Perceptions and costs of seal impacts on Atlantic salmon fisheries in the Moray Firth, Scotland: implications for the adaptive co-management of seal-fishery conflict

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Abstract

The Moray Firth Seal Management Plan (MFSMP) was introduced in Scotland in 2005 as a pilot for resolving conflict between Atlantic salmon fisheries and conservation imperatives for protected harbour and grey seals. This adaptive co-management model is now being applied nationally through the Marine (Scotland) Bill (2009). However, no information exists on salmon fishery stakeholders' perceptions of seal predation impacts and related costs, which could influence the success of the MFSMP and other similar initiatives. In 2006 we undertook a questionnaire survey of the 95 salmon rod fisheries in seven major Moray Firth rivers, and all 20 active salmon netting stations in the Firth. Forty-five fishery owners, 39 ghillies, 120 anglers and 11 netsmen (representing 17 netting stations) responded. The majority (81%) believed that seals had a significant or moderate impact on stocks and catches, 77% believed that all seals were responsible and 47% supported seal culling. Seals were sighted by 38% of rod fisheries, and 18% lost angler days from seal interference. Overall, 0.2% of total reported angler days were lost annually. The estimated direct cost of seal interference for responding rod fisheries was £14,960 annum^{-1}, and losses of catches and damage to nets was £16,500 annum^{-1} for responding netsmen. Stakeholders' perceptions were largely inconsistent with their low direct costs and the aims of the MFSMP. We discuss possible reasons for this, and implications for the governance of future adaptive co-management initiatives for seal-fishery conflict.

Key words: Atlantic salmon; adaptive co-management; grey seal; harbour seal; livelihoods; Special Area of Conservation

1. Introduction

Adaptive co-management is emerging as an effective alternative to centralised, government-dominated governance of complex social-ecological systems [1]. It is characterised by an evolving process triggered by a natural resource crisis, whereby multi-scale partnerships are formed amongst stakeholders in the common resource, combining experimentation in alternative management with iterative co-learning, conflict resolution and power-sharing [2-6]. However, participation by local stakeholders who are most affected by management arrangements is a pre-requisite for successful co-management [7]. If these stakeholders are not fully included, and their views and perceived economic losses not accounted for, protracted disputes may emerge instead of consensus-based compromise [e.g. 8].

Interactions between protected marine mammals and fisheries are complex and controversial [9,10]. In Scotland there is a long history of conflict between harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals and fisheries for anadromous Atlantic salmon (*Salmo salar*) and sea trout (*S. trutta*). Seals prey on fish migrating through rivers and estuaries and around coastal netting stations [11-20]. Hence they may have an indirect economic impact on fisheries by reducing numbers available for capture. They also have a direct impact on rod fisheries by interfering with angling activity [21] and on net fisheries by damaging nets and trapped fish [12,14].

Conflict between seals and fishermen has intensified due to the rapid growth of the UK grey seal population in the 20th century [22]. Following legislation to regulate seal culling, estimated numbers in Scottish waters increased from 4,000 in 1927 [11] to 35,000 in the 1960s [23] and 163,000 in 2007 [24]. By comparison harbour seals are

less numerous; the minimum number counted in Scotland was 20,000 in 2007, but populations have been declining sharply in some areas [24,25]. The impact of grey and harbour seals on salmon and other commercially important fisheries has been estimated as substantial by some studies, resulting in proposals for the reduction of seal populations through culling [11,23,26,27].

Managing interactions between seals and fisheries has been complicated by the implementation of the EU 'Habitats Directive' (Council Directive 92.43/EEC) in 1992, which aims to secure the favourable conservation status of listed species of European importance through the designation of Special Areas of Conservation (SACs) [28]. Harbour and grey seals are listed in Annex II of the Directive, and fishery stakeholders' demands for a seal cull have been rejected by government partly due to their protected status [23]. Meanwhile, the growing popularity of wildlife tourism in Scotland based on marine mammals has further justified seal conservation [29].

The Moray Firth in north-east Scotland is a contemporary example of these complex issues. The region supports important salmon and sea trout fisheries and marine wildlife tourism, and SACs were established for harbour seals in the Dornoch Firth in 2000 and for salmon in six rivers in 1999. Harbour seal numbers were declining in the 1990s, potentially due to widespread and indiscriminate shooting by fisheries [30] threatening their conservation status in the Dornoch Firth SAC, and some salmon stocks were also at low levels. In response to this situation, negotiations began in 2002 between the Scottish Government, the 12 District Salmon Fishery Boards (DSFBs) in the Moray Firth, Scottish Natural Heritage (the government's

conservation agency) and tourism interests. A partnership was formed between these stakeholders, and in 2005 a pilot adaptive co-management scheme, the Moray Firth Seal Management Plan (MFSMP), was introduced as a novel approach to balancing the control of seal predation by fisheries with the protection of the harbour seal population, salmon and wildlife tourism [22]. Rather than aiming to reduce grey and harbour seal populations as previously practiced [30], stakeholders agreed that seal predation should be managed by targeting 'problem' seals frequenting rivers and netting stations, where they potentially have the greatest impacts on fisheries. Management areas were established to allow the licensed shooting of a limited number of these seals by trained marksmen, while minimising interference with the tourism industry, and the plan is reviewed annually. Since 2005 the MFSMP has reduced the numbers of seals shot in the Moray Firth by 60%; consequently it is regarded as a success by the Scottish Government, and the model is now being applied nationally to manage seal-fishery conflict under the recent Marine (Scotland) Bill (2009) [31].

To compliment the MFSMP a research program was established in 2004, which has investigated the efficacy of non-lethal acoustic deterrent devices to exclude seals from rivers as an alternative to shooting [32], and the impact of seal predation on salmon and sea trout stocks in rivers. Results of this research will be integrated within the adaptive framework to inform future revisions and modifications of the plan. Non-lethal methods have also been prioritised as a preferred measure for mitigating seal-fishery conflict by the Marine (Scotland) Bill, and the research results will inform other co-management initiatives introduced under the Bill.

Although the MFSMP was developed in partnership between the government and the Moray Firth DSFBs, no information exists on the perceptions of salmon fishery stakeholders represented by DSFBs of seal impacts on fisheries in the Moray Firth. Similarly, no such information exists elsewhere in Scotland. Since these stakeholders are among those potentially most affected by co-management initiatives it is important to understand their perceptions of seal impacts, the costs they incur from seal predation, and how to account for these within adaptive co-management arrangements. This paper presents the results of a survey undertaken in 2006 to assess the opinions of Moray Firth rod and net fishery stakeholders about seal impacts on salmon and sea trout stocks, and seal management measures relative to the MSFMP's aims. The study also estimates the direct economic costs of seals to rod and net fisheries and relates these to fishery stakeholders' perceptions. The implications of the results for the governance of the MFSMP and other forthcoming schemes initiated by the Marine (Scotland) Bill are considered.

2. Study site

The Moray Firth (58^0N 3^0W) is a large embayment in north-east Scotland covering 5230 km^2 (Fig. 1). Eighteen major rivers run into the Firth. In 1999 the Spey, Moriston (a tributary of Loch Ness), Oykel, Cassley, Langwell and Berriedale were designated as SACs for Atlantic salmon. In 2000 the Dornoch Firth, located in the inner Moray Firth (Fig. 1), was designated an SAC for harbour seals. Because harbour seals from the SAC are known to range throughout the Moray Firth, the SAC is managed through the MFSMP. Moray Firth grey seals are part of a wider North Sea population which are not protected by the Dornoch Firth SAC [22].

Fig. 1

In Scotland rights of access to rod fisheries are private, and anglers must pay rent or purchase permits from the owner before fishing. Salmon and sea trout stocks and fisheries are managed by DSFBs through the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act (2003) (see www.hmso.gov.uk/legislation/Scotland). DSFBs have delineated jurisdictions over catchments and up to 5 km seaward from the mean low water spring tide line. All rod and commercial net fishery owners and tenants within these areas are represented on DSFBs by elected individuals. Fishing guides ('ghillies') are employed by many fishery owners to assist anglers, but are not formally represented on DSFBs. Provisions also exist in the legislation for representatives of anglers' clubs or associations to be co-opted onto DSFBs, but these have rarely been applied by Moray Firth DSFBs. Salmon rod fishery seasons run from spring to autumn, with some variations in opening and closing dates.

In 2006 there were 20 active coastal netting stations in the Moray Firth (Fig. 1), operated by 14 netsmen. Fifteen of the sites use beach seine or 'sweep' nets, and five use trap or 'stake' nets.

3. Methods

3.1. Rod fishery perceptions and costs

To assess the perceptions of rod fishery stakeholders (anglers, ghillies and owners), the seven largest rivers were selected: the Spey, Ness, Conon, plus the Shin, Carron, Oykel and Cassley, collectively referred to as the Kyle of Sutherland (KoS). Together

these rivers contributed 70% of the total declared Moray Firth salmon and sea trout rod catch in 2001-2005 (Marine Scotland, unpubl. data).

During the 2006 fishing season self-completion questionnaires were posted to all owners and ghillies by the managers of the rivers' DSFBs. Owners were also asked to distribute questionnaires to anglers visiting their fishery. Following guidelines for questionnaire design [33], the following three closed questions with optional answers were presented to all anglers, ghillies and owners:

Q1. *Is seal predation having an impact on salmon and sea trout stocks and catches in the Moray Firth?* Optional answers were 'no impact', 'little', 'moderate' and 'significant'. Responses were standardised by stating that 'significant' meant that seal predation was the greatest factor influencing stocks and catches in the Moray Firth.

Q2. *Are a few 'problem' seals responsible for the impact on stocks and catches, or is it all seals?* Optional answers were 'problem seals' and 'all seals'. Those who responded 'no impact' to Q1 were asked not to answer Q2.

Q3. *How should seal predation be controlled?* Optional management measures were 'no control', 'non-lethal methods', 'shoot problem seals at netting stations and in rivers' and 'population reduction through culling'. For non-lethal methods the example of acoustic deterrents was given. Respondents were able to select a combination of measures.

For the 5 year period 2001-2005 owners were also asked to estimate:

- The average annual angler effort expended in their fishery expressed as angler days (defined as one person fishing for part or all of one day);
- The average number of days that seals were sighted annually in their fishery during the rod fishing season;
- The annual average number of angler days that fishermen reported they had to stop fishing due to the interference of seals, termed 'lost angler days'.

The river channel distance (km) from the fishery's downstream limit to the river mouth was measured and compared to sighting frequencies and the number of lost angler days.

The potential cost of lost days to the local economy was calculated from average daily angler expenditure (2003 prices) of £228 day^{-1} for the Spey [34], and £186 day^{-1} for the Highland region (covering the Ness, Conon and KoS) [35]. To correct these to 2006 prices we applied an inflationary factor of 7.6% taken from the UK GDP Implicit Price Deflator [36]. This resulted in daily expenditure estimates of £245 day^{-1} for the Spey and £200 day^{-1} for the Ness, Conon and KoS.

3.2. Netting station perceptions and costs

In 2006 self-completion questionnaires were also sent to the 14 netsmen operating the 20 active netting stations. They were asked the same three questions as the rod fisheries for the period 2001-2005, and also estimated the average direct annual cost of damage to nets and catches by seals based on their catch and repair records.

253

254 *3.3. Statistical analyses*

255 We compared the relative proportions of anglers, ghillies and owners and netsmen
256 responding to the optional answers for Q1, Q2 and Q3 using χ^2 contingency tables.
257 We did not compare perceptions between rivers due to the small sample sizes ($n \leq 10$)
258 of owners and ghillies who responded from the Ness, Conon and KoS (Table 1). To
259 assess the relationship between days with seal sightings and lost angler days across
260 rod fisheries we calculated Pearson's correlation coefficients for paired fishery data.
261 All results were considered statistically significant where $p < 0.05$.

262

263 **4. Results**

264 *4.1. Rod fishery and netsmens' perceptions*

265 There were a total of 95 rod fisheries in the seven rivers (Table 1). Overall 45 (47%)
266 of the owners responded. The 95 fisheries employed a total of 82 ghillies, of which 39
267 (48%) responded. In addition 120 anglers responded, 77 from the Spey, 6 from the
268 Ness, 12 from the Conon and 25 from the KoS. Because the total number of anglers
269 visiting rivers is not accurately monitored by all fisheries it was not possible to
270 calculate the response rate. Eleven (79%) of the 14 netsmen responded, representing
271 17 (85%) of the 20 netting stations.

272

273 For Q1 there was a marginally statistically significant difference between the
274 responses of anglers, ghillies and owners ($\chi^2 = 12.83$; d.f. = 6; $p = 0.049$). This was due
275 to a higher percentage (54%) of ghillies responding that seals had a moderate impact
276 compared to other groups. In all other cases the highest percentage believed that seals
277 had a significant impact (anglers 43%, owners 53%, netsmen 64%). There was no

278 statistically significant difference between pooled rod fishery responses and netsmens'
279 responses. Overall, 43% believed that seals had a significant impact, and 38%
280 believed they had a moderate impact (Fig. 2).
281
282 **Fig. 2**
283
284 For Q2 a large majority of anglers (80%), ghillies (68%) and owners (85%) believed
285 that all seals were responsible, while the remaining minority implicated problem seals,
286 and there was no significant difference between their relative responses. The majority
287 of netsmen also believed that all seals were responsible (57%). There was no
288 statistically significant difference between pooled rod fishery responses and netsmens'
289 responses. Overall, 77% identified all seals as responsible for impacts (Fig. 3).
290
291 **Fig. 3**
292
293 For Q3 the favoured measure for anglers (44%) and owners (52%) was population
294 reduction, with ghillies favouring shooting problem seals (49%), although 45% also
295 favoured population reduction. There was no statistically significant difference
296 between the responses of the anglers, ghillies and owners. The majority of netsmens'
297 responses (52%) supported population reduction. There was no statistically significant
298 difference between pooled rod fishery responses and netsmens' responses. Overall,
299 47% supported population reduction, followed by 42% favouring shooting problem
300 seals (Fig. 4). A small minority (6%) supported non-lethal methods.
301
302 **Fig. 4**

303

304 *4.2. Rod fishery costs*

305 Seals were sighted by 17 (38%) of the 45 responding rod fisheries with a frequency
306 range of 1 day (Spey) to 228 days annum^{-1} (KoS). Within each river, fisheries closest
307 to the river mouth experienced the highest frequencies, and this declined rapidly with
308 distance upstream (Fig. 5a). The greatest distances upstream that seals were reported
309 were 31.5 km on the Spey, 42 km on the Ness (in Loch Ness), 4.5 km on the Conon
310 and 11 km on the KoS.

311

312 Eight (47%) of the 17 fisheries that sighted seals lost angler days. There was a
313 statistically significant positive correlation between seal sightings and lost angler days
314 ($r = 0.485$; $p = 0.041$), but there was wide variation in the relationship. For example
315 all four fisheries responding in the Ness sighted seals up to 39 days annum^{-1} but none
316 reported lost angler days. With a similar sighting frequency (33 days annum^{-1})
317 Fisheries A and B on the Spey lost 13 angler days annum^{-1} each. For all rivers the
318 highest numbers of lost angler days occurred in fisheries nearest the river mouth and
319 rapidly declined with distance upstream (Fig. 5b).

320

321 **Fig. 5**

322

323 A total of 36,689 angler days annum^{-1} were reported by the 45 fisheries, of which 64
324 annum^{-1} (0.2%) were lost by the eight fisheries. The proportion of angler days lost for
325 each river ranged from none (Ness) to 0.4% (Conon; Table 2). The total cost was
326 £14,960 annum^{-1} and for each river ranged from none (Ness) to £11,760 annum^{-1}
327 (Spey). When the eight fisheries were examined individually (Table 3), the highest

328 proportion of angler days lost annually (1.8%) was from Fishery A on the Spey,
329 which was located at the river mouth (Fig. 5b). With Fishery B on the Spey, this
330 fishery also incurred the highest cost (£3,185 annum^{-1}).
331
332 *4.3. Netting station costs*
333 All 11 netsmen reported losses at their 17 netting stations. Estimates of annual costs
334 were £250 (6), £750 (2), £1,500 (1) and £6,000 (2). The lower estimates (£250 and
335 £750 annum^{-1}) were incurred by sweep net operators, and the higher estimates (£1,500
336 and £6,000 annum^{-1}) were reported by stake net operators. The total cost was £16,500
337 annum^{-1}.
338
339 **5. Discussion**
340 With the possible exception of the responses of ghillies to Q1 and Q3, there was
341 relative unanimity amongst stakeholders' perceptions, with no statistically significant
342 differences between anglers, ghillies, owners and netsmen surveyed. However,
343 statistical comparisons may have been limited by the small sample sizes of netsmen (n
344 = 11), ghillies (n = 39) and owners (n = 45). Also, given that ghillies are employed by
345 fishery owners, and anglers have regular contact with ghillies, it may not be surprising
346 that they have similar views, and therefore can not be treated as completely
347 independent groups.
348
349 Considering that the Spey, Ness, Conon and KoS rivers contributed 70% of the total
350 salmon and sea trout rod catch and therefore the majority of rod fisheries in the Moray
351 Firth, and 47% of fishery owners and 48% of ghillies on these rivers responded, the
352 results probably reflect the views of a significant proportion of these rod fishery

353 stakeholders in the MFSMP region. Furthermore, 11 (79%) of the 14 netsmen
354 responded, representing 17 (85%) of the 20 active sites in the Moray Firth. However,
355 it is possible that non-respondents did not have strong views about seal predation, and
356 therefore the results are only representative of a sub-group who either perceived or
357 had experienced seal impacts. Nonetheless, given that even a small number of
358 disaffected stakeholders can have a marked negative impact on the progress of co-
359 management [7,8], these results may have important implications for the MFSMP.
360
361 Overall, the highest proportion of responding stakeholders believed that seals have a
362 significant impact (i.e. they are the greatest factor influencing stocks and catches), that
363 all seals rather than problem seals are responsible, and that population reduction
364 through culling was the favoured management measure. These perceptions are largely
365 inconsistent with the principles of the MFSMP, which aims to target problem seals
366 frequenting rivers and netting stations which are likely to have the greatest direct and
367 indirect impacts on rod and net fisheries [22]. The plan does not advocate culling of
368 harbour or grey seals because elevated mortality may limit harbour seal population
369 recovery [30], further threatening their conservation status in the Dornoch Firth SAC,
370 and potentially adversely affecting wildlife tourism in the Moray Firth [22]. Also,
371 scientific evidence indicates that salmon and sea trout contribute a minor component
372 of these species' diet in the Moray Firth [16,20,37,38], and population reduction may
373 not result in a direct compensatory increase in stocks and catches of salmon and sea
374 trout, in common with other marine mammal-fishery interactions [10].
375
376 Rod fishery stakeholders' perceptions are also inconsistent with the low direct costs
377 from seal interference. Only 0.2% of total reported annual angler days were lost at an

estimated cost of £14,960 annum^{-1}, with the Conon losing the highest proportion (0.4%). Seventeen (38%) fisheries sighted seals, and only eight (18%) reported lost angler days, and these were largely located nearest the river mouth. Yet even these fisheries lost only a small proportion of days, with a maximum of 1.8% at Fishery A on the Spey. The perceptions of netsmen are more consistent with their direct costs, since all 11 owners reported seal damage at their 17 stations, at a higher total cost of £16,500 annum^{-1}. However, without information on the netsmens' total fishery and other income it is difficult to assess the full impact of these losses on their livelihoods.

Rod fishery stakeholders' opinions may instead be based on their perceptions of the indirect impacts of seal predation. Thirty-eight percent of fisheries sighted seals in rivers during the fishing season, and they are also present in the closed season in the Spey [39] and Loch Ness [21], and if preying on adult salmonids they could have a significant impact on smaller populations [40]. External physical damage to rod-caught fish is also regularly observed by ghillies and anglers, perhaps indicating further evidence of indirect impacts, although studies on the Conon and Spey indicate that not all damage is attributable to seals [18, authors' unpubl. data]. Their opinions could also reflect the longstanding public debate about seal population reduction, driven by the rapid growth of the grey seal population during the 20th century [23.27]. Rae [11] calculated considerable impacts of seals on fisheries and fish stocks in UK waters, and concluded that seal populations must be reduced and maintained at levels which do not interfere with commercial fisheries. In 1997 the Salmon Strategy Task Force came to a similar conclusion [26]. Moore [23] also surveyed trawler and creel fishermen on the Scottish west coast, and 86% were in favour of a seal cull due to the local growth in grey seal numbers and threats they posed to their livelihoods.

403

404 The potential direct costs to rod fisheries and the local economy was estimated based
405 on the reported number of lost angler days. These are underestimates since 50 of the
406 95 owners did not respond, including three located at the mouth of the Conon, Ness
407 and KoS, which this study suggests could have experienced some lost angler days.
408 Furthermore, there are likely to have been some lost angler days on other un-surveyed
409 rivers. However, this is counterbalanced by the likely overestimation of the loss
410 derived from angler expenditure. Anglers purchase permits before fishing, and can not
411 easily request a rebate if they experience seal interference. Hence the costs calculated
412 here at most represent a loss in anglers' economic utility due to lost fishing time,
413 rather than the impact on the local economy. Nonetheless, as suggested for conflict
414 between piscivorous birds and fisheries [41] it is also possible that anglers who
415 experience seal interference choose not to revisit a fishery, resulting in indirect costs.
416

417 By contrast, netsmens' losses caused by damage to gear and catches did represent
418 direct economic costs. However, there was wide variation. Sweep netting stations
419 incurred lower costs, with the majority of operators losing £250 $annum^{-1}$ relative to
420 stake nets which lost £1,500 and £6,000 $annum^{-1}$. These higher costs are probably due
421 to the nature of stake nets which are set unattended over extended periods, allowing
422 seals ample opportunity to raid them [11,13,14]. The overall reported cost was
423 £16,500 $annum^{-1}$, but this is an underestimate since three did not respond, and they
424 were all stake netting stations. These estimates could be useful for future cost-benefit
425 analyses of alternative non-lethal management measures, such as the modification of
426 stake nets to reduce seal damage, as practiced in Sweden [42,43], or acoustic
427 deterrents [32].

The direct costs identified by our study should also be compared with the economic benefits that seals provide. Marine wildlife tourism is a growing sector of the Scottish tourist economy, and represents an important source of environmentally sustainable revenue for rural areas [29,44]. In 1998 tourism in the Moray Firth based largely on bottlenose dolphins (*Tursiops truncatus*) and other cetaceans generated £2.34 million expenditure [45]. In 2006 there were nine registered boat operators and two land-based centres in the Moray Firth, and a questionnaire survey showed that on average they ranked seals second as a tourist attraction after cetaceans, and ahead of seabirds and other wildlife (authors' unpubl. data). Hence, even as a proportion of the tourist expenditure estimated by Hoyt [45], the economic benefits of seals are likely to outweigh their combined direct costs to rod and net fisheries. A full cost-benefit analysis of the value of seals to the economy, including other affected sectors such as marine fisheries was beyond the scope of this study, but may be an important avenue for future research under the MFSMP.

The establishment of the MFSMP is an example of adaptive co-management, where the Scottish Government, DSFBs, Scottish Natural Heritage and the tourism industry agreed to an experimental co-management model for seal, fishery and tourism governance set within an adaptive learning framework in response to concerns over declining harbour seal and salmon abundance [22]. The study suggests that in 2006, one year after the MFSMP's inception, rod and net fishery stakeholders' perceptions of seal-fishery interactions and preferred management measures were largely inconsistent with the plan's principles, and the science underpinning them. This is probably because the learning and power-sharing process implicit in adaptive co-

453 management was at an early stage at the time of the survey. Also, the initial
454 stakeholder negotiations only involved chairmen and managers of DSFBs, and board
455 members may not have been adequately engaged, stifling the communication of the
456 MFSMP's details to the broader body of fishery stakeholders they represented.
457 Participation by local stakeholders who are most affected by management
458 arrangements is an important pre-requisites for successful co-management of fisheries
459 [7]; this study suggests that the rod and net fishery stakeholders' engagement in the
460 MFSMP process needs to be improved if co-learning and conflict resolution is to
461 evolve.
462
463 One mechanism to achieve this would be to increase their involvement in the research
464 program. This has experimentally demonstrated the efficacy of non-lethal acoustic
465 deterrents to exclude seals from rivers [32], but in 2006 they had not been trialled
466 with Moray Firth fisheries, perhaps explaining why only a small minority favoured
467 this management measure. It is also possible that many stakeholders are unaware of
468 local harbour and grey seal ecology and management objectives, as also shown by
469 Moore's [23] survey of trawler and creel fishermen. This has partly been addressed,
470 since some ghillies and netsmen receive training in seal identification, biology and
471 management as a condition of licensing to shoot [22], but it could be extended to all
472 fishery stakeholders. Applying the provisions of the Salmon and Freshwater Fisheries
473 (Consolidation) (Scotland) Act to improve the representation of ghillies and anglers
474 on DSFBs could also increase their awareness and engagement with the MFSMP
475 process. Although owners are already represented on DSFBs, those from fisheries
476 nearest the mouths of rivers could also be targeted for greater inclusion since they
477 sight seals most frequently, and a sub-set may incur economic losses.

It is likely that the perceptions revealed in this study will also be found amongst salmon and sea trout fishery stakeholders in other regions of Scotland. This is probable for anglers, since the majority visiting the surveyed rivers also fish in many different regions of the UK [34,35]. Hence prior to the establishment of adaptive co-management initiatives in other regions of Scotland under the Marine (Scotland) Bill, the perceptions of fishery stakeholders should be first gauged, and appropriate governance arrangements put in place to account for their views and potential economic losses. While initiatives such as the MFSMP may have been successful in the short-term, long-term success is more likely if the adaptive co-management process evolves to better include owners, ghillies, anglers and netsmen. Preliminary surveys similar to this study could also provide a useful baseline against which to measure the progress of such initiatives.

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Table 1. Details of (a) the salmon and sea trout rod fisheries and owners, and (b) ghillies surveyed in the selected Moray Firth rivers. The Kyle of Sutherland (KoS) represents the Rivers Oykel, Shin, Carron and Cassley combined.

	Spey	Ness	Conon	KoS	Total
(a) Owners					
Owners/rod fisheries	39	7	6	43	95
Responses	31	4	4	6	45
Response rate (%)	79	57	67	14	47
(b) Ghillies					
Ghillies	44	7	7	24	82
Responses	19	5	5	10	39
Response rate (%)	43	71	71	42	48

Table 2. Annual average numbers of angler days reported by rod fishery owners who responded from the study rivers, and the average number of lost angler days due to seal interference in their fishery. Kyle of Sutherland (KoS) represents the Rivers Oykel, Shin, Carron and Cassley combined.

	Spey	Ness	Conon	KoS	Total
Total angler days	29,372	2,276	865	4,176	36,689
Fisheries with lost angler days	6	0	1	1	8
Lost angler days	48	0	3	13	64
Lost angler days (%)	0.2	0	0.4	0.3	0.2
Cost (£)	11,760[a]	0	600[b]	2,600[b]	14,960

a. Applying the average daily expenditure of Spey salmon and sea trout anglers in 2006 prices of £245 day^{-1}
b. Applying the average daily expenditure of salmon and sea trout anglers in the Highland region in 2006 prices of £200 day^{-1}

Table 3. Annual average numbers of angler days reported by the eight rod fishery owners who lost angler days due to seal interference in their fishery. Kyle of Sutherland (KoS) represents the Rivers Oykel, Shin, Carron and Cassley combined. See Figure 5b for location of fisheries relative to river mouths.

	Spey						Conon	KoS
Fishery	A	B	C	D	E	F	G	H
Angler days	717	5,200	930	990	930	990	780	1,000
Lost angler days	13	13	8	8	3	3	3	13
Lost angler days (%)	1.8	0.3	0.9	0.8	0.3	0.3	0.4	1.3
Cost (£)	3,185[a]	3,185[a]	1,960[a]	1,960[a]	735[a]	735[a]	600[b]	2,600[b]

a. Applying the average daily expenditure of Spey salmon and sea trout anglers in 2006 prices of £245 day^{-1}
b. Applying the average daily expenditure of salmon and sea trout anglers in the Highland region in 2006 prices of £200 day^{-1}

Figure captions

Fig. 1. The Moray Firth, showing the locations of the surveyed rivers, Kyle of Sutherland, Dornoch Firth SAC and netting stations

Fig. 2. The proportion of anglers, ghillies, rod fishery owners and netsmen responding to the four options provided for Q1: '*Is seal predation impacting on salmon and sea trout stocks and catches in the Moray Firth?'*

Fig. 3. The proportion of anglers, ghillies and rod fishery owners and netsmen responding to the two options provided for Q2: *'Are a few 'problem' seals responsible for the impacts on stocks and catches, or is it all seals?'*

Fig. 4. The proportion of anglers', ghillies', rod fishery owners' and netsmens' responses to the four options provided for Q3: '*How should seal predation be controlled?'*

Fig. 5. (a) The annual frequency of seal sightings in rod fisheries and (b) angler days reported lost annually due to the interference of seals relative to the fisheries' distance to the river mouth. In (b) code A-H refers to fisheries detailed in Table 3.

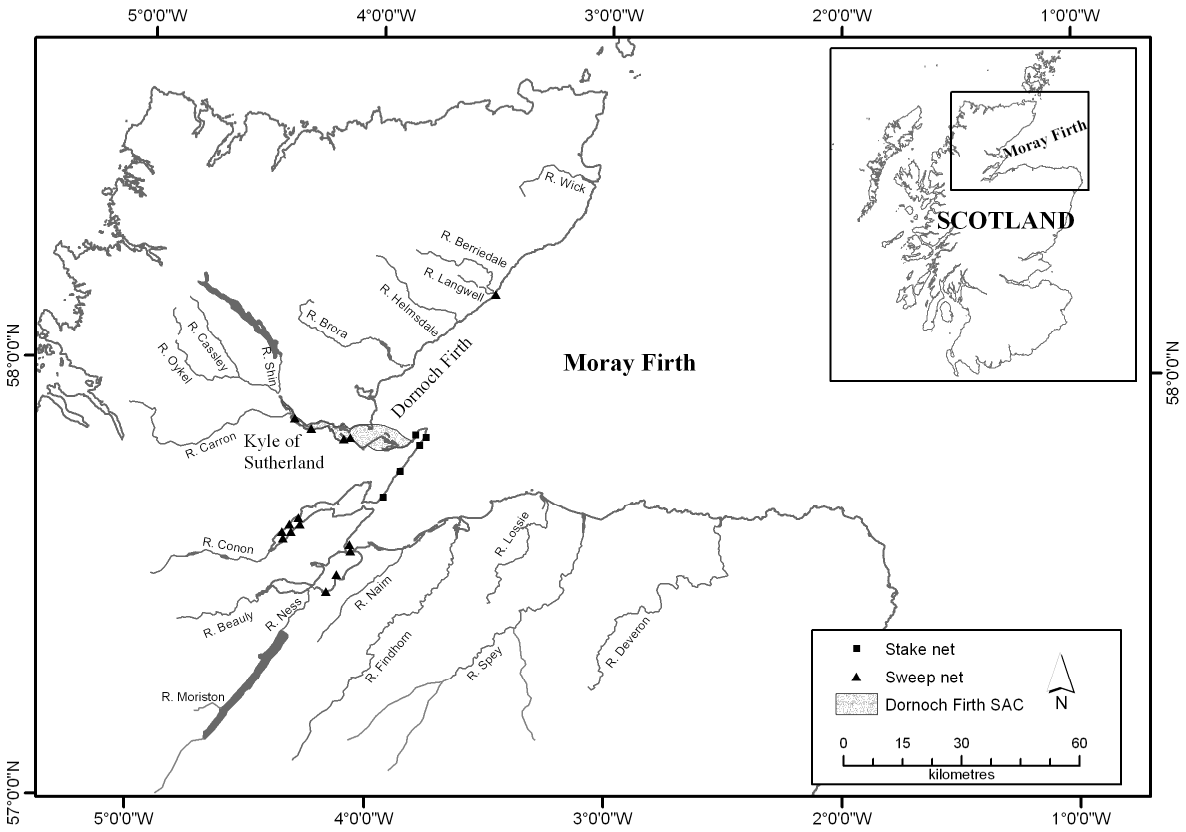
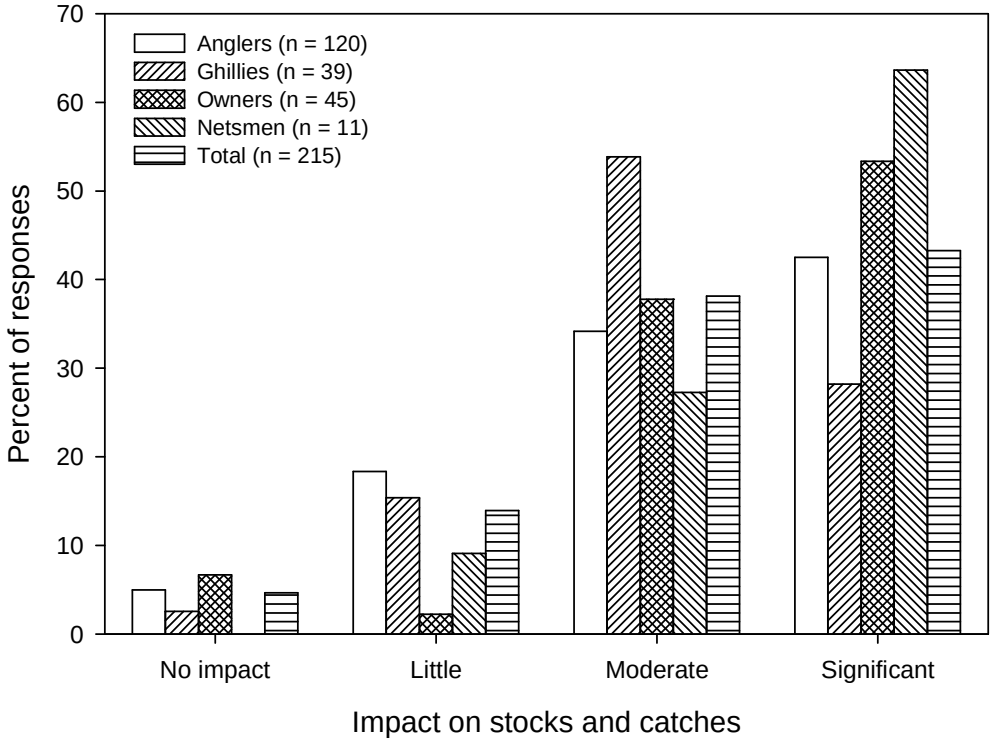

5°0'0"W
4°0'0"W
3°0'0"W
2°0'0"W
1°0'0"W
58°0'0"N
57°0'0"N
Moray Firth
SCOTLAND
R. Wick
R. Berriedale
R. Langwell
R. Helmsdale
R. Brora
R. Gasskey
R. Oykel
R. Shin
Dornoch Firth
Moray Firth
R. Carron
Kyle of Sutherland
R. Conon
R. Beauly
R. Ness
R. Moriston
R. Naim
R. Findhorn
R. Lossie
R. Spey
R. Deveron
Stake net
Sweep net
Dornoch Firth SAC
N
0
15
30
60
kilometres

Fig. 1



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874 **Fig. 2**
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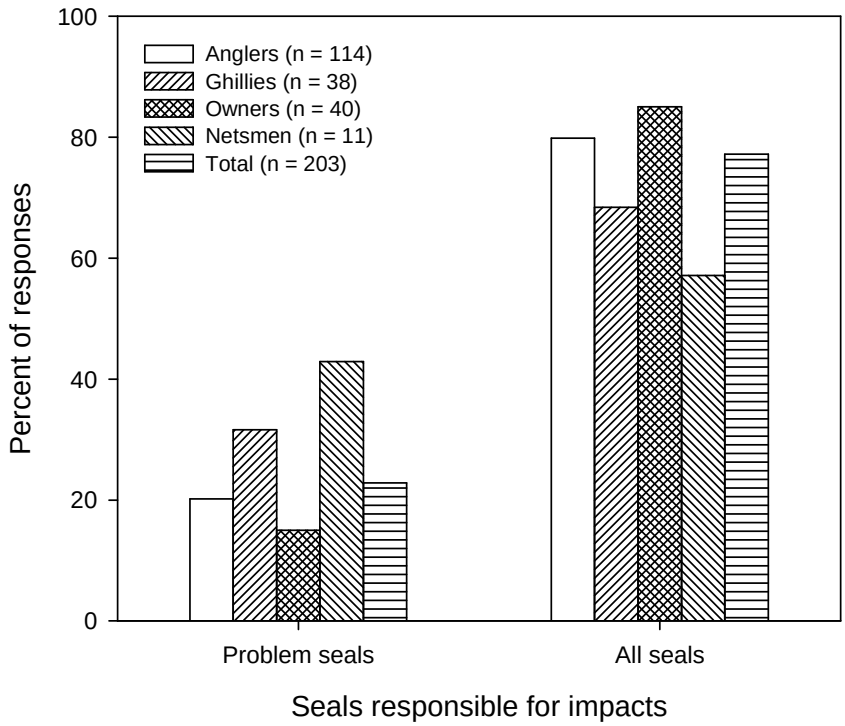

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881 **Fig. 3**
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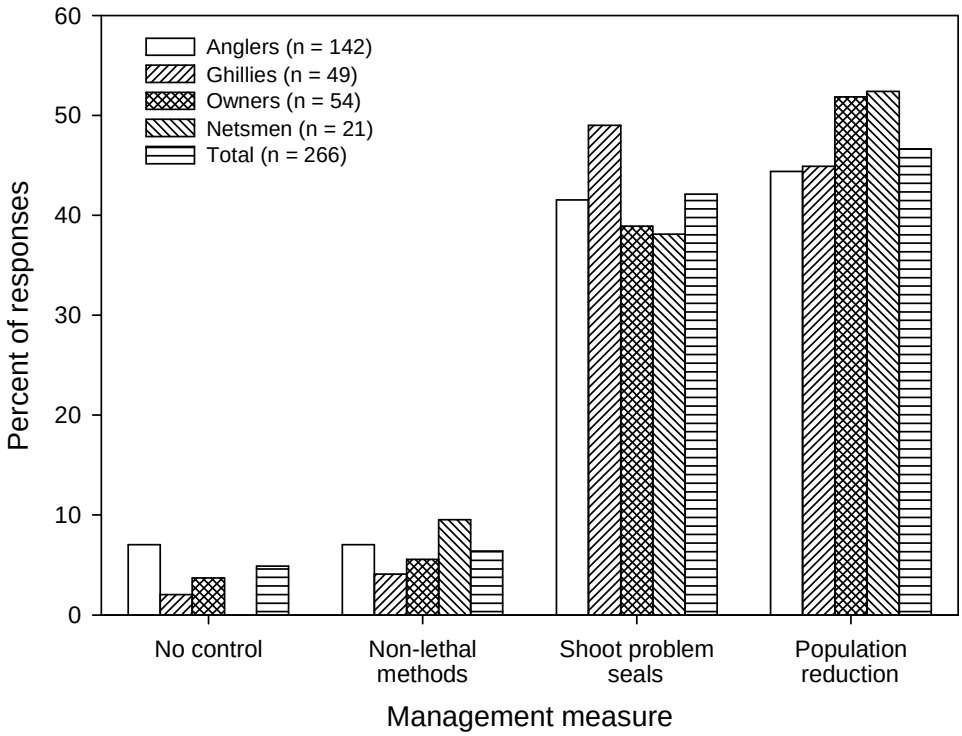

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890 **Fig. 4**
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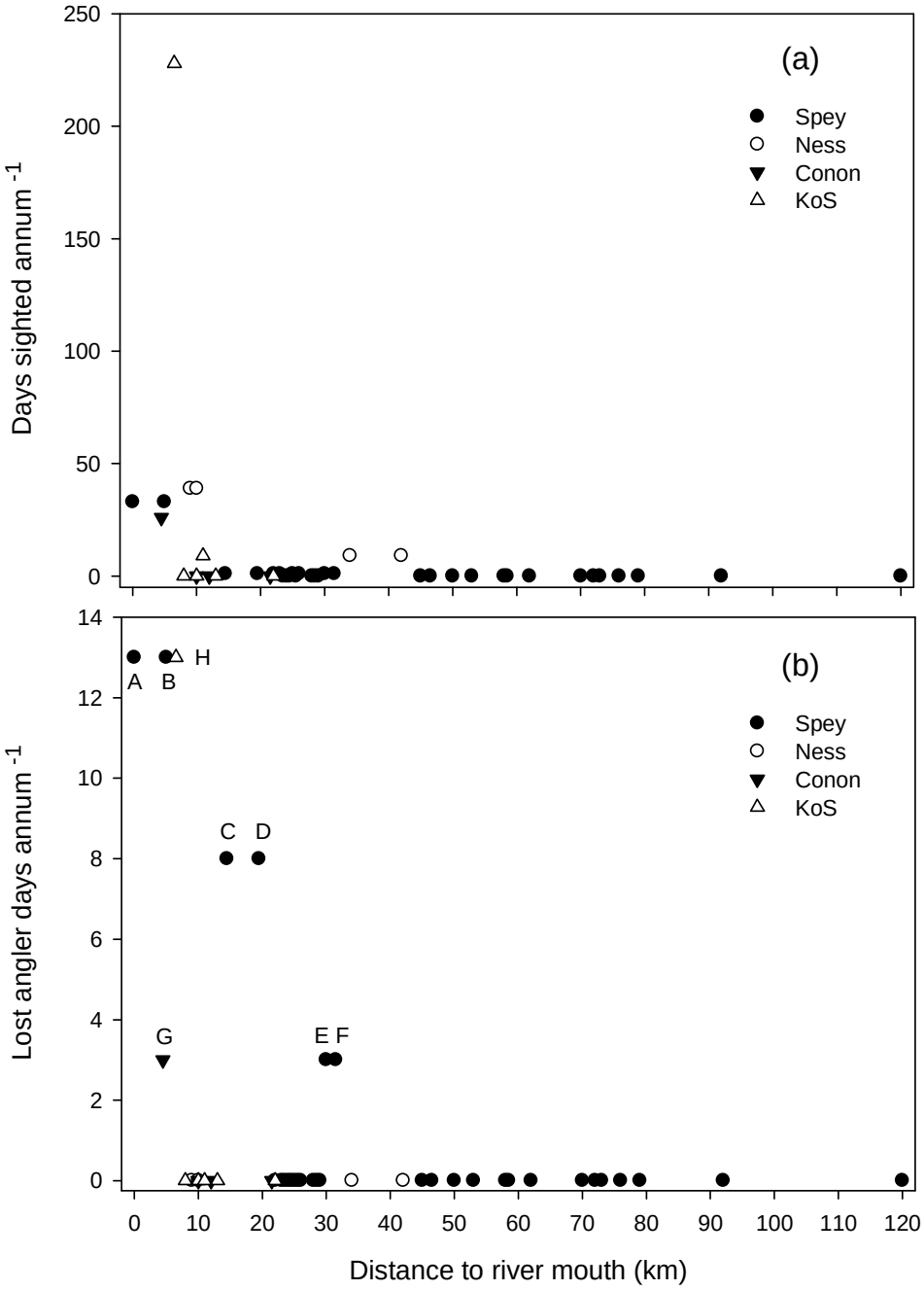
(a)
Spey
Ness
Conon
KoS
Days sighted annum -1
250
200
150
100
50
0
(b)
Spey
Ness
Conon
KoS
Lost angler days annum -1
A
B
H
C
D
G
E
F
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
110
120
Distance to river mouth (km)

Fig. 5