

The Moray Firth Seal Management Plan: an adaptive framework for balancing the conservation of seals, salmon, fisheries and wildlife tourism in the UK

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ABSTRACT

1. Within the Moray Firth, north-east Scotland, there is a history of conflict between seals and salmon fisheries. Under the UK's Conservation of Seals Act 1970 (CoSA) seals are shot to protect fisheries. In 1999 six rivers in the Moray Firth were designated as Special Areas of Conservation (SACs) for Atlantic salmon under the EU Habitats Directive, and in 2000 an SAC for harbour seals was designated in the Dornoch Firth.

2. In the 1990s salmon stocks declined. Fisheries managers believed the decline was partly caused by seal predation and consequently increased shooting effort. In years 1993–2003 Moray Firth harbour seal numbers declined possibly due to shooting, posing a potential threat to the status of the Dornoch Firth SAC. Meanwhile wildlife tourism based on marine mammals has increased. The declines in salmon and harbour seals, and the implementation of the Habitats Directive forced a watershed in the approach of statutory authorities to managing seals, salmon and tourism.

3. In years 2002–2005 local District Salmon Fishery Boards, the Scottish Executive, Scottish Natural Heritage and stakeholders negotiated a pilot Moray Firth Seal Management Plan to restore the favourable conservation status of seal and salmon SACs, and to reduce shooting of harbour seals and seal predation on salmon.

4. Key facets of the plan are the management of the Moray Firth region under a CoSA Conservation Order; application of the Potential Biological Removal concept to identify a limit of seals to be killed; management areas where removal of seals is targeted to protect salmon, while avoiding seal pupping and tourism sites;

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a training and reporting system for marksmen; a research programme, and a framework allowing an annual review of the plan.

5. The plan was introduced in April 2005. A maximum limit of 60 harbour and 70 grey seals was set. Forty-six harbour and 33 grey seals were killed in 2005 while in 2006 these figures were 16 and 42 respectively. Although the numbers killed were below the maximum limits in both years the returns raised questions about the plan's ability to manage seal shooting at netting stations. The plan provides a useful adaptive co-management framework for balancing seal and salmon conservation with the protection of fisheries and/or fish farms and tourism for application in the UK and internationally.

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INTRODUCTION

Interactions between protected marine mammals and fisheries are often controversial, complex and difficult to resolve (Harwood and Croxall, 1988; Yodzis, 2001). In the UK there is a long history of conflict between harbour (*Phoca vitulina* L.) and grey (*Halichoerus grypus* Fabricius) seals and Atlantic salmon (*Salmo salar* L.) fisheries. Seals attack coastal nets (Rae, 1960, 1962, 1968; Lockie, 1962; Shearer, 1962; Rae and Shearer, 1965; Parrish and Shearer, 1977; Pierce *et al.*, 1991a) and salmon farms (Quick *et al.*, 2004), and prey on migrating juvenile and adult salmon in rivers and estuaries (Rae, 1960, 1968; Williamson, 1988; Pierce *et al.*, 1991b; Carter *et al.*, 2001; Middlemas *et al.*, 2003, 2006; NERC, 2004). During the late 20th century tension intensified owing to the growth of the grey seal population and declining salmon abundance (Scottish Office, Agriculture, 1997; Middlemas *et al.*, 2003). The recent establishment of wildlife tourism based on marine mammals has also increased interest in seal conservation (Young, 1998).

Seal impacts on salmon fisheries are managed under the UK's Conservation of Seals Act 1970 (CoSA), whereby seals can be shot to protect fisheries by any person with a suitable firearm and a police endorsement on their firearms certificate (Bonner, 1989; Scottish Office, Agriculture, 1997). CoSA restricts shooting during pupping periods, with close seasons extending from 1 June–31 August for harbour seals, and 1 September–31 December for grey seals. CoSA also enables government to impose Conservation Orders which extend close seasons throughout the year. In Scotland, District Salmon Fishery Boards (DSFBs) are the statutory bodies responsible for the management of salmon fisheries. Under CoSA they may shoot seals outside close seasons, and can apply to the Scottish Executive for a licence to shoot during close seasons or Conservation Orders. Salmon netmen can shoot seals 'in the vicinity of nets' at any time, and neither close season nor Conservation Order restrictions apply. With

the exception of shooting under licence, CoSA does not require the submission of records of seals shot to the Executive.

In 1992 the UK government adopted the EU 'Habitats Directive' (Council Directive 92.43/EEC), which aims to secure the favourable conservation status of listed species of European importance (Annex II) through the designation of Special Areas of Conservation (SACs) (Scottish Executive, 2000). The objectives of SACs are to avoid deterioration of the habitats of qualifying species or significant disturbance to those species, ensuring that the integrity of the site is maintained and that it achieves favourable conservation status of the qualifying features. The Directive also requires that 'relevant authorities' must carry out appropriate assessments of their activities to protect SACs (Scottish Executive, 2000). Atlantic salmon (in freshwater), harbour and grey seals are listed in Annex II of the Directive. In Scotland the Scottish Executive, its nature conservation agency Scottish Natural Heritage (SNH) and DSFBs are relevant authorities, and therefore have a statutory responsibility to safeguard the conservation interests of seal and salmon SACs (SNH, 1995), while DSFBs must also protect and enhance salmon fisheries.

Consequently the management of conflict between seals and salmon fisheries has been further complicated in the 1990s. The new challenge is that:

- Salmon fisheries still regard seals as a cause of stock declines, and legally shoot them under CoSA. However, marine wildlife tourism is growing, and promotes the conservation of seals.
- The shooting of seals to protect fisheries may impinge upon the objectives of seal SACs by disturbing seals and causing population declines.
- The lack of comprehensive recording of seals shot precludes the reliable assessment of anthropogenic impacts on seal SACs.

- Seal predation of salmon may impinge upon the objectives of salmon SACs.

This paper presents a case study in the Moray Firth, north-east Scotland, where there has been ongoing conflict between seals and salmon fisheries. In 1999 and 2000 adjacent SACs were established for salmon and harbour seals, forcing a reassessment of established approaches by DSFBs, SNH and the Executive to seal and salmon management. In 2005 a watershed was reached with the launch of the Moray Firth Seal Management Plan. Based on an adaptive co-management framework which integrates relevant authorities, stakeholders and scientific research, the plan aims to balance seal conservation with the protection of fisheries and tourism within the context of CoSA and the Habitats Directive. The process of developing the plan, and lessons learned in its first two years of operation are described.

BACKGROUND

The Moray Firth

The Moray Firth (58°N, 3°W) is a large embayment in north-east Scotland covering approximately 5230 km². The Inner Moray Firth is characterized by an indented coastline including the Dornoch Firth (Figure 1).

Atlantic salmon stocks and fisheries

Eighteen major rivers run into the Moray Firth, from the River Wick in the north to the River Deveron in the south-east, and are managed by 12 DSFBs. In 1999 Atlantic salmon were identified as a qualifying interest in six SACs for the Spey, Moriston, Oykel, Cassley, Langwell and Berriedale (Figure 1).

DSFBs enforce salmon fishing seasons set within their jurisdictions. Seasons for freshwater rod fisheries run from January/February to September/October and from February to August for coastal netting stations. Since 1999 netting stations have delayed starting fishing until June to help conserve depleted spring-running sub-stocks (see below). There are rod fisheries in all Moray Firth rivers, plus 20 active netting stations, and three seabed leases for salmon farms (Figure 1) which have been inactive since 2002.

In the Moray Firth rod catches of adult salmon provide a reliable index of their in-river abundance (Thorley *et al.*, 2005). Combining long-term total rod and net catch data for Moray Firth rivers, estimates of pre-fishery abundance of salmon have been made (Butler, 2004). During the period 1952–2003 abundance has ranged from ~142 000 to ~350 000 (Figure 2). Abundance has declined since the mid-1980s, and the five lowest estimates have occurred since 1990. A similar pattern has been observed throughout Scotland, driven by a general decrease in survival during the marine

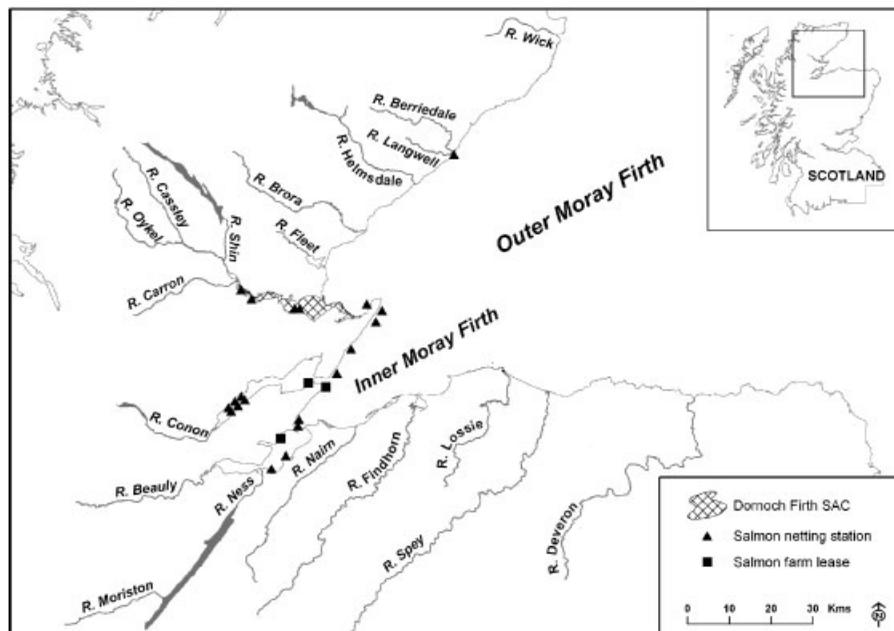


Figure 1. The Moray Firth, showing the 18 salmon rivers including the Spey, Moriston, Oykel, Cassley, Langwell and Berriedale SACs, active salmon netting stations and the Dornoch Firth SAC.

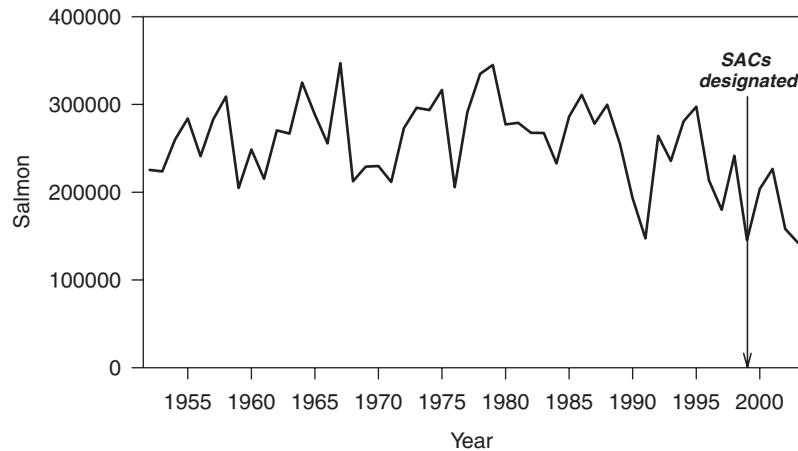


Figure 2. Estimated pre-fishery abundance of wild adult salmon returning to the Moray Firth, 1952–2003, relative to the designation of SACs for the Rivers Spey, Moriston, Oykel, Cassley, Langwell and Berriedale in 1999.

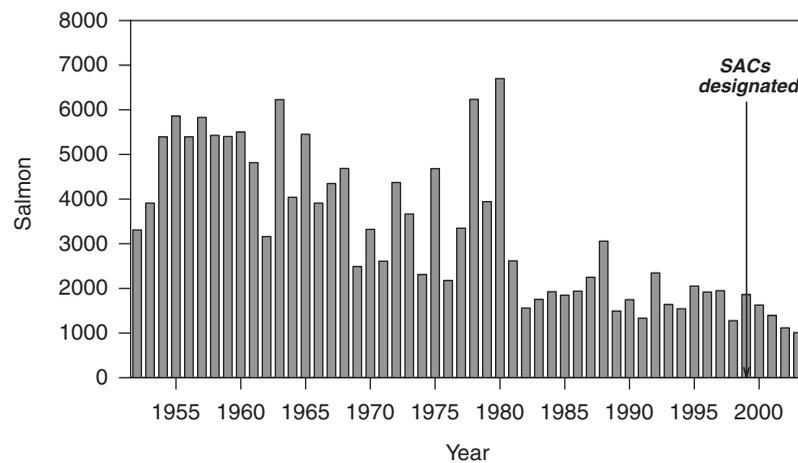


Figure 3. Annual declared rod catch of wild spring-running salmon (January–April) for Fishery Districts in the Moray Firth (Wick–Deveron), 1952–2003, relative to the designation of SACs for the Rivers Spey, Moriston, Oykel, Cassley, Langwell and Berriedale in 1999.

phase of the salmon's lifecycle (Friedland *et al.*, 2000; Youngson *et al.*, 2002; ICES, 2003; Boisclair, 2004; Jonsson and Jonsson, 2004).

Salmon populations are genetically structured into sub-stocks within catchments (Jordan *et al.*, 1997), and structuring is exhibited by adult run-timing into rivers (Stewart *et al.*, 2002; Youngson *et al.*, 2003). While there has been a decline in Moray Firth stocks generally since the mid-1980s, rod catches indicate that spring-running sub-stocks have declined most markedly, with an 83% reduction between 1955 and 2003 (Figure 3). Adult fish counts in the Cassley and Moriston SACs show that spring salmon spawning escapement in years

1997–2003 has only attained local DSFBs' conservation targets in 71% and 33% of years, respectively (Butler, 2004). Hence SACs have been introduced on Moray Firth rivers during a period of declining salmon abundance, and when spring sub-stocks are failing conservation targets in some years.

Harbour seal populations

In the period 1992–2006 the Sea Mammal Research Unit (SMRU) carried out eight aerial surveys of Moray Firth coastal haul-out sites between the mouths of the Rivers Findhorn and Berriedale during the August moult. In years

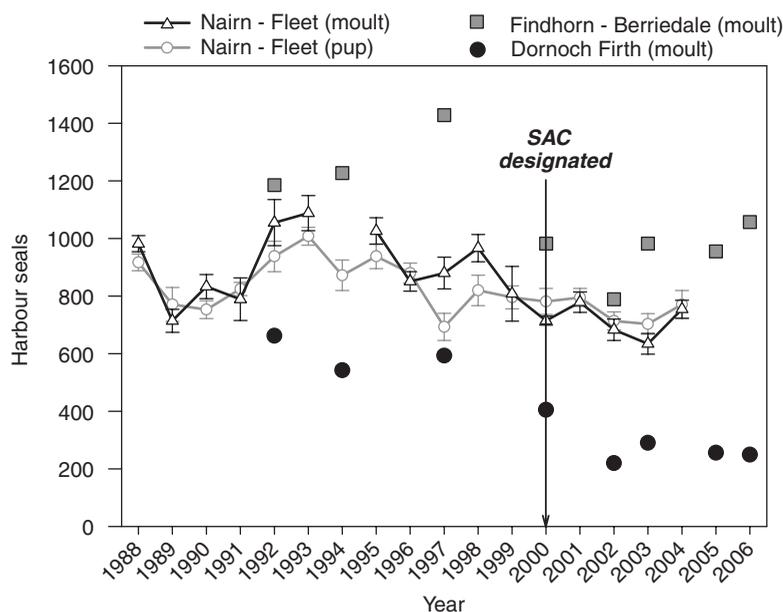


Figure 4. Pup and moult season counts (\pm SE) of harbour seals in the Moray Firth, 1988–2006, carried out by the University of Aberdeen (lines) and SMRU (symbols), relative to the designation of the Dornoch Firth SAC in 2000.

1992–1997 SMRU counted between 1200 and 1400 harbour seals (Figure 4). Based on these data, SNH proposed harbour seals as a qualifying interest in the Dornoch Firth SAC in 2000 because it supported 40–50% of the total Moray Firth population (Figure 4), and almost 2% of the total UK population.

Since 1988 the University of Aberdeen has also undertaken annual censuses of harbour seals using shore-based counts at haul-out sites between the mouths of the Rivers Nairn and Fleet during the pupping and moult seasons (Thompson *et al.*, 1997), accounting for 69–79% of the total Moray Firth population (Thompson *et al.*, 2007). Following a decline in seal numbers after a Phocine Distemper Virus (PDV) outbreak in 1988, counts increased to a peak of \sim 1100 in 1993.

However, all censuses showed a decline from the mid-1990s, with lowest counts recorded in 2002/2003. SMRU aerial counts showed a 57% decline in the Dornoch Firth SAC, from \sim 690 animals in 1992 to \sim 200 in 2002 (Figure 4).

In response to falling salmon abundance, Moray Firth DSFBs, netmen and salmon farmers increased shooting effort to protect stocks, and their records show that during period 1994–2002 up to 425 seals were shot annually (Figure 5). In years 1998–2002 shooting further intensified when DSFBs introduced a bounty scheme to provide an incentive for netmen to shoot more seals, often outside the CoSA limits of the 'vicinity' of their nets. Thompson *et al.* (2007) estimated that the maximum number of harbour seals shot annually

ranged between 161 and 327, and concluded that shooting at this scale could have caused the population decline observed between 1993 and 2003.

In 2002 there was a second PDV outbreak in European harbour seals, which prompted the Executive to introduce a precautionary national Conservation Order for this species for the period September 2002 — September 2004. While no reference level had been set, in the Executive's view the decline in the number of seals in the Moray Firth, and Dornoch Firth in particular (Figure 4), and the increased level of shooting in years 1998–2002 (Figure 5) represented a potential threat to the integrity of the Dornoch Firth SAC. It therefore introduced a second Conservation Order in September 2004 specifically for the Moray Firth, and included grey seals to reduce the risk of harbour seals being mistakenly shot as greys.

Grey seal populations

The UK grey seal population in 2003 was estimated by SMRU to be approximately 113 000, of which 103 000 (91%) were associated with Scottish breeding sites. Pup production has been increasing since the 1980s, with current annual rates of increase of 1–3% (NERC, 2004). Grey seals are known to range over larger distances than harbour seals, and therefore animals in the Moray Firth represent part of a wider North Sea population (Thompson *et al.*, 1996; NERC, 2004). This population was estimated to number approximately 11 700 in

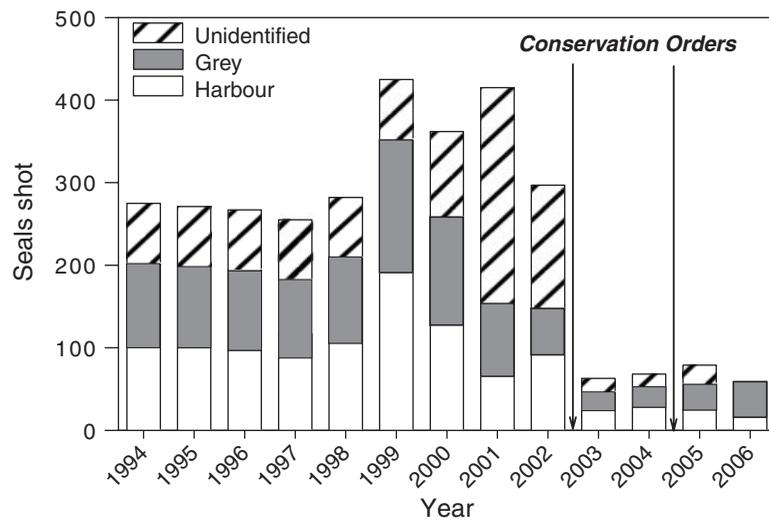


Figure 5. Numbers of seals recorded shot by DSFBs, netting stations and salmon farms in the Moray Firth, 1994–2006, relative to the introduction of Conservation Orders in September 2002 and 2004.

2003, and numbers counted by SMRU aerial surveys in the Moray Firth have ranged from 200 to 900 during the period 1992–2003. Grey seals breed on rocky shores along the coast of the Moray Firth north from the River Helmsdale.

Economic value of salmon fisheries and marine wildlife tourism

In 2003 expenditure by salmon anglers generated £11.8 million and supported 367 full-time equivalent jobs in the River Spey catchment (Riddington *et al.*, 2004). Extrapolation of these results to all Moray Firth rivers indicates that angling generated approximately £28.8 million in the area in 2003 (Butler, 2004). No data are available on the current value of salmon netting in the Moray Firth.

Marine wildlife watching is a growing sector of the Scottish tourist economy, and represents an important source of environmentally sustainable revenue for rural areas (Young, 1998; Parsons *et al.*, 2003). In 1998 wildlife tourism in the Moray Firth based on bottlenose dolphins (*Tursiops truncatus* Montagu) and other marine mammals, including seals, generated £2.34 million (Hoyt, 2001). In 2004 there were nine registered boat operators and two land-based centres in the Moray Firth.

Historical salmon and seal management

Traditionally, management of seals in the Moray Firth has been undertaken independently by each of the 12 DSFBs within their local jurisdictions. Applications under CoSA for

licences were not coordinated among DSFBs, and licences were issued by the Executive without formal consideration of regional salmon, seal or tourism management issues. Outside close seasons or Conservation Orders there was no obligation for DSFBs to keep or submit any information on seals shot, and no requirement for netting stations at any time, including seals killed as by-catch. Consequently it was difficult to assess the impact of shooting on local seal populations. Seals were shot indiscriminately, particularly in years 1998–2002 when the bounty scheme encouraged netsmen to intensify shooting, and there was no strategy to target only individual ‘problem’ seals around netting stations or in rivers (Table 1).

The Moray Firth Partnership, an integrated coastal zone management group, was established in 1999 (Moray Firth Partnership, 2001), and provided an opportunity for coordination between tourism, fisheries and other local stakeholders. However, engagement with DSFBs was limited. Although research aimed at understanding the interactions of seals and salmonids had been undertaken in the Moray Firth (Pierce *et al.*, 1991a; Middlemas *et al.*, 2006), this was not targeted at the management of these interactions.

MORAY FIRTH SEAL MANAGEMENT PLAN

The watershed

The introduction of the 2002 Conservation Order by the Scottish Executive marked a turning point in the approach of

Table 1. Summary of the management of seals and salmon in the Moray Firth before and after the introduction of the Moray Firth Seal Management Plan in 2005

Issue	Pre-2005	Moray Firth Seal Management Plan
1. Management coordination	Individual DSFBs and salmon netting stations	12 DSFBs and 20 netting stations coordinated
2. Seal management area	Individual DSFBs and salmon netting stations	Moray Firth for harbour seals, North Sea for grey seals
3. Official shooting records	Only data from DSFBs shooting under licence	Data from all DSFBs and netting stations
4. By-catch reporting	None	Reported by netting stations
5. Assessment of impact on seals	None	Possible from DSFB and netting station shooting and by-catch data
6. Shooting zones	Restricted for DSFBs under licence to local jurisdictions. Netting stations shooting indiscriminately within and outside vicinity of nets	Management Areas targeting 'problem' seals in rivers, avoiding pupping sites and tourism interests; netting stations shooting only in vicinity of nets
7. Shooting of harbour seals	High: largely unrestricted	Reduced: limited by Potential Biological Removal, and legally controlled by Conservation Order
8. Marksmen training	None	Training course completion a condition of licence
9. Coordination with local stakeholders	None	Engagement through Moray Firth Partnership
10. Coordination with national stakeholders	None	Coordination through Seals Working Group
11. Integration of science and management	Limited	Potential Biological Removal applied for seals; conservation targets for spring salmon sub-stocks; Seal and Salmon Research Programme

government, DSFBs and stakeholders in the Moray Firth to seal and salmon management. The main drivers for change were:

- Declining numbers of harbour seals, possibly caused by shooting.
- Long-term decline of spring salmon sub-stocks, and salmon stocks generally.
- Recognition by relevant authorities of their obligations under the Habitats Directive for local seal and salmon SACs, and the need to balance the objectives of CoSA with those of the Habitats Directive.
- Recognition of the local economic importance of salmon fisheries and growth of marine wildlife tourism.
- Emergence of the Moray Firth Partnership as a stakeholder forum for local coastal zone issues, including seal and salmon management.
- The need to integrate research on seal–salmon interactions, and to apply results to facilitate conflict resolution.

Beginning in 2002, Moray Firth DSFBs agreed to collaborate together to meet their common responsibilities as relevant authorities. Negotiations began with the Executive and SNH to plan a new approach to managing seals and salmon, and interactions between them. Engagement with the wildlife tourism industry, local communities and other fisheries sectors was achieved through the DSFBs' increased involvement in the Moray Firth Partnership. During this process the following key steps were taken: the setting of

mutually agreed goals, transfer of information (e.g. DSFBs' seal shooting records), and the development of trust between the parties.

Goals

Five goals were identified for the plan:

1. Restore and maintain the favourable conservation status of harbour seals in the Dornoch Firth SAC, and salmon in the Spey, Moriston, Oykel, Cassley, Berriedale and Langwell SACs.
2. Reduce the impact of shooting by salmon fisheries on the harbour seal population.
3. Reduce the impact of harbour and grey seal predation on depleted spring salmon sub-stocks.
4. Monitor and research the status of harbour and grey seal populations, salmon stocks and interactions between them.
5. Develop and implement non-lethal methods of reducing seal–salmon interactions.

In order to achieve these, an adaptive framework was agreed (Figure 6). The Moray Firth Seal Management Plan was launched in April 2005 with the following key facets:

1. Moray Firth Seal Conservation Order 2004

While the Dornoch Firth SAC creates an obvious management area for harbour seals, individuals are known to move between

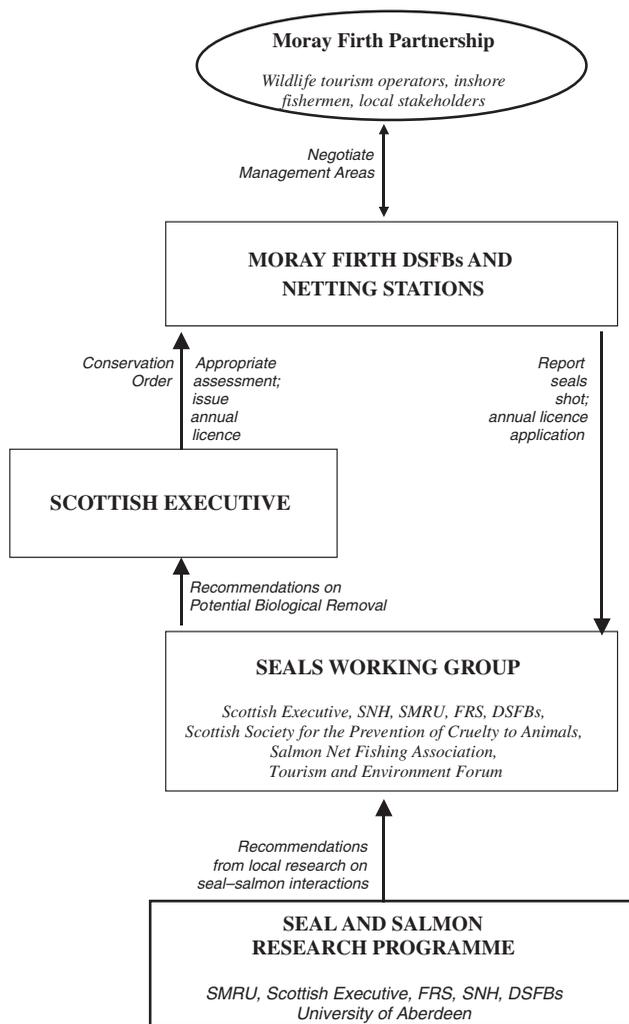


Figure 6. The adaptive co-management framework established for the Moray Firth Seal Management Plan, and stakeholder organisations involved.

haul-out sites throughout the Moray Firth (Thompson *et al.*, 1996; SMRU unpublished data). Although information on the population structure of harbour seals in Scotland is not available, Moray Firth seals are geographically isolated from the nearest large concentrations in Orkney to the north and the Firth of Tay to the south (NERC, 2004). Therefore it was decided to manage harbour seals in the Moray Firth as one discreet population unit, while grey seals were regarded as part of the North Sea population. The Conservation Order of September 2004 was used as the legal basis for the plan, since it covered the entire Moray Firth and thus the assumed discreet population unit for harbour seals. Under the Order, DSFBs

apply annually for a single joint licence to shoot a specified number of each species for the protection of salmon fisheries.

2. Potential Biological Removal of harbour seals

On receipt of the licence application, the Scottish Executive conducts an appropriate assessment to determine whether the proposed level of shooting will have a detrimental impact on the favourable conservation status of the Dornoch Firth SAC, as required by the Habitats Directive. In consultation with its advisers (SNH, SMRU and Fisheries Research Services (FRS)) the Potential Biological Removal (PBR) method (Wade, 1998) is used to estimate the number of harbour seals that can be removed without causing a population decline, based on knowledge of the size and maximum rate of increase for the Moray Firth population:

$$PBR = N_{\text{MIN}} * R_{\text{MAX}} * RF/2$$

where N_{MIN} is the minimum population estimate, R_{MAX} is the maximum rate of increase of the population, and RF is a recovery factor set to 1.

The 2003 SMRU aerial survey was used to produce a minimum population estimate for harbour seals in the Moray Firth of 1,512; from this the PBR for 2005 was calculated to be 76 animals, based on an R_{MAX} of 0.10.

A licence was issued for DSFBs to shoot 50 harbour seals during the period April–December 2005. The level was set below the PBR because salmon netting stations do not require a licence, and with 10 harbour seals estimated to be shot by them, this gave a total predicted removal of 60 animals, thus leaving a safety margin of 16 to allow for any extra shot by netmen or unforeseen circumstances (Table 2). A PBR was not set for grey seals, since exploitation is not likely to affect the population's status in the North Sea area (NERC, 2004). The Executive licensed 60 grey seals to be shot by DSFBs during April–December 2005, plus 10 anticipated to be shot by netting stations (Table 2).

In November 2005 the DSFBs applied for the same removal of animals during January–December 2006. The Executive issued a licence in January 2006 for the same numbers of seals granted in 2005. The harbour seal PBR was maintained at 76.

3. Management areas

In the absence of scientific data to prove otherwise, it was assumed that seals present in rivers and river mouths are most likely to be preying on salmon. Management Areas were established to cover these zones to allow the targeting of such 'problem' animals. These were also delineated to avoid known harbour and grey seal pupping sites to minimize potential disturbance of breeding animals. For example, the Dornoch Firth Management Area is restricted to the freshwater reaches

Table 2. Details of the licence to shoot harbour and grey seals issued by the Scottish Executive to Moray Firth DSFBs for the periods April–December 2005 and January–December 2006, and numbers anticipated to be shot by salmon netting stations. For DSFBs the numbers ‘permitted’ are the maximum limits stipulated by the annual licence. Numbers reported shot in each reporting period are given, plus by-catch mortalities in salmon nets. Under the terms of the plan unidentified seals were counted as harbour seals and the number of unidentified seals is given in brackets in the harbour seal column

	Harbour seals			Grey seals		
	Permitted	Reported 2005	Reported 2006	Permitted	Reported 2005	Reported 2006
(a) DSFBs						
Caithness	0	0	0	13	0	0
Helmsdale	0	0	0	12	8	7
Brora	4	0	0	3	0	0
Kyle of Sutherland	9	0	1	5	0	0
Conon	7	0	0	3	0	0
Beaully	7	2	1	2	0	0
Ness	5	4 (1)	0	5	0	0
Nairn	1	0	0	1	0	0
Findhorn	7	7	4	2	2	1
Lossie	2	0	0	3	0	0
Spey	5	1	5	5	3	4
Deveron	3	1	1	6	1	3
Sub-total	50	15 (1)	12	60	14	15
(b) Netting stations	10	29 (21)	4(1)	10	18	27
By-catch	0	2	0	0	1	0
Sub-total	10	31 (21)	4(1)	10	19	27
Total	60	46 (22)	16(1)	70	33	42

and mouths of the River Oykel and Cassley SACs, and the Rivers Shin and Carron, and does not overlap the Dornoch Firth SAC and pupping sites within it (Figure 7). Delineation of Management Areas was also agreed with local tourism interests via the Moray Firth Partnership. Salmon netting stations only shoot seals within the vicinity of their nets, as permitted under CoSA.

The Scottish Executive licence for DSFBs stipulates a maximum permitted limit of seals to be shot in each Management Area, based on the numbers requested by each DSFB in the joint application (Table 2). As a condition of the licence, numbers may not be transferred between Management Areas.

4. Training nominated marksmen and reporting

Under CoSA only persons with a suitable firearm and an endorsement from local police on their firearms certificate may shoot seals. DSFBs and netting stations assigned 25 nominated marksmen with endorsed firearms certificates to be responsible for shooting. A training course was designed by the Executive, DSFBs, SMRU and police; nominated marksmen must complete the course as a condition of the licence. Modules cover legal issues, the terms of the plan, firearms safety, public

relations, seal biology, species identification and animal welfare.

Marksmen are also required to identify and record the species, date and location of seals shot, and return these data to the Executive via DSFBs. Although there is no legal requirement for marksmen at netting stations to do the same, under the plan these data are supplied voluntarily, including by-catch of animals entrapped in nets. To improve species identification and to contribute to the Seal and Salmon Research Programme (see below) carcasses are retrieved wherever possible. As a precautionary measure all seals reported as unidentified are recorded as harbour seals.

5. Monitoring and the Seal and Salmon Research Programme

SMRU has continued aerial censuses of harbour and grey seal populations. DSFBs continue to monitor salmon stocks using fish counters and catches. In 2005, SMRU began a Seal and Salmon Research Programme partly funded by the Executive and SNH, and in collaboration with FRS, DSFBs and the University of Aberdeen. The principal aims are to investigate:

- the use of non-lethal acoustic deterrent devices to exclude seals from rivers;

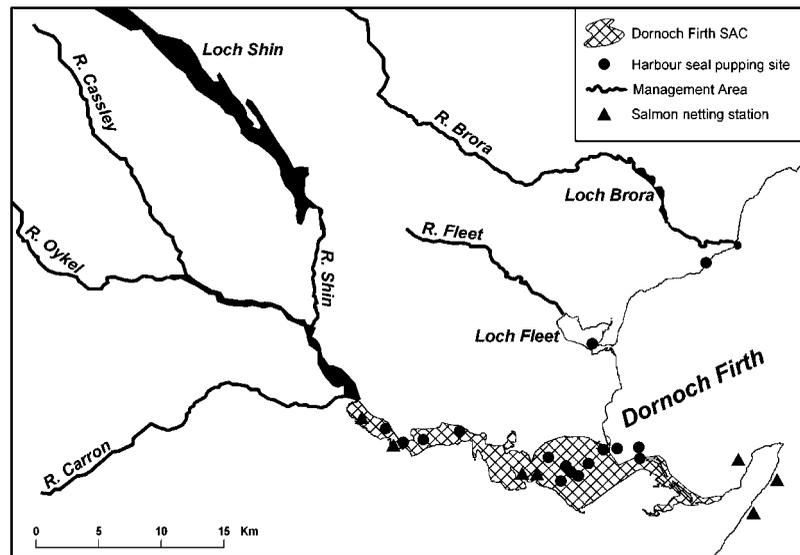


Figure 7. Management Areas for the Rivers Carron, Oykel, Cassley, Shin, Fleet and Brora relative to the Dornoch Firth SAC, harbour seal pupping sites and active salmon netting stations.

- patterns of seals' use of rivers;
- the impact of seal predation on salmon stocks.

The results of this research and monitoring are integrated within the adaptive framework to inform future revisions and modifications of the plan (Figure 6), including the basis for Management Areas.

6. Adaptive framework

The plan is set within an adaptive framework, whereby progress is measured annually through the process of the DSFBs' joint licence application under the Conservation Order, and the Executive's appropriate assessment under the Habitats Directive. The plan is reviewed by the Seals Working Group, a consultative forum established by the Executive including representation from SMRU, SNH, FRS, DSFBs and national stakeholders such as the Scottish Society for the Prevention of Cruelty to Animals (Figure 6). The group considers the results of seal and salmon population monitoring, the Seal and Salmon Research Programme, and other relevant data. Information from the group, together with formal consultation with their advisers, is used by the Executive to form the basis for their decision to issue the annual licence, and the number of seals permitted to be shot. The framework includes consultation with local stakeholders via the Moray Firth Partnership, and the wildlife tourism industry in particular.

DISCUSSION

The Moray Firth Seal Management Plan represents the first attempt in the UK to balance the potentially conflicting objectives of SACs for seals and salmon, fisheries and wildlife tourism. Although its development has involved statutory and non-government stakeholders particular to Scotland and the Moray Firth, the principles behind the application of CoSA and the adaptive framework could be transferable to similar situations in other parts of the UK. For example, conflict between seals and fisheries occurs in the Firth of Clyde (Moore, 2003), the Orkney Islands (Thompson *et al.*, 2001) and between seals and salmon farmers on the Scottish west coast (Quick *et al.*, 2004). Internationally this model may also be applicable to unresolved marine mammal conservation problems, for example fisheries conflict with the endangered saimaa ringed seal (*Phoca hispida saimensis*) in the Baltic Sea (Tonder and Salmi, 2004) and over-harvesting of dugong by indigenous people in the Torres Strait, northern Australia (Heinsohn *et al.*, 2004; Marsh *et al.*, 2004). It also has relevance for managing protected fish-eating birds which impact upon fisheries (Marquiss *et al.*, 1998; Cosgrove *et al.*, 2004).

The first two years of the plan's operation provides useful lessons for refinement of the model. In 2005 a total of 46 'harbour' seals were killed (including 22 unidentified) while in 2006 this figure was 16 (including one unidentified) (Table 2; Figure 5). In both years the removals of harbour seals were less than the permitted maximum limit of 60. However, there were

differences between DSFBs and netting stations: in both years DSFBs killed substantially less than the maximum of 50, with no DSFB exceeding their permitted limit. Netting stations exceeded the anticipated level of 10 harbour seals in 2005 (reporting 31 animals killed), but not in 2006. A similar pattern exists for grey seals with DSFBs falling well within their licence levels while netting stations exceeded their expected levels in both years (Table 2).

This raises questions about the plan's ability to manage seal shooting at netting stations. Under CoSA netmen may shoot seals in the vicinity of their nets, and do not require a licence. The imposition of a Conservation Order does not alter this situation, and hence it is not possible to set statutory limits on the numbers of seals killed by them. One approach is to anticipate larger numbers of seals to be killed at nets, and to compensate by setting the permitted limit remaining for DSFBs at a lower level. Predicting the numbers of seals that will be shot by netting stations during a season is difficult as the actual number is likely to be highly variable. This is illustrated by the returns in 2005, where a total of 50 seals were shot at netting stations, and 2006 where this figure had dropped to 31. It would also be possible to use a more precautionary calculation for the harbour seal PBR, reducing the recovery factor to <1 , as recommended for situations with large levels of uncertainty (Wade, 1998). In effect this approach was taken in 2005 and 2006, when the estimated PBR was 76, but the Executive assumed a target of only 60. Another approach may be to establish voluntary limits by netmen, and if necessary this can be explored in future iterations of the plan.

Another issue is the difficulty of identifying seals killed. Over the two years, one (2%) out of a total of 56 seals shot by DSFBs was unidentified. However, of the 81 killed by netting stations, 22 (27%) were unidentified (Table 2). The improvement in species identification in 2006 compared to 2005 (1/58 versus 22/79 unidentified) is likely to be due to the impact of the training received by the nominated marksmen. It was not possible to train all of the nominated marksmen for the start of the 2005 licence period, and the final training workshop was held in early 2006. The apparent decrease in the number of harbour seals shot from 46 in 2005 to 16 in 2006 can partly explain the decrease in returns of unidentified seals (Figure 5). It was suggested by marksmen that differences in the ability of DSFBs and netting station marksmen to identify seals were attributable to the nature of shooting conditions. Seals shot within the more sheltered river environment of Management Areas were easier to initially identify in the water, whereas at netting stations sea conditions often impaired visibility. Relying on carcass retrieval to positively identify seals also proved unsuccessful due to the tendency of shot animals to sink immediately. Only 10 (12%) of 81 killed at netting stations were retrieved, and three (5%) of 56 shot within Management Areas.

Until this situation can be improved the plan should maintain the precautionary approach and assume that unidentified animals are harbour seals.

Despite these problems, the new reporting system improves the Seals Working Group's ability to monitor anthropogenic impacts on local seal populations. Before 2005 shooting records were informal and unreliable, complicating the interpretation of harbour seal declines in the Moray Firth (Thompson *et al.*, 2007). The system also allows the collation of mortality from by-catch in salmon net fisheries, which had previously not been available. In 2005 three seals were killed by entrapment in nets (Table 2). In addition, the submission of detailed temporal data enables analysis of potential impacts on seal populations through the year. In 2005 and 2006 the majority of harbour seals were killed during June and July (Figure 8), reflecting the salmon netting season and to a lesser extent periods of high seal abundance during the angling season in some rivers (Middlemas *et al.*, 2006). This has potential implications for management of the Dornoch Firth SAC, and the population as a whole, since this is the harbour seal pupping season (Thompson *et al.*, 1997). It is feasible that

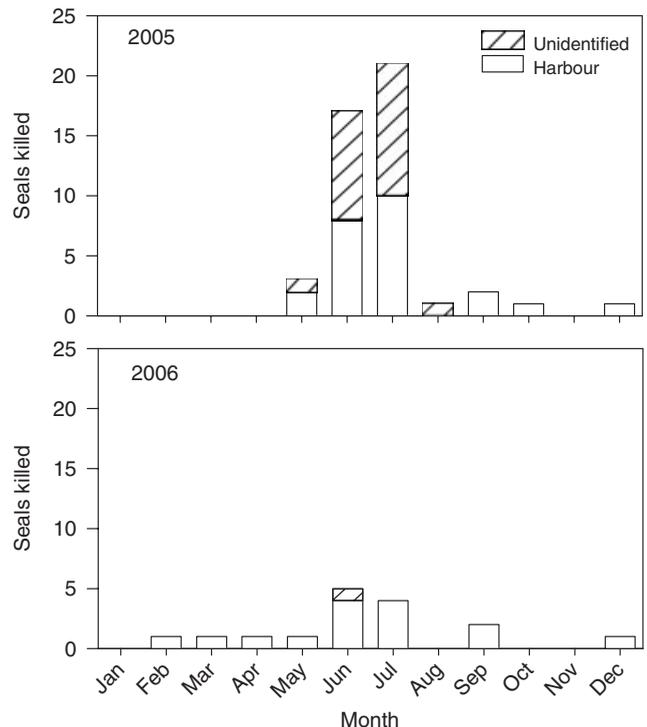


Figure 8. Monthly numbers of harbour and unidentified seals reported killed under the Moray Firth Seal Management Plan in April–December 2005 and January–December 2006. Numbers include by-catch.

adult females with dependent young have been shot, which may imply significant disturbance as defined by the Habitats Directive. This could be of particular concern for the Dornoch Firth, where seven netting stations are active in or adjacent to the SAC (Figure 7), although no seals were shot within the SAC in 2005 or 2006.

While the benefits of the plan are already clear in terms of reducing and monitoring the impact of salmon fisheries on harbour seals and the Dornoch Firth SAC, they are not immediately obvious for salmon populations in the Spey, Moriston, Oykel, Cassley, Berriedale and Langwell SACs, or salmon fisheries generally. Improvement in the salmon population, and fishery, will have an associated time lag while natural fluctuations in salmon mortality caused by other factors may mask any reduction in predation by seals (Middlemas *et al.*, 2003). Work undertaken by the Research Programme has shown that the greatest seasonal impact of seal predation is likely to be on spring sub-stocks, and efforts to reduce predation should therefore be focused on January–May (Butler *et al.*, 2006). Although most seals were shot during June and July (Figure 8) this was primarily due to the influence of netting stations. In contrast, the numbers of seals of both species shot by DSFBs were more evenly spread throughout the year.

In the first two years of the plan greatest progress was made towards achieving the second of the plan's goals, namely to reduce the impact of shooting on the harbour seal population. This maintains the reductions initiated in 2002 with the introduction of the first Conservation Order (Figure 5), which may have contributed to the stabilization of seal numbers from 2004 onwards (Figure 4). However, it is too early to assess progress towards achieving the goal of reducing impacts of seal predation on spring salmon sub-stocks and salmon SACs. Equally, the testing of acoustic deterrent devices as part of the Research Programme to simultaneously minimize seal predation and further reduce numbers shot is at an early stage. Having clarified patterns of seals' use of rivers and their impact on salmon stocks, these research results will also be incorporated into the plan.

The main achievement has been to demonstrate the process and framework required to resolve a complex and entrenched social–ecological problem surrounding conflict between marine mammal conservation and fisheries. Holling and Gunderson (2002) describe such re-organizations of natural resource management policy in terms of adaptive cycles. In this case, the declines in harbour seals and salmon, and the designation of SACs triggered a watershed in the long-established management system, and forced the negotiation of a plan between statutory bodies and local stakeholders within the legal structures of the Habitats Directive and CoSA. The resulting plan and framework is an example of adaptive co-management, whereby institutional arrangements and

ecological knowledge are tested and revised in an iterative, dynamic process of learning-by-doing (Folke *et al.*, 2002; Ashby, 2003). Such integration of scientific knowledge with participatory planning has been recommended for biodiversity conservation (Buck *et al.*, 2001), and is successfully applied in protected area management elsewhere (Biggs and Rogers, 2003; Borrini-Feyerabend *et al.*, 2004). As demonstrated in the Moray Firth, key steps include collective goal-setting, transfer of information, and the establishment of trust between previously disparate parties.

If the problems of shooting by netting stations can be overcome, and numbers shot or by-caught maintained within the annual PBR, Thompson *et al.* (2007) predict that if no other extrinsic factors constrain growth the harbour seal population may recover to 1993 levels within 10 years, and the conservation status of the Dornoch Firth SAC could be restored. However, there is evidence of a general decline in most of the large harbour seal colonies around Britain (Loneragan *et al.*, 2007). The widespread nature of this decline suggests that a larger scale process may also be driving the observed trends, and the Executive has responded by issuing Conservation Orders for the affected areas. In this situation local anthropogenic factors, such as shooting, need more stringent regulation to provide greater protection to a potentially compromised seal population, while still balancing the needs of other interest groups. The development of the plan provides a useful model for managing conflicts between marine mammals, fisheries and wildlife tourism internationally, and particularly in the UK where seal SACs require coordination with CoSA and fisheries legislation. In a Scottish context the plan has achieved 11 major changes to the traditional approach of managing seal–salmon interactions (Table 1) which could be replicated elsewhere.

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REFERENCES

- Ashby J. 2003. Introduction: uniting science and participation in the process of innovation — research for development. In *Managing Natural Resources for Sustainable Livelihoods*, Pound B, Snapp S, McDougall C, Braun A (eds). Earthscan Publications: London; 1–19.
- Biggs HC, Rogers KH. 2003. An adaptive system to link science, monitoring and management in practice. In *The Kruger Experience: Ecology and Management of Savanna Heterogeneity*, du Toit JT, Rogers KH, Biggs HC (eds). Island Press: Washington; 59–80.
- Boisclair D. 2004. The status of Atlantic salmon (*Salmo salar*) populations and habitat. *Canadian Journal of Fisheries and Aquatic Sciences* **61**: 2267–2270.
- Bonner WN. 1989. Seals and man — a changing relationship. *Biological Journal of the Linnean Society of London* **38**: 53–60.
- Borrini-Feyerabend G, Kothari A, Oviedo G. 2004. *Indigenous and Local Communities and Protected Areas: Towards Equity and Enhanced Conservation*. IUCN The World Conservation Union. World Commission on Protected Areas Best Practice Protected Area Guidelines Series No. 11. IUCN: Gland.
- Buck LE, Geisler CC, Schelhas J, Wollenberg E. 2001. *Biological Diversity Balancing Interests through Adaptive Collaborative Management*. CRC Press: Boca Raton, Florida.
- Butler JRA. 2004. *Moray Firth Seal Management Plan; a Pilot Project for Managing Interactions Between Seals and Salmon in Scotland*. Spey Fishery Board: Aberlour, Moray-shire.
- Butler JRA, Middlemas SJ, Graham IM, Thompson PM, Armstrong JD. 2006. Modelling the impacts of removing seal predation from Atlantic salmon, *Salmo salar* L., rivers in Scotland: a tool for targeting conflict resolution. *Fisheries Management and Ecology* **13**: 285–291.
- Carter TJ, Pierce GJ, Hislop JRG, Houseman JA, Boyle PR. 2001. Predation by seals on salmonids in two Scottish estuaries. *Fisheries Management and Ecology* **8**: 207–225.
- Cosgrove PJ, Butler JRA, Laughton RL. 2004. Canoe and walking surveys of wintering goosanders, mergansers, cormorants and goldeneyes on the River Spey, 1994–2003. *Scottish Birds* **24**: 1–10.
- Folke C, Carpenter S, Elmqvist T, Gunderson L, Holling CS, Walker B. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformation. *Ambio* **31**: 437–440.
- Friedland KD, Hansen LP, Dunkley DA, Maclean JC. 2000. Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (*Salmo salar* L.) in the North Sea area. *ICES Journal of Marine Science* **57**: 419–429.
- Harwood J, Croxall JP. 1988. The assessment of competition between seals and commercial fisheries in the North Sea and the Antarctic. *Marine Mammal Science* **4**: 13–33.
- Heinsohn R, Lacy RC, Lindenmayer DB, Marsh H, Kwan D, Lawler IR. 2004. Unsustainable harvest of dugongs in Torres Strait and Cape York (Australia) waters: two case studies using population viability analysis. *Animal Conservation* **7**: 417–425.
- Holling CS, Gunderson LH. 2002. Resilience and adaptive cycles. In *Panarchy: Understanding Transformations in Human and Natural Systems*, Gunderson LH, Holling CS (eds). Island Press: Washington; 25–62.
- Hoyt E. 2001. *Whale-watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits*. International Fund for Animal Welfare: Crowborough.
- ICES. 2003. *Report of the Working Group on North Atlantic Salmon*. ICES C.M. 2003/ACFM: 19.
- Jonsson B, Jonsson N. 2004. Factors affecting marine production of Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Sciences* **61**: 2369–2383.
- Jordan WC, Verspoor E, Youngson AF. 1997. The effect of natural selection on estimates of genetic divergence among populations of the Atlantic salmon (*Salmo salar* L.). *Journal of Fish Biology* **51**: 546–560.
- Lockie JD. 1962. Grey seals as competitors with man for salmon. In *The Exploitation of Natural Animal Populations*, Le Cren ED, Holdgate MW (eds). British Ecological Society Symposium No. 2, Blackwell Scientific Publications: Oxford; 316–322.
- Lonergan M, Duck CD, Thompson D, Mackey BL, Cunningham L, Boyd IL. 2007. Using sparse survey data to investigate the declining abundance of British harbour seals. *Journal of Zoology* **271**: 261–269.
- Marquiss M, Carss DN, Armstrong JD, Gardner R. 1998. *Fish Eating Birds and Salmonids in Scotland: Report on Fish-eating Birds Research (1990-97) to the Scottish Office Agriculture, Environment and Fisheries Department*. The Scottish Office: Edinburgh.
- Marsh H, Lawler IR, Kwan D, Delean S, Pollock K, Alldredge M. 2004. Aerial surveys and the potential biological removal technique indicate that the Torres Strait dugong fishery is unsustainable. *Animal Conservation* **7**: 435–443.
- Middlemas SJ, Armstrong JD, Thompson PM. 2003. The significance of marine mammal predation on salmon and sea trout. In *Salmon at the Edge*, Mills DH (ed.). Blackwell Scientific Publications: Oxford; 42–60.
- Middlemas SJ, Barton TR, Armstrong JD, Thompson PM. 2006. Functional and aggregative responses of harbour seal predation to changes in salmonid abundance. *Proceedings of the Royal Society B* **273**: 193–198.

- Moore PG. 2003. Seals and fisheries in the Clyde Sea area (Scotland): traditional knowledge informs science. *Fisheries Research* **63**: 51–61.
- Moray Firth Partnership. 2001. *The Moray Firth candidate Special Area of Conservation Management Scheme*. The Moray Firth Partnership: Inverness.
- NERC. 2004. *Scientific Advice on Matters Related to the Management of Seal Populations: 2004*. NERC, UK, Special Committee on Seals, Advice 2004.
- Parrish BB, Shearer WM. 1977. *Effects of seals on fisheries*. ICES, International Council for the Exploitation of the Sea: Copenhagen, 1977/M14.
- Parsons ECM, Warburton CA, Woods-Ballard A, Hughes A, Johnston P. 2003. The value of conserving whales: the impacts of cetacean-related tourism on the economy of rural West Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems* **13**: 397–415.
- Pierce GJ, Boyle PR, Diack JSW. 1991a. Digestive tract contents of seals in Scottish waters: comparison of samples from salmon nets and elsewhere. *Journal of Zoology, London* **225**: 670–676.
- Pierce GJ, Thompson PM, Miller A, Diack JSW, Miller D, Boyle PR. 1991b. Seasonal variation in the diet of common seals (*Phoca vitulina*) in the Moray Firth area of Scotland. *Journal of Zoology, London* **223**: 641–652.
- Quick NJ, Middlemas SJ, Armstrong JD. 2004. A survey of antipredator controls at marine salmon farms in Scotland. *Aquaculture* **230**(1–4): 169–180.
- Rae BB. 1960. Seals and Scottish Fisheries. *Marine Research* **1960** (2): 1–39.
- Rae BB. 1962. The effect of seal stocks on Scottish marine fisheries. In *The Exploitation of Natural Animal Populations*, Le Cren ED, Holdgate MW (eds). British Ecological Society Symposium No. 2, Blackwell Scientific Publications: Oxford; 305–311.
- Rae BB. 1968. The food of seals in Scottish waters. *Marine Research* **1968** (2): 1–23.
- Rae BB, Shearer WM. 1965. Seal damage to salmon fisheries. *Marine Research* **1965** (2): 1–39.
- Riddington G, Radford A, Anderson J, Higgins P. 2004. *An Assessment of the Economic Impact of Water-related Recreation and Tourism in the Spey Catchment in 2003*. Division of Economics and Enterprise, Glasgow Caledonian University: Glasgow.
- Scottish Executive. 2000. *Revised Guidance Updating Scottish Office Circular No. 6/1995. Nature Conservation: Implementation in Scotland of EC Directives on the Conservation of Natural Habitats and of Wild Flora and Fauna and the Conservation of Wild Birds (The Habitats and Bird Directives)*. Scottish Executive: Edinburgh.
- Scottish Natural Heritage. 1995. *Natura 2000: a Guide to the 1992 EC Habitats Directive in Scotland's Marine Environment*. Scottish Natural Heritage: Battleby, Perth.
- Scottish Office, Agriculture. 1997. *Report of the Scottish Salmon Strategy Task Force*. Scottish Office Agriculture, Environment and Fisheries Department: Edinburgh.
- Shearer WM. 1962. Seals and salmon nets. In *The Exploitation of Natural Animal Populations*, Le Cren ED, Holdgate MW (eds). British Ecological Society Symposium No. 2, Blackwell Scientific Publications: Oxford; 312–315.
- Stewart DC, Smith GW, Youngson AF. 2002. Tributary-specific variation in timing of return of adult Atlantic salmon (*Salmo salar*) to freshwater has a genetic component. *Canadian Journal of Fisheries & Aquatic Science* **59**: 276–281.
- Thompson PM, McConnell BJ, Tollit DJ, Mackay A, Hunter C, Racey PA. 1996. Comparative distribution, movements and diet of harbour and grey seals from the Moray Firth, N.E. Scotland. *Journal of Applied Ecology* **33**: 1572–1584.
- Thompson PM, Tollit DJ, Wood D, Corpe HM, Hammond PS, Mackay A. 1997. Estimating harbour seal abundance and status in an estuarine habitat in north-east Scotland. *Journal of Applied Ecology* **34**: 43–52.
- Thompson PM, Van Parijs S, Kovacs KM. 2001. Local declines in the abundance of harbour seals: implications for the designation and monitoring of protected areas. *Journal of Applied Ecology* **38**: 117–125.
- Thompson PM, Mackey B, Barton TM, Duck C, Butler JRA. 2007. Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals in NE Scotland. *Animal Conservation* **10**: 48–56.
- Thorley JL, Eatherley DMR, Stephen AB, Simpson I, MacLean JC, Youngson AF. 2005. Congruence between automatic fish counter data and rod catches of Atlantic salmon (*Salmo salar*) in Scottish rivers. *ICES Journal of Marine Science* **62**: 809–817.
- Tonder M, Salmi P. 2004. Institutional changes in fisheries governance: the case of the saimaa ringed seal, *Phoca hispida saimensis*, conservation. *Fisheries Management and Ecology* **11**: 283–290.
- Wade PR. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. *Marine Mammal Science* **14**: 1–37.
- Williamson GR. 1988. Seals in Loch Ness. Scientific Report of the Whales Research Institute No. 39.
- Yodzis P. 2001. Must top predators be culled for the sake of fisheries? *Trends in Ecology and Evolution* **16**: 78–83.
- Young K. 1998. *Seal Watching in the UK and Republic of Ireland*. International Fund for Animal Welfare: Crowborough.
- Youngson AF, Maclean JC, Fryer RJ. 2002. Rod catch trends for early running MSW salmon in Scottish rivers (1952–1997): divergence among stock components. *ICES Journal of Marine Science* **59**: 836–849.
- Youngson AF, Jordon WC, Verspoor E, McGinnity P, Cross T, Ferguson A. 2003. Management of salmonid fisheries in the British Isles: towards a practical approach based on population genetics. *Fisheries Research* **62**: 193–209.