This report not to be cited without prior reference to the Council[x)]

International Council for the Exploration of the Sea

CM 1977/N: 11
Marine Mammal Committee

ICES WORKING GROUP ON GREY SEALS

REPORT OF THE FIRST MEETING, 16-20 MAY 1977, CAMBRIDGE, UK

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 an advice given on behalf of the Council. The The proviso that it shall not be cited without the consent of the Council should be strictly observed

x) General Secretary, ICES, Charlottenlund Slot, 2920 Charlottenlund, Denmark

TDB

INTRODUCTION

Damage to fisheries by the Grey seal, *Halichoerus grypus*, has been a serious problem in the UK and Canada for a number of years. The recent local increases in the abundance of the Grey seal in Norway, with an apparently related increase in fishery damage is seen as a problem which could become widespread if not checked in the near future. In order to give greater consideration to the problems associated with increases in stock size, an ICES Working Group was set up (C Res. 1976/2:15) to ".... review the current status and trends in stock sizes, methodological problems of censusing and factors responsible for the present expansion of the species. Data on the effects on fish resources, including codworm and gear damage, should be collected and their economic implications considered. The ultimate aim of the Working Group should be to find feasible solutions to this complex problem ....". The Working Group (see Annex 1) met in Cambridge, UK, from 16-20 May 1977, and the agenda of that meeting is appended as Annex 2.

1. POPULATION STUDIES

1.1 Population Identity

Methods used in determining stock relations were evaluated. The best evidence of reproductive isolation is geographical separation, as between the W. Atlantic and Baltic stocks, and different times of breeding, as between the Baltic and E. Atlantic stocks.

Evidence from marked animals is most valuable where the marks are permanent. Hot iron branding, preferably with individual cyphers rather than year class cyphers, is preferred to freeze branding in the relatively aseptic ice breeding situations of Canada and the Baltic but may result in some wound infection at terrestrial pupping sites. Explosive brands have not been fully exploited because of difficulties with patents. Tags provide useful information about the movement of young animals, but do not usually remain attached long enough to occur in the breeding stock. However, the considerable variation in the efficiency of tags suggests that better results may be obtained by 1) consulting the manufacturer with a view to improving the quality of the tags, 2) ensuring a high degree of expertise among taggers and 3) publicising the tagging programme to encourage returns from fishermen, coastguards etc. It is felt that there is a need for a rapid technique for permanently marking unrestrained adults. To this end, such possibilities as aerosol freeze branding and bone labelling, with tetracycline for example, should be investigated. The opportunity to test the efficiency of marking techniques using double marks should be taken wherever possible.

Biochemical evidence for stock separation obtained from investigations of enzyme polymorphisms has yielded little information about Grey seal populations. The small amount of published work describes only few polymorphic systems and it is felt that little progress will be made in this field without the investment of long term specialist expertise.

On the basis of evidence from a combination of the above sources, it is possible to regard the W. Atlantic, E. Atlantic and Baltic populations as distinct with the probability of further separate populations within the E. Atlantic group. There is a need for more work to be done on this particular problem 1) to determine stock relations in connection with fishery damage and 2) to establish the dependence of peripheral populations on centres of population expansion and the mechanism(s) by which colonisation is achieved.

1.2 Population Size

It is felt that the most meaningful estimate of population size is obtained from pup production data which can be obtained either directly or indirectly. Direct censuses involve marking and counting each individual born throughout the pupping season and have been done in several British breeding assemblies. Indirect methods involve either the derivation of a birth rate curve from the age structure of the available part of the year class, or the measurement of some reliable index of pup production. Birth rate curves have been derived indirectly for Sable Island and some British localities. An index of pup production, e.g. the maximum number of live pups counted in ground censuses or aerial photographs, has been used in Norway and routinely for most British breeding assemblies. Factors which may affect the accuracy of indirect methods are 1) variability of the duration of pup growth classes utilised in constructing a birth rate curve from a small number of counts, 2) possible underestimation in aerial photographic counts and 3) variability in the relationship between actual pup production and the index measured.

Other methods of estimating population size include Seber-Jolly mark-recapture and virtual population analysis. Both require some kind of continuous sampling programme, e.g. through bounty hunting. In Sweden, where tag returns are only obtained from animals found dead, a high proportion of marks have been recaptured.

Estimates of pup production are available for several breeding assemblies, and reveal trends in population size. In Canada and the UK there has been a recent population increase of about 7% annually. This figure applies to undisturbed populations and may be locally much higher, e.g. Sable Island and the Monach Isles, as a result of immigration. Where active management has been carried out on a large scale, e.g. pup culling in Orkney from 1962 to date and adult culling at Farne Islands in 1972 and 1975, these trends have been modified. The rate of the increase recently noted in Norway is not known.

Likely factors responsible for these increases are a reduction in predation by man and an increase in the availability of new breeding sites formerly inhabited by man. In Norwegian localities, where seal damage is severe enough to cause the closure of a fishery, there have been subsequent reductions in the numbers of pups killed in gear which have led to increases in the abundance of seals.

Data are not available from other E. Atlantic assemblies with which to describe trends, and in particular there is a lack of recent reliable information from Iceland, Faroe, Ireland and USSR.

The Baltic stock has declined to an alarmingly low level as a result of over-exploitation and, recently, pollution and although the Grey seal is likely to be totally protected in the Baltic its recovery is unlikely to be rapid because of the high incidence of female sterility caused by PCB contamination of the environment. Work in the Baltic has been further complicated by the difficulties of achieving effective international co-operation.

A current estimate of the world status of the Grey seal is detailed in Annex 3.

1.3 Population Dynamics

Sex ratios, adult mortality and fecundity have been measured directly in Canada from shot samples. This has facilitated the construction of a life-table from which a population estimate of 24000 can be derived for the W. Atlantic stock.

An independent estimate of stock size obtained from virtual population analysis is in preparation. In Sweden, analysis of bounty samples has revealed a drop in the age of sexual maturity in response to the severe depletion of the stock. First pupping occurs at 3 years of age compared with 4 years in Canada and 5 years in the UK. At the Farne Islands two large samples of adult females were obtained during the breeding season of 1972 and 1975. From the age structure it is possible to determine adult mortality and longevity. Examination of the transition from wide to narrow rings in the cementum layers of canine teeth reveals the probable age at first pupping for each specimen. This provides fecundity values for the recruiting year classes. By using a Leslie-matrix format for the life table, it is possible to simulate changes in stock size through time and to predict the effects of various management strategies. These are discussed further below.

2. IMPACT ON FISHERIES

2.1 Direct Predation, Predation on fish in nets and damage to gear

Norway

Damage to fisheries became a noticeable problem in the early 1970's in the area of South Helegeland,but has now started to spread to other areas. Most of the damage is caused by Grey seals to gill net fisheries and cod traps, although on the north-west coast of Norway the Common seal, *Phoca vitulina vitulina*, affects salmon fisheries by following boats to sea and, in the north, there are reports of increasing damage to cod fisheries. Grey seal damage has become so severe in some areas that fishing has changed from netting to handlining, or has even ceased altogether. It is thought that individual seals are responsible for the damage, and that the increasing number of Grey seals has decreased fish stocks in the Helegeland area. More work is required to quantify the damage caused by seals, which results in severe economic problems in some communities.

Finland

Fishing for salmon by drift net, drift line, anchored line and fixed coastal stations occurin the Gulfs of Bothnia and Finland and in the Baltic proper. In general, damage is low, although anchored line fishing is seriously affected. Both Ringed seals, *Pusa hispida botnica*, and Grey seals are responsible for damage. Theoretical estimates of damage suggest that, excluding coastal stations, about 15000 Kg of salmon are lost to seals each year at an estimated value of 315,000 FM (£50,000). There is a possibility that the removal of the bounty on Grey seals and the expected total protection of the species in the Baltic may result in an increase in damage in the future.

Sweden

The important salmon fisheries of the Gotland area suffer low damage from a small population of about 50 Grey seals. Approximately 1% of the total catch is damaged, and the problem is not serious. Theoretical studies of direct predation suggest that this stock utilises only 6% of the primary production required to support the fishery.

Canada

Direct predation by the Grey seal in Canadian waters has been calculated as 47000 tons per year, using estimates of food consumed by the total seal population, and this value is not large compared with the total fisheries catch. Seal damage to fishing operations became a problem in the mid-1960's when Grey seal populations started increasing rapidly. Damage occurs both on the east

coast of Nova Scotia and in the Gulf of St Lawrence, and there appears to be an association between sites where damage occurs and Grey seal breeding assemblies. Gill net, trap net and lobster fisheries are affected by Grey seals. The gill nets used for taking herring and mackerel, which are fished primarily for bait for the lucrative lobster fishery, suffer considerable damage. The average loss from net damage alone is $300/year per fisherman, or as much as $500,000 for the area. In some areas, damage is so severe that fishing has stopped altogether. Damage to salmon gill net fisheries is essentially a local problem and in the past was dealt with by introducing a local bounty, e.g.in the Miramichi estuary.

Trap fisheries for schooling fish, such as mackerel and herring, suffer losses of fish rather than damage to gear. Fish may be driven from the net as well as taken whole or left mutilated in the trap, and several thousand Kg of fish can be lost in this way. Salmon trap fisheries are few in number but losses of fish can be as high as 30-45% of the catch.

Lobster pots previously suffered damage from seals opening them to take the bait but this problem has been reduced by using salted bait or by modifying the door to the traps.

UK

Direct predation on UK fish stocks by Grey seals is estimated at 168,000 tons per annum, of which 112,000 tons consist of exploitable species. Assuming that 50% of these fish could be caught, a figure based on conservative estimates of the rate of exploitation by fisheries, the loss to the industry would be equivalent to 1-2% of the total fish catch from British waters. In monetary terms, based on 1974 Scottish cod prices, this would represent a loss of £15-20 million. This is considered to be a significant amount, particularly in view of the probable increase of fishing pressure on British coastal waters. The problem of Grey seal competition for fish stocks may be locally acute in the vicinity of large breeding assemblies such as the Farne Islands.

Salmon fisheries in the rivers and on the coasts of Scotland and NE England first reported serious seal damage problems in 1959. Net damage has been reduced to almost negligible proportions since the mid-1960's by the introduction of synthetic fibre, instead of natural materials, in the construction of nets but drift nets used in the English fishery still suffer serious damage. Continuing damage at fixed engine stations and net & coble fisheries consists of :-

1. Total loss of fish from nets or serious mutilation

2. Wounding and marking of fish, both in nets and at sea, so that the market value is reduced.

3. The scaring away of fish which otherwise would be caught.

Damage during the spring is higher than in the second half of the season because the summer runs contain a high proportion of grilse, which, being smaller than the spring salmon, may be taken whole by seals so that the proportion of damaged fish in the catch decreases even though the total losses may in fact be higher. Similarly, recorded damage for sea trout is less than that for salmon, possibly because whole fish are taken. Most of the damage to salmonid fisheries is caused by Grey seals, although occasionally Common seals may be involved. Levels of damage of all types show considerable variation from station to station and from year to year. In general, the percentage of seal-damaged salmon in the catch is less than 10%, although much higher figures have been recorded. In Scotland, some netting stations have been forced to close because seal damage has made fishing uneconomic. Figures for fixed engines and net & coble fisheries are lower than

those from drift net fisheries where, until they were made illegal in Scotland in 1962, 15-50% of the catch was damaged. At English drift net fisheries damage may be around 15-20%, but when fish are scarce losses may be as high as 100%. Reliable statistics are not available for other areas but damage to salmon fisheries in the Foyle area of Northern Ireland has recently been reported, while the cod fishery off Angus and the E. Anglian fisheries sustain serious seal damage.

Because of the high value of the salmonid fisheries the damage described above is of considerable economic significance, and can create severe local problems where fisheries have to close. It appears from the long time series of data on Scottish fisheries that levels of damage have not followed the recorded increase in Grey seal populations. Control measures at the Farne Islands produced no decline in damage at nearby fishing stations. It would appear that resident seals which have learned net-raiding behaviour are responsible for fixed net damage, although drift nets may be attacked by larger numbers of opportunistically feeding seals.

Irish Republic

Within the last 5 years the salmon drift net fishery around the coast has expanded rapidly. As yet there are few reports of seal damage but more information is required.

Iceland, Faroe and USSR

No information.

2.2 Codworm

Infestation of cod with *Phocanema decipiens* (synonyms are *Porrocaecum decipiens* and *Terranova decipiens*) via one of its definitive hosts, the Grey seal, is a serious problem in Canada, UK and Norway. This parasitic nematode, known as codworm, is absent from the Baltic fish and seals, perhaps because the intermediate host is absent from the brackish waters of the Baltic. Concern is felt over the lack of knowledge of the life-cycle of the codworm, although it is noted that publication is expected shortly of a three year study completed by G McClelland (Dalhousie University). There is a corresponding lack of information on levels of infestation in cod, except in the UK, where samples of cod are examined regularly. The relative importance of codworm and other nematode parasites in cod and seals is summarised for each country:

UK	In the seal :	Contracaecum > Phocanema > Anisakis (few)
	In codflesh :	Phocanema > Anisakis (few)
Canada	In the seal :	Phocanema > Anisakis > Contracaecum
	In codflesh :	Phocanema
Norway	In the seal :	Phocanema > Anisakis (few) > Contracaecum (few)
	In codflesh :	Phocanema > Anisakis (few)

It is apparent that there are considerable differences in worm burdens of seals from area to area, both in proportions of parasites present and in numbers found. Most countries have found that older seals and fish tend to carry heavier worm burdens than younger animals.

Present work in Norway indicates that codworm has spread very quickly; in the

Helegeland area very high worm burdens in ground-fish have occurred within the last 3 or 4 years and the codworm problem appears to be spreading rapidly along the coast. Suggestions that codworm is prevalent in shallow waters perhaps indicate that the invertebrate host is a shallow water species. In the UK, there was an increase in levels of worm infestation during the 1960's, but no further increase to accompany the seal population expansion of 1965 onwards. This would indicate that there is not a direct relationship between absolute numbers of seals and fish infestation.

The presence of codworm in cod flesh creates a marketing problem. Worms must be removed by hand, a method which is not completely effective and which results in high processing costs. In Canada it is estimated that removing worms from cod fillets for export cost $2 million per year. In Norway the most heavily infested fish are discarded because the cost of treatment is too high, so that codworm creates very serious problems for small communities dependent on fishing for their livelihood. It is noted that processing costs are not linearly related to worm burden in fish and that a small increase in the level of infestation may reach the threshold at which marketing becomes uneconomic.

Codworm is killed by freezing or adequate cooking, so that there is a health hazard only in those countries where fish is eaten raw or only lightly salted. Cases of human infection by nematode parasites have been documented from Holland, Japan and Canada.

3. ASSESSMENT OF POSSIBLE METHODS OF MANAGEMENT AND CONTROL

3.1 Control at breeding assemblies

The culling of seals at breeding assemblies for fishery protection purposes has been carried out in Canada (average 800 pups plus a variable smaller number of adults annually) and in Orkney (1000 pups annually) for some time. However, these levels of culling have not been sufficiently high to bring about either a reduction in stock size or any measurable reduction in fishery damage. At the Farne Islands, the culling of several hundred breeding females in 1972 and 1975 in order to prevent excessive habitat destruction at seabird breeding sites, has had a directly quantitative effect on subsequent pup production. But even this measure of success in achieving a stock reduction has not been accompanied by any reduction in damage to nearby salmon netting stations. It is clear that the relationship between seal abundance and effect on fisheries is complex, although direct predation on exploitable fish at sea is likely to be a function of seal numbers.

In considering strategies for achieving stock reductions it has been possible, using the model derived from the Farne Islands sample, to simulate the effects of possible culling regimes. To control an expanding population it is necessary to take some pups annually. However, to achieve a stock reduction by taking only pups is inadvisable because during the time lag before a year class is recruited to the breeding stock, when the effect of the operation is first reflected in pup production, small changes in the value of life-table parameters could lead to an irreversible decline in population size. An immediate reduction to the desired level by the removal of the appropriate number of breeding females requires a dangerously high crop of pups to establish a static population. Greater control is achieved by killing annually a number of adults, related to the previous year's pup production. The effects of this type of operation are immediately apparent and oscillations in population size are minimised. A commercial crop of moulted pups may also be taken.

Factors affecting the success of adult culls include 1) timing of the operation in relation to the pupping season 2) disturbance caused by removal of carcasses

and sustained human presence leading to desertion by cows which are then no longer available to be shot 3) terrain, e.g. limited access to the sea 'funnels' the seals and increases the marksman's chance of shooting large numbers 4) behaviour, e.g. timid animals escape quickly to the sea and 5) accessibility, e.g. logistic difficulties of this type of operation on ice or where breeding areas are widely scattered.

3.2 Bounties

Since fishery damage became important in the Baltic during the early part of the century, bounty hunters have brought about a dramatic and perhaps irreversible decline of the stock. However, if bounties are paid only to licensed fishermen there is a greater likelihood of ensuring that a large effort will go into seal hunting only where seal damage is considered serious by the fishermen. The bounty also provides some compensation for lost fishing time and damage. In Norway the current legislation (see Annex 4) prevents effective stock control in some areas; if local fishermen were licensed to take seals then the two objectives of damage control and scientific sampling would be met.

3.3 Control at fishing gear

Seal damage to fishing operations, which has been a long standing problem throughout the range of the Grey seal, causes serious problems where it affects high value fisheries or small communities dependent on fishing. Because it appears that damage at fishing stations is caused mainly by resident seals, although young seals dispersing from pupping grounds are also implicated, it is important to have a method of local control. At present, an effective control measure is not available. The following methods have been used or suggested:

1. Shooting is used with some success at a few sites but the practical difficulties and the dangers of accidents, through ricochet, curtail the effectiveness of this method.

2. The development of a suitable poison to replace strychnine in bait, explicitly banned in the UK (Conservation of Seals Act 1970) appears to be promising. The costs of production and encapsulation require further investigation. However, such a method would only be used at some sites in the UK, and it is thought to be an unacceptable method for most countries.

3. The use of a variety of sounds to scare seals from nets has been investigated and found to be ineffective but sonar may be worth further study.

4. It is suggested that a bait containing an emetic, such as 'Ipecac', might discourage seals from raiding nets and, if effective, would be more acceptable than poison.

It is agreed that control at the nets has to be considered in conjunction with stock reduction. The difficulties of relating experimental results to the field situation are noted but it is felt that there is an urgent need for further work to solve this problem.

RECOMMENDATIONS

1. Recent data on population status of the Grey seal are unavailable from Iceland, Faroe, Ireland and USSR. If in existence, these should be made available through the committee.

2. Information on fishery damage in Norway and England is scant, and not available from Iceland, Faroe, Ireland and USSR. This should be collected.

3. 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.

4. There is a need for an international marking scheme within the E. Atlantic stock of Grey seals to provide more information on stock relationships.

5. The tag manufacturer should be approached to determine the possibility of improving the quality of tagging equipment.

6. Emetics should be considered for use against seals at nets. Experimental work could be done with captive animals.

7. The production costs for an alternative poison to strychnine, for use against seals at nets in the UK, should be determined even though it is unlikely to be used in most countries.

8. A second meeting of the group should be convened with the agreement of the committee.

ANNEX 1

MEMBERS OF ICES WORKING GROUP ON THE GREY SEAL

C F Summers (Chairman)
IMER Seals Research Division
c/o British Antarctic Survey
Madingley Road
Cambridge CB3 OET, UK

Sheila S Anderson(Rapporteur)
IMER Seals Research Division
c/o British Antarctic Survey
Madingley Road
Cambridge CB3 OET, UK

T Benjaminsen
Institute of Marine Research
PO Box 1870-72
5011 Bergen-Nordnes
Norway

B Bergflødt
Institute of Marine Research
PO Box 1870-72
5011 Bergen-Nordnes
Norway

P Brodie
Fisheries and Marine Service
Marine Ecology Laboratory
Bedford Institute of Oceanography
Dartmouth
Nova Scotia B2Y 4A2
Canada

J Gilbert
School of Forest Resources
University of Maine
Orono Maine 04473
USA

A W Mansfield
Arctic Biological Station
PO Box 400
Ste. Anne de Bellevue
Province Quebec H9X 3L6
Canada

D Prieur
Université de Bretagne Occidentale
Laboratoire de Zoologie
Aquaculture et Pollutions Marines
6 Avenue le Gorgeu
29 283 Brest Cedex
France

W M Shearer
Dept of Agriculture and Fisheries
for Scotland
6 California Street
Montrose
Angus, UK

S Söderberg
Naturhistoriska Riksmuseet
Sektionen för Vertebratzoologi
Fack
104 05 Stockholm 50
Sweden

O Stenman
Finnish Game and Fisheries Research
Institute
Game Division
Unioninkatu 45B
SF 00170
Helsinki 17
Finland

A Swain
Ministry of Agriculture, Fisheries and
Food
Salmon & Freshwater Fisheries Lab.
Room 4
Whitehall Place East
London SW1A 2HH, UK

P Warner
Dept of Lands (Forestry & Wildlife Service)
22 Upper Merrian Street
Dublin 2
Ireland

ANNEX 2

Unpublished reports not to be cited without prior reference to the author

AGENDA AND BIBLIOGRAPHY

1. POPULATION STUDIES

Benjaminsen, T & Bergflødt, B (1976)
Telling av havert på norskekysten fra Halten-Froan til Bodø og undersøkelse av kveisinfeksjonen i fisk ved Vega. Rapporteur, nr 1 - 1976

Benjaminsen, T, Brodie, P & Toklum, K (unpub. ms 1977)
Grey seal investigations on the Norwegian Coast from Lofoten to Frøya, September-November 1976 (English summary)

* Bonner, W N (1976)
Stocks of Grey seals and Common seals in Great Britain. NERC Publications Series C No. 16, 16 pp

Brien, Y & Prieur, D (1973)
Les Phoques de Bretagne. Penn ar Bed, 9, No. 74: 175-184

Fisher, H D (unpub. ms 1955)
The Grey seal (Halichoerus grypus (Fabricius)) in the West Atlantic

* Hewer, H R (1974)
British seals. London, 256 pp

Hook, O & Johnels, A G (1972)
The breeding and distribution of the Grey seal (Halichoerus grypus Fab.) in the Baltic Sea, with observations on other seals of the area. Proc. R. Soc. Lond., Ser. B., Biol. Sci., 182: 37-58

Joensen, A H, Søndergaard, N & Hansen, E B (1976)
Occurrence of Seals and Seal Hunting in Denmark. Danish Review of Game Biology, Vol. 10, 1

Karpovich, V M, Kokhanov, V D & Tatarinkova, I P (1967)
The Grey seal on the Murman Coast. Trudy PINRO 21, 117-125 (available in English, Fisheries Res. Bd. Can. Translation Series No. 1030)

Mansfield, A W (1966)
The Grey seal in Eastern Canadian Waters. Can. Audubon Mag. 28(4): 161-166

Mansfield, A W (1971)
The distribution and population status of the Grey seal (Halichoerus grypus) in Eastern Canadian waters. ICES CM 1971/N:7

* General papers relevant to other sections

POPULATION STUDIES (Contd)

* Mansfield, A W & Beck, B (1977)
The Grey seal in eastern Canada. Environment Canada, Fisheries & Marine Service Technical Report No. 704

Smith, E A (1966)
A review of the world's Grey seal population. J. Zool., Lond. 150, 463-489

Tormosov, D D & Reznov, G V (unpub. ms)
Information of distribution, number and feeding habits of Ringed and Grey seals in the Gulfs of Finland and Riga in the Baltic Sea

Tsalkin, V I (1936)
Halichoerus grypus Fabr. (Grey seal) in the waters of Franz-Josef Archepelagos. J. "Priroda", No. 1

Zheglov, V A (1973)
On the seasonal distribution and behaviour of Baltic Grey seal (Halichoerus grypus Fabr., 1871). In collection "Fishery investigations in the Atlantic Ocean" Part II, Trudy AtlantNIRO iss. 51, Kaliningrad, p.150-160

1.1 Population Identity

Harwood, J, Anderson, S S & Curry, M G (1976)
Branded Grey seals (Halichoerus grypus) at the Monach Isles, Outer Hebrides. J. Zool. Lond. (1976) 180, 506-508

McDermid, E M & Bonner, W N (1975)
Red cell and serum protein systems of Grey seals and Harbour seals. Comp. Biochem. Physiol., 50B: 97-102

1.2 Population size - census techniques, derivation of pup production estimates, trends in population size

Anderson, S S & Curry, M G (1976)
Grey seals at the Monach Isles, Outer Hebrides, 1975. ICES CM 1976/N:9

Bonner, W N & Hickling, G (1971)
Seals of the Farne Islands, 1969-71. Trans. Nat. Hist. Soc. Northumb. 17, 141-162

Boyd, J M,Lockie, J D & Hewer, H R (1962)
The breeding colony of Grey seals on North Rona, 1959. Proc. zool. Soc. Lond. 138, 257-277

Coulson, J C & Hickling, G (1964)
The breeding biology of the Grey seal (Halichoerus grypus (Fab.)) on the Farne Islands, Northumberland. J. Anim. Ecol. 33, 485-512

Lockley, R M (1966)
The distribution of Grey and Common seals on the coasts of Ireland. Irish Nat. J. 15, 136-143

1.2 (contd)

Radford, P J, Summers, C F & Young, K M (in press)
A statistical procedure for estimating Grey seal pup production from a single census

Summers, C F (1974)
The Grey seal (Halichoerus grypus) in Cornwall and the Isles of Scilly. Bio. Con. 6, 285-291

Summers, C F, Burton, R W & Anderson, S S (1975)
Grey seal (Halichoerus grypus) pup production at North Rona: a study of birth and survival statistics collected in 1972. J. Zool. Lond. 175, 439-451

Summers, C F,Vaughan, R W & Witthames, S R (1975)
Increasing numbers of Grey seals in the Hebrides. ICES CM 1975/N:17

Summers, C F (1976)
Grey seal pup production in Orkney 1960-1975. ICES CM 1976/N:11

Summers, C F (unpub. ms)
Trends in size of British Grey seal populations

Summers, C F (unpub. ms)
Summary of the current status and management of Grey and Common seals in Gt Britain

Vaughan, R W (1971)
Aerial photography in seals research. In 'The application of aerial photography to the work of the Nature Conservancy'. Ed. by R Goodier, Nat. Cons. Edinburgh

Zheglov, V A & Chapsky, K K (1971)
Experimental aerial calculation of Ringed seals and Grey seals in the Baltic Sea and Lake Ladoga. Marine Mammal Investigations, Trudy AtlantNIRO, iss. 39, Kaliningrad, pp 323-72

1.3 Population dynamics - evaluation of life table parameters, factors influencing these parameters

Harwood, J & Prime, J H (unpub. ms)
Factors affecting the size of British Grey seal populations

Hewer, H R (1964)
The determination of age, sexual maturity, longevity and a life table in the Grey seal (Halichoerus grypus). Proc. zool. Soc. Lond. 142, 593-624

Platt, N E, Prime, J H & Witthames, S R (1975)
The age of the Grey seal at the Farne Islands. Trans. Nat. Hist. Soc. Northumb. 41, 99-106

Söderberg, S (1977, unpub. ms)
Falling age at sexual maturity in Baltic seals

2. IMPACT ON FISHERIES

Parrish, B B (unpub. ms 1977)
Notes on the effects of seals on fisheries

Mansfield, A W & Beck, B (1977)
The Grey seal in eastern Canada. Environment Canada, Fisheries and Marine Service, Technical Report No. 704

Söderberg, S (1971)
Commercial damage and feeding habits of seals in the Baltic; a preliminary report. ICES CM 1971/N:3

2.1 Direct predation, predation on fish in nets and damage to gear

Directorate of Fisheries Research Reports 1964-72
Scotland Dep. Agric. Fish.

Fisher, H D & Mackenzie, B A (unpub. ms 1955)
Food habits of seals in the Maritimes. Fish. Res. Bd. Can., Atlantic coast stations, Progress Rep. 61: 5-9

Lockie, J D (1959)
Grey seals and salmon fisheries on the Northumberland and Berwickshire coast. Salmon Trout Mag. (London) 157, 165-175

Lockie, J D (1962)
Grey seals as competitors with man for salmon. In 'The exploitation of natural animal populations'. Ed. by E D Le Cren & M W Holdgate, 316-322

Mountford, M D & Smith, E A (1963)
Damage to fixed net salmon fisheries. In 'Grey seals and fisheries' HMSO, London 33-41

Rae, B B (1968)
The food of seals in Scottish waters. Scotland.Dep. Agric. Fish., Mar. Res., 1968/2

Rae, B B (1960)
Seals and Scottish fisheries. ibid 1960/2

Rae, B B (1962)
The effect of seal stocks on Scottish marine fisheries. In 'The exploitation of natural animal populations'. Ed. by E D Le Cren & M W Holdgate, 305-311

Rae, B B (1973)
Further observations on the food of seals. J. Zool., Lond. 169, 287-297

Rae, B B & Shearer, W M (1965)
Seal damage to salmon fisheries. Scotland. Dep. Agric. Fish., Mar. Res., 1965/2

Rae, B B (1963)
The food of Grey seals. In 'Grey seals and fisheries', HMSO London, 28-33

2.1 (contd)

Summers, C F, Bonner, W N & Van Haaften, J (in press)
Changes in the seal populations of the North Sea. In 'ICES Symposium on Changes in the North Sea Fish Stocks and their Causes'. Ed. by G Hempel. Rapp. P.-v. Reun. Cons. perm. int. Explor. Mer

2.2 Codworm

Davey, J T & Lowe, D M (1973)
Anisakine nematode investigations on the Farne Island Grey seal population following the 1972 cull. Parasitology 67, 28-29

Grigg, U M & Wiles, M (1970, unpub. report)
Final report on the nematodes parasitic in a collection of stomachs of the Grey seal, Halichoerus grypus (Fab)

Mansfield, A W (unpub. ms, 1966)
Studies of Grey, Harbour and Harp seals as vectors of the Codworm (Porrocaecum decipiens) in the Maritime Provinces

Mansfield, A W & Sergeant (unpub. ms, 1965)
Relative importance of seal species as vectors of codworm (Porrocaecum decipiens) in the Maritime Provinces

Mansfield, A W (unpub. ms, 1968)
Seals as vectors of Porrocaecum in the Maritime Provinces

Platt, N E (1975)
Infestation of cod (Gadus morhua L.) with larvae of codworm (Terranova decipiens Krabbe) and herringworm, Anisakis Sp. (Nematoda Ascaridata) in North Atlantic and Arctic waters. J. appl. Ecol. 12, 437-450

Prime, J H (1973)
Infection of young Grey seals with stomach nematodes. ICES CM 1973/N:5

Rae, B B (1963)
The incidence of larvae of Porrocaecum decipiens in the flesh of cod. Scotland. Dep. Agric. Fish., Mar. Res. 1963/2

Rae, B B (1972)
A review of the codworm problem in the North Sea and in Western Scottish waters 1958-1970. ibid 1972/2

Scott, D M & Fisher, H D (1958)
Incidence of the ascarid Porrocaecum decipiens in the stomachs of three species of seals along the southern Canadian Atlantic mainland. J. Fish. Res. Bd. Can. 15(4): 495-516

Young, P C (1972)
The relationship between the presence of larval Anisakine nematodes in cod and marine mammals in British home waters. J. appl. Ecol. 9, 459-485

3. ASSESSMENT OF POSSIBLE METHODS OF MANAGEMENT AND CONTROL

3.1 Control at breeding assemblies

Bonner, W N & Hickling, G (1971)
Grey seals at the Farne Islands : A management plan

Bonner, W N & Hickling, G (1974)
The Grey seals of the Farne Islands 1971 to 1973. Trans. Nat. Hist. Soc. Northumb. 42, 65-84

Hickling, G,Hawkey, P & Harwood, L H (1976)
The Grey seals of the Farne Islands: The 1975 breeding season. ibid 42, 107-114

SRD internal document (unpub. ms)
"Options for management strategies"

Summers, C F (1976)
Grey seal pup production in Orkney 1960-1975. ICES CM 1976/N:11

3.2 Bounties

Söderberg, S (1971)
Sealhunting in Sweden and Finland during the 20th century. ICES CM 1971/N:2

Söderberg, S (1972)
Gears and methods used for sealhunting in Sweden. ICES CM 1972/N:8

3.3 Control at fishing gear

Anderson, Sheila S (in press)
Scaring seals by sound

Anderson, Sheila S (unpub. ms)
Controlling seals at salmon nets: a substitute for strychnine. Desk study report

CURRENT WORLD STATUS OF THE GREY SEAL

Canada	24000	
USA	+	
		24000
Iceland	1000[a]	
Faroe	3000[b]	
Gt Britain	70000	
Ireland	2000[b]	
Norway	3000+	
Sweden (W. coast)	+	
France	+	
USSR (Murman coast)	3000[c]	
		82000
Baltic	2000	
		2000
		108000

a Derived from Arnlaughsson (1973, unpublished)

b Smith (1966)

c Derived from Karpovitch et al (1968)

ANNEX 4

SUMMARY OF GREY SEAL LEGISLATION

CANADA — From 1976 bounties on 1+ yr olds. Pupping localities protected Jan/Feb. Bounties on pups away from pupping localities after end of February. Licences to Govt. agents to kill in pupping season.

FINLAND — Bounty to 1976. Close season 1975-77 from March 10 - May 31. Total protection planned.

FRANCE — Total protection since 1961.

IRELAND — Local bounties prior to 1977 (no date). From 1977 total protection except for licences to kill for fishery protection, scientific research.

NORWAY — From 1973 total protection except December - April from Møre north. Salmon net protection.

SWEDEN — Bounties to 1974. Total protection except at nets since 1974.

UK * — Protected during breeding season under 1914 and 1932 Grey Seals Protection Acts with special suspensions for control of fishery damage under 1932 Grey Seals Protection Act. The Conservation of Seals Act of 1970 retained close season (September 1 - December 31) but provision for licences to kill seals for fishery protection, management, commercial hunting, scientific research. Net protection at all times.

USA — Massachusetts bounty to 1965. Protected since 1965.
1972 Marine Mammals Federal Protection Act.

USSR — Total protection since 1970 in the Baltic.

* excluding Channel Isles, Isle of Man and Northern Ireland where there is no legislation relating to seals