therefore, very difficult to use them for research.

Returns to ICES for publication in 'Bulletin Statistique' are made on the basis of this data collection system and it should be understood that the area of origin of capture identified in these returns is very roughly estimated on the basis of knowledge of the fishery rather than on a systematic system of effort data collection. The location of capture (by ICES Division for example) is therefore imprecise and the system provides only a limited quantity of data on catch-rates.

(b) The new system of ISTPM -

There will be 4 levels of information compilation and processing. (1) All landings will be recorded either individually or by vessel groups to determine quantity and value. (2) Vessels fishing the open sea or inshore vessels which make trips of longer than 24 h will be required to complete a fishing return or log-book which will give fishing position, fishing time and gear used. The information in log-books will be checked by comparison with all observations made by surveillance planes and vessels in the 200-mile zone. The information will be used to identify the location of capture and effort details associated with each landing recorded at the first level. (3) Biological samples will be obtained by scientists either at sea or on land to determine the size composition of catches, rejects and any other biological information as the need arises. (4) A data base will be constructed using the information from the other three levels which will allow rapid access to every aspect of the data in its most basic form.

Three information channels will operate initially and the data will be collected by both ISTPM and 'Affaires Maritimes' staff. As the system develops and ISTPM recruit more staff these channels will eventually reduce to two corresponding to data from public auction markets and those from ports without a market.

Channel A -

This will operate at ports with a public auction service and at which an investigator of ISTPM is employed. Fish market officials will supply details of landings by each vessel on a daily basis and will transmit these data directly by terminal or indirectly by post to one of ISTPM's computers (Boulogne, la Rochelle or Lorient). Each morning the ISTPM investigator will collect log-books corresponding to each landing and, after scrutiny, will transmit them to the ISTPM computer.

Channel B -

This will be temporary and will be incorporated into Channel A as more ISTPM staff are recruited. It will cover sales at fish markets in which there is not yet an ISTPM investigator (i.e. 10-15% of total auction sales). This channel will be the responsibility of the officials of 'Affaires Maritimes' who will obtain aggregated landing statistics from the fish markets and will, whenever possible, obtain information on vessel and gear types. Log-books will be collected and, along with landings information will be sent to the 'Quartier' offices who will transmit the information to ISTPM laboratories.

Channel C -

This channel will remain the responsibility of the officials of 'Affaires Maritimes'. Their work will be re-organised and up-graded and they will report landings by individual vessels. They will also be asked to give estimated catch-rates by species, gear and type of vessel. These estimates will be checked by ISTPM by sampling. All this information will be sent to the CAAM computer and also to the ISTPM computers for input and final computation.

It is anticipated, therefore, that the new system will give comprehensive and rapid coverage of all landings in France and will make it possible to identify quantities and values of each species by area of capture, giving details of gear and fishing time for individual vessels for the majority of landings.

(iv) Summary

The system of 'Affaires Maritimes' provides a very complete vessel file for the French fleet giving details of each vessel, its equipment and crew. Even though the data are available in written form and also on magnetic tape at CAAM and EUROSTAT it has proved difficult to access them because of the way the files are organised and due to the lack of suitable retrieval programmes. The old system provides estimates of the quantity of fish landed in France by species and these landings are ascribed to ICES areas on the basis of knowledge of the fishery rather than by systematic data collection. It is not possible to break down the landings into those by vessel categories (size, type or gear) or individual vessels nor are any catch-rate data available. It is certainly not possible to use the data from the old system for an analysis of fishing capacity. The data collection only fulfills the need to provide landings data to ICES for assessment purposes and the data are often of dubious origin and value.

Significant improvements are expected under the new system which will provide detailed data for each landing for the major part of French landings which occur at ports with auction markets (approximately 80% of the total). This system has been introduced to La Rochelle, Les Sables d'Olonne, Hendaye and part of Lorient and will be extended to most other ports in 1982 as recruitment to the new posts in ISTPM take place. In addition the system will provide a well-organised vessel file. It should eventually be possible to use the data provided by the new system to make a detailed analysis of fishing capacity but it is likely that this will not be possible until 1983 or later.

I.1.3 Data available in the UK

The United Kingdom has a large, dispersed fleet consisting of over 7 000 registered vessels (1979), 90% of which are smaller than 50 gross registered tonnes. In addition there are large and unknown numbers of small unregistered vessels, particularly in England, which are operated by part-time fishermen and anglers. In England and Wales alone there are 278 recognised landing places; 60% of the total landings, however, take place at 13 major ports.

The United Kingdom is separated into three parts for the purposes of fisheries administration and data collection. Data collection in England and Wales is the responsibility of the Ministry of Agriculture, Fisheries and Food (MAFF), in Scotland the same responsibility is held by the Department of Agriculture and Fisheries for Scotland (DAFS) and in Northern Ireland by the Department of Agriculture for Northern Ireland (DANI). The data collection systems are now integrated to the extent that similar data are available for each region, and the basic data for

England, Wales and Northern Ireland are centrally available on the MAFF computer at Guildford; there are plans to exchange data between MAFF and DAFS. Summaries of the UK statistics are published by MAFF each year in 'Sea Fisheries Statistical Tables'.

A. Data collection in England and Wales

(i) Organisation

The maintenance of vessel lists and the collection of catch, effort and biological data are the responsibility of the Fisheries Inspectorate of MAFF. The Chief Inspector of Fisheries is supported by 10 District Inspectors (DI's), 9 of whom are stationed at major ports around the coast. The DI's are responsible for local enforcement of fisheries legislation, liaison between fishermen and the Navy, and for fisheries data collection. Each DI is supported by a Fishery Officer who undertakes the first two roles and also by 2 to 7 Collectors of Statistics who carry out the third.

(ii) Catch and effort data

The recording medium for catch and effort data is a computer punch document called the 'H-Form'. Two versions are used, the H1-Form for landings by larger vessels from several grounds, and the H2-Form for landings from single grounds by individual vessels or for returning summaries of the landings of groups of vessels less than 40 ft in length. Examples of the forms are included in Annex 1.

Each form gives details of the vessel making the landing, which allows additional data on vessel characteristics to be obtained from the vessel files. The port, date of landing, gear used, details of effort expended, the ground (ICES rectangle) and the quantity and value of each species in the landing are recorded on each form.

Collectors of Statistics obtain the information for completing H-Forms by direct inspection of the landings on the markets, by examination of sales notes and by interview of the skipper or mate. Collectors are assisted in this at minor ports by 'part-time collectors' who are usually members of the public closely connected with the local fishing industry. The data collection system aims to be a complete census of all landings in England and Wales by full-time fishermen using registered fishing vessels. This aim is largely achieved for landings but not so well for effort; short-falls in recorded landings occur for small inshore fishing vessels and part-time fishermen. The quantities involved are probably relatively minor (less than 5%).

Completed H-Forms are posted to the Data Processing Section of MAFF at Guildford and entered into MAFF's main computer. Tabulations of data are routinely prepared every month on the basis of the forms received and the records are added to the historic file of catch and effort data. Non-standard retrievals have to be specially programmed which entails a variable delay depending upon difficulty and priority. In principle the system can provide details of every landing by vessels over 40 ft in length and monthly summaries for the landings of smaller vessels, and any level of aggregation greater than this. It is therefore possible to provide data on landings in the UK by vessel group, gear type, rectangle of capture, port of landing, giving details of fishing time and the quantity and value by species. Some reservations exist on the accuracy of the rectangle data and some effort details such as hours fishing, but one can be confident about the ICES Division of capture, the month of capture, the number of days fished, the gear used and the quantity and value of landed fish.

(ii) Vessel file

A vessel file is maintained on the MAFF computer which contains the following details for each registered fishing vessel larger than 40 ft:

Registered length

Gross registered tonnage

Date of building

Vessel type/gears used.

This record is up-dated as the need arises on the basis of information provided by the District Inspectors. There are plans to improve the vessel file by including more details (engine-power, for example).

(iii) Future developments

Discussions are being held on the introduction of a new system of catch and effort data collection which will include the use of EEC log-books to replace H-Forms for landings of vessels exceeding 10 m which are landing quota species. An up-dated version of the present form will be used for other landings and an on-line data retrieval system is being made available. It is intended that the new system will give similar coverage of the landings as the present system.

B. Data collection in Scotland

Scottish sea fisheries statistics are the responsibility of the Department of Agriculture and Fisheries for Scotland (DAFS). Eighteen fishery districts cover the coasts of the mainland and islands of Scotland. Statistics are collected on a daily basis and are normally obtained by interview of the vessel skipper or mate by Fishery office staff. If this is impracticable the information is obtained from secondary sources such as sales notes.

A detailed record of each trip by vessels over 35 ft is made on Form F/FS1. Landings of smaller vessels are reported on a grouped monthly basis for individual landing places. Form F/FS1 includes details of the vessel, date of landing, ground fished, the fishing gear used and the effort expended. The ground is given as the main rectangle fished.

Quantity and value are also recorded on the form for each species landed. Herring landings, in addition, are summarised on a weekly basis by landing place on F/FS2, which gives details of the final disposal of the fish.

The records are vetted and entered into a computer. Monthly statistics on landings, value and effort are usually available within 6 weeks from the end of the month concerned.

Recently the Scottish data have been converted to a MAFF-compatible format and the data will be routinely transferred to MAFF's computer in the future. A file of vessel characteristics for Scotland is maintained for vessels over 35 ft which contains details of registered length and gross registered tonnage.

C. Data collection in North Ireland

Prior to May 1980, landings data were collected and recorded by hand for the three main ports (Portovogie, Ardglass and Kilkeel). Since then the MAFF H-Form system has been in operation and the forms are submitted to MAFF for processing. A vessel file is maintained which gives vessel length and tonnage.

D. Summary

The majority of landings in the UK are recorded by trips; summaries are recorded for small inshore vessels and it is possible to distinguish between ports, months, ICES Division and gear. A small proportion of the total landings is not recorded, amounting to about 5% or less, consisting mainly of the landings of part-time fishermen. The data are stored on computer files and are accessible in their most basic form. Computerised vessel files are maintained for over 40 ft vessels in England and Wales and Northern Ireland, and for over 35 ft vessels in Scotland which contain details of vessel lengths and tonnages. Data on costs of catching and the capacity of processing facilities are not collected on a national basis.

I.1.4. Data collection in other Member States

This brief review is taken from the ICES Cooperative Research Report No. 91 and the 1978 Report of the ICES Statistics Liaison Committee, supplemented with additional information from a variety of sources. The review excludes Italy and Greece, which are not members of ICES.

(i) Belgium

Belgium is well placed to operate an efficient statistical system; most of the catches are landed at only three ports and there were only 216 vessels in 1978, all except six being 25 tons or larger.

Statistics are collected from two sources. One source is the record of auction sales which indicates the weight and value of landings, the characteristics of the vessel and the method of catching. The other source is a log-book system operated by all fishing vessels in which are recorded dates of departure and return of the vessel, days fishing, number of hauls, their position by ICES rectangle and the duration of hauls. Data from both sources are received within 48 hours after the return of the vessel to port and are then transferred to computer format and stored on magnetic tape at the Central Statistical Office in Brussels. The information is also stored in computer form at Ostend where it is used for detailed biological and economic research work.

It would appear that inshore fishing by small boats escapes the system. These vessels are, however, monitored by port officers who register all vessel movements (and can thus check departure and return dates of the larger vessels). The catches of small vessels are assessed by sampling surveys.

The system provides comprehensive and detailed coverage of all landings by Belgian fishing vessels.

(ii) The Netherlands

Most landings are sold at auctions and data on quantity and value by species are recorded on 'auction forms' by the market officials. Effort data (dates, gear, time spent fishing and rectangle of capture) are collected by statistical officers and added to the same form. Information on the quantity and value of frozen and salted fish is submitted 2 to 3 weeks after landing. Auction forms and details of frozen and salted fish are sent to the Central Bureau of Statistics in The Hague for punching and computer processing. This results in a number of standard tables which are used to report landings to ICES and to supply data to the research institutions dealing with biological, technical and economic research in fisheries.

Since it is not obligatory to sell fish by auction, the data are incomplete and it is generally recognised that major problems exist in recording the total landings of species under quota (e.g. sole). (To be fair, similar problems exist in other Member States but may not be admitted). Retrieval of data in its basic form is difficult and research workers have to rely upon manual extraction of data from the standard tabulations for detailed studies.

The information on vessel data as required on the ICES data Form 6 (fishing craft and fishermen) is taken from a national register of fishing vessels. This register is kept up to date with the collaboration of local authorities responsible for shipping registers in the different ports. Two forms are in use, one for collecting information in the ports, and the other as a file card on which all data and any changes in the vessel are recorded and which is used for the annual compilation in printed form.

To summarise, it appears that the usefulness of the well-organised Dutch data collection system is limited by incomplete coverage of landings and the inaccessibility of their data.

(iii) Germany

In 1979 and 1980 there were 47 distant water vessels (two for herring), 710 middle water vessels (around 100 GRT) and 453 inshore vessels, many of which fish for shrimp and have engines of around 250 bhp.

A log-book system has been in force for the large vessels fishing in distant waters ('luggers') since 1974. Catches (including discards) are recorded daily as well as details of fishing position and the gear used. Sales records are used to verify the estimated catches in the log-books and to register a wide range of species in the catch.

The landings of 'cutters' fishing in the North Sea and Baltic are similarly treated using log-books on a haul-by-haul basis although in 1977 only 60% of the vessels were covered by the system; landings of the remainder are obtained from sales records.

No effort data are available for landings by small coastal vessels; landings are obtained from sales records and by interview.

The basic data are held by the Statistical Office in Weisbaden and also by the Institute for Sea Fisheries in Hamburg. Much of the processing is by electronic calculator which has been found to give quicker results than by using the main computer in Weisbaden.

Usable data therefore exist for the great part of the German fleet, although a number of small, inshore vessels fall outside the main system.

(iv) Ireland

In Ireland, as in France, there are a large number of landing ports, a high proportion (74%) of the fleet consists of small vessels (under 25 GRT), responsibility for statistics lies with a department that is short-handed and has much other work to do, and it takes a long time (over three months) to produce the statistics.

Details of the quantity and value of landings by species are collected on a monthly basis by area officers of the Department of

Fisheries for the 100 or so regular landing places in the Republic. These data can be roughly allocated to stocks on the basis of knowledge of the fisheries. Completed forms are forwarded to the administrative section in Dublin which prepares summaries by hand. Landings are, therefore, comprehensively recorded in Ireland.

The returns are for the landings of all vessels at a port during the month and therefore no detailed breakdown is available. Catch and effort data are not available on a national basis, although since 1977, such data have been collected for each landing at the major port (Killybegs) and weekly catch per effort data has been recorded for the herring fisheries off the Irish coast.

Improvements in the Irish system have been announced. The European log-book will be introduced shortly and data processing is to be computerized as there is no other way to cope with the sharp increase in the mass of information that will result. It is probable, however, that a large proportion of the fleet will be exempted from the system, as presently envisaged, under special waivers.

I.1.5 Centrally available data

(i) ICES

The principal source of international statistics for the North East Atlantic is the 'Bulletin Statistique' published by the International Council for the Exploration of the Sea (ICES). This is a very full compilation of the STATLANT 27A and 27B returns sent by the ICES Member States. It comprises 22 tables presenting the information in different ways.

The largest of the tables is the seventh, entitled 'Fishing Effort and Nominal Catch in 19.. by Fishing Area, Month, Gear, Vessel Category, Main species Sought and Country'. Since 1981 (data for 1978) it has been withdrawn from the Statistical Bulletin as it was too long (220 pages) and very little used. It is available for those who wish in the form of a print-out and will soon be available on microfiche as well.

The statistics published by the ICES are a very valuable source of information on fishing but are quite inadequate as a basis for a fishing capacity development policy, for the following reasons:

- The delay before publication is roughly two years, which is far too long;
- The accuracy of the published figures is very uneven.

The degree of efficiency of the statistical network varies from one country to another and from one type of fishing to another, i.e. the results exhibit different degrees of accuracy, detail and bias. We have seen that weaknesses often occur in regard to direct sales, small-boat fishing and industrial fishing.

Further difficulties as to accuracy have arisen in the last few years with the introduction of quotas and licences as few countries are prepared to circulate information proving that commitments entered into have not been respected.

The use of these statistics can therefore only be entrusted to experts familiar with all aspects of fisheries who can assess what use can be made of them and rectify any erroneous or fraudulent declarations.

For these reasons the members of the ICES working groups make little use of the figures but produce more complete, more sophisticated and generally more accurate information from their national statistics supplemented by samplings and 'corrections' that allow the sometimes-camouflaged truth to be discreetly revealed.

(ii) EUROSTAT

Two sets of statistics are available at European level:

- fisheries statistics (Cronos system)
- the vessel files transmitted by the Member States.

(a) The Cronos system

This is a data base run by Eurostat for the European Community covering a number of areas, one of which, entitled FISH, is concerned with fisheries statistics. It contains 16 000 entries (1981) containing data on annual catches broken down by area, monthly data on landings and statistics on the fishing fleet. Each entry is a sequence of numbers linked to a date and can be identified by a nine-digit key which specifies the species, area of capture and nation. These keys have to be numerical, which does not allow the ICES (alphanumeric) codes to be used. In addition a nine-digit code is too limited in scope. It does not allow series to be compiled by gear, vessel type, port or fishing area other than ICES region.

The remarks made on the statistics published by the ICES apply to the Cronos system, as the source of information is the same. The advantages of Cronos are prompt updating, ease and rapidity of access, and the ease and speed with which simple statistical calculations can be made, formulae applied, series combined, and graphs drawn.

Other series are envisaged:

- fleet statistics
- monthly catch figures
- external trade figures
- fishing activities
- catches by national fisheries zone
- annual landing figures
- supply estimates.

The same difficulties will apply in the case of each of the above.

In conclusion, we can say that because of a high level of aggregation and a lack of economic information the Cronos system does not give the information needed to develop a practical fisheries development policy.

(b) Vessel files

Eurostat has attempted to assemble at Luxembourg the vessel files of the EEC Member States. There have been various difficulties: confidentiality and the fact that in certain countries there is no vessel file.

It is intended to introduce a log-book and landing declaration system which will furnish a considerable mass of information annually on all vessels more than 17 metres long, but at the same time no updated list of these vessels will be available every year. This situation is obviously unsatisfactory.

(ii) FAO

The FAO publishes some statistics of a general nature based on ICES or Eurostat statistics. They are therefore irrelevant to our study.

I.1.6 Summary

All Member States provide estimates of the total landings by species and ICES area for publication in ICES Bulletins Statistique. The data are mostly complete although it is recognised that under-reporting of quota species exists in perhaps most countries, and the landings record for small vessels is usually incomplete. The accuracy of the location of capture varies between countries depending upon the system of collection.

Most Member States have a vessel file, at least for large vessels, but this information is absent in Ireland and is difficult to retrieve in France.

Detailed catch and effort data by individual vessels or vessel groups covering the majority of the fleet do not exist for France, Denmark and Ireland but are available for most of the UK, Belgian, Dutch and German fleets. Difficulties in data retrieval are experienced in each country and all but the UK and Belgium would have to depend upon manual extraction from the basic forms to carry out any detailed analysis.

A detailed analysis of fishing capacity as outlined in the Introduction, is therefore likely to be impossible for France, Denmark and Ireland given the existing data, and difficult even for countries which routinely collect catch and effort statistics because of the lack of adequate data retrieval systems.

I.2 REVIEW OF METHODS USED

As we have indicated in the Introduction, the measurement of the fishing capacity of individual vessels or fleets is not easy in a complex fishery in which vessels of different types fish several resources simultaneously. Vessels and fishermen are flexible in the sense that they can change the fishing gear which they use, they can switch their attention to different target species and they have a certain amount of freedom to fish in areas which are not the traditional ones for them. The bulk of the fisheries are complex in this sense and the solution to the overall problem of matching the fleets to the resources which are available must be sought in methods which take account of this flexibility.

In addition, it is our opinion that a suitable method would be one which allows a full range of objectives for fleet optimisation to be explored, over and above the immediate need to match the fleet to the TACs. Even if the present TACs were the main constraint on the fleet, the natural flexibility of the individual vessels suggests that the TACs could be achieved with a variety of fleet structures, and it is important to identify methods which allow fishery managers to make an informed choice between the different solutions.

Looking further ahead, we can anticipate that there is a need to rationalise the fleet structure on a Community basis. Whilst there may not be the political will to do this at the moment, we feel that it is important to identify methods which will be useful in this respect if only to show that such a procedure may be at least theoretically possible and to point out the types of data and models which would be required.

The search for appropriate methods which had already been developed for measuring fishing capacity began with work in the UK, France and Denmark. Since only a limited amount of study has been carried out on this subject, the scope was widened to include Scandinavian countries, Canada, the USA and Australasia. Only four studies were found which addressed the problem of matching capacity to the resources available in a mixed fishery, although there are a number of examples applied to single species, single vessel type fisheries. The latter are instructive but they are not particularly relevant to the fisheries in EEC waters, which are mainly fisheries composed of a number of types of vessels fishing the same resource, and often fishing several resources simultaneously.

The shortage of relevant studies is surprising because of the interest in managing mixed fisheries by limited entry in Canada, the USA and Australasia in particular. However, it is clear that domestic vessel and quota licences are usually issued to the fishermen in a restrictive way without specific calculation of the exact number required and the final control of numbers may be left to economic forces by making the licences transferable (see, for example, Anon., 1979). Such an approach is practicable when the resources are owned and controlled by one state; it is clearly more difficult to employ when the resource is jointly owned by several states which have different political, economic and social backgrounds and objectives.

There are two main types of approach to the problem of modelling mixed fisheries; one is simulation in which individual vessels or vessel groups are dynamically followed through time within a computer model, and which is particularly applicable to situations in which the shore-based processing facilities are an important constraint on the fish production and when the fleet directs its attention to a succession of species; the other approach is mathematical or linear programming which is a non-dynamic approach to the allocation of resources between vessels or vessel groups so as to achieve specified objectives within a set of constraints, and which is particularly applicable to complex fisheries in which there is a heterogeneous and flexible fleet which may exploit a number of resources simultaneously.

The scope of the methods may vary from a simple framework in which the available resource is imposed from outside the model and in which the only objective is to take a quota or TAC, to a complex framework in which the system is modelled dynamically and in which economic and social objectives can be explored in both the short- and long-term. In fact an almost infinite range of approaches is possible and a particular method has to be developed to meet the specific requirements at the time.

Relevant studies have been carried out and published by fisheries scientists in the UK, Norway and the USA; this work is reviewed in the remainder of this section.

I.2.1 Capacity studies in the UK

Following the contraction of the catch possibilities for the UK fleet, an inter-departmental group was established in 1975 to develop methods of assessing the performance of the UK fish catching industry with the intention of forming a view of what its future structure might be. The group developed a method which used the most recent information about the catch-rates obtained by the existing fleet to determine the size and structure of fleet which would be required to take the quotas allocated to it (Garrod and Shepherd, 1981).

The problem which the UK group addressed is therefore similar to that given to the present study group, with the difference that the present group has to find a method which is generally applicable to the Member States given the different types of data available. The UK fleet is composed of a large number of different types of vessel which exploit a wide variety of species (often simultaneously) in most resource areas and in this, the mixed fishery aspect, is equivalent to many of the other EEC fleets. The main difficulty faced by the UK group was to find a method which dealt with the mixed fishery aspect adequately, allowing for the fact that one particular vessel might catch a number of quota species on the same trip. As has been indicated in the Introduction, it is necessary to specify an objective, in addition to the quota objective, in order to solve the problem of allocation of the resources between different types of vessels.

The UK group developed two versions of the 'fleet operation model' which differed only in the way the objectives were formulated and in the way the allocation problem was solved. The method was of the 'mathematical programming' type rather than simulation. Both versions used the same basic data and the same basic method of predicting future catches by modelling the fishery production system in a way which closely agrees with that discussed in the Introduction. The potential catch of a fleet (split by vessel categories) in the quota year is estimated by calculating the ratio of catch-rate to biomass in a recent year and by applying this ratio to the biomass in the quota year to estimate the future catch-rate. Potential catch is then estimated by multiplying the catch-rate by the amount of fishing time which the fleet exerts. Initially the fishing time is that of the present fleet but is progressively adjusted by the model as it searches for a solution. The fleet operation model does not specifically set out to measure the fishing capacity of the existing fleet but calculates the fishing time which is required in each component of the fleet to catch the quotas under a particular set of objectives. Over or under-capacity is measured in terms of the fishing time required for the quota year compared with the fishing time which it would be feasible for the existing fleet to exert. The model could, however, have equally well expressed the results in terms of potential catch but this would have been a notional figure because it would have been derived from a linear relationship of catch and effort (see Introduction, Section 3.5).

(i) Model structure

The existing fleet was divided into a number of components characterised by vessel size and gear; twenty components were found to be the minimum required to ensure an adequate description of the fleet such that, within each component, the catchability for each species (ratio of catch-rate to biomass) could be reasonably regarded as having one value. The base port of the vessels was important since this often dictates which resources the vessels are able to exploit and therefore the fleet was further divided into sixteen groups corresponding to the fishing districts of England, Wales and Scotland (Northern Ireland was not considered). These fleet divisions are listed in the table below.

Table 3 Details of sub-divisions used for the UK fleet operation model

Fishing vessel type			Fishery districts	
No	Vessel length	Gear/method	No	Name
1	Less than 40 ft	All	1	North-east England
2	"	Demersal trawl	2	Hull
3	"	Demersal seine	3	Grimsby
4	"	Lining	4	Eastern England
5	40 to 65 ft	Pelagic trawl	5	Thames
6	"	Pelagic seine	6	South-east England
7	"	Other pelagic	7	South-west England
8	"	Miscellaneous	8	Wales
9	"	Demersal trawl	9	North-west England
10	"	Demersal seine	10	South-west Scotland
11	"	Lining	11	North-west Scotland
12	65 to 80 ft	Pelagic trawl	12	Lerwick
13	"	Pelagic seine	13	Moray Firth
14	"	Other pelagic	14	Peterhead
15	"	Miscellaneous	15	Aberdeen
16	80 to 110 ft	Trawl	16	Firth of Forth
17	"	Other		
18	110 to 140 ft	All		
19	More than 140 ft	Freshers		
20	"	Freezers		

In order to describe the fish resources exploited by the UK fleet it was necessary to consider fifteen resource areas, corresponding to the ICES Divisions adopted for stock management, and fourteen species groups. The latter were selected so that each quota species could be separately identified and so that both quota and non-quota species were included. The inclusion of non-quota species was necessary because it was the intention to simulate the real behaviour of the fleet (shifts in gear and grounds) and to examine vessel profitability. Both of these are influenced by the total resource available. Resource categories are listed below:

Table 4 Details of sub-divisions used for the UK fleet operation model

Resource area			Species	
No	Name	Definition	No	Definition
1	Northern North Sea	104A	1	Cod
2	Central North Sea	104B	2	Haddock
3	Southern North Sea	104C	3	Plaice
4	Eastern Channel	107D	4	Saithe
5	Western Channel	107E	5	Sole
6	Irish Sea	107A	6	Whiting
7	Bristol Channel	107F	7	Norway Pout and sandeels
8	South-east Ireland	107G	8	Other demersal
9	Other Westerly	107B,C,H,J & K	9	-
10	West of Scotland	106A	10	Herring
11	Rockall	106B	11	Mackerel
12	Faroe	105	12	Sprats and other pelagic
13	Iceland	111	13	Blue whiting
14	North-east Arctic	101,102,113	14	Crustaceans
15	Other distant water	Others	15	Molluscs and other shellfish

Quarters of the year were selected as the basic time unit for the model, principally because it was expected that catchability would vary between seasons for most fisheries, but also because the time spent fishing by the smaller categories of vessel was known to vary with the seasons due to weather constraints.

The effort expended by the fleet was measured in 'days absent' and consequently catch-rates were measured as 'catch per day absent'.

(ii) <u>Data requirements for the basic calculation</u>

The model requires:

(a) The number of days fishing expended by the existing fleet in a recent year broken down by the 20 vessel types, 15 resource areas and 16 fishery districts by each quarter of the year.

(b) The catch-rate (catch per day absent) in a recent year for each of 14 species groups with the same breakdown as the effort data. Of the 19 200 possible combinations 'only' 1 500 were found to occur in the fishery.

(c) The biomass of each of the 14 species groups in each of the 15 resource areas in the recent year.

(d) The biomasses for each species group and resource area expected in the quota year and the quotas allocated to the UK.

The fleet performance data (a and b) were obtained from the historic file of data maintained by MAFF and DAFS, collected as described in Section I.1.3. Biomass estimates for quota species were derived from ICES Working Group Reports. Those for non-quota species were estimated independently using the best data available which usually involved consideration of the production/biomass ratio which could be expected for that stock. In default of any information the historic catch-rate was used without modification.

(iii) <u>Method of catch-rate prediction</u>

For most stocks the fleet operation model uses the catchabilities observed in a recent year to predict catch-rates in the quota year. The detailed breakdown of the fleet into vessel categories ensures that the problem of comparison of fishing power is largely avoided. In its present form the model assumes that a change in biomass will result (for demersal species) in the same relative change in catch-rate of each fleet component. In other words, the model does not consider the age-structure effects which were discussed in the Introduction. In principle it is not difficult to incorporate this important detail into the model but, in practice, it was made difficult by the large amount of additional data which would have had to have been processed.

For some stocks and fisheries, i.e. the purse-seine and trawl fisheries for schooling pelagic species such as mackerel and herring, catch-rates were assumed to be constant and were therefore not treated as dependent upon stock biomass as was the case for the other stocks considered. Potentially, the relationship between catch-rate and biomass could take many forms (as suggested in the Introduction) and in adopting only two of them the fleet operation model is a simplification. A wider variety of relationships could be incorporated but this would depend upon having suitable information available to determine their form (time series data of catch-rate and biomass).

(ii) <u>Methods of achieving the solution</u>

The calculations using the disaggregated fleet data are directly capable of providing an estimate of the catch of each species in each resource area which would be taken in the quota year given the existing deployment of the fleet. This has been defined earlier as the fishing capacity. The fleet operation model was designed to estimate the required fleet for a given set of quotas and therefore proceeds further than the estimation of capacity by calculating the amount of fishing time which is required within each section of the fleet to take the quotas.

This poses two problems:

(a) The required fishing time within a vessel category might be different for each quota species caught.

(b) There will be several ways of taking the quotas.

The former problem will be minimised if the TACs between species are compatible. The second problem requires the identification of objectives other than that of matching the fleet to the quotas.

In the first version of the fleet operation model (Mark I), solutions were found which minimised the costs of catching fixed quantities (by value) of demersal fish, subject to quota constraints and maximum numbers of vessels available. The mathematical technique used was 'linear programming', in which the amount of fishing time by each vessel category was progressively adjusted until the minimum of the objective function was found. When this technique was used it was found that the changes in fleet structure indicated by the model were unrealistically extreme and over-sensitive to small changes in assumptions about the catchabilities and costs of catching. The Mark I model ruthlessly sought the absolute minimum value for the objective and gave very different solutions if the input values were changed only slightly.

These unwanted features are overcome in the Mark II model (developed principally by Shepherd) by allowing a non-linear objective function, and introducing a penalty for departure from some reference solution (usually the status quo). The mathematical routine cannot handle a constrained problem, so the quotas are also handled by penalty functions, which permits slight under- or over-shoot of the quotas. The compound objective function in the Mark II model incorporates:

(a) a penalty for exceeding or not reaching the quota

(b) a penalty for fleet disruption

(c) a profit objective.

Different strategies and objectives can be explored in the model by 'weighting' the component parts of the objective by different amounts. The Mark II model can therefore estimate the fleet structure required to take the quotas under least change from the existing fleet by giving the profit component a low weight and the disruption component a relatively high weighting. It was considered important to include profit into most calculations because profit is a real motivating force in the existing fishery, even though inclusion of the profit objective is not essential to the solution of the problem. Profit was calculated simply as revenue (catch x prices) minus costs (fishing time x cost per unit time).

The 'optimisation' procedure operates by calculating the rate and direction of change of the compound objective function with respect to each effort variable simultaneously (i.e. the number of days fishing in each section of the fleet) and repeatedly adjusts the effort variables accordingly until the objective function shows little change between repeats of the calculation. The exact mathematical method is explained in Shepherd and Garrod (1981) and Shepherd (1980).

The Mark II model was found to simulate accurately the changes of the fleet in the past and was used to indicate the fleet structure which the UK would require under a given set of quotas. As expected, a reduced fleet was predicted and it was possible to identify, in general terms, the types of vessel which were in excess. The model has also been operated using a longer-term expectation of quotas (5 years ahead), rather than those for the forthcoming year, by extending the ICES forecasts into the future.

(v) <u>Summary</u>

Clearly the fleet operation model is very demanding of data in that both comprehensive and detailed information are required on the fishing time expended by the fleet and on the catch-rates which they obtain for both quota and non-quota species. Data on the costs of operating each type of vessel are also required. In the case of the UK model approximate costs were obtained from some fishing companies and extended to the whole fleet.

A number of improvements to the basic model can be suggested - by allowing for age structure effects and by introducing better established relationships between catch-rate and biomass for example. Nonetheless the technique of 'cautious non-linear optimisation' used by the Mark II model was a significant advance over earlier solutions and allows the investigation of the problem of matching capacity to resources under a variety of different objectives.

I.2.2 Capacity studies in Norway

Since the early 1970s there has been an intensive research effort into the capacity of the Norwegian fishing fleet. The Norwegian fishery for industrial purposes increased rapidly in the 1960s but the catch has been approximately constant since then. The main part of the catch in the earlier period was Atlanto-Scandian and North Sea herring and North Sea mackerel, whilst the capelin fishery in the Barents Sea has been dominant more recently.

This change in fishing has changed the need for processing plants from the southern part of Norway to the north. In addition, as a result of increased cargo capacity and efficiency of individual vessels, there is over-capacity of the fleet. The research has therefore concentrated upon both the industrial fishing fleet and the processing plants.

The research has been done at the Christian Michelsen Instituut, Bergen, at the Norwegian School of Economics and Business Administration and also at the University of Bergen (Ervik et al., 1981; Bjørndal, 1981). In parallel with this, some work has been carried out by the Ministry of Fisheries of Norway to develop the models further, and to make use of the results in the management of the fishery. The models developed in Norway are of the simulation type. The following is a summary of the work at the first two institutes.

I.2.2.1 Simulation model developed at the Chr. Michelson Instituut

One of the main purposes of the work was to evaluate the economic gains which could be obtained from the Norwegian industrial fishery. This was done by means of an economic model of the fishery, the project for which has been developed in several stages. For example the project leading to an economic model of the Barents Sea capelin fishery was divided into the following parts:

(1) biological model

(2) catch and distribution model

(3) economic model

and (4) data analysis.

In this summary we will deal with the catch and distribution model; the method is discribed in detail in Tjelmeland and Ervik (1977).

(i) The catch and distribution model

The catch and its distribution to the processing plants are simulated on a computer by following each vessel and factory dynamically through time. The daily catch by a specific fleet can be calculated and this is distributed to different processing plants. The fishery in a particular year can be repeatedly simulated under different assumptions of fleet size, landing strategy, quota restriction and length of the fishing season. Each of these trials can be evaluated in economic terms using cost relations for the fishing vessels and the value of the catch. The detailed output can be used to identify earnings and time spent fishing by vessel categories, the demand for labour, and the profitability for each processing plant upon which the evaluation is based.

A great deal of information is required to construct a reliable simulation model and the workings of the fishery must be thoroughly understood. Data are required on:

(a) the stock - the TAC for the year in question and the length of the fishing season;

(b) the fleet - the number of vessels (in 5 categories), their average cargo capacity and average speed, and estimates of costs and man-power utilisation;

and (c) the processing industry - indentification of each plant and its distance from the fishing grounds, it processing and storage capacity, the costs of operating it and the value of the end product.

(ii) Dynamics of the simulation

Every vessel is followed continuously in the model and each vessel is considered to be in one of 5 states:

(a) steaming to the fishing ground

(b) searching or fishing

(c) steaming from the fishing ground

(d) waiting to unload

(e) unloading.

The time spent in each state depends on vessel characteristics, on the fishery, on the status of other vessels, and on the capacity of the processing plants. For a given TAC, the vessels fish following specific rules in the model and the flow of fish to the plants is the result.

The stock is not incorporated as a full biological model. The 'available' stock is given as a TAC which is to be taken during the fishing season. In other words, the stock component of the model does not reflect the fact that only some of actual stock is fished and that the survivors, together with the recruits, constitute the stock in the following year. This restricts the use of the model to short-term studies, although some work is being done to develop the biological model further.

A vessel belonging to a specific category always catches a fixed quantity of fish which is determined by its cargo capacity. The catch-rate is treated as independent of stock size (as it will be, approximately, in a pelagic fishery) and the time needed for a particular ship to deliver a full load depends only on the distance between the fishing ground and the processing plant.

(iii) Capacity calculations

The simulation model has been extended recently to calculate the fleet capacity required to take the quota whilst maximising profitability (Flåm and Hilstad, 1981). A variety of possible calculations exist and the solutions can be constrained to conserve some parts of the fleet or processing industry. These results can be compared with the simulation which maximises profit in order to calculate the costs of over-capacity. The authors point out that the sequence and overlap between the fishing seasons on different species has a strong influence on the number of vessels required to take the TAC.

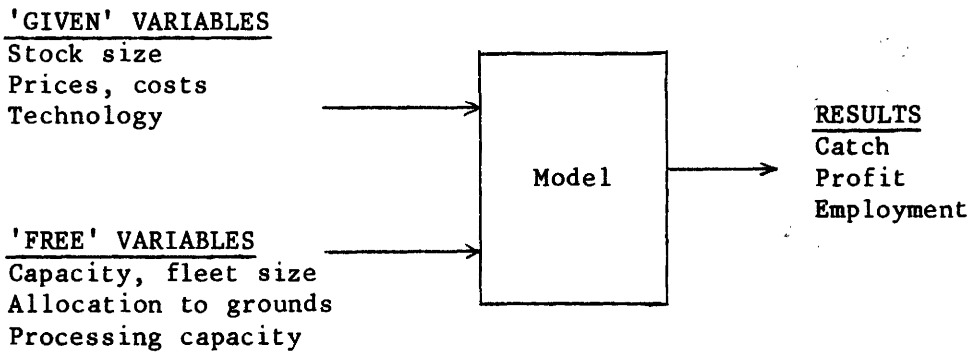
I.2.2.2 Simulation model developed at the Norwegian School of Economics and Business Administration

The basic ideas behind this model are similar to those used in the model developed at the Chr. Michelson Instituut. The detailed construction, which is different, is decribed in detail by Bjørndal (1979) and is summarised below. One of the principal features is that the available stock is randomly variable in the model (that is, it is a stochastic variable) and the results are presented as the expected catch and profit with corresponding variances which reflect the uncertainty about the expected stock.

(i) Model dynamics

The weekly catch is calculated from the catch per trip and the number of trips per week. The catch of each species in a particular year is found by combining this with the information on the expected TAC and the length of the fishing season. It is assumed that there is no interaction between the stock size and the catch per week.

A distinction can be made between fixed (or 'given') variables in the model and those variables which can be chosen with more freedom ('free') variables). This is illustrated in the following diagram:



(ii) Given variables

(a) The stock - when the stock size is known, the Norwegian TAC can be calculated on the basis of established percentages. In some fisheries (e.g. capelin) the length of the fishing season depends upon stock size and can be incorporated into the model on an empirical basis. For long-term analyses the stock is incorporated into the model as a random variable, the exact formulation of which is based upon past data and experience. The stock sizes in successive years are therefore independent, and the 'stock' part of the model is not a full biological model.

(b) Prices and costs - fish meal and oil prices determine the total revenue of the industry. Costs are more complex to deal with. The main idea is that the industry is viewed from a national point of view rather than from that of individual companies. This influences the treatment of capital costs in particular:

Capital costs - these consist of interest on capital. It is difficult to determine the stock of capital from a national point of view because it depends on the alternative uses of the capital. That is, can the fleet and plant be used elsewhere in society or can they be sold abroad? If the fleet has full alternative use then the capital costs are the rebuilding costs. If, on the other hand, there is no alternative use for the fleet then the capital value is zero from a national point of view, and the fleet will be profitable as long as its revenue covers its variable costs.

In Bjørndal (1979), 2 options are chosen; one being a capital value of 100% of the rebuilding costs and the other being 50% which would reflect limited alternative use of the fleet.

Other capital costs are depreciation of capital and repair costs.

Wages - the level of wages from a national point of view depends on alternative employment opportunities. If labour is needed in other sectors of industry then the wage should have the value of the average wage. If there are few alternative employment possibilities then a lower wage should used in the calculation.

In Bjørndal (1979) the wage in the processing industry is taken as 70% of the average industrial wage in Norway; reflecting the limited alternative opportunities near the processing plants. The wages of fishermen are 70% higher than the average wage because of the longer working time and greater inconvenience whilst fishing.

Variable costs - these consist of several components - fuel, harbour dues and food etc. The costs are based on 'Budsjettnemda for Fiskerinaeringen 1977' and are grouped into vessel categories.

(iii) Free variables

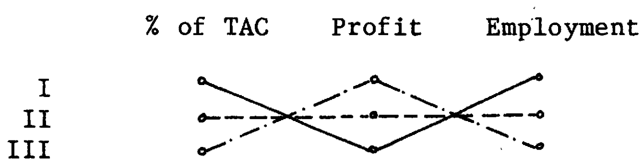
(a) Fleet size and processing capacity - different fleet sizes can be used when operating the model and any change in relation to the present fleet is possible. Bjørndal (1979) chose 2 options - a proportional reduction of either 25 or 50% in the number of vessels in each category. Changes in the processing industry can be treated in the same way and the combined effect of changes in fleet and processing capacity can be analysed.

(b) Supply strategy - this is a particularly Norwegian problem in that the processing plants are situated at a long distance from the fishing grounds. The choice of vessels to supply the more distant plants alters the production and this can be analysed in the model.

(iv) Results

The analysis gives values for the catch, profit and level of employment which may be compared for different fleet structures. The catch is measured as a percentage of the quota; preferably this and the corresponding profit and employment level should be high. However, these are often in conflict because high employment is achieved with a large fleet giving low profit.

Bjørndal (1979) present results for three fleet levels ranging from the present fleet (I), through a 25% reduction (II), to a fleet at half the present strength (III). The results can be illustrated as in the figure below:



I.2.3. Capacity studies in the USA

The US Fishery Conservation and Management Act (FCMA) of 1976 requires that fishery management plans should: 'assess and specify ... the capacity and the extent to which fishing vessels of the United States, on an annual basis, will harvest the optimum yield'. Two studies have specifically addressed the problem posed by the FCMA which are summarised below.

I.2.3.1 An approach by Siegel et al. (1979)

Siegel *et al.* (1979) consider the problems of defining and measuring capacity in the context of the FCMA and suggest a method of calculating the capacity of a fishing fleet using linear programming.

(i) Definitions

Siegel *et al.* (1979) reject the idea of technical or physical capacity on the grounds of limited applicability (resources are never unlimited) and suggest the following definition of economic capacity:

'Capacity is the amount of fish that the fleet is expected to harvest during a specified period with the existing stock of capital (vessels and gear) and technology, given catch quotas, processing capabilities, and market conditions.'

This differs from the present definition (Introduction 3.5) in that capacity in this sense is constrained by the existence of quotas and influenced by costs of fishing and prices. Seigel *et al.* (1979) were intent upon measuring the catch which the US fleet would actually take under these conditions, so as to identify the stocks for which a deficit in capacity existed. The expected domestic catch is equivalent to the 'extent to which' idea expressed in the FCMA and allows the management authorities to allocate surplus catch possibilities to the fleets of other countries.

This definition is not useful in the EEC situation because it is necessary to identify both over and under-capacities in the EEC domestic fleet and this requires that capacity be defined as the catch which the existing fleet would obtain without quota restraints. The inclusion of economic factors in the definition is also useful to the purposes of the FCMA. Economic factors are obviously important in the EEC context as well but, because their precise influence on fishing capacity cannot yet be measured, we consider that there is no practical purpose in considering them within the definition of fishing capacity as such.

(ii) Method

The suggested method is similar to that developed and abandoned in the UK in that it uses linear programming to determine an allocation of catches to the fleet to maximise a stated objective. It is also similar in suggesting that the resources and the fleet should be handled by disaggregating their availability and activity into fishing areas and time periods and that several different species and several vessel categories should be handled at the same time.

The objective which is to be maximised is the net revenue to the fleet which is calculated by adding the difference between total revenue and costs for each species/area/time period component in the formulation. The catches are to be constrained by the TACs for the year in question and also by the amount of processing capacity which is available in an particular time period. A further constraint suggested is the physical upper limit on the amount of fish which can be handled by the fleet in a particular season (i.e. by the physical capacity, also referred to as the harvesting capacity).

(iii) Application

The method was applied to the New England otter-trawl fleet for 1977, the historic data from which were used to estimate values for total processing capacity of the fleet. These were not determined by summing the individual elements but simply on the basis of past, aggregate performance. In the absence of harvesting cost data the application maximised only gross revenues from the fleet. Individual vessel catch-rate data were not available and so the catches in 1977 were simply predicted from the future total abundance and the ratio of total catch over total abundance for earlier years modified by the change in total tonnage of the fleet.

A very simple situation consisting of 11 species, 1 vessel category, 1 time period and 1 area was considered in the application and the objective of the problem was to maximise the gross revenues assuming 1977 catch restrictions, the most recent by-catch ratios and an estimate of the US harvesting capacity (physical capacity) for 1977. Model results for 1977 were compared with data from the fishery in 1977 to test the reliability of the model. In general, surpluses in catch possibilities were correctly identified by the model which suggested that the method would be useful for this purpose.

(iv) Summary

The method is not appropriate to the EEC situation because it can only identify under-capacity in the domestic fleet; this results from the inclusion of TAC constraints in the definition of capacity. This, in our view, limits the usefulness of the method and does not help to clarify the present problem. There is little in the Siegel et al. (1979) formulation which is not better handled by the method developed by Shepherd for the UK fleet. It is also likely that the sensible results which were obtained were due to the adoption of tight constraints in the solution.

I.2.3.2 An approach by Anderson et al. (1981)

A paper by Anderson et al. (1981) describes in detail a method for determining the 'optimal harvest' (or effort) through time in a mixed fishery using a simulation model. The optimal harvest (or effort) is allocated using linear programming amongst the various vessels. The models incorporate economic factors as well as biological ones, and therefore the optimal harvests and allocations can take account of profitability and also 'the social value' which is defined as the sum of profit and consumer surplus (defined below). The suggested procedure is an attractive one since it combines the two main types of approach (simulation and linear programming) to discover the best overall route to the objective through time and to allocate the resource to the fleet in an optimal way. To some extent it avoids the non-dynamic features of linear programming when used alone and overcomes the difficulties of solving allocation problems which occur with the simulation approach.

Probably the most important feature of Anderson's approach is that it deals with the biological and economic sectors of the fishery system simultaneously. Potentially it can overcome the severe problems which occur if the objectives for the fishery are set only in a biological framework and is a step towards matching fleet capacity to the resources in a systematic and realistic way (i.e. considering economics).

A full description of the formulation is not possible here, that is best achieved by reference to the paper. However the main features are summarised below:

(i) Simulation model

The model has a biological sector and an economic sector with the link between them being the number of fishing days generated by the economic sector.

The biological sector consists of stocks of fish measured as numbers in each age group. Recruitment is described by a stock and recruitment relationship and a system of differential equations describes the biological interactions between the various species and age-groups and the effects of fishing mortality. An important difficulty (pointed out by Anderson) is that of obtaining reliable estimates of the interactions, to which we may add the difficulty of establishing the stock and recruitment relationship.

The economic sector consists of different fleets which direct their effort at particular species of fish. Costs of fishing are included and, in trying to maximise profits, the various vessels generate fishing effort which obtains a certain amount of catch when applied to the stock. The amount caught depends upon the catchability coefficient of the vessel for that species and age-group and the size of the stock. The amount of fish sold determines the profit (or loss) for fishermen and the consumer surplus for the purchasers of fish. The number of days fished in a time period is assumed to be the same for each vessel type and this is converted to standardised effort by multiplying by the relative fishing power coefficient of the vessel. In order to consider the technical interdependence between stocks the fishing mortality of each species and age-group is determined from the sums of the effort (directed and non-directed) of all fleets.

The numbers of the fish caught in the model are converted to weight. The price of each species is determined by a demand curve which defines the relationship between price and the amount of fish landed (the price may differ depending upon whether the fish is landed as a directed catch or as a bycatch). Revenue per vessel is calculated as price times the vessel catch. The cost function takes into account fixed and variable costs per days fishing which, with the revenue, is used to calculate the profit level per vessel.

Given the demand curve, it is possible to determine consumer surplus. This is defined as the area between the demand curve and the price line. The social value obtained from fishing is said to be the sum of profits and consumer surplus. (We note that this places a high value on profit and a relatively small value on employment levels). By comparison of different simulation runs it is possible to find out how the social value varies with different regulation techniques (quotas, landing taxes, restrictive licensing) or different fleet structures. It is also possible to simulate the entry and exit of vessels to the fleets.

The simulation can be used to evaluate and compare alternative management policies.

(ii) Linear programming

The approach is similar to that used in the fleet operation model developed by the UK group. The problem is to determine management policies (harvests and effort allocations) that are optimal in the sense of maximising a prescribed objective (profits plus consumer surplus) subject to relevant constraints on various factors (e.g. on the numbers of fishing vessels, on shore facilities and on minimum employment). In contrast to UK model, the stocks are expressed as a set of feasible catch levels obtained by excluding levels which are too low from a stock survival standpoint or too high for efficient harvesting. The stock levels are assumed to be constant in time although the approach is 'dynamic' in the sense that the model explores the optimal harvests and allocations over a period of time (the 'planning horizon') in the life of the stock.

The discounted present value (using the interest rate) of the fishery at a certain time is found at a certain stock level with a specified number of time periods remaining in the planning horizon. The solution yields the 'optimal present value' and the 'optimal standardised effort' for each stock. The optimal 'social' value or return is found by the optimal allocation of the effort amongst the various vessel types using linear programming.

(iii) Summary

It is likely that that the linear programming model suffers from the same problems as were found in the Mark I UK model - the solutions will be 'hard up' against the constraints and sensitive to minor changes in the input parameters. There are difficulties in defining a standardised effort measure between vessel types in that it is usually impossible to equate the number of days fishing by one type of vessel on a stock with those of another type of vessel because, for example, of differences in gear and the spatial and temporal distributions of effort.

The simulation has a number of valuable features especially that of simultaneously dealing with a full biological model of the resource (which includes technical and biological interdependence and stock and recruitment relationships) and a full economic model of the fleet. The main difficulty is that of establishing realistic values for the various parameters (catchabilities, biological interaction and recruitment functions). Application to complex fisheries such as those which occur in EEC waters, would require more comprehensive information than is available at present and would also, probably, require a very large computer. If carefully applied and even more carefully interpreted, a model of this type, but perhaps giving more weight to biological factors, would probably be of value to fisheries managers in the EEC in the future, if and when there is a political will to rationalise the EEC fisheries as a whole, in the sense of managing them to achieve an agreed set of political, economic and social objectives.

PART II

ANALYSIS AND RECOMMENDATIONS

PART II - ANALYSIS AND RECOMMENDATIONS

In Part I we have defined fishing capacity in a way which is appropriate to the current problem. We have also described the data collection systems of Member States to identify the data which are available and have reviewed a number of methods of calculating the surplus or deficit in fishing capacity of a fleet in relation to the resources which are available. It should already be clear that the problem, whilst complex, is soluble given adequate data and expertise. In Part II we go on to analyse the application of particular methods to EEC fisheries (II.2) and proceed to recommendations about methods which could be used now and those which should be used in the future (II.3). Before that (II.1) we have felt it would be useful to identify the particular problems of matching fleet capacity to resources in EEC fisheries even though this is likely to repeat some of the ground which has been covered in Part I.

II.1 The problems of measuring fishing capacity in the EEC fisheries

There are two categories of problem associated with selecting a method for the identification of over- or under-capacity in the EEC fleets. The first is the strategic problem of defining a suitable framework for the analysis. The second is the technical problem of deciding which models to use and of finding suitable data to support them. We approach the latter problem by attempting to describe the nature of EEC fisheries in order to identify significant features which have to be included in the models.

II.1.1 Framework for the analysis

As we have already explained in the Introduction (section 2), the real world in which a fishery operates is broad and complex. There is a strong interdependance between the biological part of the system (stocks) and the economic sector (fleets). The fleet is linked to the rest of the human world through economic and social factors and the stocks are linked to the physical world through environmental factors. The framework for a fishing capacity analysis could encompass a large field ranging from the price of oil on the economic side to the long-term trends in environmental conditions on the other. Whether it should is determined by practical consideration such as:

- is the time scale of the effect of the factor such that it is significant?
- is the effect predictable?
- is it feasible to construct models in an extended framework and, if so, is it possible to understand the results?
- is such a framework practical, given the existing political and institutional situation?

Much of the broad field can be excluded on one or more of these grounds. However there are dangers in doing this, particularly if the excluding consideration is the final one in our list, since known important factors may be excluded not because of their own nature but because of the nature of man's institutions and agreements.

To take the present problem, the fisheries management arrangements in EEC waters impose the following restrictions:

1. Objectives for the fishery are determined on essentially biological grounds.
2. Freedom to rationalise fleets is restricted to rationalisation within Member States.

These restrictions, if adhered to, impose a rigid framework on the problem. Economic and social costs and benefits cannot be full evaluated or optimised and the stock-fleet interaction cannot be modelled dynamically through time since the biological models are operated in isolation of other components of the system.

Whilst Member States may seek to match their fleets to short-term quotas this may result in economic and social costs which are excessive in relation to those which could be experienced if less weight was given to the biological factors and more weight to economic ones. In choosing to adopt the TACs as currently calculated within the biological models, Member States have chosen a particular political objective. In aiming to achieve MSY, Member States will have to reduce their fleets (and employment) by a considerable amount and, if achieved, MSY will lead to improved economic efficiency (profit), the benefits of which will accrue to a relatively small number of individuals. The costs of these reductions, unless supported by buy-back finance, will be borne by those who are excluded from the fishery.

There may be no alternative to this. It would however be useful to extend the framework in which the advice is formulated so that economics could be considered and so that the interactions between the biological and economic sectors could be properly dealt with. It would then be possible to fully explore the consequences of particular management policies and to minimise the costs involved.

II.1.2 The nature of EEC fisheries

A description of the EEC fleet and the fish stocks in EEC waters is needed so as to identify significant features which should be included in the models used for capacity calculations. This is approached by looking at examples of the fleets in the UK, Denmark and France, from the point of view of their technical interactions and the factors which govern the transferability of vessels between different fisheries. We also briefly describe some of the fish resources in EEC waters and attempt to identify possible interactions between them and establish their significance to capacity studies.

(i) Examples of the EEC fishing fleet

The term 'mixed fishery' is used when a fleet is catching more than one species. In relation to capacity studies it is convenient to distinguish between mixed fisheries which occur because of technical reasons and those which occur because the fishermen have different target species during the season. The method of modelling the fleet and capacity calculations will probably be different for the two types of mixed fishery. They are defined as follows:

Type A - mixed fisheries which occur because it is not possible to avoid catching more than one species at the same time.

Type B - mixed fisheries which occur through the choice of the fishermen who, during the season, move from one species to another.

In addition, within a fleet of similar vessels, some may participate in a fishery for one species on a particular ground and others may participate in other single-species fisheries on other fishing grounds.

(a) The UK fleet

Shepherd and Pope (1980) examined the catch data for the UK fleet in order to identify the existence, or otherwise, of single species fisheries. The relative value of a species in relation to the total was used to define the target species; if the value was more than 50% of the value of the total landing then this species was regarded as the target. The analysis was done on partially aggregated data (the aggregations were similar to those used in the UK fleet model). Table 5 shows the results (which have already been referred to in the Introduction). With the exception of the fishery for Norway pout and sandeels, all the other fisheries produce a 'bycatch' of non-target species. There is a clear distinction between pelagic, shellfish and demersal fisheries, as might be expected, and there is an (imperfect) distinction between the demersal fisheries for flatfish and roundfish.

To sum up, the UK fleet consists largely of Type A mixed fisheries but it is known that sections of the fleet (purse-seiners and freezer trawlers) operate mainly in single species fisheries but move from one species to another during a season (Type B).

(b) The Danish fleet

It is difficult to describe the total Danish fleet in detail because of the lack of catch-effort statistics. The catch-effort data collected in 1973 to 1977 make it possible to describe the industrial fishing fleet in these years. The fleet fishing for human consumption is sampled at a lower level and only some rough indications can be given.

The industrial fleet fishes for sprat, sandeel and Norway pout. Because of the strong seasonality in these fisheries no vessels fish one of these species exclusively. The species and the grounds fished by a vessel depend on the type of vessel (especially the size) and the home port of the vessel. As an example, only the larger vessels of Esbjerg fish Norway pout in the northern North Sea. However, a general feature of the industrial fleet is the seasonal pattern of the species fished. The sprat fishery begins in March and is followed by the Sandeel fishery in May. This is again followed by the Norway pout fishery in the autumn continues until the sprat fishery begins in the early spring.

Figure 1 shows, for the group of vessels that participate in all three fisheries, the catch plotted against the date. Different symbols are used for the three species and the figure shows the marked seasonal variation in the species caught. It should be noted that only vessels catching all three species are included in the figure. Other industrial vessels would show another type of pattern and the type of pattern and species caught depend on the size of the vessel and its home port.

The Danish industrial fishery is, therefore, an example of a Type B mixed fishery, in which the individual landings may consist largely of one species but in which individual vessels operate in different fisheries at different times of the year.

The vessels of the consumption fleet in the North Sea fish several species during a single voyage. The species are mainly cod and plaice or cod and haddock. Other landings consist of saithe and plaice or cod, haddock and saithe. Although the data are not complete for the consumption fleet, data were collected during the 1970s which can be used to exemplify the nature of the Danish consumption fleet which, as in the UK, participates in a mixed fishery Type A.

The fleet using Danish seine in Esbjerg in 1973 caught 99% of the total cod catches and 98% of the total plaice landings in Esbjerg. The gear is used on sandy substrates where both cod and plaice are found. This means that due to a technical reasons, it is impossible to catch only one of the species using a Danish seine.

In Figure 2 the catch of cod and plaice by vessel by trip is shown. In this figure, the catch of cod is plotted against the catch of plaice using the symbol 'a'. Two identical landings are indicated by the symbol 'b' and three identical ones by the symbol 'c'. The figure shows that catches of neither species can be regarded as a minor by-catch of the other, nor would it be possible to categorise the fleet using a Danish seine either as a cod fishing fleet or as a plaice fishing fleet.

When constructing the production model both plaice and cod must be considered at the same time.

(c) The French fleet

A complete description of even the fleets which exploit one area, such as the Bay of Biscay, is not possible here. As an example we have chosen to describe fleet activities at 'Les Sables d'Olonne' for August 1981. This harbour gives a good picture of the diversity of the fishing activities in the Bay of Biscay.

Table 6 gives a list of the 18 vessel categories ('metiers') which existed in the harbour in August 1981, and, for each 'metier' the table gives the number of boats and the number of landings.

Table 7 gives, for each species, the 'metiers' involved and all the ICES Divisions from which the landings were obtained. Tuna fishing took place in the Southern Central North Atlantic (10) and the Northern Central North Atlantic (12). Clearly the fishing is very diverse and consists largely of mixed fisheries (Type A).

(d) Conflicting fisheries

When mixed fisheries occur there is likely to be a conflict between the fisheries directed at different species. The exploitation of one species which leads to the exploitation of another as a bycatch, may introduce difficult problems of management, especially if the mesh size used in the bycatch fishery is smaller than that used in the directed fishery.

The EEC fisheries provide a number of examples of 'conflicting fisheries' the management of which is likely to be a compromise. 'Optimal exploitation' can only be determined by consideration of economic and social factors. At present they are managed principally by attempting to maintain the present balance between them, which may not be optimal in biological or economic terms.

The most obvious examples are:

1. The fisheries for human consumption and industrial species in the North Sea.

   The small-meshed industrial fishery produces a bycatch of small haddock and whiting in the North Sea. This fishery conflicts with the large-meshed human consumption fishery for haddock and whiting, by removing quantities of small individuals which might otherwise grow and contribute to the consumption fishery.

2. Shrimp and flatfish fisheries

   Small meshed fisheries for brown shrimp (Crangon) occur in the coastal waters of the North Sea, English Channel and Bay of Biscay. Juvenile plaice and sole inhabit the same inshore grounds as the shrimp and are caught in large numbers as a bycatch. The shrimp fishery is therefore potentially in conflict with the offshore fisheries for plaice and sole in reducing the numbers of young fish which can enter the fishery.

3. Nephrops and roundfish fisheries

   The Nephrops fisheries in the Bay of Biscay, Celtic Sea and Irish Sea produce a large bycatch of young hake and whiting, for example, and are in conflict with the human consumption fisheries for these species by reducing the hake and whiting stocks.

(ii) The EEC fish stocks

Table 8 shows the catches by the EEC Member State of the most important fish species in the North Sea in 1979. The table shows that each Member State participates in nearly all fisheries, although the main catches by species are different for each country.

The main feature is the difference between catches of fish used for human consumption and species used for fish meal and oil. Denmark is the only EEC Member State which fishes large quantities of sprat, sandeel and Norway pout, for industrial processing.

Scotland, Denmark, England, Holland and France catch large quantities of fish used for human consumption. Scotland fishes mainly for haddock, whiting and cod, while Denmark is fishing mainly for cod and plaice. The dominant English catches are cod and plaice, while Holland is fishing for cod, plaice and soles. The most important species for France in the North Sea in 1979 was saithe followed by whiting and cod. Belgium and Germany are generally fishing the smallest catches, mainly cod.

It should be noted that the quantities in Table 8 are in weight. If the table was expressed in value the importance of sprat, sand-eel and Norway pout would be diminished, because the price of these species is approximately a tenth of the price of fish used for human consumption.

Future catches are influenced by the random year-class strength of the recruits to the fishery, and secondly by the management of the fish stocks. At present the fishing mortality on most species is being reduced to increase the long-term yield. In the present advisory and management regime this is done for each species individually. It is not explicitly taken into account that the species interact through the fact that they feed on each other. An incorporation of species interaction would lead to more accurate assessments and forecasts of the stocks, but today it is difficult to quantify the interactions.

The reason why we discuss species interactions in the context of capacity is to show that the catch possibilities of individual species in the North Sea are not static, but might be increased by decreasing the stock of their predators or their competitors.

In Table 9 we have attempted to outline the interaction of the species included in Table 8. As mentioned earlier it is difficult to quantify the interactions, and in Table 9 we only indicate the nature of the interaction. A '+' indicates that a decreased biomass of the species in the row will lead to an increased biomass of the species in the column.

Several fish species feed on fish eggs and larvae but the effect of this predation is unknown. Table 9 is based only on stomach sample data of large fish and so does not cover these effects of predation.

(iii) Models

From this brief and incomplete review of EEC fisheries, it is clear that the models which are used to estimate over- or under-capacity should take account of the 'mixed fishery' nature of the fleets. In most instances this can be handled by the use of 'by-catch tables' which indicate, for each vessel category, the catch (or fishing mortality) of non-target species relative to the catch or fishing mortality of target species. The transferability of fishing effort from species to species is difficult, but important, to quantify and may be a significant factor in many fisheries, as for example, in the beam-trawl fishery for flatfish in the North Sea (switching from sole to plaice as the sole stock declines) Species interactions may also be important in some instances.

II.2 Methods which can be applied to EEC fisheries

The methods which we have described in Part I.2 can be categorised in a number of ways. The common feature between them is that they take account of the technical interactions between fisheries, and, as we have attempted to show above, this will be a necessary feature of any fishing capacity analysis of the EEC fleets. These methods are very demanding of data in that catch and effort information by species is required for the entire fleet, and needs to be available by fishing areas and well-defined categories of vessel. It is clear, from Part I.1, that these data are not available for every Member State in the EEC at the time of writing (1981) because the data collection systems of at least 3 Member States of the 7 involved (Denmark, France and Ireland) do not identify landings of individual vessels or by vessel groups and, in addition, they do not collect comprehensive effort data.

The most relevant methods for an immediate analysis are those in which the output of the biological models (in the form of TACs) is imposed from outside and which do not model the interactions between the fleet and the stocks over a period of time dynamically. These models are of 2 types:

(a) mathematical programming allocation models (e.g. the UK fleet operation model) and

(b) simulation models (e.g. the Norwegian industrial fishery models).

The former are likely to be more relevant to the problem of matching capacity to short-term quotas in the majority of EEC fisheries, since these are mainly Type A mixed fisheries. The simulation methods will be relevant to capacity analysis in the Danish industrial fishery and possibly in the mackerel and herring fisheries, which are Type B mixed fisheries.

The dangers of matching fleets to short-term TACs have already been discussed. The main danger lies in the fact that the objectives for the fisheries (i.e. the TACs) have been set without full knowledge of the economic effects. A further problem is that, for fisheries for which fishing has been banned in the short-term, matching fishing capacity to the zero TAC will not produce a fleet which is matched to the longer-term availability of the resource. This problem can be overcome if the models use both with the short-term TACs and the longer-term expectation of resource availablity, (i.e. forecasts of catch and biomass for 5 to 10 years ahead). The long-term fishing capacity will be an indication of the size of fleet which it is necessary to lay up rather than scrap. A better solution would be obtained if the method could model the interaction between fleet and stock over a period of time dynamically . The biological and economic consequences of particular fleet re-structuring programmes could then be evaluated and the fleet structure could be optimised in the way suggested by Anderson (1981). For the present zero TAC stocks such an analysis would be conditional upon the course of stock recovery; any recommendations on fleet structure would have to be based upon a balance of probabilities calculated using a stochastic model.

For those Member States with adequate data (Belgium, the Netherlands Germany and the UK) it would be possible to calculate the required fleet structure and size for the short-term TACs using a model similar to UK fleet operation model. The first step would be to calculate the catch of each quota species in each area for the TAC year, using the fishery production model which we have described in the Introduction. (A step by step procedure for this calculation is given in Section II.3.3, below.) Initially this calculation would not need to involve complex allocation procedures but could be used to give a rough indication of the surplus or deficit in capacity for each quota species. The method would require detailed catch per effort data for all vessel categories for a recent year.

For Member States without comprehensive catch-rate data (Ireland, Denmark and France) a similar analysis could eventually be achieved by collecting representative data on a sampling basis over the period of one year. This could be used to give a rough indication of the surplus or deficit in capacity using the same method. Alternatively it may be possible, if the numbers of vessels fishing in each ICES area were known and if there were an estimate of their percentage utilisation in these areas, to give a rough indication of surplus or deficit without collecting catch-rate data. Knowledge of the landings (by area of capture) and the number of vessel-years employed in each area will itself give a rough indication of the catch-rate, which could be used to estimate the potential catch (fishing capacity) in the TAC year. (A further explanation of this alternative is given in Section II.3.3, below.)

It is already obvious that the detailed requirements of the Commission's proposal (COM(80)420), described in the Introduction (Section 1), cannot easily be met by any of the methods which we have described even if the data were available. It is not possible to identify the fishing capacity of individual vessels in a meaningful way because of their inherent flexibility and the 'mixed fishery' nature of their operations. All one could do is to identify, in approximate terms, the number of vessel-years (or vessel days) which are in excess or deficit in particular vessel categories. Having done this, it will eventually be necessary to identify individual vessels which are to be deleted from or introduced to the fishery, but it certainly is not generally possible to give an estimate of their 'fishing capacity' as such.

II.3 Recommendations

II.3.1 On data

In Part I.1 we noted a number of deficiencies in the various data collection systems of Member States which (in some instances) will prevent even the most rudimentary analyses of fishing capacity from being made. We also noted that new systems were being planned or implemented during 1981 which should improve the chances of carrying out an analysis in the future.

The essential requirements for a simple analysis are:

(i) total landings by species and resource area;

(ii) catch-rate and effort data by species and resource area for each vessel category in the fleet.

The definition of vessel categories should ensure that the vessels within it have similar fishing powers and areas of operation; generally speaking, a division by vessel size, gear and base port will be adequate.

For more sophisticated analyses, involving optimisation of the fleet in economic or social terms, it will also be necessary to obtain such information as:

(iii) average price by species;

(iv) costs per unit of effort by vessel categories;

(v) numbers of men employed per vessel by vessel categories.

In fisheries in which processing facilities are a constraint on landings the following will be required:

(vi) the processing capacity of the industry in quantities of fish per day;

(vii) detailed information on the fishing operation - hold capacity, steaming time, searching time, fishing time, unloading time by vessel categories.

If an optimisation procedure is to be adopted it is important that the basic data on total landings and catch-rates (i and ii) should include all species caught and not just the quota species. The EEC log-book is deficient in this respect in that it is not mandatory to record non-quota species in the daily log-book. Although it may be impractical to incorporate them into the log-book, it is essential that the landing declarations include non-quota species.

It is planned that the EEC log-book and landings declaration should not apply to vessels which are less than a certain length or to vessels which are landing non-quota species. This is likely to lead to some deficiences in the fisheries data for Member States which are proposing to meet the legal requirements of the Common Fisheries Policy and no more. It is essential that the landings, prices and catch-rates of non-quota species are fully recorded. We anticipate that Member States will need to use an optimisation or allocation procedure to estimate the surplus or deficit in fishing capacity in their fleets and this requires that a comprehensive record of all fish landings is made.

It also seems very unwise to design a data collection system on the basis of the current management policy (the TAC system) which we know to be inadequate in a number of respects and which it may be desirable to change in the future.

II.3.2 On retrieval of data

Most Member States which already have comprehensive data collection systems have great difficulty in retrieving the data in a suitable form, particularly for the type of analyses which are necessary for capacity studies. We can anticipate that access to the data will become more difficult as Member States adopt the use of EEC log-books and landings declarations.

As is usual for fishery data collection systems, the planners of the EEC log-book system are paying scant regard to the problems of data processing and retrieval. The volume of additional data is likely to be considerable since the log-sheets will be completed in a daily basis and there are, potentially, a number of different sources of information to be processed and combined to produce useful output. For example, it will be necessary to link the landings declaration to specific log-books and to check that the data are in agreement. As presently planned, the landings declaration might not include non-quota species and it will be necessary to provide for the collection and input of these data. It will also be necessary to collect data on the landings of small vessels since, in some areas, they catch a significant proportion of the TAC and also of vessels which are not landing quota species so as to allow the development of fleet optimisation studies.

The design of adequate data processing and retrieval systems in this situation is not easy and it is probable that most Member States will take a number of years to solve these difficulties even if they attempt it. It may be important to widen the scope of the EEC log-book discussions to cover the recording of all data and to discuss the common problems of data processing and retrieval.

II.3.3 On immediate methods

Since TACs have been proposed and agreement on their allocation to Member States may be reached in the near future, it is necessary to have a method of caculating what the potential catch (or fishing capacity) of the existing fleet will be in the TAC year. The simplest procedure for doing this is as follows:

(i) Calculate the ratio of catch-rate divided by stock biomass (i.e. the catchability) for the most recent complete year for which data are available. This should be done for each vessel category and each quota species and resource area.

(ii) Using these catchabilities and the estimates of stock biomass for the TAC year, calculate the potential catch-rate for the TAC year from the product of catchability times the predicted stock biomass.

(iii) Using the total fishing time which each vessel category could realistically employ if each vessel fished to its fullest extent, estimate the potential total catch of each quota species in each resource area for the TAC year from the product of fishing time times potential catch-rate.

The potential catch (or fishing capacity) of each quota species in each resource area can then be compared with the allocated quotas to find out whether a surplus or deficit of capacity exists for each quota.

This would be an important and valuable first step towards matching the fleets to the quotas because it would approximately identify the magnitude of the discrepancy between the potential catch of the existing fleet and that allocated to it.

This step would, however, be difficult for some Member States because of the absence of catch and effort data by vessel categories. An approximate answer could be obtained by using the reported total landings of each stock (an estimate of which exists for each Member State) and by identifying the approximate number of vessel-years deployed in each resource area, as explained in Section II.2.4, above. Approximate catch-rates could be obtained by a limited sampling exercise within each vessel category or, in some instances, by comparison with the catch-rate data of other Member States within similar vessel categories. This information could be used, employing the basic method described above, to calculate the potential catch of the fleet in the TAC year. Again, this procedure would establish the approximate magnitude of the discrepancy between fishing capacity and the quotas.

For zero TAC stocks, and also for stocks which exceed (in fishing mortality terms) their presently defined optimum level of exploitation, it would be useful to use the same method of calculation to estimate the surplus or deficit in capacity in relation to a long-term expectation of the abundance of the resource and the quotas which will be associated with it. ICES could provide this information in the form of a TAC and stock biomass for a period 5 or 10 years ahead. The figure would be fairly speculative, owing to the doubts about future recruitment and the level of fishing mortality in the intervening years, and would also be conditional upon the validity of the biological models. This calculation would nevertheless provide a useful indication of the size of the fleet which would be required in the long term.

The principal advantage of this procedure will be to give an indication of the magnitude of the fleet reduction which will be required if the present objectives are to be pursued to their conclusion. We anticipate that, if clearly spelt out, that the consequences of the present 'biological' objectives would not be acceptable to all Member States. It might then be reasonable to consider revising the objectives of EEC fisheries management rather than to consider looking for ways in which the fleet could be adjusted to the TACs which arise from the present objectives.

If, on the other hand, the consequences are acceptable then it only remains to convert the surplus or deficit in potential catch by stocks into a surplus or deficit of vessels by vessel category. It is likely that the discrepancies between catches and quotas will be different for different species. Even if the discrepancy were the same for each species it is still likely that the quotas could be more efficiently achieved by means other than reducing or increasing the fleet equally in each vessel category. The long-term solution to these problems would be to employ the method of allocation or optimisation which is used in the UK fleet operation model, that is, a fairly sophisticated computer programme which searches for an optimal fleet structure and which is capable of incorporating economic factors into the optimisation. A simpler and more approximate solution would be to calculate an average discrepancy over the range of quota species within each species group (industrial pelagic, roundfish, flatfish and shellfish) for each resource area. This could be used to obtain a rough value of the increase or reduction in fishing time which is required to achieve the quotas and which would apply to each vessel category.

II.3.4 On objectives and longer-term solutions

The methods suggested in the previous section apply to the currently conceived management regime for European fisheries, in which the short-term limits on catches are set with reference to the long-term predictions of biological models. The TACs aim to achieve stock survival in the first place and, ultimately, are designed to achieve the maximum sustainable yield (MSY) from each resource.

The MSY objective may be criticised on a number of points of detail which include (a) that the present biological models may not identify the true F_{max} (the fishing mortality which would achieve MSY) by failing to incorporate density dependent effects and biological interactions in a realistic way, and (b) that MSY is not an absolute measure but is conditional upon the existing exploitation pattern (i.e. the level of fishing mortality on each age-group) being maintained.

The latter point is perhaps not a strong point of criticism but it reveals the inconsistencies which can arise in advice based upon achieving the present 'conditional' MSYs. As a result of technical interactions between fisheries it is clear that the absolute maximum yield cannot be achieved for each stock (e.g. the MSY for Norway pout is unlikely to be compatible with the MSY for haddock in the North Sea). This means that the present set of objectives for fish resources in European waters, expressed as they are in terms of conditional MSY, implicitly incorporate the economic and social objective of maintaining the '<u>status quo</u>' of the relative balance between different fisheries. In other words, the present management policy aims to maintain the current exploitation patterns irrespective of their economic implications. This is particularly evident for the 'conflicting' fisheries which use different mesh sizes.

The former point of criticism (i.e. poor models) gives some cause for concern since the magnitude of the reduction in fishing mortality which is required to achieve MSY is seen to be dependent upon the biological model which is adopted for the assessment. The established models are, of necessity, the simplest formulation of the biology of the stock which can be supported by existing evidence and are, therefore, probably not completely realistic. This suggests that the rapid pursuit of the MSY position indicated by the existing models, in stocks which are not threatened by recruitment failure, is perhaps premature.

These criticisms are on points of detail, which should urge caution in the interpretation of the MSY objective, rather than its abandonment. It is certain that a fleet which is adjusted to MSY will be more profitable and, therefore, more efficient in economic terms than a fleet which operates at the uncontrolled bio-economic equilibrium. MSY would, therefore, be a desirable objective in the long term if economic efficiency were the only criterion.

The European fleets, however, have become established at a size which is incompatible with MSY for most stocks. The costs of the fleet reductions which will be necessary to achieve MSY, in terms of the costs of laying-up or scrapping vessels and of reduced employment opportunities are likely to be considerable. The present management advice, by dealing only with the biological models, does not explicitly consider these aspects of fisheries management. They can only be fully considered by the development of bio-economic models which are capable of simulating the fishery over a period of years. The interactions between the biological and economic sectors need to be modelled and the biological and economic consequences of a variety of management tactics would need to be evaluated and compared. The method developed by Anderson et al. (1981) would provide a suitable framework for this type of analysis, although, for EEC fisheries which are generally overexploited, the model would have to give greater weight to biological factors than is given in the specific model developed by Anderson.

Alternative objectives to MSY could be explored using this type of model and one could envisage that the advisors would provide a set of biologically feasible objectives to the fisheries managers who would then be able to make an informed choice between them. Attempts should be made now to solve the problems of constructing this type of model for at least parts of the EEC fishery so that suitable techniques and data are available when the need becomes both obvious and urgent. This may well occur within a short period after the Common Fisheries Policy is agreed and when the effects of TACs which aim to achieve MSY begin to be recognised. This is clearly an area of study which could and should be funded by the EEC.

SUMMARY OF RECOMMENDATIONS

1. The data collection and retrieval systems of most Member States need to be up-graded so that it is possible to identify the following:

(i) the total landings from TAC and non-TAC stocks,

(ii) the fishing time expended by identified and homogeneous vessel categories (vessel size, type, base port, area of operation, gear),

(iii) the catch-rates obtained by the same vessel categories on each TAC and non-TAC stock.

Additional information may also be required on the value of landings, costs of catching and the capacity of processing facilities. Some States also need to improve their input to the stock assessments by providing better catch and age composition data.

The EEC log-book system may be deficient in that it will not provide information on non-quota species or on landings by some sizes of vessel; the system will also make it more difficult to retrieve data because of the increased volume which it will generate. These aspects of the EEC log book system should be examined more thoroughly.

2. For some Member States it is already possible to estimate the fishing capacity for the TAC year and to determine whether or not excess capacity exists. The simple method for doing this is as follows:

(i) estimate the catchability of the stock for each vessel category by dividing the catch-rate in a recent year by the biomass in the same year,

(ii) predict the future catch for the TAC year for each vessel category by multiplying the predicted biomass in the TAC year by the catchability,

(iii) accumulate the future catches by vessel categories to obtain the fishing capacity for that stock for the whole fleet,

(iv) calculate the average percentage excess or deficit in capacity across all the TAC stocks within a species group (industrial, pelagic, shellfish, roundfish or flatfish) to determine the percentage by which the fishing time of the involved vessel categories should be increased or decreased to achieve the TAC.

A similar calculation could be done for Member States which do not have catch-rate data by obtaining catch-rate data for one year on a sample basis or by using another Member State's data for similar vessel categories.

More sophisticated solutions can be obtained by adopting a model such as the UK fleet operation model, described in the text; this will handle the technical interactions more thoroughly.

3. The main shortcoming of the present management advice and TAC system is that the TACs are set with reference only to biological objectives and do not incorporate economic or social considerations. We recommend that the Community should fund the development of appropriate bio-economic models of several aspects of the EEC fisheries so that suitable techniques, data and expertise are available when the consequences of the MSY objective for fishing fleets becomes fully appreciated and when it may become necessary to explore alternative management policies and objectives.

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Table 5 UK fleet - relative landed weight by directed fishery (i.e. assuming target species weight = 1.0)

Target species	Bycatch groups					
	R	F	OD	I	P	S
Cod	0.25	0.12	0.17	0.06	0.01	0.01
Haddock	0.60	0.07	0.12	-	+	+
Saithe	0.21	+	0.07	-	+	-
Whiting	0.31	+	0.09	-	+	+
Plaice	0.21	+	0.12	-	+	+
Soles	0.52	0.44	1.09	-	+	0.07
Other demersal	0.19	0.05	(1.00)	-	0.06	0.09
Norway pout and sandeels	+	-	+	(1.00)	-	-
Herring	+	-	+	+	0.17	-
Mackerel	+	+	+	-	0.04	+
Sprats and other pelagic	+	-	-	-	0.01	-
Crustacea	0.20	0.04	0.15	-	0.09	0.31
Molluscs	0.01	+	0.02	-	+	0.03

Key: R = roundfish other than the target species
F = flatfish other than the target species
OD = other demersal
I = industrial species
P = pelagic species
S = shellfish species

TABLE 6. Les Sables d'Olonne August 81

METIERS

N°	type	Gear	Number Boats	Number Landings	Total Production	Mean Power (KW)
1	Côtiers	Traps	5	24	310	26
2	Semi Industriels	Trolling line	1	1	5 249	324
3	Côtiers	Trolling line	7	7	52 596	241
4	Côtiers	Set Lines	1	4	3 319	81
5	Artisans	Drifting Longlines	3	8	19 076	95
6	Côtiers	Drifting Longlines	25	296	10 859	59
7	Artisans	Gillnets	8	11	36 239	265
8	Côtiers	Gillnets	1	5	681	177
9	Côtiers	Trammel nets	8	85	6 310	66
10	Semi Industriels	Bottom otter trawls	4	9	98 541	379
11	Artisans	Bottom otter trawls	59	154	497 337	216
12	Côtiers	Bottom otter trawls	13	101	24 254	68
13	Artisans	Midwater otter trawls	1	1	5 670	324
14	Côtiers	Bottom shrimp trawls	23	329	19 169	60
15	Artisans	Many trawls	1	1	6 210	331
16	Artisans	Midwater pair trawls	2	3	26 840	307
17	Côtiers	Midwater pair trawls	4	56	68 092	94
18	Artisan	Many pair trawls	1	1	10 280	320

TABLE 7. August 1981 LES SABLES D'OLONNES

SPECIES	METIERS	DIVISIONS	QUANTITIES
Atlantic Salmon	........X.......X.	0	13
Megrims	.........XX.......	000	10931
Turbot	....XX.XXXXX.X....	00000	1081
Brill	..............X...	0	70
Common Dab	.........XX.......	0000	2610
Lemon sole	.........X........	0 0	1310
European Flounder	.........X........	0 00	360
European Plaice	.........XXX...X..	00000	2920
Ceteau	..........X..X....	00	4064
Thickback Sole	..........X.......	00	2180
Common Sole	........XXXX.XX...	0 000	34261
European Hake	......X..XXXXXXXXX	00000	145441
Atlantic Cod	.........XX.......	000	33010
Haddock	.........XX.......	00 0	2630
Whiting	XXXXXXXXX	00000	43312
Pollack	.....XX.XXXX..X...	0	9487
Saithe	.........XX.......	000	3310
Pouting	.....X..XXXX.X.X.X	0 000	12433
Ling	...XXXX..XX.......	00000	7646
Greater Forkbeard	..........X...X...	0	1770
European Conger	X..XXX..X.........	00	9294
European Sea-bass	...XX...X.XX.X.XXX	00	8806
Meagre	.....X..X.........	0	8
Red Mullets	...........X......	0	89
Common Seabream	....X.............		100
Read Seabream	.....X....X....X..	00	2502
Axillary Seabream	..........X....X.X	00	400
Common Pandor	....X.............	0	17
Bogue	X	0	360
Black bream	................X.	0	167
European Sandeels	................X;	0	220
Greater Weever	..........X....X..	00	530
Anglerfishes	....X..XXXXX.XXX.X	00000	61597
Grondins	.........XX...X...	0 00	3600
Garfish	................X.	0	80
Horse Mackerels	.........XX.X.XXXX	00	69985
European Mullets	................X.	0	21
European Pilchard	................X.	0	15386
European Anchovy	................X.	0	1301
Mis. Tunas	.XX............X..	000	57386
Atlantic Mackerel	.....X..XXXXXX.XXX	0 000	31457
Porbeagle	....X.X...........	00	3883
Dogfishes	....XX...XX...X...	00000	10315
Picked Dogfish	.........X........	0 0	1630
Mis. Sharks	.....XX...X....XX.	00	2327
Mis . Skates	..........X.......	0	870
Mis. Rays	....XX...XXX......	00000	15209
Mis; Marines Fishes	...XXXXXXXXXXXXXXX	00000	109680
Edible Crab	X.......XXXX.XX...	000	7503
Swimming Crab	........X.XX.X....	00	428
European Lobster	X.......X.XX.X....	00	147
Norway Lobster	.........XX...X...	0 000	137240
Common Shrimp	..............X....	0	1242
Common Cuttlefish	........X.XX.X....	00	11211
Short-Pinned Squid	..........X..X.XX.	00	2745
Mis. Squidq Cuttlefish	..........XX..X...	00	3756
			891044

Table 8. Catches by EEC-member states in the North Sea. 1979. (thousand tons).

	Belgium	Denmark	France	FRG	Holland	England	Scotland	Other countries	Total
Herring x)	-	10.5	2.6	0	-	2.3	0.2	3.6	19.2
Sprat	-	268.3	-	1.8	-	14.3	11.8	81.4	377.6
Mackerel xx)	-	19.2	3.6	0.2	1.0	0.1	5.3	122.9	152.3
Sandeel	-	449.8	-	-	-	-	-	115.6	565.4
Norway Pout	-	219.9	-	-	-	-	3.0	154.3	377.2
Cod	12.6	48.5	12.6	20.4	34.8	54.9	42.4	4.2	230.4
Whiting	3.9	42.0	27.6	1.3	13.4	7.6	44.8	0.7	141.3
Haddock	0.7	8.2	7.2	2.5	1.0	10.8	54.1	2.1	86.6
Saithe xx)	0.0	10.5	39.7	18.8	1.5	6.3	8.3	27.7	112.8
Plaice	7.7	25.7	0.7	4.3	38.4	25.8	4.1	-	106.7
Sole	2.0	0.3	0.3	0.2	7.6	0.6	-	-	11.1

x) incl. The Channel

xx) incl. the Skagerrak-Kattegat

Table 9 Species interaction. '+' indicates that a decreased biomass of the row species will lead to an increased biomass of the species in the column

	Herring	Mackerel	Sprat	Sandeel	Nor. pout	Cod	Haddock	Whiting	Saithe	Plaice	Sole
Herring				+							
Mackerel					(+)		(+)	(+)			
Sprat											
Sandeel											
Norway pout											
Cod	+		+	+	+		+	+			
Haddock				(+)							
Whiting	+		+	+	+	+	+				
Saithe					+		+				
Plaice											
Sole											

Stomach sample data
(pers. comm. Henrik Gislason, DFM)
Brackets indicate some doubt about the importance of the interaction.

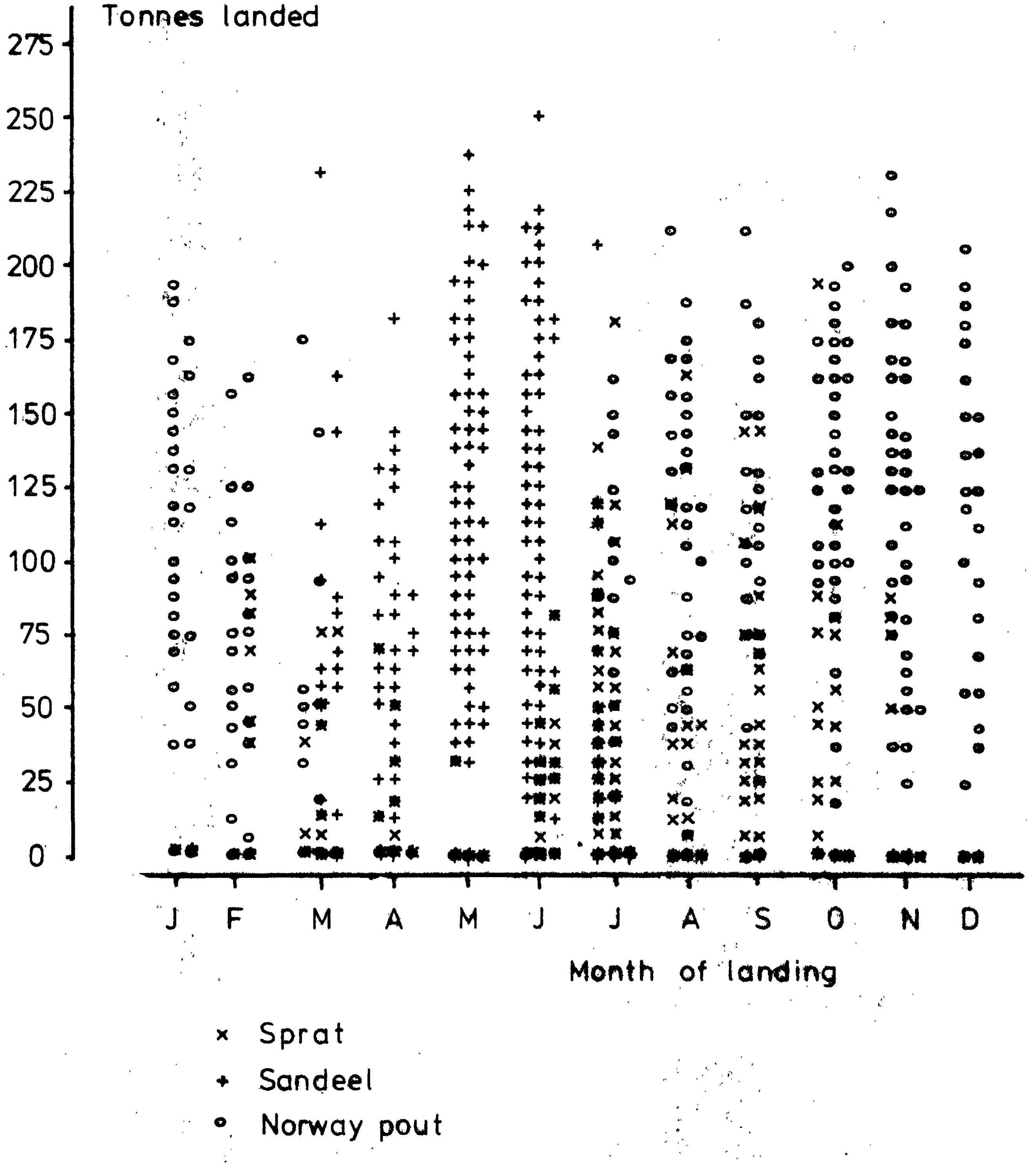


Figure 1. Example of a Type $ mixed fishery - distribution of the catches of 3 species in the Danish industrial fishery against date.

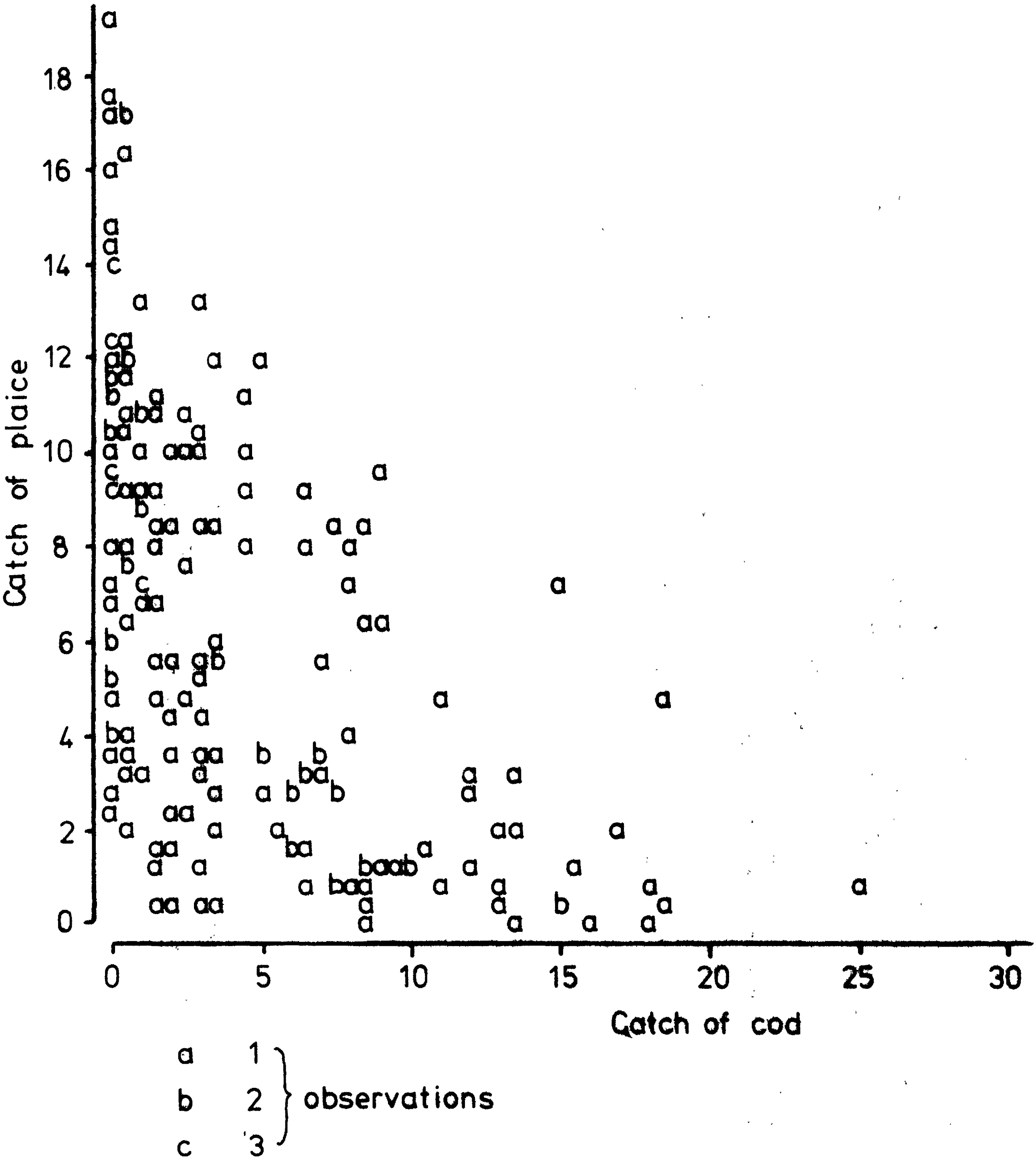


Figure 2. Example of a Type A mixed fishery - relationship between the catch of plaice and cod in individual landings by Danish seiners at Esbjerg in 1973.

ANNEX 1

Examples of data forms which are currently being used

DEN 1 - Form used for collecting vessel file data in Denmark

FRA 1 - Landings record used in the old 'Affaires Maritimes' System in France

UK 1 - Form used for recording catch and effort statistics in the UK

FARTØJSREGISTERSKEMA

Fiskeriministeriet
Dataadministrationen
Stormgade 2
1470 København K

havnekendingsbogstaver	Registered
havnekendingsnummer	number
radiokaldesignal	Call-sign
fartøjets navn	Name

MOMSREGISTRERINGSNUMMER
hvis fartøjet ejes af et firma, udfyldes feltet med firmaets momsregistreringsnummer

V.A.T number

BASISHAVN
feltet udfyldes med navnet på den havn, hvor fartøjet er hjemmehørende.

Harbour

EJERFORHOLD, sæt X Ownership details	enkelt ejer	
	flere ejere	
	I/S	
	ApS	
	A/S	
	offentligt ejet	
andet (angiv art):		

EJER Owner hvis skibet ejes af flere end én, udfyldes rubrikken: Parthavere.	navn	
	adresse	
	evt. c/o navn	
	postnummer	
	by/postdistrikt	
FARTØJSFØRER (Udfyldes kun, hvis fartøjet føres af en anden end fartøjets ejer). Skipper	navn	
	adresse	
	evt. c/o navn	
	postnummer	
	by/postdistrikt	

DEN 1

FARTØJSREGISTERSKEMA

PARTHAVERE: Names of part-owners

1.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt
2.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt
3.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt
4.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt
5.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt
6.	antal parter i fartøjet angivet i brøkdele	navn
		adresse
		evt. c/o navn
		postnummer
		by/postdistrikt

FARTØJSTYPE, sæt X Type of vessel	sidetrawler	
	hæktrawler	
	kombinationstrawler (side/hæk)	
	bomtrawler	
	andre trawlere	
	snurpenot	
	snurrevod	Varioustypes
	fiskefabriksfartøj	
	kombinationsfartøj (not/trawler)	
	jolle/robåd	
	garn/krogfartøj	
	fisketransportfartøj	
andre fiskerfartøjer (angiv type):		
FARTØJSOPLYSNINGER Vessel details	byggeår	Year of construction
	byggeland	Country of ---"----
	fiskestartår	Year started fishing
	længde overalt i m (1 decimal)	Length
	kendingslængde i m (1 decimal)	
	kendingsbredde i m (2 decimaler)	Width or beam
	kendingsdybde i m (2 decimaler)	
	BRT (2 decimaler)	Tonnage - gross reg.
	NRT (2 decimaler)	---"--- - net reg.
	antal besætningsmedlemmer (inkl. fartøjsfører)	Men employed
	forsikringsværdi i kr.	Insurance value
	vurderingsår	Year of valuation
	HK maksimal ydelse	Engine power - max
	HK officiel effekt	-----"---- - effective
	motorinstallationsår	Engine type
	motorfabrikationsår	Engine maker

FARTØJSREGISTERSKEMA

BYGGEMATERIALE, sæt X Construction material	stål	
	træ	
	glasfiber	
andet (angiv art):		
MOTORTYPE, sæt X Engine type	semidiesel/glødehovedmotor	
	diesel direkte koblet	
	diesel med reduktionsgear	
andet (angiv art):		
DATOER, (udfyldes af fiskeriministeriet) Dates	seneste ajourføring	
	andre datoer	
OPLYSNINGER VEDRØRENDE KØB Transfer of vessel	tidligere havnekendingsbogstaver	
	tidligere havnekendingsnummer	
	købsdato	
	fartøjets tidligere navn	

OPLYSNINGER VEDRØRENDE SALG, OPHUGNING, FORLIS Selling or stopping fishing	ophørsårsag, sæt X Reason	ophugning	
		forlis	
		salg til fiskeri i EF	
		salg til fiskeri uden for EF	
		salg til andet formål i EF	
		salg til andet formål uden for EF	

ophørsdato:		tilskud til ophør	ja ☐ nej ☐
		tilskud i kr.:	

UNDERSKRIFT Signature			
Ejeren/korresponderende reder hæfter med sin underskrift for rigtigheden af de givne oplysninger.			
telefon		forretningstelefon	
dato		underskrift	

DEN 1

FARTØJSREGISTERSKEMA: FANGSTUDSTYR

Fiskeriministeriet
Dataadministrationen
Stormgade 2
1470 København K

INFORMATION ON FISHING GEAR

havnekendingsbogstaver	
havnekendingsnummer	Registration number
radiokaldesignal	
fartøjets navn	

		antal	anslået værdi i kr.
BUNDGARN Pound-nets	sildebundgarn		
	ålebundgarn		
	rejebundgarn		
	andre bundgarn		
	pæle		
RUSER Fyke-nets	kasteruser		
	åleruser		
	tejner		
	andre ruser		
NOT Purse seine	snurpenot (not)		
GARN Gill-nets	drivgarn		
	sættegarn		
	andre garn		
	vagere (dræg)		
VOD Seines	snurrevod		
	andre vod		
	tovruller à 120 favne		
BUNDTRAWL Bottom trawls	enkelt trawl		
	tvilling trawl		
	industrifisk poser 0 - 29 mm		
	konsum sildeposer 30 - 59 mm		
	konsumposer 60 - mm		

DEN 1

FARTØJSREGISTERSKEMA: FANGSTUDSTYR

		antal	anslået værdi i kr.
PELAGISK TRAWL Pelagic trawls	enkelt trawl		
	tvilling trawl		
	industrifisk poser 0 - 29 mm		
	konsum sildeposer 30 - 59 mm		
	konsum poser 60 - mm		
BOMTRAWL Beam-trawl	rejetrawl		
	åletrawl		
	fladfisk trawl		
TRAWL-TILBEHØR (f.eks. antal skovle og lign.) angiv art Trawl aids			
KROGLINER Lines	kroge		
LANGLINER Long-lines	samlet længde		
	kroge		
ANDRE HJÆLPEMIDLER Other aids	redskabsskure		
	hyttefade		
	joller		
	muslingeskrabere		
REDSKABER DER IKKE ER NÆVNT OVENFOR, angiv art Other gears, aids etc.			
NAVIGATIONSUDSTYR angiv antal Navigational aids	decca navigator		
	loran C		
	radar		
	pejler		
	autopilot		
	gyro		
	satellit modtager		
	omega		
andet (angiv art):			

FISKESØGNINGSUDSTYR angiv antal Sonar equipment	ekkolod	
	sonar-asdic	
	fiskelup	
	netsonde	
andet (angiv art):		
BEHANDLINGSKAPACITET angiv antal tons pr. dag Handling capacity	frysekapacitet	
	kogekapacitet	
andet (angiv art):		
KOMMUNIKATIONSUDSTYR angiv antal Communication aids	VHF	
	radiotelex	
	radiostation	
	vejrkortmodtager	
andet (angiv art):		
OPBEVARINGSMULIGHED, sæt X	fersk fisk	
	kølelast	
	fryseanlæg	
	dam	
andet (angiv art):		
SPECIALUDSTYR angiv antal Special aids	fiskepumpe	
	kraftblok	
	nettromle	
	sorteringsanlæg	
	mekanisk isningsanlæg	
	rensemaskine	
andet (angiv art):		

dato		underskrift	

MARINE MARCHANDE

Direction des Pêches Maritimes

STATISTIQUES

Direction . ______

Quartier . ______ 03 07

Port ______

PECHES MARITIMES

STATISTIQUES MENSUELLES DES PRODUITS DEBARQUES

[1] Produits débarqués par des navires du port

[0] Produits débarqués par des navires de 08 12

MOIS DE ______ 197__ 71 74

N° de document 76 79

— Produits débarqués à l'état frais : ______ [1] 13

— Produits débarqués à l'état congelé : ______ [3] 13

— Produits débarqués à l'état salé ______ [2] 13

(N.B. . Etablir un état par catégorie de produits débarqués)

	ESPECES					QUANTITES DEBARQUEES					1	VENTES ENREGISTREES PAR LES HALLES A MAREE [1] 21					2
	(1)	(2)				(3)	(4)	(5)	(6)	(7)	(8) 80	Ventes directes à la consommation locale			Ventes aux enchères à la criée 80		
												(9)	(10)	(11)	(12)	(13)	(14)
	Nomenclatures	Espèces (en clair)	tailles	présentation	fraîcheur	Total quantités	Par des navires de 100 TJB et plus	Par des navires de moins de 100 TJB	Valeur totale	Prix moyen au kg	Parts réservées aux équipages (quantités)	Quantités	Valeur	Prix kg	Quantités	Valeur	Prix kg
[0] 02	14 16 18	19 22	23	24	25	26 33	34 41	42 49	50 57	62	63 70	22 29	30 37	38 42	43 50	51 58	59 63
01																	
02																	
03																	
04																	
05																	
06																	
07																	
08																	
09																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	

FRA I

Instructions **Exemple**

Etablir une fiche de pêche par marée

Indiquer obligatoirement : le nom du navire le port et le numéro d'immatriculation

Porter la date et l'heure de départ du port la date et l'heure de retour au port

Indiquer l'engin ou les engins utilisés et le type

NAVIRE : ....

Port d'immatriculation : ....

N° d'immatriculation : ....

Patron : ....

Armement : ....

Vente à : ....

le ⌊_ _ _ _ _ _⌋

	Année	Mois	Jour	Heure
Départ				
Retour				

Chalut { Fond ☐ type : .... semi-pélagique ☐ type : ....
G.O.V. ☐ type : .... pélagique ☐ type : ....

Filets ☐ genre : .... longueur nappe : ....

Lignes ☐ genre : .... nombre hameçons : ....

Autres engins ☐ genre : .... type : ....

Instructions	Exemple							Réservé pour le service			
Repérer les secteurs de pêche fréquentés à l'aide de la carte au recto.	6A20	**Secteur fréquenté**									
Indiquer le nombre de jours de présence dans chaque secteur.	4,5 J	**Temps de présence**									
A l'intérieur du temps de présence indiquer les heures d'immobilisation.	15 H	**Cape, Avarie Arrêts, Chaule**									
Indiquer le nombre total de traits de chalut dans chaque secteur.	18	**Nombre de traits**									
		Quantités travaillées à bord, par secteur et espèce									
		Hareng									
		Maquereau									
		Merlan { Petit									
	2,3 t	**Merlan** { Gros									
		Cabillaud { Petit									
	9 t	**Cabillaud** { Gros									
		Merluchon									
		Merlu									
		Eglefin ou Anon { Petit									
		Eglefin ou Anon { Gros									
	8,2 t	**Lieu noir** { Petit									
	6,3 t	**Lieu noir** { Gros									
	1,5 t	**Lingue bleue**									
		Lingue Franche (Julienne)									
	1 t	**Sébaste ou Rascasse**									
		Chien									
		Baudroie ou Lotte									
		Plie ou Carrelet									
		Cardine									
		Dorade { Petite									
		Dorade { Grosse									
		Encornet									
		Langoustine									
Argentine	1,5 t										
Exemple :	3 t	**Divers**									
	Gre 2 t	**Rejets** {									
	Div 1 t	**Rejets** {									

Porter les quantités pêchées de chaque espèce, de préférence en tonnes avec une décimale (à défaut en caisses ou paniers en précisant l'unité).

Exemple :

Un chalutier a pêché dans le secteur Nord Hébrides durant 4 jours et demi.

Il est resté 12 heures à la cape et a été stoppé 3 heures pour avaries. Il a donc eu 15 heures d'immobilisation.

Il a effectué 18 traits de chalut durant ces 4,5 jours.

Le détail de ces captures est :

2,3 tonnes de gros merlan
9 tonnes de gros cabillaud
6,3 tonnes de gros lieu noir
8,2 tonnes de petit lieu noir
1,5 tonne de lingue bleue
1 tonne de sébaste ou rascasse
1,5 tonne d'argentine
3 tonnes de divers
2 tonnes de grenadiers rejetés à la mer
1 tonne de divers rejetés à la mer ou transformées en hydrolysats.

Si un nom d'espèce ne se trouve pas préimprimé utiliser une ligne blanche en portant dans la case de gauche le nom de l'espèce

Les principales espèces rejetées ou tranformées en hydrolysats doivent être indiquées en tonnes par secteur, avec indication de leur nom.

Navires étrangers en pêche par secteur :
(indiquer, si possible, nationalité et type)

Autres observations :
(lieu et heures d'escale)

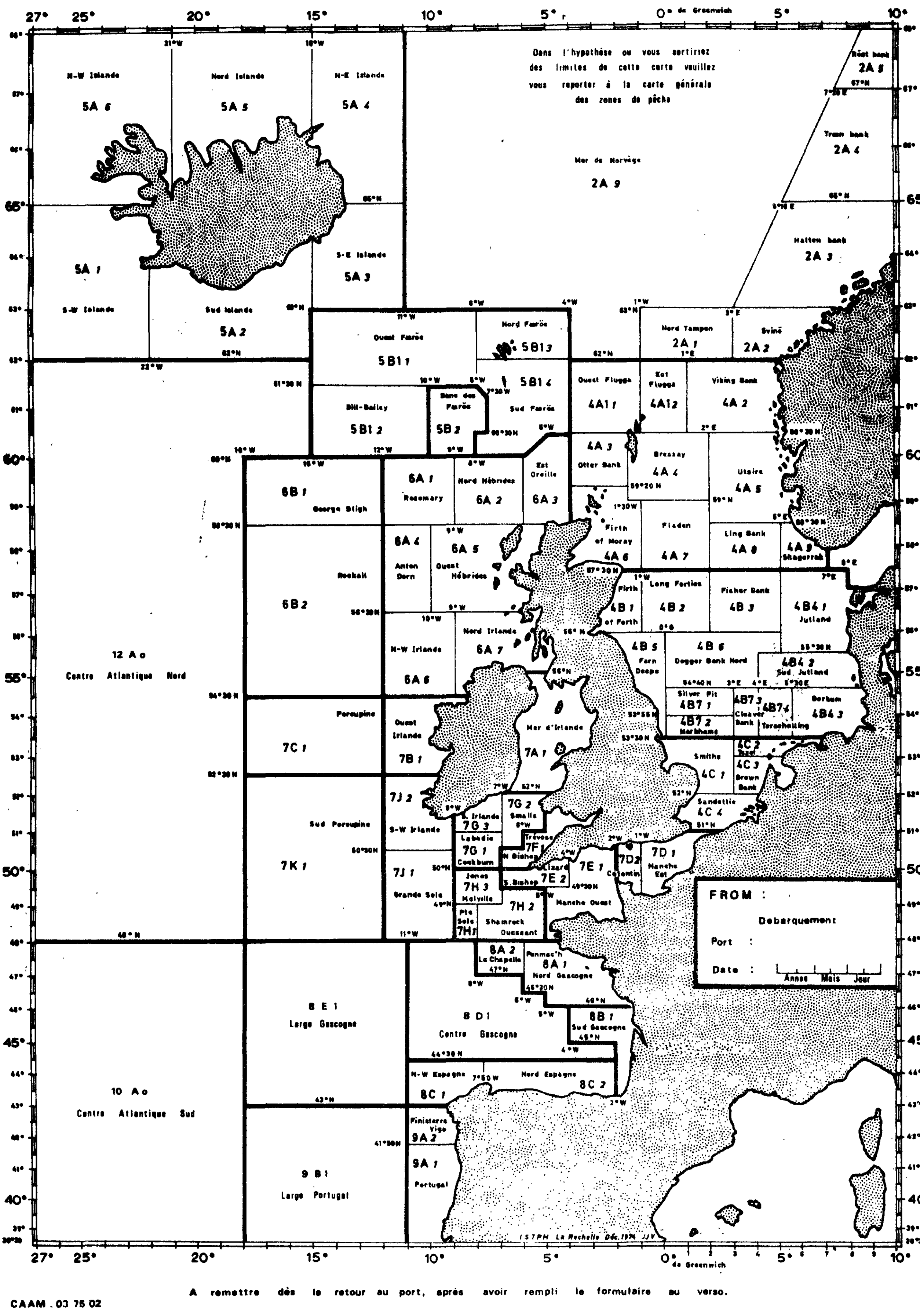
FRA 1

MARINE MARCHANDE

FICHE DE PECHE

PECHE AU LARGE

INSTITUT SCIENTIFIQUE
ET TECHNIQUE
DES PECHES MARITIMES



A remettre dès le retour au port, après avoir rempli le formulaire au verso.

CAAM . 03 75 02

FRA 1

Ministry of Agriculture Fisheries and Food
Return of fish landed

Section A

№ ______ N/L

101 N/L

Port ....NORTH SHIELDS........

Name of Vessel .... N/L

Registered letter and No. and Nationality .... N/L

Date of landing .... N/L

Days absent .... N/L

No. of grounds fished .... N/L

Section B

Particulars of fishing ground ....

		Main grounds	2nd. ground	3rd. ground	4th. ground	
Region	1					N/L
Rectangle	2					N/L
Sub-rectangle	8					N/L
Method of capture	3					N/L
No. of hauls or shots	4					N/L
Av. duration of haul	5	•	•	•	•	N/L
Days or % of fishing	6					N/L
Rejection	7					N/L

R = Rejection, X = No Rejection, N = No Information

Section C

If only one ground was fished, rejection figures only are required.

Species code	Rejected	Est. qty. landed	Rejected	Est. qty. landed	Rejected	Est. qty. landed	Rejected	Est. qty. landed	
									N/L
									N/L
									N/L
									N/L
									N/L
									N/L
									N/L
									N/L
Unit of qty. Z Z Z									N/L

1 = Kitt 2 = % (not rejection) 3 = Baskets 4 = Stones 5 = Cwt. 11 = Kilograms

Section D

To be completed only for pair fishing

Names of additional vessels

Names of additional vessels	Registered letter & No. Nationality			
....				N/L
....				N/L
....				N/L

Section E

Species	code	Quantity	£	
UNSold	UNS	→	→	N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
CONdemned	CON	→	→	N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
SALters	SAL	→	→	N/L
				N/L
				N/L
				N/L
				N/L
				N/L
FREezers	FRE	→	→	N/L
				N/L
				N/L
				N/L
				N/L
				N/L
Animal Food Stuffs	AFS	⇒	⇒	N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
	END	⇒	⇒	N/L

Section F

Species	code	Quantity	£	
BREam	BRE			N/L
BriLL	BLL			N/L
CATfish	CAT			N/L
COD, unsorted	COD			N/L
(COD) large	CD1			N/L
" medium	CD2			N/L
" small	CD3			N/L
Dabs, Long Rough	DLR			N/L
DABS, other	DAB			N/L
DoGfish, Spurdogs	DGS			N/L
GUrnard and Latchet	GUL			N/L
HADdock, unsorted	HAD			N/L
(HAD) large	HD1			N/L
" medium	HD2			N/L
" small	HD3			N/L
HAKe	HAK			N/L
HALibut	HAL			N/L
HAlibut, Mock	HAM			N/L
LEMon Soles	LEM			N/L
LINg	LIN			N/L
MEGrims	MEG			N/L
MOnks or Anglers	MOA			N/L
PLAice	PLA			N/L
POLlock	POL			N/L
REDfish	RED			N/L
SaiTHe, coalfish	STH			N/L
SKates and Rays	SKR			N/L
TORsk	TOR			N/L
TURbot	TUR			N/L
WHitinG	WHG			N/L
WITches	WIT			N/L
ROEs	ROE			N/L
MiXed Demersal	MXD			N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
				N/L
TOTal	TOT			N/L
			*	N/L

UK 1

H—1/1 North Shields

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Return of Fish Landed

Nº 26507

Port... Month........................... Year 19 Unit of Quantity N/L

Port Letters	A							N/L
and numbers	B							N/L
Nationality	C							N/L
Day of landing	D							N/L
Region	E							N/L
Rectangle	F							N/L
Sub-rectangle	G							N/L
Nos. voyages	H							N/L
Days	I							N/L
Details of effort (see instructions)	J							N/L
	K							N/L
Method of capture	L							N/L

Species	Cat	Qty	£	Qty	£	Qty	£	Qty	£	Qty	£	Qty	£	
B L L	1													N/L
C O D	1													N/L
D A B	1													N/L
D G N	1													N/L
F L F	1													N/L
H A D	1													N/L
L E M	1													N/L
M U G	1													N/L
P L A	1													N/L
S K R	1													N/L
S O L	1													N/L
T U R	1													N/L
W H G	1													N/L
W H P	1													N/L
M X D	1													N/L
														N/L
														N/L
														N/L
														N/L
														N/L
														N/L
H E R	1													N/L
M A C	1													N/L
S P R	1													N/L
														N/L
														N/L
C L M	1													N/L
C O C	1													N/L
C R B	1													N/L
L O B	1													N/L
O Y N	1													N/L
O Y P	1													N/L
P E R	1													N/L
P R E	1													N/L
W H E	1													N/L
														N/L
T Ø T	1													N/L

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ANNEX 2

Linear programming

Linear programming is a technique for solving problems of allocation in such a way as to maximise or minimise an objective, subject to constraints on the way in which the allocation may be made. A full description of the technique can be found in Hadley (1962). The following explanation has been taken from an early report of the UK modelling group (unpublished).

"The technique is applicable to the problem of how a fishing fleet might be deployed when there are constraints on how much fish may be caught and how many vessels are available. The objective might be, for example, to maximise total profits or to minimise the costs incurred in landing a specific quantity of fish. The basic principles of LP are illustrated in Figure 1 where the vessels of a fleet are to be allocated to catch a specified quantity of fish at minimum costs. There are two classes of vessels, inshore and offshore, each with their characteristic cost and catch-rate. Given these relativities, isolines can be constructed defining the (mix of) vessels that would have equal cost or equal catch values. The fishery is subject to three constraints, the numbers of vessels of each class available to fish (i.e. 2 constraints), and the amount of fish that may be caught under a quota regulation. The feasible region for the fishery to operate therefore lies within the area OABCD. If the objective is to catch the quota at minimum costs then, following the isolines of increasing cost, the optimal solution lies at B. This solution uses all the vessels which are least expensive to run and the balance of the catch available is taken with the other vessel category.

Linear programming is used to solve allocation problems of the kind illustrated but which may involve several thousand variables (i.e. a large number of vessel, gear, area and species categories)".

In the simple example given above, the solution can be seen to lie hard up against the constraints (the number of vessels available and the catch quota). This is always a feature of LP solutions. The cost surface is like an inclined plane and the constraints can be represented as boundaries to the plane; consequently the final resting place of a ball placed on the plane will always be at the boundary. LP solutions are therefore sparse and extreme. A small advantage in cost per vessel in one category will swing the solution towards fully utilising those vessels at the expense of the other categories. This is why LP solutions are ruthless and also highly sensitive to the chosen parameters leading to very different allocations of the resource for very minor changes in the parameters (Garrod and Shepherd, 1981).

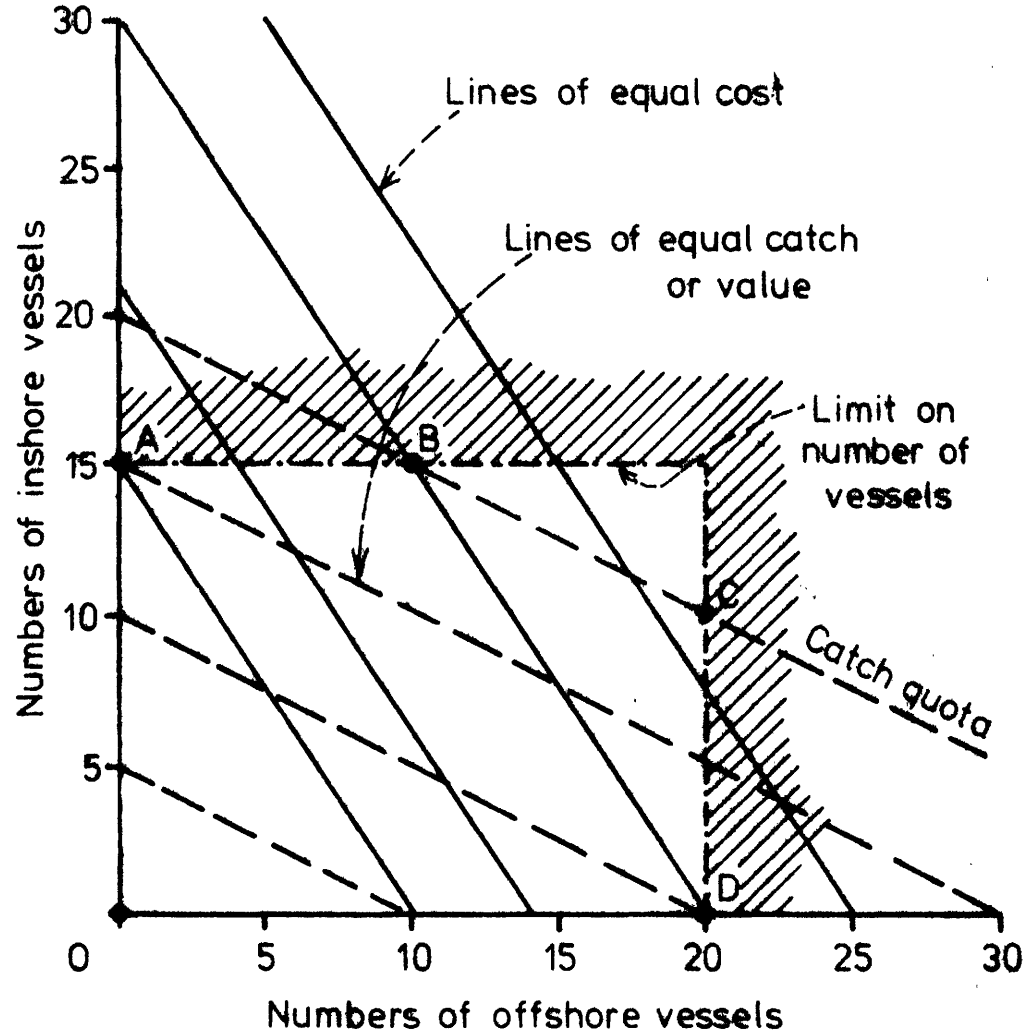

Figure 1. Example of the principle of linear programming. The cost per day offshore = $1\frac{1}{2}$ x inshore; the catch (or value) per day offshore = $\frac{1}{2}$ x inshore.

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