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International Council for the
Exploration of the Sea

C.M.1979/N:5
Marine Mammals Committee

ICES AD HOC WORKING GROUP ON INTERACTION BETWEEN GREY SEAL POPULATIONS AND FISH SPECIES

Charlottenlund, Denmark, 14-18 May 1979

This report has not yet been approved by the International Council for the Exploration of the Sea; it has therefore at present the status of an internal document and does not represent advice given on behalf of the Council. The proviso that it shall not be cited without the consent of the Council should be strictly observed.

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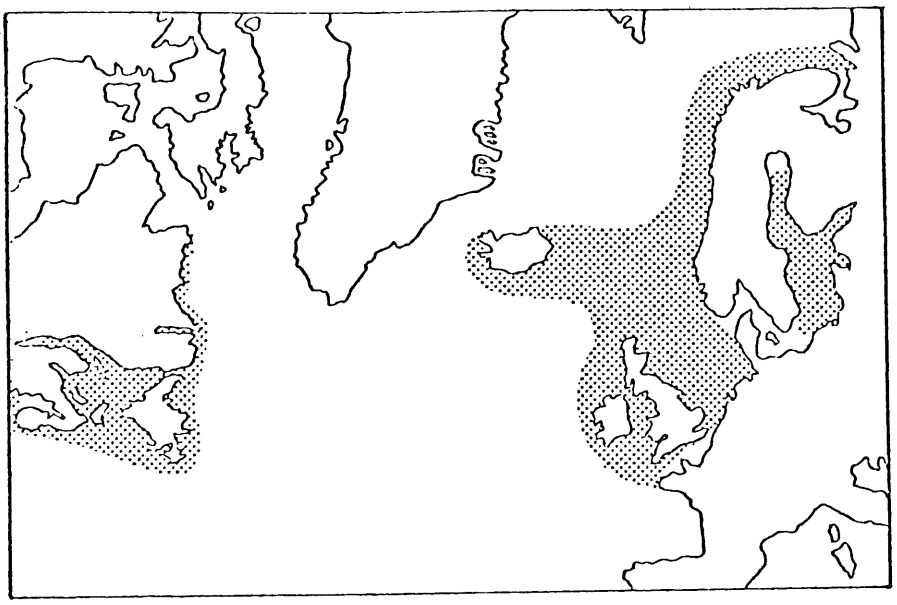

Fig. 1(a). World distribution of the grey seal.

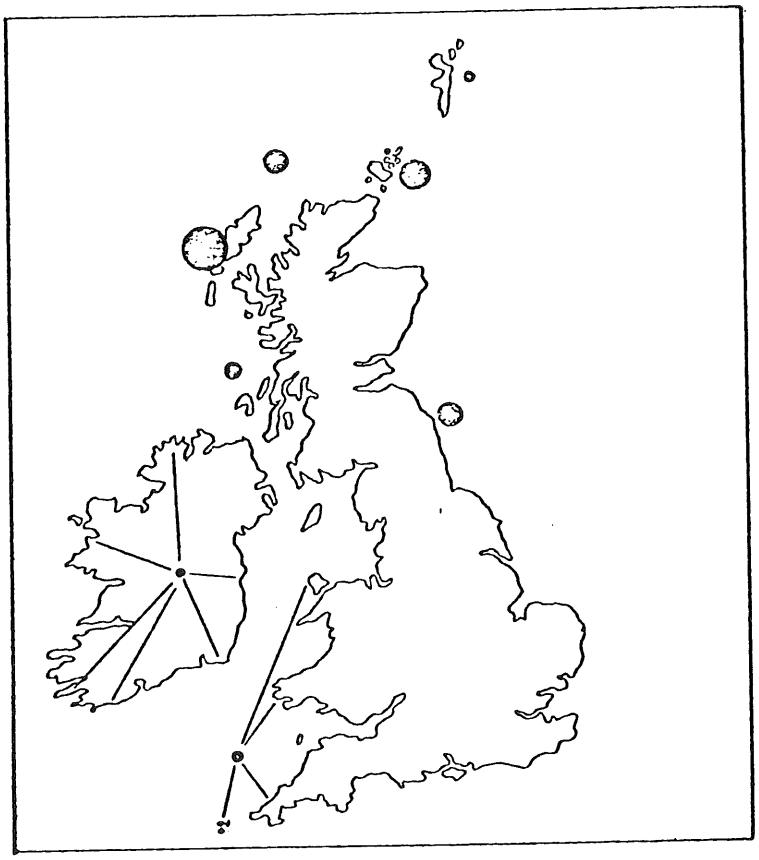

Fig. 1(b). Distribution of the grey seal about the British Isles (areas of circles proportional to local breeding populations).

1. INTRODUCTION

The grey seal Halichoerus grypus is found in temperate and sub-arctic waters on both sides of the North Atlantic (Figure 1). It is a gregarious species, forming large concentrations on land during a generally well-defined breeding season. There is great sexual disparity in size, the full-grown male weighing about 350 kg, nearly twice as much as the female. Sexual behaviour is highly developed, the dominant males defending loosely defined territories among the breeding females. The pup is suckled by the female for at least two weeks, increasing its weight nearly three-fold during this time. The female generally remains with the pup until it is weaned and then, after mating, returns to the sea.

The grey seal feeds on a wide variety of fish, especially those which are of economic importance to man. It occasionally feeds on invertebrates, particularly squids and bottom-living crustaceans such as crabs and shrimps, but rarely kills lobsters. In some areas the grey seal not only preys on local fish stocks but causes substantial damage to nets and the fish caught in them. Sometimes the problem is so severe that fishing becomes impracticable.

The grey seal also affects fisheries indirectly by acting as the final host in the life cycle of the codworm Porrocaecum (Terranova, Phocanema) decipiens, the parasitic nematode of cod and other important groundfish. This parasite adds a great economic burden to the fishing industry because the larvae must be removed from fillets by laborious hand-picking to make the fish attractive to consumers.

Observations on grey seal numbers in the United Kingdom, Canada and Norway in recent years show that undisturbed populations have been growing at an annual rate of 6-7%. In order to assess the problems associated with this increase in stock size, an ICES Working Group was set up (C.Res.1976/2:15) and met in May 1977 at Cambridge. That Working Group's report is available as ICES document C.M.1977/N:11 and contains much information relevant to the present situation.

In an attempt to solve some of the problems associated with large numbers of grey seals, the United Kingdom government has carried out several schemes to control the rising population. The most recent of these commencing in 1977 was aimed at reducing the Scottish grey seal population to the level of the mid-1960's through a series of annual culls of adults and pups on the breeding sites. However, in 1978 the culling operations under this scheme had to be abandoned owing to disruptions caused by its opponents, notably the international conservation activist group "Greenpeace." The matter was subsequently debated in the European Parliament and led to the Commission of the European Communities requesting ICES to study the problem and provide 'scientific advice on the management of grey seals and its relation to the management of fish stocks in certain areas.' The proposed terms of reference were as follows:

to 1) Up-date the status of the grey seal in the North-East Atlantic with special attention to the stocks around Scotland.

2) Assess biological interactions between grey seal populations and fish species on which they feed and also with regard to parasites which infest cod.

3) Assess the effects of seal behaviour in some coastal fisheries (damage to fishing gear, competition with fishermen).

4) Give advice on scientific factors which would form the basis for possible management measures, taking into account both the negative aspects of any over-large populations on fishing activities and the need for maintaining or improving a natural ecological equilibrium so that this species will not be threatened in the future.

The Council accepted the request and on 1 February 1979 invited Delegates to nominate members to an ad hoc Working Group under the Chairmanship of Dr A.W. Mansfield, Canada. The following report summarises the discussions of the Working Group. Participants are listed in Appendix IV.

2. CURRENT STATUS OF THE GREY SEAL POPULATION IN THE NORTH-EAST ATLANTIC

a) Population identity

Small numbers of young of the year tagged on United Kingdom breeding sites have been recovered as juveniles in many other European locations, but there is no indication that they stay to breed. Adult seals are known to return to the same breeding site year after year. Furthermore, it has been possible to predict the effect of culling operations by assuming that breeding populations are discrete. Thus we can assume that the Icelandic, Faroese, Norwegian, Baltic and United Kingdom stocks are separate management units.

Within the waters of the United Kingdom, there is a marked difference between the dates of the breeding season of seals at the Farne Islands and those in Scottish waters. Also the effects of controlled kills of pups and breeding females on pup production at the Farne Islands are consistent with this being a discrete management unit.

The breeding seasons of seals at Orkney, N. Rona and the Outer Hebrides are the same. Seals branded at N. Rona have been found as breeding adults in the Outer Hebrides and it is probable that the seals at N. Rona and the Outer Hebrides form one management unit. However, population changes in Orkney can be explained without assuming a connection with other breeding groups.

b) Estimation of pup production and recent trends in population sizes

The only component of a grey seal population which can be counted accurately is the number of pups born each year. If the population age structure is stable, pup production is a constant fraction of the size of the total population. Estimates of the grey seal population in the United Kingdom have relied on the total number of pups being a fixed multiple of the maximum number of pups present during the breeding season. This is based on about 40 observations from the Farne Islands over a period of 15 years and shows that this relationship does not vary significantly with time, or between the four main islands in the group. These observations indicate that the confidence interval for an estimate of pup production, based on a single maximum count, is $\pm$ 20%.

The conversion of an estimate of pup production to an estimate of total population size requires a knowledge of age specific mortality and fecundity rates. Analysis of individual cohorts from 1972 and 1975 Farne Islands culls show that there is no trend in adult survival rates with age (0.94 ± 0.03). Assuming that estimates of fecundity rates exhibit a similar degree of variation and that rates do not differ between breeding colonies, then estimates of total population size from pup production are accurate to within $\pm$ 10%, when derived from directly measured pup production.

Although these variations make it difficult to detect changes from year to year, a series of counts over a number of years will provide an accurate indication of population trends. Available data from the United Kingdom, Canada and Norway indicate that undisturbed populations have grown at an annual rate of 6-7%. There is no evidence that natural limiting factors will have an effect on this rate of increase in the near future, although clearly it could not be sustained indefinitely.

Estimated changes in United Kingdom population numbers since 1968 are given in Table 1.

3. IMPACT OF GREY SEALS ON FISH STOCKS AND FISHERIES

a) Species and quantities of fish consumed

Analyses of stomach contents from the United Kingdom, Canada, Iceland and Norway show that grey seals are opportunistic feeders, taking primarily fish species exploited by man. The samples have been collected mostly in inshore waters and may not, therefore, reflect the general distribution of grey seals. However, we believe that the present evidence from sampling away from salmon nets adequately describes the proportion of commercial fish in the diet of the grey seal.

Table 1.

Estimates of the grey seal population of the British Isles.

	Orkney, Outer Hebrides and N. Rona	Farne Islands	Other Stocks	Total
1977	51 000	8 500	13 500	73 000
1973	46 000	8 500	13 000	67 000
1968	35 000	8 000	12 000	55 000

Estimates of grey seal pup production for the British Isles.

1977	13 500	1 200	3 700	18 400
1973	11 000	1 700	3 500	16 200
1968	8 000	1 900	3 200	13 100

Other stocks = Southern Hebrides, Southwest England, Ireland, Shetland.

Recent Canadian experiments on captive harbour, harp and ringed seals, and estimates of food consumption from grey and harbour seal stomach analyses suggest an average, daily food intake throughout the year of 3-5% of body weight for an all-age population.

Using this range and an average body weight of 120 kg, derived from a large and representative sample of grey seals, the annual food consumption of an assumed British population of 70 000 is estimated to lie between 90 000 and 150 000 tonnes. This revises the estimate of 168 000 tonnes given in the previous ICES Working Group report. However, since grey seals are believed to kill more fish than they eat, these figures are probably underestimates of the amount actually killed.

b) Damage to fishing gear and entrapped fish

In Scotland this concerns primarily the coastal salmon trap fishery where the damage caused by seals to the gear and its entrapped catch has been monitored continuously since the early 1960's. The results indicate that the incidence of gear damage decreased during the 1960's and is now very small. The incidence of damaged fish, although differing considerably between fishing stations, shows no significant trend throughout the period: it currently averages about 3%. However, there is new evidence on the proportion of fish removed from drift nets by seals. Experiments were carried out on the drift net fishery off the northeast coast of England; for 1 275 salmon landed, at least 30 were seen to be taken from the nets by grey seals, that is about 2.3% of the catch.

c) Parasites

In Scotland and elsewhere high levels of infestation of cod by parasitic nematodes, particularly the codworm Porrocaecum decipiens, continue to be maintaned, especially in those areas where there are major breeding colonies of grey seals and continue to cause costly processing problems. Because of the high fecundity of this parasite and the existence of alternative hosts, we are unable to say whether a reduction of infection in cod would result from a reduction in seal numbers.

4. COMPETITION BETWEEN MAN, SEALS AND OTHER PREDATORS

a) Commercial catches of important fish species

In the period 1975-77, the commercial catches of 20 species of fish important to man and seals, in the waters about the British Isles (North Sea, northwest Scotland, Northern Ireland, Rockall, the Irish Sea and the west coast of Ireland; ICES statistical Sub-areas and Divisions IV, VIa and b, VIIa, b and c) varied between 3 and 4 million tonnes, corresponding to a fishable biomass of 5 to 10 million tonnes. The population of grey seals consumes an estimated 90-150 thousand tonnes of fish but reducing these estimates by one third in order to allow for commercially unimportant species eaten by grey seals and younger fish not represented in the commercial catch (the unfished biomass), gives an annual consumption from the exploited biomass of 60-100 thousand tonnes. This represents 0.6-2.0% of the exploited biomass and 1.5-3.3% of the commercial catch of all species combined.

The effect of grey seals on overall fish biomass does not indicate the level of impact on individual fish species. The salmon fishery provides a special case where some aspects of this impact can be estimated. In 1977, the total commercial catch from the salmon stocks exploited in the United Kingdom, the Republic of Ireland and France was about 5 000 tonnes. If salmon constitutes 3-5% of the grey seals' diet, then the seals would have a similar impact on the stock as the commercial fishery. Results of a food contents analysis of grey seal stomachs sampled away from the immediate vicinity of salmon nets (more than 1.5 km) in Scottish waters in the period 1958-78 showed 110 to have recognisable fish remains, 5% of which contained identifiable salmon remains (stomachs taken from seals caught in salmon nets or in their immediate vicinity showed an incidence of 42% salmon remains. Hence the impact of grey seals on the salmon stock may be of the order of the impact of the commercial fishery.

b) Consumption of important fish species by predators other than seals

There is almost no published information about the food consumption of other large predators such as sharks and whales in the waters around the British Isles. Birds also prey on fish stocks. Their numbers and diet are generally well known and the quantity of exploitable fish species consumed is similar to that consumed by grey seals.

Intraspecific and interspecific predation occurs amongst some of the commercial fish species utilised by grey seals. For example, it is estimated that the North Sea cod consumes its own weight of fish annually; at present this is in the order of 400 000 tonnes.

5. MANAGEMENT OF UNITED KINGDOM GREY SEAL POPULATION

a) Management options and their anticipated effects

(i) No killing of grey seals

There is no evidence to suggest that the present rate of increase will change, which means that the population will reach a level of 98 000 in 1983. This estimate has probable confidence limits of ± 10%, provided that the present population level is, in fact 73 000 and that all population parameters remain unchanged until 1983. Assuming that the food consumption per seal does not increase, the total food consumption would be 130-210 thousand tonnes at the new level, an increase of 40-60 thousand tonnes. However, only two-thirds of this increased food consumption is assumed to be of commercially exploitable fish; that is, 25-40 thousand tonnes (see section 4 a). The model in Appendix I can then be used to estimate loss to fisheries. This loss amounts to 7-12 thousand tonnes in the first year and may increase to 25-40 thousand tonnes at equilibrium. These estimates, however, take no account of fish which may be killed but not eaten (see section 3 a).

On the basis of past data, we would anticipate no increase of damage to netted salmon in the Scottish salmon fishery, but the consumption of salmon may rise in proportion to the increase in seal numbers. It is possible that eventually a point would be reached at which the total predation by seals and man would prevent any spawning escapement of salmon.

The already high levels of codworm infection in Scottish waters are unlikely to increase significantly with increased numbers of grey seals. However, the infected area might increase with the establishment of new breeding colonies and the extension of feeding range. Grey seals are a tourist attraction, but the effect of an increase in numbers cannot be assessed. Their effect on the terrestrial environment deserved special consideration since they have been known to cause erosion of island soils. In the Farne Islands, puffin burrows have been destroyed and there is a potential for dune erosion in the Monach Isles in the Outer Hebrides. Grey seals may conflict with some species of sea birds, but, in general, populations of other competing predators are not likely to be affected by increased seal numbers.

(ii) Maintaining the population at its present level

No significant change would be expected from the current situation described in Sections 3 and 4. The stability and the predictability of the grey seal population will alter, depending on the method of control.

(iii) Reducing the population

In the early 1960's, the Consultative Committee on Grey Seals and Fisheries was formed in the United Kingdom to consider the increasing problems arising from grey seals. It recommended that the populations in Orkney and the Farne Islands should be stabilized by culling of pups but the quotas applied failed to achieve this objective. In 1977, the United Kingdom introduced a management plan, the objective of which was to reduce the Scottish population to its mid-1960's level of about 35 000 by a series of annual culls. If this reduction were carried out and the other breeding groups managed as at present, the total population would amount to about 55 000. If the age distribution were not radically altered then total food consumption following a reduction to this level could be estimated as before. This amounts to 70-120 thousand tonnes, representing a decrease of 20-30 thousand tonnes, two-thirds of which are commercially exploitable fish. Using the model in Appendix I, the gain to fisheries in the first year following the full reduction is estimated to be 4-6 thousand tonnes and it may increase to 13-20 thousand tonnes at equilibrium.

At this level of population, other predators are unlikely to be affected, but it is not possible to say whether the levels of damage to netted salmon and the levels of infection by codworm would show a significant reduction from their present levels. Environmental impact of seals at the Monach Isles would likely be negligible.

b) Management strategies

In this section we consider the advantages and disadvantages of three strategies by which seal populations can be managed.

(i) Breeding season culls of pups only

Advantages:

1. The results are predictable in the short term, if the cull is carried out after the adults have left the breeding site, because there is then no interference with breeding as a result of disturbance.

2. The pups are easily taken and can be killed efficiently and humanely.

3. The dead seals can be used as a resource.

4. The sex balance is maintained.

Disadvantages:

1. Cropping at a high level over several years makes the population susceptible to any long-term environmental changes. Little is known of the distribution of immature grey seals and it is not until the year classes which have been culled have recruited to the breeding population that the effects of culling can be assessed.

2. It takes many years to reduce the breeding population.

3. Minimal scientific data are obtained.

(ii) Breeding season culls of adults and pups

Advantages:

1. A rapid reduction in the population is achieved.

2. The cull is spread over all adult age groups.

3. Scientific data on the age structure and maturity of the breeding population are obtained and these can be related to the breeding population from which they were taken.

4. The dead seals can be used as a resource (but see disadvantage 1).

Disadvantages:

1. Unless the cull is carried out in such a way as to keep disturbance to the minimum, breeding behaviour is affected and long-term changes in population size cannot be monitored or predicted.

2. More female than male adults are likely to be shot, resulting in an imbalance in the sexes which could lead to changes in breeding behaviour with consequences similar to those described in disadvantage 1.

(iii) Culls out of the breeding season

Advantages:

1. The cull is spread over all age groups, including the immature seals.

2. The sex balance is maintained.

3. Scientific information on age structure, pregnancy rates and feeding is obtained (but see disadvantage 1).

4. There is no disturbance of the breeding behaviour and therefore no long-term unpredictable consequences.

5. The reduction in the population is more rapid than with a pup cull but less rapid than with a cull at the breeding site for the same number of seals killed.

Disadvantages:

1. It is not possible to relate the seals to a specific breeding population so that the results are not predictable.

2. Larger numbers of seals have to be killed than with a cull of adults at the breeding sites to achieve the same reduction over a given time span.

3. There are unknown losses of seals which cannot be recovered.

4. The probability of only wounding seals is higher than with the two previous management strategies.

5. It is difficult to recover the carcasses and to use them as a resource.

6. It is the most difficult management strategy to put into effect because of the location of the haul-out sites, where culling would take place, and because seals desert these sites rapidly once disturbed; that is, the culling operation has to be very mobile.

We consider shooting seals at fishing stations a special case of culls out of the breeding season. However, its main objective is to eliminate those seals which have learnt to raid fish traps and nets rather than to reduce the overall population.

c) Means of applying control

The Group considered three means by which management strategies might be carried out.

1. Government-controlled culls
2. Bounties
3. Removal of restrictive legislation

It concluded that government-controlled culling is the most efficient method if seal numbers are to be reduced. This method also has the advantage that it provides the maximum scientific information.

Bounty schemes are considered to be an effective means of reducing seal populations. One of the advantages is that scientific data can be obtained; for example, in Canada the bounty is paid on the lower jaws, from which the age structure of the killed seals is obtained. If licensed bounty hunters are especially trained, the amount of data collected can be increased. The disadvantage of this method is that there is no control over the number of seals killed and, therefore, no precise control over any management plan. Once the scheme is started, the bounty has to be paid on each animal shot when the item on which the bounty is paid is brought in. If not, the item is hoarded until payments restart, and this would reduce the scientific value of the data.

The Group is against removing restrictive legislation because there will be no control over and no knowledge of the number of seals killed and no scientific information obtained. Controlled management of the seal populations will not be achieved and it will be impossible to interpret fluctuations in numbers observed on the breeding sites. Also, it is concluded that this method will lead to indiscriminate killing, possibly by inhumane methods.

Whatever means of control is used, the Group considers that the killed seals should be fully utilised, where possible.

6. RECOMMENDATIONS

a) Calculations on food consumption of grey seals rely on data obtained from seals found close to shore. Observations should be carried out to delineate the feeding range of the grey seal and sampling should be attempted throughout this range to obtain a more representative estimate of the species composition of the food.

b) Drugs are now available to control fertility in animals. The feasibility and effect of using these on grey seals should be studied.

c) Where feasible, experiments should be done to investigate how substantial local reduction of grey seals would influence levels of infestation by codworm and the amount of damage to fisheries.

d) Investigations should be made into the availability, practicality and effect of repellants to discourage the predation by grey seals on fish in nets.

e) Experimental work should be done on the energetics of grey seals and their minimal food requirements.

APPENDIX I

RESPONSE OF FISH BIOMASS AND FISHERIES YIELD TO CHANGES IN NUMBERS OF GREY SEALS

It is difficult to quantify the change in fish biomass and hence fishing yield resulting from a change in grey seal numbers because there are interactions between fish species as well as compensatory changes by other high level predators and density-dependent effects within single stocks. Though it is realised that stocks are not independent, fisheries management is usually based on single stock models because multi-species interrelationships are poorly understood and extremely complex. If we ignore interactions, then we can assume that the biomass of commercially important species that would be eaten by the number of grey seals added or removed can be directly added or removed from the biomass available to the fishery. This biomass change takes place over the first year, after a cull or population increase, but we can approximate this by assuming the whole change takes place at mid-year. Let this biomass be B; this biomass decreases over time due to natural and fishing mortalities (M and F) and increases due to growth of individual fish (at rate G). The yield to the fishery in the first t years after this biomass is lost or becomes available would change by:

$$Y = \int_{0.0}^{t-0.5} FB \exp\{-(F+M-G)x\}\, dx$$

$$= \frac{FB}{F+M-G} \left(1-\exp\{-(F+M-G)(t-0.5)\}\right)$$

To reflect current conditions, we will assume F = 0.7, M = 0.2 and, to be conservative, G = 0, so the return in the first year is 0.28B, or approximately the figure calculated in a different way in the Council of Nature paper. Hence a return or loss to the fishery of 28% of the change in amount consumed by grey seals, is a realistic approximation for the first year. If the assumptions hold indefinitely, the total yield from this biomass change would be

$$Y = \frac{FB}{F+M-G}$$

or, using the above figures, about 0.78B.

Though available knowledge of the interactions between species does not allow a detailed calculation of long-term changes in fishery yields, qualitative answers can be found by considering general production models. These have been used for single stocks, stock complexes and total yield of all species in a given area, and hence

the following discussion may be applied to either the return to all commercial fisheries affected or the fishery for one particular stock. Most stocks in the areas affected by the British grey seal population are over-exploited, with effort levels being above those giving maximum sustainable yield (MSY). Since grey seals take mainly fish of commercial size from commercially utilized species, we can combine the seal effort with the fishery effort. In Figure 2, we can assume we are at an effort level such as E shown. The long-term equilibrium catch to man and grey seal at this level would be Y. However, it is not known if present catches are above or below this. If we reduce the number of grey seals and keep fishing effort constant, we reduce the effort to a level such as E^1 shown. The equilibrium level of yield should rise since effort change would be small and not likely to move to below levels that will yield MSY. Since total yield rises and yield taken by grey seals falls, we can predict that in the long term the fishery will recover more than 100% of the consumption that would have gone to grey seals. Similarly, an increase in grey seals will increase effort and decrease total equilibrium yield, leading to the fishery losing more than 100% of the extra consumption taken by grey seals.

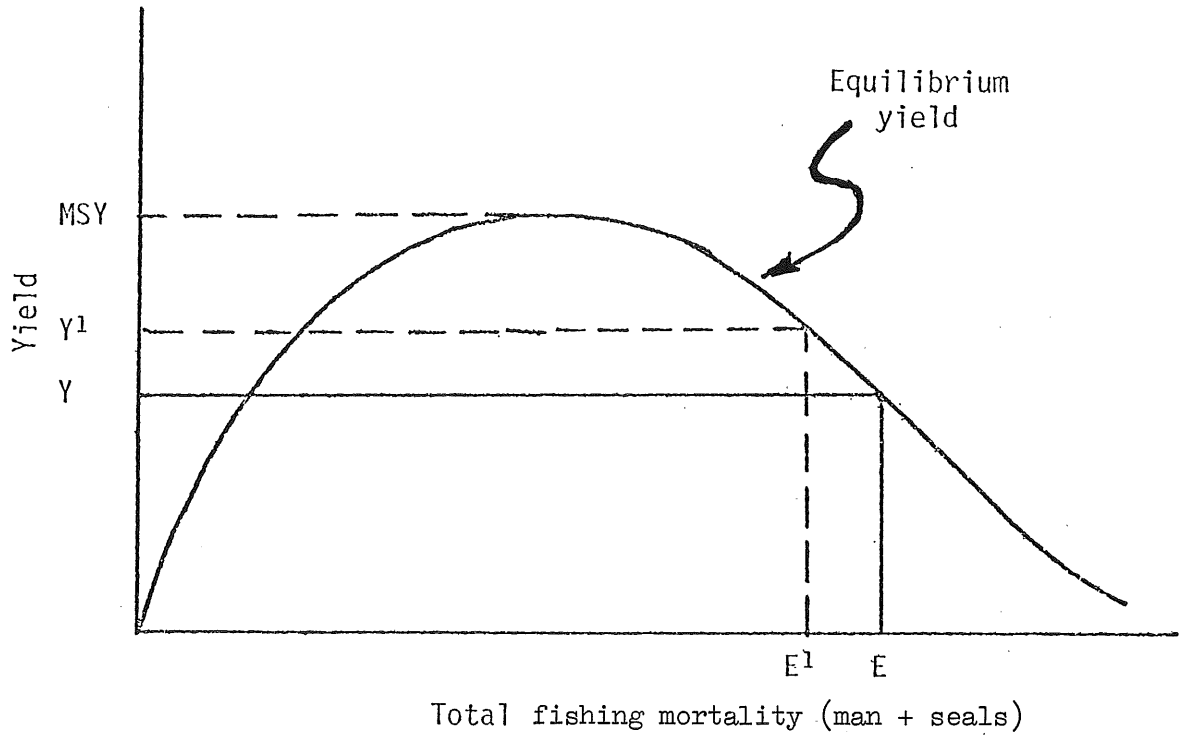

Fig. 2. General production model.

APPENDIX II

FISH SPECIES REFERRED TO IN REPORT

Lemon sole	*Microstomus kitt*
Megrim	*Lepidorhombus whiffiagonis*
Plaice	*Pleuronectes platessa*
Common sole	*Solea solea*
Turbot	*Rhombus (=Psetta) maximus*
Witch	*Glyptocephalus cynoglossus*
Cod	*Gadus morhua*
Haddock	*Melanogrammus aeglefinus*
Ling	*Molva molva*
Norway pout	*Trisopterus (=Gadus) esmarkii*
Pollack	*Pollachius pollachius*
Saithe	*Pollachius virens*
Tusk	*Brosme brosme*
Whiting	*Merlangius merlangus*
Sandeel	*Ammodytes* spp.
Horse Mackerel	*Trachurus trachurus*
Sprat	*Sprattus sprattus*
Atlantic mackerel	*Scomber scombrus*
Norway lobster	*Nephrops norvegicus*
Atlantic salmon	*Salmo salar*

APPENDIX III

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APPENDIX I

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APPENDIX IV

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