Research article

Evaluating adaptive co-management as conservation conflict resolution: Learning from seals and salmon

CrossMark

J.R.A. Butler [a, *], J.C. Young [b], I.A.G. McMyn [c], B. Leyshon [d], I.M. Graham [e], I. Walker [f], J.M. Baxter [g], J. Dodd [h], C. Warburton [i]

[a] CSIRO Land and Water Flagship, GPO Box 2583, Brisbane, QLD, 4001, Australia
[b] NERC Centre for Ecology and Hydrology, Bush Estate, Penicuik, EH26 0QB, UK
[c] ECUS Ltd., Scion House, Stirling University Innovation Park, Stirling, FK9 4NF, UK
[d] Scottish Natural Heritage, Dingwall Business Park, Dingwall, Ross-shire, IV15 9XB, UK
[e] Lighthouse Field Station, Institute of Biological and Environmental Sciences, University of Aberdeen, Cromarty, IV11 8YL, UK
[f] Scottish Government Wildlife and Habitats Division, Area G-H93, Victoria Quay, Edinburgh, EH6 6QQ, UK
[g] Scottish Natural Heritage, Silvan House, 3rd Floor East, 231 Corstorphine Road, Edinburgh, EH12 7AT, UK
[h] Scottish Natural Heritage, Cameron House, Oban, Argyll, PA34 4AE, UK
[i] Wild Scotland, Old Town Jail, St. John Street, Stirling, FK8 1EA, UK

ARTICLE INFO

ABSTRACT

By linking iterative learning and knowledge generation with power-sharing, adaptive co-management (ACM) provides a potential solution to resolving complex social-ecological problems. In this paper we evaluate ACM as a mechanism for resolving conservation conflict using a case study in Scotland, where seal and salmon fishery stakeholders have opposing and entrenched objectives. ACM emerged in 2002, successfully resolving this long-standing conflict. Applying evaluation approaches from the literature, in 2011 we interviewed stakeholders to characterise the evolution of ACM, and factors associated with its success over 10 years. In common with other ACM cases, triggers for the process were shifts in slow variables controlling the system (seal and salmon abundance, public perceptions of seal shooting), and exogenous shocks (changes in legal mandates, a seal disease outbreak). Also typical of ACM, three phases of evolution were evident: emerging local leadership preparing the system for change, a policy window of opportunity, and stakeholder partnerships building the resilience of the system. Parameters maintaining ACM were legal mechanisms and structures, legal power held by government, and the willingness of all stakeholders to reach a compromise and experiment with an alternative governance approach. Results highlighted the critical role of government power and support in resolving conservation conflict, which may constrain the extent of local stakeholder-driven ACM. The evaluation also demonstrated how, following perceived success, the trajectory of ACM has shifted to a 'stakeholder apathy' phase, with declining leadership, knowledge exchange, stakeholder engagement, and system resilience. We discuss remedial actions required to revive the process, and the importance of long term government resourcing and alternative financing schemes for successful conflict resolution. Based on the results we present a generic indicator framework and participatory method for the longitudinal evaluation of ACM applied to conservation conflict resolution.

1. Introduction

Adaptive co-management (ACM) is a novel form of environmental governance that can enhance social-ecological systems' resilience and adaptability to uncertainty and change (Armitage et al., 2009; Plummer et al., 2012). In contrast to conventional, centralised 'command-and-control' approaches, it combines the iterative learning, knowledge generation and problem-solving of

* Corresponding author.
E-mail addresses: James.Butler@csiro.au (J.R.A. Butler), jyo@ceh.ac.uk (J.C. Young), Iain.McMyn@ecusltd.co.uk (I.A.G. McMyn), Ben.Leyshon@snh.gov.uk (B. Leyshon), i.graham@abdn.ac.uk (I.M. Graham), Ian.Walker@scotland.gsi.gov.uk (I. Walker), John.Baxter@snh.gov.uk (J.M. Baxter), Jane.Dodd@snh.gov.uk (J. Dodd), Caroline.Warburton@stalliance.co.uk (C. Warburton).

adaptive management with the stakeholder power-sharing and conflict resolution of co-management (Olsson et al., 2004a; Folke et al., 2005; Armitage et al., 2007; Fabricius and Currie, 2015). Folke et al. (2002, p. 8) broadly define ACM as "a process by which institutional arrangements and ecological knowledge are tested and revised in a dynamic, ongoing, self-organized process of trial-and-error", which is known to evolve through stages (Olsson et al., 2004b; Berkes et al., 2007; Plummer and Baird, 2013).

One context where the utility of ACM has not been assessed is conservation conflict (Butler, 2011), which occurs when conservation interests wish to protect wildlife species that impact the livelihoods of others (Redpath et al., 2013). Examples include predation of livestock (e.g. Butler, 2000, Butler et al., 2014) or game (e.g. Graham et al., 2005; White et al., 2009) by protected predators, and retaliatory killing by the affected stakeholders. These conflicts are often intractable because actors' worldviews and values are polarised and have become entrenched (Young et al., 2010). Eliminating conflict permanently is unlikely, but reducing the negative impacts on species and stakeholders by finding compromises is sometimes feasible (Colyvan and Regan, 2011). Designing mechanisms that can achieve sustained conflict resolution is an evolving field of research (Dickman, 2010; Redpath et al., 2013). Early evidence suggests that keys to success are ongoing collaborative decision-making processes which involve all stakeholders equitably (Young et al., 2013a), trial innovative ideas, and include evaluation to provide learning (Walkerden, 2005; Redpath et al., 2013).

To understand the value of ACM for conservation conflict resolution requires systematic evaluation of case studies. Plummer and Armitage (2007) proposed a generic framework to evaluate ACM interventions based on outcome parameters. Armitage et al. (2009) also suggested 10 pre-conditions that must exist for successful ACM to be maintained. These approaches illustrate the necessity for measuring progress towards intended outcomes, plus assessing whether the outcomes have created pre-conditions for the collaborative process to continue (Innes and Booher, 1999; Berkes et al., 2007). While some methods have been designed to monitor components of ACM (e.g. Cundill and Fabricius, 2010; Smedstad and Gosnell, 2013; Fabricius and Currie, 2015), none have explicitly integrated the parameters developed by Plummer and Armitage (2007) and Armitage et al. (2009), nor calibrated them against successful ACM interventions (Plummer et al., 2012).

In this paper we investigate the characteristics of successful ACM in the context of a conservation conflict. We use a case study in Scotland, the Moray Firth Seal Management Plan (MFSMP), which was launched in 2005 as a pilot initiative to balance conflicting stakeholder interests in seal conservation and salmon fisheries (Butler et al., 2008). Following its perceived success, the model is being scaled-out through national legislation (The Scottish Government, 2014).

We had three research goals. First, we aimed to understand the evolution of ACM in the context of conservation conflict, and the factors that triggered the process. Second, we sought to identify the factors associated with the MFSMP's success in terms of Plummer and Armitage (2007) and Armitage et al.'s (2009) ACM parameter frameworks by calibrating them against the attainment of the MFSMP's objectives. Third, we aimed to develop and test a participatory method to integrate and implement the frameworks for the longitudinal evaluation of ACM. Informed by the results we present a generic indicator framework for evaluating pre-conditions and outcomes of ACM applied to conservation conflict resolution.

2. Study area

2.1. The Moray Firth and seal-salmon fishery conflict

The Moray Firth is a 5230 km^2 marine embayment in northeast Scotland (Fig. 1). Eighteen major rivers flow into the Firth which have historically supported an annual run of up to 270,000 adult Atlantic salmon (*Salmo salar*) (Fig. 2). At the time of the MFSMP's development there were 20 coastal salmon netting stations plus more than 100 in-river rod fisheries, managed by 12 statutory District Salmon Fishery Boards (DSFBs). Angling tourism is of high economic importance to the Moray Firth (Butler et al., 2009). The region is also a nationally important site for marine mammals. In the 1990s up to 1500 harbour seals (*Phoca vitulina*) were resident in the Firth, plus 900 grey seals (*Halichoerus grypus*) which are part of a larger North Sea population (Butler et al., 2008). Together with bottlenose dolphins (*Tursiops truncatus*), these species supported a small but expanding marine wildlife tourism industry (Hoyt, 2001).

Throughout Scotland marine survival rates of salmon declined from the mid-1980s to the early 2000s due to a number of pressures including climatic changes in their North Atlantic feeding grounds (Jonsson and Jonsson, 2004). This resulted in periods of low abundance in 1991−1992 and 1996−2003. Spring-running sub-populations declined most markedly (Butler et al., 2008). Harbour seal numbers also declined steeply over this period (Fig. 2).

There has been a long history of conflict between salmon fisheries and seals in Scotland. Seals prey on fish migrating into river estuaries and around coastal netting stations, interfering with fishing and reducing the numbers available for capture, resulting in demands from fishery stakeholders for seal culling (Moore, 2003). In the Moray Firth the economic impacts are small, but in 2005 the majority of fishery stakeholders still believed that seal culling was necessary (Butler et al., 2011). Fishermen and scientists' perceptions of the extent of seal predation on salmon are polarised (e.g. Graesser, 1991; Scottish Salmon Strategy Task Force, 1997; Middlemas et al., 2003, 2006).

Historically, under national legislation it has been legal for fishery managers to shoot seals to protect fisheries. Outside closed seasons covering pupping periods, when managers must apply to the government for licenses to kill seals, shooting was unrestricted and unreported. In the 1990s opposition to shooting from animal welfare groups intensified (e.g. Advocates for Animals, 2002), and the wildlife tourism industry was also promoting seal conservation (Young, 1998). The decline in salmon abundance during the 1990s prompted Moray Firth fisheries to intensify shooting, with up to 425 seals shot annually (Butler et al., 2008). Thompson et al. (2007) concluded that this could have caused the decline in harbour seals observed in 1992−2003 (Fig. 2).

2.2. The Moray Firth seal management plan

In 1992 the UK government adopted the European Union Habitats Directive, which aims to secure the favourable conservation status of listed species through the designation of Special Areas of Conservation (SACs). Atlantic salmon, harbour and grey seals are listed, and in 1999 salmon were included in SACs covering six Moray Firth rivers. In 2000 harbour seals were included in the Dornoch Firth SAC (Fig. 1). The designations presented an unprecedented challenge for seal and salmon management, because they imposed new statutory responsibilities on the government and DSFBs to ensure the favourable condition of the seal and salmon SACs, yet the protection of one species potentially impinged upon the status of the other. The situation was exacerbated in 2002 when an outbreak of Phocine Distemper Virus in Europe prompted the
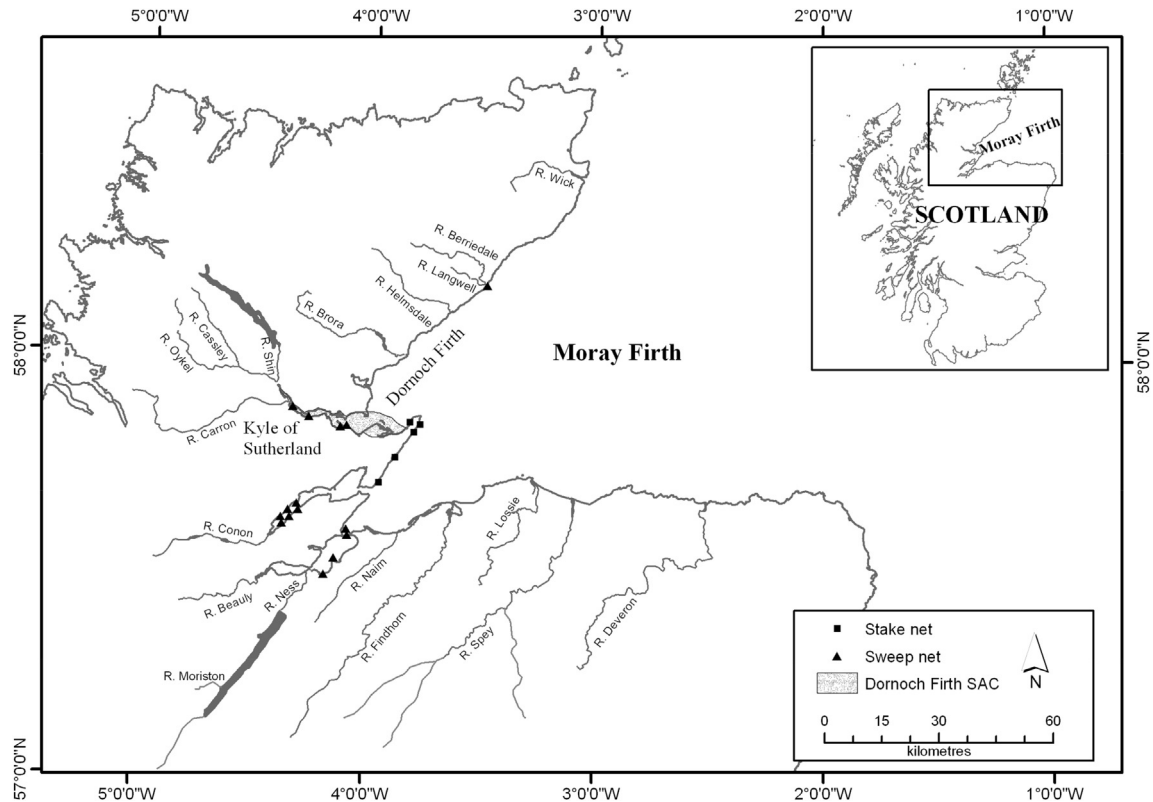
Fig. 1. The Moray Firth, showing the locations of salmon rivers, the Dornoch Firth Special Area of Conservation (SAC) and salmon netting stations.
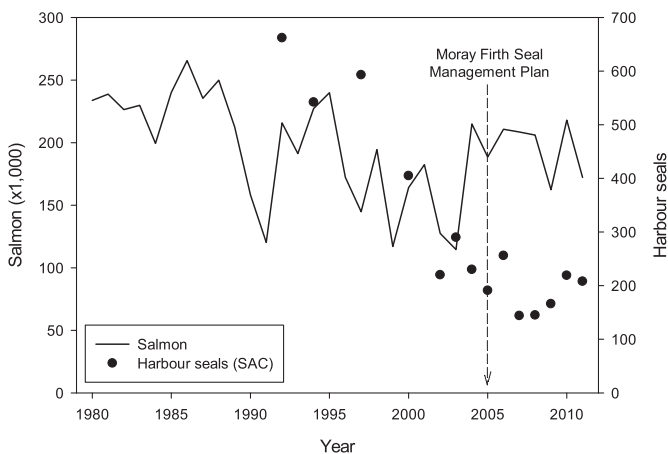

Fig. 2. Estimated numbers of wild adult salmon returning to Moray Firth rivers (1980—2011), relative to harbour seals counted in the Dornoch Firth Special Area of Conservation (SAC; 1992—2011) and the introduction of the MFSMP. Salmon abundance is estimated from Marine Scotland catch statistics following Butler (2004). Seal census data are from Duck et al. (2013).

government to introduce a permanent national close season ('Conservation Order') for seal shooting. In the Moray Firth, no licences were granted to DSFBs due to the government's concern about declining harbour seal numbers in the Dornoch Firth SAC.

In response, a DSFB executive convened meetings between the Moray Firth DSFBs and netsmen, who agreed to collectively negotiate with the government to develop an alternative management approach for seals and salmon. As a first step they provided historical seal-shooting records to the government to enable an assessment of shooting impacts on local seal populations. DSFBs

also engaged the wildlife tourism industry and other local stakeholders through the Moray Firth Partnership, an integrated coastal zone management group. National-level stakeholders were engaged through the Seals Working Group, a consultative forum established by the government in 2002.

Following three years of negotiation, the MFSMP was launched in 2005 with five objectives:

1. Restore and maintain the favourable conservation status of harbour seal and salmon SACs;
2. Reduce the impact of shooting on the harbour seal population;
3. Reduce the impact of seal predation on spring salmon, smolts and salmon fisheries;
4. Monitor and research the status of seal and salmon populations, and interactions between them;
5. Develop and implement non-lethal methods of managing seal predation on salmon.

Key facets were as follows (see Butler et al. (2008) for details):

- A Moray Firth-specific Conservation Order was introduced in 2004, maintaining the annual close season. Moray Firth DSFBs apply jointly for an annual licence to shoot a specified number of seals;
- In consultation with its advisory agencies, the government applies the Potential Biological Removal (PBR) method (Wade, 1998) to estimate the number of seals that can be removed without causing a population decline, based on annual censuses of Moray Firth seal populations;
- Fishery and tourism stakeholders agreed that only 'rogue' seals which enter river mouths and harass netting stations

should be shot. Management Areas were established which covered these zones but excluded seal haul out sites. These seals would be principally be targeted in January–June to protect spring-running adult salmon and emigrating juvenile salmon smolts;

- Marksmen were nominated and trained in firearms safety, public relations, seal identification and retrieval of shot carcasses for research;
- A research program was funded by the government in 2005–2010, involving collaboration between government science agencies, universities and fishery stakeholders. Research investigated the efficacy of acoustic deterrent devices (ADDs) as a non-lethal deterrent for rogue seals, and the impact of seal predation on fisheries.

The MFSMP was set within a multi-level governance framework (Fig. 3). The primary governance process is the DSFBs' annual licence application, including records of seals shot. This is reviewed by the government in consultation with its advisory agencies and the Seals Working Group. At the local level, DSFBs delegate an executive to coordinate licence applications, collate shooting data and liaise with the government.

3. Methods

3.1. Characterising the evolution of ACM

Our first research goal was to understand the evolution of ACM in the context of conservation conflict, and the factors that triggered the process. To achieve this, we qualitatively analysed key events in 2002–2005 relative to the three phases of ACM identified by Olsson et al. (2004b): Phase 1 'preparing the system for change', Phase 2 'the window of opportunity', and Phase 3 'building resilience of the desired state'. This was undertaken through content analysis of interview data published by Young (2010) from 20 stakeholders.

3.2. Identifying factors associated with success

Our second research goal was to identify the factors associated with the MFSMP's success.

3.2.1. Progress towards objectives

To most clearly identify parameters associated with effective ACM, it is important to calibrate them against empirical evidence of the attainment of an intervention's objectives (Plummer et al., 2012). Hence, to assess the MFSMP's progress, in 2011 we reviewed available condition reports for the SACs, results from the research program, licence applications, shooting records, seal census and salmon catch data.

3.2.2. Outcome parameters

To identify the parameters linked to the MFSMP's progress, we applied Plummer and Armitage's (2007) outcome evaluation framework. This proposes outcome parameters to be measured within three components: ecosystem condition (incorporating slow and fast variables that determine the state of the social-ecological system), sustainable livelihoods (incorporating sustainable resource use, institutions, power, vulnerability and adaptive capacity), and process (incorporating pluralism and linkages, communication and negotiation, trans-active decision-making and learning). The components are combined to create 20 overlapping parameters across three scales (Table 1): first order (tangible and intangible accruing from the intervention), second order (accruing outside the intervention's problem domain) and third order (latent outcomes manifesting after the intervention's completion).

3.2.3. Trends in pre-conditions

To analyse the strength of pre-conditions necessary for the maintenance of ACM, and to assess whether these had altered over time, we applied Armitage et al.'s (2009) 10 parameters. To identify how these pre-conditions had changed, we evaluated the parameters retrospectively for 2005 (when the MFSMP was launched),
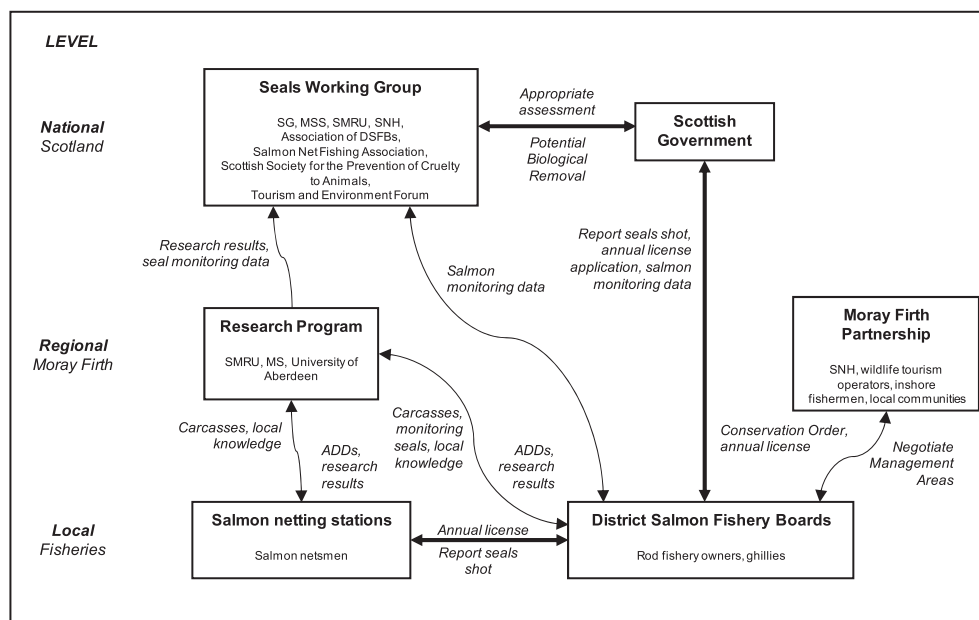

Fig. 3. The MFSMP's governance framework and stakeholders' levels and linkages. Thicker lines represent the primary governance processes. Abbreviations are: SG Scottish Government; MSS Marine Scotland Science; SMRU Sea Mammal Research Unit; SNH Scottish Natural Heritage; DSFB District Salmon Fishery Board; ADD acoustic deterrent device.

Table 1
Plummer and Armitage's (2007) ACM outcome parameters showing their groups and components (E ecosystem condition; L sustainable livelihoods; P process), and summaries of interviewees' explanatory statements for their scores (see Fig. 5). Duplicated statements are listed only once.

Parameter		Component	Summaries of statements
First order, tangible (from the initiative)	1. Resource management plans	E, L	Production of MFSMP; integration of MFSMP measures into DSFB management plans
	2. Conflict resolution regarding resource	P	Fishery and conservation stakeholders have accepted compromise; shooting transparency
	3. Codified statement of action	P	Clear objectives for all parties; clear actions on numbers and locations for shooting
	4. Agreed upon sanctions	P	Conservation Order provided the option for withdrawing licences as a sanction
	5. New institutional arrangements	P, L	MFSMP a new arrangement; it precipitated the Marine (Scotland) Act and national approach
First order, intangible (from the initiative)	6. Legitimisation of policies and actions	P	Licensed shooting and marksmen legitimise MFSMP and government; respect for PBR
	7. Greater adaptive capacity	L	DSFBs accept that seal-salmon interactions are more complex; PBR is an adaptive tool
	8. Social and human capital	L	Greater collaboration and trust amongst fisheries and scientists; training of marksmen
	9. Creative ideas for problem solving	P	Annual PBR and licences for DSFBs and nets; regional-scale coordination; ADDs
	10. Questioning of routines, values and	P	Challenged fishery pre-conceptions of seal predation; forced stakeholders to see others' governance perspectives
Second order (outside the initiative)	1. New co-operation beyond problem	P	DSFB and government sawbill duck plan discussions; Moray Firth Sea Trout Project 2008
	2. Engagement and learning across scales	P	Scaling-out of MFSMP model through Marine (Scotland) Act; learning among stakeholders
	3. Changes in perceptions and actions	P	Fisheries see seal predation and conservation differently; MFSMP influenced national policy
	4. Efficiency responding to other issues	P	Stakeholders' ability to respond to distemper and sawbill duck issues enhanced
	5. Addressing other issues within the problem	P	Marine (Scotland) Act implemented; brought salmon farming industry into seal management
Third order (evident subsequently)	1. Local learning to live with uncertainty	L	DSFBs more adaptive (catch and release, reviewing hatcheries, habitat improvement)
	2. Local self-organization matching scales	L	DSFBs improving application of science and regional coordination
	3. Empowerment of broader community	L	Fishery stakeholders engaged in seal monitoring and fisheries research; Moray Firth Partnership and community not well engaged
	4. Ongoing co-operative approaches	P	DSFB and government sawbill duck management; anglers involved in management
	5. New institutions codified in law	P, L	Moray Firth Conservation Order and Marine (Scotland) Act

and in 2011.

3.2.4. Stakeholder interviews and data analysis

Our third goal was to develop and test a participatory method to operationalise Plummer and Armitage's (2007) and Armitage et al.'s (2009) parameter frameworks. In September–October 2011 the first and second authors carried out structured interviews with seven stakeholders from government, government agencies, salmon fisheries and wildlife tourism. These were selected because they had been involved in the design and implementation of the MFSMP since 2005, and therefore had the greatest longitudinal knowledge of its evolution.

Interviews were carried out individually. To counter 'memory distortion' (Wiek et al., 2014), the MFSMP's genesis and evolution was reviewed at the interview's start. In each interview, Plummer and Armitage's (2007) 20 parameters were posed sequentially as propositions (Appendix 1), and the interviewee was asked to respond on a 5-point Likert scale of 'strongly agree' (2), 'agree' (1), 'maybe' (0), 'disagree' (−1), and 'strongly disagree' (−2). For each score the interviewee was asked to provide an explanatory statement for their score. Armitage et al.'s (2009) 10 pre-condition parameters were then also posed as propositions (Appendix 1), and scored from 'weak' (1) to 'very strong' (5) for 2005 and then 2011. Explanatory statements were also requested for each score.

Interviews took 1–2 h. Interviewee's scores and summaries of their statements were typed directly into a pre-prepared spreadsheet on a laptop. To mitigate 'response style bias', the seven Likert scores given for each parameter were later averaged to standardise responses (van Vaerenbergh and Thomas, 2013). Also, for Plummer and Armitage's (2007) first, second and third order outcome parameters, all scores in each group of parameters were averaged. This provided a more robust composite measure of outcomes in each parameter group (de Vaus, 2002).

4. Results

4.1. Characterising the evolution of ACM

The evolution of ACM in 2002–2005 matched the three phases identified by Olsson et al. (2004b):

- Phase 1 Preparing the system for change: triggered by a resource crisis, or an exogenous shock, leadership emerges amongst local resource stewards. These 'policy entrepreneurs' build ecological knowledge of the problem, develop bridging social networks between stakeholders from different levels, and provide a vision and goal for an alternative pathway (Olsson et al., 2004b). In the Moray Firth this phase was triggered by the designation of seal and salmon SACs, which altered the statutory remits of government and DSFBs. Combined with a growing wildlife tourism industry, opposition to seal shooting, the potential distemper epidemic and declines in harbour seal and salmon abundance, DSFBs were forced to collaborate and compromise with the government, which maintained control by withholding licences under the national Conservation Order. The role of policy entrepreneur was taken by a DSFB executive, who brokered collaboration among the fishery stakeholders, and engaged with

the government to discuss alternative options based on a Moray Firth-specific Conservation Order and Management Areas. He also established trust by negotiating the provision of seal shooting records to the government. In turn, government officials were willing to experiment and champion the alternative approach.

- Phase 2 The window of opportunity: in this phase policy entrepreneurs exploit policy windows at higher political levels to enact the alternative management agreed in Phase 1 (Olsson et al., 2004b). In the Moray Firth, the window was the expiry of the national Conservation Order in 2004, and the opportunity to introduce a Moray Firth-specific Order. The formation of the Moray Firth Partnership and the Seals Working Group also provided a forum for DSFBs to legitimise the seal-salmon fishery conflict and broker support amongst regional and national stakeholders.
- Phase 3 Building resilience of the desired state: following Phases 1 and 2, a 'policy community' is formed. This consists of social networks and alliances between stakeholders with common interests that arise during the window of opportunity, who act to re-build resilience of the social-ecological system's desired state (Olsson et al., 2004b). The introduction of the MFSMP represented the culmination of partnership and trust-building between the DSFBs, netsmen and other local, regional and national stakeholders. The initiation of the research program also required scientists and fishery stakeholders to co-design investigations into seal-salmon interactions and ADDs.

The resulting governance framework (Fig. 3) also reflects attributes of ACM. From the adaptive perspective it involves an annual cycle of licence application and reporting by DSFBs, appropriate assessment and licensing based on annual seal censuses and the PBR method, augmented by the research program's results. Co-management is evident in the negotiations between DSFBs and the government over annual licences, the cross-level linkages and networks between stakeholders, and the multi-stakeholder forum provided by the Seals Working Group. Knowledge integration and learning is evident in the training of marksmen and the research program, which draw on science and fishery stakeholders' knowledge.

4.2. Identifying factors associated with success

4.2.1. Progress towards objectives

- Objective 1 Restore and maintain the favourable conservation status of harbour seal and salmon SACs: in 2003–2004 the government carried out condition assessments for the salmon SACs, and all were classified as 'unfavourable recovering'. In 2009 harbour seals in the Dornoch Firth SAC were assessed, and also classified as 'unfavourable recovering'. In 2011 all of these sites were re-assessed, and all but one was judged to be improving or recovered.
- Objective 2 Reduce the impact of shooting on the harbour seal population: licences for harbour and grey seals varied according to annual census data, and as a precautionary measure were set below the PBR (Fig. 4). Numbers of seals shot never exceeded the licences, and in 2005–2011 declined from 47 to 6 harbour seals, and 46 to 16 grey seals.
- Objective 3 Reduce the impact of seal predation on spring salmon, smolts and salmon fisheries: monthly details of seals shot were only available for 2005, 2006 and 2011. Overall, 43% of seals were shot during January–June, but it was impossible to
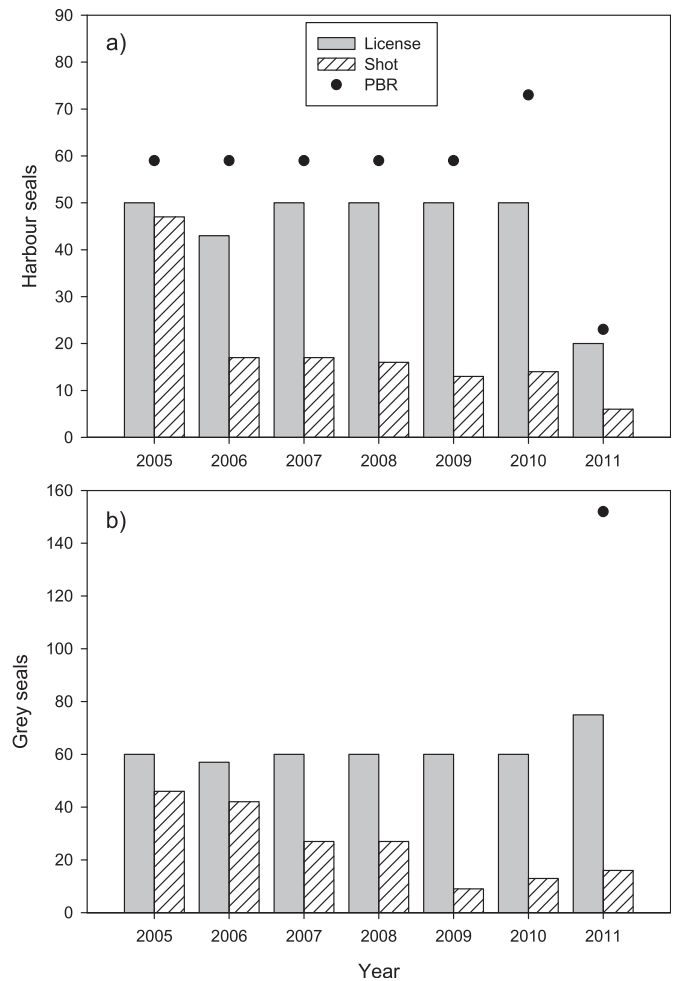

Fig. 4. The annual Potential Biological Removal (PBR), numbers licensed and recorded shot for a) harbour seals and b) grey seals in the Moray Firth, 2005–2011. PBRs were not calculated for grey seals in 2005–2010.

assess the benefits for spring salmon, smolts or fisheries due the lack of appropriate information.

- Objective 4 Monitor and research the status of seal and salmon populations, and interactions between them: harbour seal numbers recovered in the Dornoch Firth SAC in 2006, but the population has not subsequently returned to levels of the early 1990s. Annual salmon runs recovered in 2006–2011 to levels similar to the mid-1990s (Fig. 2), reflecting a period of improved marine survival (Marine Scotland, 2013). Monitoring of seal abundance in rivers showed that the highest numbers occurred during the winter and early spring (Graham et al., 2011a), confirming modelling that spring salmon are most likely to be impacted by predation (Butler et al., 2006). Photo-identification and telemetry demonstrated that some individual seals specialize in using rivers (Graham et al., 2011a, b). Samples collected from seals shot in rivers showed that these individuals were more likely to consume salmonids than seals hauling out at coastal sites (Graham et al., 2011b). Together the results justified the targeting of rogue seals in Management Areas (Graham and Harris, 2010).
- Objective 5 Develop and implement non-lethal methods of managing seal predation on salmon: one ADD was trialled successfully in a river mouth in 2007–2008, where it reduced upstream seal movement by 50% (Graham et al., 2009). Another was tested at a netting station in 2009–2010 with some success
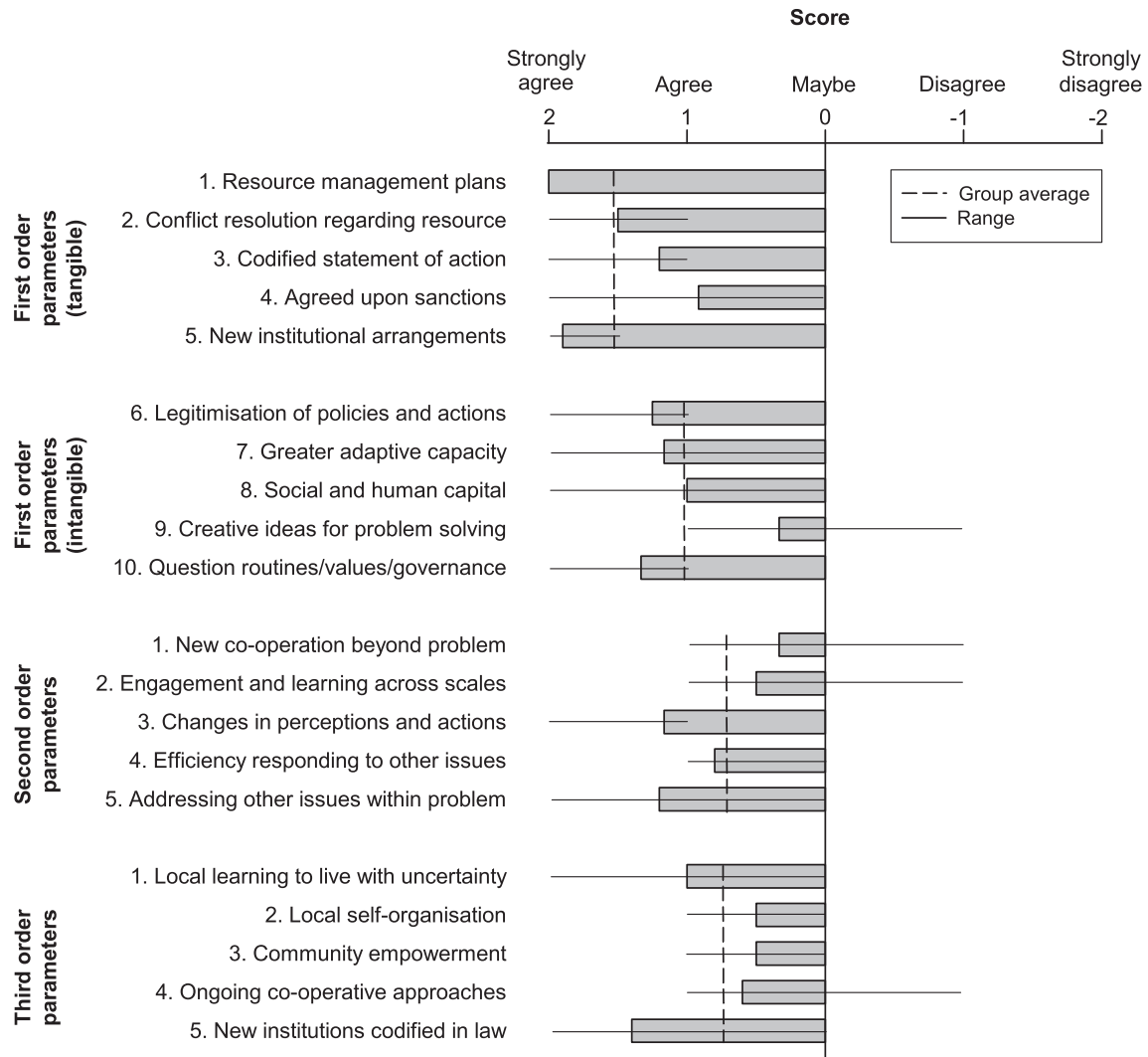
Fig. 5. Average scores and ranges given by interviewees for Plummer and Armitage's (2007) ACM outcome parameters (n = 7 scores for each parameter), and averages across the groups of tangible first order, intangible first order, second and third order parameters (n = 35 scores for each group). See Table 1 for summaries of interviewees' explanatory statements.

(Harris et al., 2014). ADDs have not been more widely adopted due to cost and operational difficulties.

4.2.2. Outcome parameters

The average scores of all parameters were positive, indicating that all ACM outcomes were evident (Fig. 5). As a group, the tangible first order parameters scored highest, followed by intangible first order parameters, indicating that the strongest outcomes had accrued directly from the MFSMP. Averages for the second and third order parameter groups were lower but similar, indicating weaker outcomes outside and subsequent to the MFSMP's introduction.

The highest scoring parameter was 'resource management plans' (Fig. 5). Interviewees' explanations showed that this was related to the production of the MFSMP, and also integration of its measures into local DSFB fishery management plans (Table 1). The second was 'new institutional arrangements', which related to the MFSMP and the national scaling-out of the approach under the Marine (Scotland) Act in 2011. Third was 'conflict resolution regarding the resource', due to the transparency of shooting arrangements and a compromise being reached by all stakeholders.

Fourth was 'new institutions codified in law', which related to the Moray Firth-specific Conservation Order and the Marine (Scotland) Act. Fifth was 'questioning routines, values and governance', which reflected the adjustment of fishery stakeholders' pre-conceptions about the impact of seal predation and appreciation of each others' perspectives. Four of these parameters were from the process component of Plummer and Armitage's (2007) framework (Table 1).

The lowest score was for 'creative ideas for problem solving', with some interviewees disagreeing that this had occurred (Fig. 5). Although the annual PBR, licensing and regional-scale coordination was innovative, ADDs had been trialled but not widely adopted (Table 1). Another weak outcome was 'new cooperation among stakeholders' outside the seal-salmon conflict, despite some collaboration between DSFBs and government in managing another conservation conflict, predation of juvenile salmon by protected sawbill ducks. 'Engagement and learning across scales' and 'ongoing co-operative approaches' were also weak.

4.2.3. Trends in pre-conditions

The first four pre-conditions suggested by Armitage et al. (2009) are a well-defined natural resource system, small scale resource

use, an identifiable set of social entities with shared interests, and clear property rights to the resources. Interviewees considered that the resources were only moderately well-defined because although harbour seals are largely resident in the Moray Firth, the ranges of grey seals and salmon extend over the North Sea and North Atlantic, respectively. Resource use, stakeholders and resource property rights were clear. Interviewees considered that these characteristics had not altered between 2005 and 2011.

Hence we only show the results for the remaining six parameters (Fig. 6, Table 2). With the exception of 'an adaptable portfolio of management measures', whose score had increased due to the introduction of the variable annual licence, PBR and ADDs, all others had declined. The highest scoring parameter, 'leaders prepared to champion the process', had fallen from very strong to medium because government leadership had diverted their attention to scaling-out the model through the Marine (Scotland) Act, and perceptions that the MFSMP had become successfully established. One interviewee stated that the MFSMP had become "part of the furniture now". 'Commitment to a long term institution-building process' and a 'policy environment supportive of collaborative management' had also declined from strong positions for similar reasons. Government interviewees noted that in 2005 "there was a desire to try and be supportive and to collaborate", and the MFSMP "was quite risky and could have gone pear-shaped". Interviewees also mentioned that the Seals Working Group had not met since 2009, and the Moray Firth Partnership was no longer engaged with the MFSMP.

'Drawing on a plurality of knowledge' had declined because of declining interest amongst stakeholders and falling numbers of stakeholders actively engaged in the process. One interviewee remarked that in 2011 "it is mainly expert knowledge and there's not a lot of openness". Provision of training, capacity building and resources had also declined slightly because since 2005 there had been no further training of marksmen or other events, and the research program had concluded in 2010 when funding ended.

5. Discussion

5.1. Characterising the evolution of ACM

Unlike ACM processes that have been intentionally engineered

(e.g. Cundill and Fabricius, 2010; Smedstad and Gosnell, 2013), the MFSMP evolved organically, as have governance transformations in the Kristianstads wetlands (Olsson et al., 2004b) and the Great Barrier Reef (Olsson et al., 2008). Olsson et al. (2004a, 2006) suggest that the process is an emergent property within social-ecological systems in response to shocks, or when slow variables approach thresholds that can alter the system's state. Plummer (2009) proposes a range of exogenous factors that may trigger ACM, including resource crises, changing legal mandates, or alterations in the socio-political context. In the Moray Firth, two exogenous shocks were instrumental: the introduction of SACs, which altered stakeholders' legal responsibilities, and the distemper outbreak that precipitated the 2002 national Conservation Order. Trends in two slow variables, the abundance of harbour seals and salmon, also reached critically low levels in the late 1990s, constituting a resource crisis. The growing public support for seal conservation driven by wildlife tourism and the animal welfare lobby's opposition to seal shooting was another important slow variable.

The resulting development and implementation of the MFSMP matched the three phases identified by Olsson et al. (2004b). Phase 1 was characterised by the leadership and vision provided by a DSFB executive who brokered collaboration and trust amongst all stakeholders, and developed an alternative pathway for managing seal and salmon conflict. This was a compromise, allowing limited seal shooting under mutually agreed conditions. In Phase 2 the DSFB executive exploited the opportunity to establish a new Moray Firth-specific Conservation Order, and engaged with the Moray Firth Partnership and the Seals Working Group to legitimise the proposal. In Phase 3 a policy community was formed and the MFSMP was launched, including cross-level linkages between multiple stakeholders that were reflected in the MFSMP's governance structure.

Plummer (2009) identified the attributes of individuals and organisations and the properties of social networks as factors that enable ACM. In the Moray Firth these were all evident. Leadership amongst local resource managers (i.e. DSFBs) was critical, and bridging networks created amongst other fishery stakeholders and government were instrumental. The willingness of government stakeholders to experiment with the suggested alternative approach was equally important.

Hence the determinants of the MFSMP's evolution mirror those
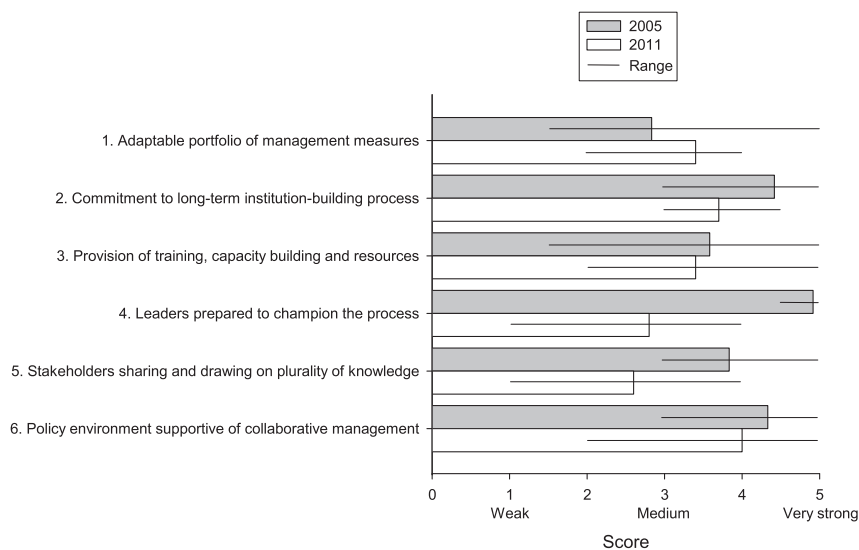

Fig. 6. Averages and ranges of interviewees' scores for Armitage et al.'s (2009) ACM pre-condition parameters in 2005 and 2011 (n = 7 scores for each parameter in each year). See Table 2 for summaries of interviewees' explanatory statements.

Table 2
Armitage et al.'s (2009) ACM pre-condition parameters, and summaries of interviewees' explanatory statements supporting their scores for each parameter for 2005 and 2011 (see Fig. 6). Duplicated statements are listed only once.

Indicator	2005	2011
1. Access to adaptable portfolio of management measures	Conservation Order was the only tool; shooting was the only option	Variable annual licence based on PBR; ADDs tested but they were designed for fish farms, not rivers; ADDs expensive, and energy source is a problem
2. Commitment to support a long term institution-building process	Key government players fully engaged through Seals Working Group; crisis engaged all stakeholders	Stakeholders less committed because MFSMP has been achieved; Marine (Scotland) Act has diverted attention to other areas; MFSMP is part of the furniture now; now it's long term, people are less committed; Seals Working Group hasn't met since 2009
3. Provision of training, capacity building and resources for local, regional, and national-level stakeholders	Training courses for marksmen; government funding for research; DSFB funding for local coordination	No training since 2005; government research funding stopped in 2010; resources generally more limited
4. Key leaders or individuals prepared to champion the process	Leadership from government and DSFBs; DSFBs convinced local fishery stakeholders and moved things forward	Only the DSFB coordinator: government less active; need to reengage with fisheries, local stakeholders and government leadership; because the MFSMP is succeeding there's less need for a champion
5. Openness of participants to share and draw upon a plurality of knowledge	Excellent example of fishermen, policy makers and scientists coming together; fishery stakeholders felt in control and everyone was working together	Less interest now because they know what they're doing; regular meetings needed to update all stakeholders on new developments; it is mainly expert knowledge and there's not a lot of openness
6. National and regional policy environment supportive of collaborative management	There was a desire to be supportive and collaborate; it was risky and could have gone pear-shaped; national government support but they left participants to get on with the MFSMP	It's now top-down; need to get together and discuss progress; the new legislation is clearer; processes are more transparent; decision-making is better and fairer; the Moray Firth Partnership is not engaged with the MFSMP as before

observed elsewhere. However, three features were distinctive. The first was the influence of changing legal mandates and structures. The designation of SACs was a key trigger, and the expiry of the national Conservation Order in 2004 provided an opportunity to introduce a Moray Firth-specific Conservation Order, which formed the legal framework and legitimacy for the alternative governance model. The second was the role of government power. Although the evolution of the MFSMP was initially bottom-up, fishery stakeholders were forced to negotiate because the government had effectively banned seal shooting in 2002. The third was a mutual acceptance of compromise. Fishery stakeholders accepted that only small numbers of rogue seals could be targeted, and conservation interests agreed that some seal shooting was necessary to protect fisheries. Hence in situations of entrenched conservation conflict these may be important pre-requisites for the emergence of ACM.

5.2. Identifying factors associated with success

Having reached Phase 3, substantial progress has been made towards three of the MFSMP's five objectives. Since 2005 the conservation status of all SACs has improved, and harbour seal shooting has been significantly reduced. Consistent monitoring of harbour and grey seals has been established, providing current data for the annual calculation of PBRs and licences, and allowing a flexible response to fluctuations in seal numbers. The identification of rogue seals was an important discovery, justifying the targeted shooting of small numbers in Management Areas. Less progress was made for two objectives. Seal shooting in Management Areas during January–June may have reduced predation on spring salmon and smolts, but evaluating this was impossible due to the lack of necessary information. Also, ADDs were successfully trialled but their adoption has been limited.

Stakeholders' evaluations using Plummer and Armitage's (2007) framework suggested that five parameters are primarily associated with this success. Most important was the production of the MFSMP itself. Following this were four process parameters: new

institutional arrangements, conflict resolution, new institutions codified in law, and the questioning of routines, values and governance. The latter underpinned conflict resolution, because fishery stakeholders' had re-considered their pre-conceptions about the extent of seal predation on salmon, and all stakeholders had reached a compromise. Because only seven stakeholders were interviewed, the average scores may not provide a robust indication of differences between parameters. However, the group averages provided a more reliable indication that the tangible first order parameters were most closely associated with the MFSMP's success, including all of those listed above with the exception of new institutions codified in law.

Interviewees' scoring of Armitage et al.'s (2009) pre-condition parameters also highlighted factors associated with success, but with the same caveat regarding averages. Highly-scored parameters at the MFSMP's introduction in 2005 were strong support from government and DSFB leaders who championed the process, plus the commitment of these stakeholders to long term institution building, and a policy environment which was supportive of collaborative management. The sharing of a plurality of knowledge by stakeholders was also strong, plus the provision of training and capacity building. However, by 2011 these pre-conditions had declined in strength because the MFSMP had been successfully established, and government stakeholders had diverted attention to scaling-out the model through the Marine (Scotland) Act. Sharing of knowledge had also declined and become focused on expert opinion. The only pre-condition which had strengthened was the portfolio of management measures.

These results provide interesting insights into how ACM can evolve after its establishment. Many published analyses examine the process up to Phase 3, referred to as 'building the resilience of the desired state' by Olsson et al. (2004b). In this case we were able to track ACM's trajectory up to and beyond Phase 3, covering 10 years from 2002 to 2011. This can be visualised in terms of three dimensions (Fig. 7): adaptive management, occurring along a spectrum from rigid to reflexive learning; co-management,
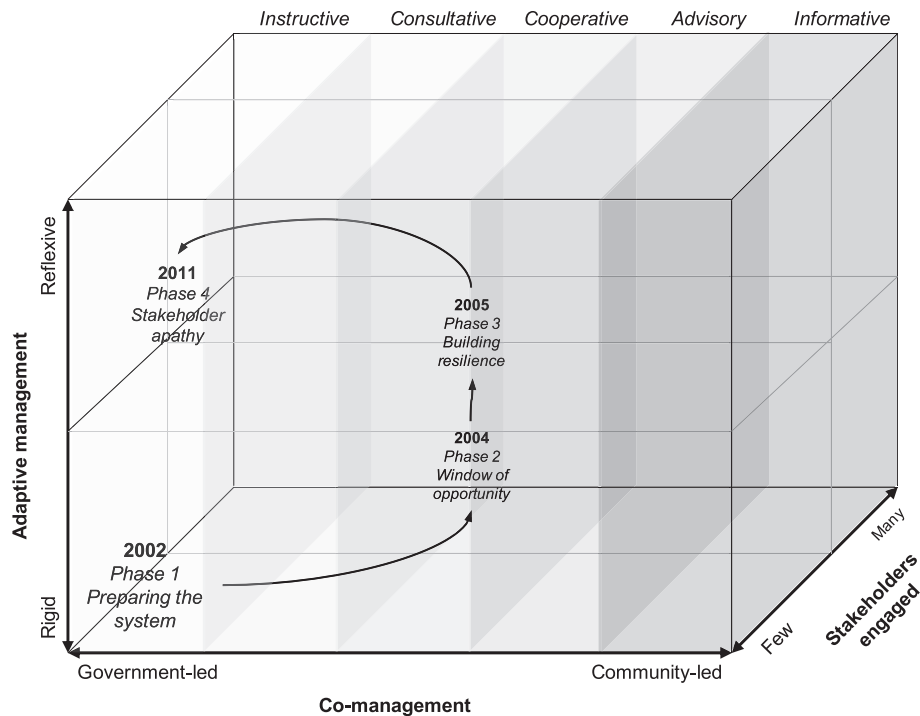
Fig. 7. ACM's trajectory in the Moray Firth in 2002–2011 in terms of the dimensions of adaptive management, co-management types, and numbers of stakeholders engaged. Olsson et al.'s (2004b) three phases are illustrated, plus the fourth phase of 'stakeholder apathy'.

occurring across a range from government-led (top-down or 'instructive') to community-led (bottom-up or 'informative'; Pomeroy and Rivera-Guieb, 2006); and the number of stakeholders actively engaged in the process. Phase 1 and Phase 2 occurred in 2002–2004, when the negotiation of the MFSMP shifted the trajectory significantly from 'instructive' to 'cooperative' co-management, and increased learning enhanced the reflexivity of adaptive management. The numbers of stakeholders engaged also peaked. Since the introduction of the MFSMP and Phase 3 in 2005, learning has grown cumulatively, but declining government support, plus the lack of cross-level dialogue, knowledge exchange and decision-making has allowed co-management to revert towards the 'instructive' type. Simultaneously, the numbers of stakeholders engaged has declined as interest has waned. Hence we suggest that ACM has entered a fourth phase of 'stakeholder apathy', which although still achieving many of the MFSMP's objectives, may result in the re-emergence of conflict and a loss of system resilience.

The interviews prompted some respondents to suggest remedial actions. First, government leadership should reengage with local fishery stakeholders to revive power-sharing and dialogue across levels. In particular, the Seals Working Group should be reconvened to maintain a national consultative forum for stakeholders, and local MFSMP stakeholders should re-engage with the Moray Firth Partnership. Second, there is a need to re-invest in capacity building and learning, including research and monitoring. Third, the sharing of information has contracted, and regular multi-stakeholder meetings are necessary to encourage knowledge exchange.

5.3. Participatory evaluation method

If undertaken with stakeholders evaluation can contribute to the reflection and learning aspects of ACM, fuelling the process (Cundill and Fabricius, 2009; Fabricius and Currie, 2015). However, indicators and data collection methods must be developed which are appropriate and understandable to all participants. Plummer and

Armitage's (2007) framework has been criticised for not being practicable (Cundill and Fabricius, 2009), and few studies have attempted to adapt it for real-world assessments (Cundill and Fabricius, 2010; Smedstad and Gosnell, 2013).

Our approach operationalised and integrated Plummer and Armitage (2007) and Armitage et al.'s (2009) frameworks into a simple, replicable method. Testing it highlighted three issues worth future consideration. First, although the interviewees had long been associated with the MFSMP, the professional roles of two had changed, hindering their ability to answer some questions confidently. This presents an obstacle to maintaining consistency in longitudinal evaluation. Second, evaluation could be undertaken as a group exercise to encourage social learning and reflection amongst stakeholders, particularly those whose livelihoods are most impacted by the conflict. Following Cundill and Fabricius (2010), focus groups could be used to discuss and score parameters, but in situations of acute conflict this may not be feasible. Third, the costs of long term evaluation should not be underestimated (Cundill and Fabricius, 2009), and must be accounted for in the funding of ACM processes.

5.4. Indicator framework for conservation conflict resolution

Based on the outcome and pre-condition parameters associated with the MFSMP's success, plus those factors which interviewees suggested should be rectified, we suggest an indicator framework for the ongoing evaluation of ACM applied to conservation conflict (Table 3). These are augmented with indicators specific to conflict resolution drawn from the literature. Indicators are intended to overlap and provide triangulation, as recommended by de Vaus (2002) and Plummer and Armitage (2007).

For outcomes we include the important process parameters identified by interviewees: new institutional arrangements, new institutions codified in law, and questioning routines, values and governance. We refine the conflict resolution process parameter by splitting it into two indicators: an outcome acceptable to all parties,

Table 3
An indicator framework for evaluating outcomes and pre-conditions for ACM addressing conservation conflict, and their related components from Plummer and Armitage (2007) and Armitage et al. (2009). Additions from the conflict resolution literature are italicised.

Indicator	Component	Source
A. Outcomes		
1. New institutional arrangements	Process and livelihoods − institutions	Plummer and Armitage, 2007
2. New institutions codified in law	Process and livelihoods − institutions	Plummer and Armitage, 2007
3. Questioning of routines, values and governance	Process − learning, conflict resolution	Plummer and Armitage, 2007
4. Legitimisation of policies and actions	Process − decision-making	Plummer and Armitage, 2007
5. Agreed upon sanctions	Process − decision-making	Plummer and Armitage, 2007
6. Outcome acceptable to all parties	Process − conflict resolution	Redpath et al., 2013
7. No party asserting its interests to the detriment of others	Process − conflict resolution	Redpath et al., 2013
8. Creative ideas for problem-solving	Process − learning, conflict resolution	Plummer and Armitage, 2007
9. Engagement and learning across scales	Process − learning, pluralism and linkages	Plummer and Armitage, 2007
10. Changes in perceptions and actions	Process − learning	Plummer and Armitage, 2007
11. Resource management plan	Ecosystem condition and livelihoods	Plummer and Armitage, 2007
12. Acceptable conservation status of all contested species	Ecosystem condition	Plummer and Armitage, 2007
B. Pre-conditions		
1. Adaptable portfolio of management resources	Learning through complexity	Armitage et al., 2009
2. Commitment to long-term institution building	Institutions, incentives and governance	Armitage et al., 2009
3. Provision of training and capacity building	Learning through complexity	Armitage et al., 2009
4. Leaders prepared to champion the process	Institutions, incentives and governance	Armitage et al., 2009
5. Stakeholders drawing on and sharing diverse knowledge	Learning through complexity	Armitage et al., 2009
6. Supportive policy environment	Linking to policy	Armitage et al., 2009
7. Formal and regular evaluation of outcomes and conditions as a stakeholder learning process	Assessment and monitoring	Armitage et al., 2009; Cundill and Fabricius, 2009
8. Quality of information and resources	Learning through complexity	Emerson et al., 2009
9. Transparency of stakeholders' goals and values	Power dynamics, conflict resolution	Adams et al., 2003; Salafsky, 2011
10. Trust amongst stakeholders	Power dynamics, conflict resolution	Ansell and Gash, 2008; Redpath et al., 2013
11. Presence of a bridging organisation or individual	Institutions, incentives and governance	Folke et al., 2005; Walkerden, 2005; Berkes, 2009
12. Participation of all impacted stakeholders	Power dynamics, conflict resolution	Ansell and Gash, 2008; Treves et al., 2009

and no party asserting its interests to the detriment of others. These reflect the need to identify whether a compromise has been reached, and to consider power dynamics amongst stakeholders (Redpath et al., 2013), which are often overlooked but influential in ACM (Nadasdy, 2007). The existence of a management plan was also highly important in the Moray Firth. Also under the ecosystem condition component we add an assessment of the conservation status of all contested species. In the Moray Firth, harbour seal and salmon abundance were important slow variables, and their declines were partly responsible for triggering ACM.

For pre-condition parameters, we include the six from Armitage et al. (2009) that were evaluated. To emphasise conflict resolution we add five additional indicators. Quality of information and resources available to stakeholders are critical in assisting dialogue and balanced decision-making (Emerson et al., 2009), and this was evident in the Moray Firth. Transparency of stakeholders' goals and values is a key element of power dynamics and should be made explicit to foster collaboration (Adams et al., 2003; Salafsky, 2011). Trust among stakeholders is fundamental (Ansell and Gash, 2008), as was apparent in the Moray Firth. The presence of a bridging organisation or individual has also been shown to assist in negotiating compromises (Walkerden, 2005; Butler et al., 2013), and is a recognised enabler of ACM (e.g. Folke et al., 2005; Berkes, 2009; Butler et al., 2013). Finally, participation of all impacted stakeholders is important to further tackle power asymmetries (Ansell and Gash, 2008; Treves et al., 2009). To these we add formal and regular evaluation as a multi-stakeholder learning process, recognising its important function in ACM (Cundill and Fabricius, 2009).

In addition, we recommend that Armitage et al.'s (2009) first four pre-condition parameters should not be ignored (i.e. a well-defined resource system, small scale resource use, an identifiable set of social entities with shared interests, and clear property rights to the resource). In the Moray Firth these conditions were only moderately satisfied due to the extensive ranges of grey seals and salmon, causing an imperfect match between the ecological and governance scales. Young et al. (2013b) also identified the

challenges of implementing community-based management at the 'meso-scale' due to the difficulty of maintaining networks and information flows among the numerous and dispersed stakeholders.

6. Conclusions

The MFSMP provided an opportunity to evaluate ACM in the novel context of conservation conflict resolution. Also, it was possible to calibrate ACM parameters against the attainment of objectives, which is necessary for effective evaluation (Plummer et al., 2012). While it evolved organically, the MFSMP's triggers and evolutionary phases corresponded with other published examples. However, distinctive factors were the importance of legal mandates and structures, the legal power held by government, and perhaps as a consequence, the willingness of all stakeholders to reach a compromise and experiment with an alternative approach. These lessons can inform the design of similar initiatives for resolving seal-salmon conflict in comparable social-ecological contexts, and also other conflict arenas such as wild carnivores preying on livestock (Butler et al., 2014).

Our study has implications for ACM and conflict resolution theory. Plummer (2009) identifies the need to understand which process parameters can be traded-off without undermining ACM. The results suggest that in situations of entrenched conservation conflict, leadership, cross-level social networks and policy windows remain key determinants which cannot be traded-off, but instead must be reinforced by legal mechanisms. Hence a strong and consistent government role is a necessity (Young et al., 2012), and consequently ACM is unlikely to progress towards a process driven entirely by local stakeholders. This raises an interesting question about the extent of power-sharing that is required to achieve conflict resolution. Also, as observed elsewhere (e.g. Cundill and Fabricius, 2010), the study highlights the need for long term government support. However, self-financing mechanisms based on local private resource users (e.g. DSFBs, tourism

operators) could be designed to augment public funding, providing a more consistent source of support.

Based on the ACM parameters and pre-conditions associated with the MFSMP's success, and augmented by a greater focus on conflict resolution, we have presented an indicator framework for further testing. This should be implemented in the MFSMP using our participatory evaluation approach to establish a long term evaluation program, and also in similar schemes being introduced in Scotland under the Marine (Scotland) Act. The framework is equally applicable to the longitudinal evaluation of conflict resolution initiatives more generally, which outwardly are not recognised as ACM but may share many of the same characteristics.

Acknowledgements

Appendix 1

Propositions posed to interviewees to elicit Likert scores and

Parameters	Proposition
A. Outcomes	
First order, tangible (from the initiative)	
1. Resource management plans	Resource management plans or agreements have been produced to address the conflict between [seal and salmon] stakeholders
2. Conflict resolution regarding the resource	Conflict between [seal and salmon] stakeholders has been resolved
3. Codified statements of action	Specific actions and objectives have been documented to address the conflict between [seal and salmon] stakeholders
4. Agreed upon sanctions	Agreed sanctions have been established to address infringements of rules by stakeholders
5. New institutional arrangements	Changes have been made to organisations, rules or usual practices regarding [seal and salmon] management
First order, intangible (from the initiative)	
6. Legitimisation of policies and actions	Government and other policies and actions relating to the [seal and salmon] conflict are regarded as more legitimate by stakeholders
7. Greater adaptive capacity	Stakeholders in the [salmon and seal] conflict have greater capacity to adapt to change and uncertainty
8. Social and human capital	Stakeholders in the [salmon and seal] conflict have developed leadership, trust, cooperation and social networks, plus new knowledge and skills
9. Creative ideas for problem solving	Creative and innovative ideas have been developed to solve the [seal and salmon] conflict
10. Questioning of routines, values, and governance underlying the problem	Stakeholders have reconsidered the underlying causes of the [seal and salmon] conflict, its complexity, and the way it is currently being thought about and managed
Second order (outside the initiative)	
1. New co-operation beyond the problem	New partnerships or projects have been designed or implemented by the stakeholders to deal with other issues beyond the [seal and salmon] conflict
2. Engagement and learning across scales	Stakeholders from different scales and levels (e.g. national government and local communities) involved in the [seal and salmon] conflict have become more engaged, and are exchanging information and learning from one another
3. Changes in perceptions and actions	Stakeholders in the [seal and salmon] conflict have changed their perceptions of the problem, and these are reflected in changes in their actions
4. Efficiency responding to other issues	Stakeholders in the [seal and salmon] conflict have gained greater ability to deal efficiently with other problems
5. Addressing other issues within the problem domain	Stakeholders in the [seal and salmon] conflict have co-operatively tackled other issues relating to [seal and salmon] management
Third order (evident subsequently)	
1. Local learning to live with uncertainty	Local stakeholders in the [seal and salmon] conflict are more able to cope with uncertainty
2. Local self-organisation matching scales	Local stakeholders in the [seal and salmon] conflict are more capable of self-organisation and matching their management to the ecological scale concerned
3. Empowerment of the broader community	Local community members who are directly affected by the [seal and salmon] conflict have become more empowered by the process
4. Ongoing co-operative approaches	Stakeholders in the [seal and salmon] conflict have continued to collaborate to address other local issues
5. New institutions codified in law	New institutions triggered by [seal and salmon] stakeholders have been established in law
Parameter	Proposition [a]
B. Pre-conditions [b]	
1. Access to adaptable portfolio of management measures	Stakeholders in the [seal and salmon] conflict have access to an adaptable portfolio of management measures to address the conflict
2. Commitment to support a long term institution-building process	Stakeholders in the [seal and salmon] conflict are committed to the process of establishing new management structures, rules and approaches to resolve the conflict
3. Provision of training, capacity-building and resources for local-, regional- and national-level stakeholders	Stakeholders in the [seal and salmon] conflict from all levels have opportunities for training, learning and skills-building
4. Key leaders or individuals prepared to champion the process	Leaders have emerged amongst the stakeholders in the [seal and salmon] conflict, and are prepared to champion the process
5. Openness of participants to share and draw upon a plurality of knowledge	Stakeholders in the [seal and salmon] conflict are willing to exchange information and accept their different kinds of knowledge
6. National and regional policy environment supportive of collaborative management	Government policies at the national and regional level are enabling collaborative management amongst the stakeholders in the [seal and salmon] conflict

[a] Each proposition was posed and a score recorded first for 2005, and then repeated for 2011.
[b] Armitage et al. (2009) also list four other pre-conditions: a well-defined natural resource system, small scale resource use, an identifiable set of social entities with shared interests, and clear property rights to the resources. Their utility for longitudinal evaluation is discussed in the paper.

explanatory statements, separated into outcome parameters (from Plummer and Armitage, 2007; see Table 1) and pre-condition parameters (from Armitage et al., 2009; see Table 2). For the outcome parameters, the 5-point Likert scale ranged from 'strongly agree' (2) to 'strongly disagree' (−2). For the pre-condition parameters, the scale ranged from 'weak' (1) to 'very strong' (5). Propositions are presented to assess conservation conflict between seal and salmon stakeholders, but these can be substituted with the species and stakeholders for the context concerned.

References

Adams, W.M., Brockington, D., Dyson, J., Vira, B., 2003. Managing tragedies: understanding conflict over common pool resources. Science 302, 1915–1916.

Advocates for Animals, 2002. A Seal's Fate: the Animal Welfare Implications of Shooting Seals in Scotland. Advocates for Animals, Edinburgh.

Ansell, C., Gash, A., 2008. Collaborative governance in theory and practice. J. Public Adm. Res. Theory 18, 543–571.

Armitage, D., Berkes, F., Doubleday, N. (Eds.), 2007. Adaptive Co-management: Collaboration, Learning, and Multi-level Governance. UBC Press, Vancouver.

Armitage, D., Plummer, R., Berkes, F., Arthur, R., Charles, A.T., Davidson-Hunt, I., Diduck, A.P., Doubleday, N.C., Johnson, D.S., Marschke, M., McCooney, P., Pinkerton, E.W., Wollenberg, E.K., 2009. Adaptive co-management for social-ecological complexity. Front. Ecol. Environ. 7, 95–102.

Berkes, F., 2009. Evolution of co-management: role of knowledge generation, bridging organisations and social learning. J. Environ. Manage 90, 1692–1702.

Berkes, F., Armitage, D., Doubleday, N., 2007. Synthesis: adapting, innovating, evolving. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), Adaptive Co-management: Collaboration, Learning, and Multi-level Governance. UBC Press, Vancouver, pp. 308–327.

Butler, J.R.A., 2000. The economic costs of wildlife predation on livestock in Gokwe communal Land, Zimbabwe. Afr. J. Ecol. 38, 23–30.

Butler, J.R.A., 2004. The Moray Firth Seal Management Plan: A Pilot Project for Managing Interactions between Seals and Salmon in Scotland. Spey District Salmon Fishery Board, Aberlour.

Butler, J.R.A., 2011. The challenge of knowledge integration in the adaptive co-management of conflicting ecosystem services provided by seals and salmon. Anim. Conserv. 14, 599–601.

Butler, J.R.A., Middlemas, S.J., Graham, I.M., Thompson, P.M., Armstrong, J.D., 2006. Modelling the impacts of removing seal predation from Atlantic salmon, *Salmo salar* L., rivers in Scotland: a tool for targeting conflict resolution. Fish. Manage. Ecol. 13, 285–291.

Butler, J.R.A., Middlemas, S.J., McKelvey, S.A., McMyn, I., Leyshon, B., Walker, I., Thompson, P.M., Boyd, I.L., Duck, C., Armstrong, J.D., Graham, I.M., Baxter, J.M., 2008. The Moray Firth seal management plan: an adaptive framework for balancing the conservation of seals, salmon, fisheries and wildlife tourism in the UK. Aquat. Conserv. Mar. Freshw. Ecosyst. 18, 1025–1038.

Butler, J.R.A., Radford, A., Riddington, G., Laughton, R.L., 2009. Evaluating an ecosystem service provided by Atlantic salmon, sea trout and other fish species in the River Spey, Scotland: the economic impact of recreational rod fisheries. Fish. Res. 96, 259–266.

Butler, J.R.A., Middlemas, S.J., Graham, I.M., Harris, R.N., 2011. Perceptions and costs of seal impacts on salmon and sea trout fisheries in the Moray Firth, Scotland: implications for the adaptive co-management of special areas of conservation. Mar. Policy 35, 317–323.

Butler, J.R.A., Gunn, R., Berry, H., Wagey, G.A., Hardesty, B.D., Wilcox, C., 2013. A value chain analysis of ghost nets in the Arafura Sea: identifying transboundary stakeholders, intervention points and livelihood trade-offs. J. Environ. Manage 3, 14–25.

Butler, J.R.A., Linnell, J.D.C., Morrant, D., Athreya, V., Lescureux, N., McKeown, A., 2014. Dog eat dog, cat eat dog: social-ecological dimensions of dog predation by wild carnivores. In: Gompper, M.E. (Ed.), Free-ranging Dogs and Wildlife Conservation. Oxford University Press, Oxford, pp. 117–143.

Colyvan, M.J., Regan, H.M., 2011. The conservation game. Biol. Conserv. 144, 1246–1253.

Cundill, G., Fabricius, C., 2009. Monitoring in adaptive co-management: toward a learning based approach. J. Environ. Manage 90, 3205–3211.

Cundill, G., Fabricius, C., 2010. Monitoring the governance dimension of natural resource co-management. Ecol. Soc. 15 (1), 15. http://www.ecologyandsociety.org/vol15/iss1/art15/.

De Vaus, D.A., 2002. Surveys in Social Research, fifth ed. Allen and Unwin.

Dickman, A.J., 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. Anim. Conserv. 13, 458–466.

Duck, C.D., Morris, C.D., Thompson, D., 2013. The status of British harbour seal populations in 2012. In: SCOS Briefing Paper 13/03 in Sea Mammal Research Unit Scientific Advice on Matters Related to the Management of Seal Populations: 2013. http://www.smru.st-and.ac.uk/documents/1619.pdf.

Emerson, K., Orr, P.J., Keyes, D.L., McKnight, K.M., 2009. Environmental conflict resolution: evaluating performance outcomes and contributing factors. Confl. Resolut. Quart. 27, 27–64.

Fabricius, C., Currie, B., 2015. Adaptive co-management. In: Allen, C.R., Garmestani, A.S. (Eds.), Adaptive Management of Social-ecological Systems. Springer Science+Business Media, Dordrecht, pp. 147–179.

Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., Walker, B., Bengtsson, J., Berkes, F., Colding, J., Danell, K., Falkenmark, M., Moberg, M., Gordon, L., Kasperson, R., Kautsky, N., Kinzig, A., Levin, S.A., Mäler, K.-G., Ohlsson, L., Olsson, P., Ostrom, E., Reid, W., Rockstöm, J., Savenije, S., Svedin, U., 2002. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. The Environmental Advisory Council to the Swedish, Stockholm. Government Scientific Background Paper.

Folke, C., Hahn, T., Olsson, P., Norberg, J., 2005. Adaptive governance of social-ecological systems. Annu. Rev. Environ. Res. 30, 441–473.

Graesser, N., 1991. Salmon. The Boydell Press, Woodbridge.

Graham, K., Beckerman, A.P., Thirgood, S., 2005. Human–predator–prey conflicts: ecological correlates, prey losses and patterns of management. Biol. Conserv. 122, 159–171.

Graham, I.M., Harris, R.N., Denny, B., Fowden, D., Pullan, D., 2009. Testing the effectiveness of an acoustic deterrent device for excluding seals from Atlantic salmon rivers in Scotland. ICES J. Mar. Sci. 66, 860–864.

Graham, I.M., Harris, R.N., 2010. Investigation of Interactions Between Seals and Salmon in Freshwater. Final Report. NERC Sea Mammal Research Unit, University of St. Andrews.

Graham, I.M., Harris, R.N., Matejusova, I., Middlemas, S.J., 2011a. Do 'rogue' seals exist? Implications for seal conservation in the UK. Anim. Conserv. 14, 1–12.

Graham, I.M., Harris, R.N., Middlemas, S.J., 2011b. Seals, salmon and stakeholders: integrating knowledge to reduce biodiversity conflict. Anim. Conserv. 14, 604–607.

Harris, R.N., Harris, C.M., Duck, C.D., Boyd, I.L., 2014. The effectiveness of a seal scarer at a wild salmon net fishery. ICES J. Mar. Sci. 71, 1913–1920.

Hoyt, E., 2001. Whale-watching 2001: Worldwide Tourism Numbers, Expenditures, and Expanding Socioeconomic Benefits. International Fund for Animal Welfare, Crowborough.

Innes, J.E., Booher, D.E., 1999. Consensus building and complex adaptive systems: a framework for evaluating collaborative planning. J. Amer. Plann. Assoc. 65, 412–423.

Jonsson, B., Jonsson, N., 2004. Factors affecting marine production of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. 61, 2369–2383.

Marine Scotland, 2013. Salmon Fishery Statistics – 2012 Season. Topic Sheet No. 68 V4 2013. http://www.scotland.gov.uk/Resource/0043/00434129.pdf. Accessed 12 July 2014.

Middlemas, S.J., Armstrong, J.D., Thompson, P.M., 2003. The significance of marine mammal predation on salmon and sea trout. In: Mills, D. (Ed.), Salmon at the Edge. Blackwell Science, Oxford, pp. 43–60.

Middlemas, S.J., Barton, T.R., Armstrong, J.D., Thompson, P.M., 2006. Functional and aggregative responses of harbour seal predation to changes in salmonid abundance. Proc. R. Soc. B 273, 193–198.

Moore, P.G., 2003. Seals and fisheries in the Clyde Sea area (Scotland): traditional knowledge informs science. Fish. Res. 63, 51–61.

Nadasdy, P., 2007. Adaptive co-management and the gospel of resilience. In: Armitage, D., Berkes, F., Doubleday, N. (Eds.), Adaptive Co-management: Collaboration, Learning, and Multi-level Governance. UBC Press, Vancouver, pp. 208–227.

Olsson, P., Folke, C., Berkes, F., 2004a. Adaptive co-management for building resilience in social-ecological systems. Environ. Manage 34, 75–90.

Olsson, P., Folke, C., Hahn, T., 2004b. Social-ecological transformation for ecosystem management: the development of adaptive co-management of a wetland landscape in southern Sweden. Ecol. Soc. 9 (4), 2. http://www.ecologyand.society.org/vol9/iss4/art2.

Olsson, P., Gunderson, L.H., Carpenter, S.R., Ryan, P., Lebel, L., Folke, C., Holling, C.S., 2006. Shooting the rapids: navigating transitions to adaptive governance of social-ecological systems. Ecol. Soc. 11 (1), 18. http://www.ecologyandsociety.org/vol11/iss1/art18/.

Olsson, P., Folke, C., Hughes, T., 2008. Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia. Proc. Natl. Acad. Sci. U. S. A. 105, 9489–9494.

Plummer, R., 2009. The adaptive co-management process: an initial synthesis of representative models and influential variables. Ecol. Soc. 14 (2), 24. http://www.ecologyandsociety.org/vol14/iss2/art24/.

Plummer, R., Armitage, D.R., 2007. A resilience-based framework for evaluating adaptive co-management: linking ecology, economics and society in a complex world. Ecol. Econ. 61, 62–74.

Plummer, R., Crona, B., Armitage, D.R., Olsson, P., Tengö, M., Yudina, O., 2012. Adaptive comanagement: a systematic review and analysis. Ecol. Soc. 17 (3), 11. http://dx.doi.org/10.5751/ES-04952-170311.

Plummer, R., Baird, J., 2013. Adaptive co-management for climate change adaptation: considerations for the Barents Region. Sustainability 5, 629–642.

Pomeroy, R., Rivera-Guieb, R., 2006. Fishery Co-management: a Practical Handbook. CABI Publishing.

Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse, A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutierrez, R.J., 2013. Understanding and managing conservation conflicts. Trends Ecol. Evol. 28, 100–109.

Salafsky, N., 2011. Integrating development with conservation: a means to a conservation end, or a mean end to conservation? Biol. Conserv. 144, 973–978.

Scottish Salmon Strategy Task Force, 1997. Report of the Scottish Salmon Strategy Task Force. Scottish Office Agriculture, Environment and Fisheries Department,

Edinburgh.

Smedstad, J.A., Gosnell, H., 2013. Do adaptive comanagement processes lead to adaptive comanagement outcomes? A multi-case study of long-term outcomes associated with the National Riparian Service Team's place-based riparian assistance. Ecol. Soc. 18 (4), 8. http://dx.doi.org/10.5751/ES-05793-180408.

The Scottish Government, 2014. http://www.scotland.gov.uk/Topics/marine/Licensing/SealLicensing. Accessed 12 July 2014.

Thompson, P.M., Mackey, B., Barton, T.M., Duck, C., Butler, J.R.A., 2007. Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals (*Phoca vitulina*) in north-east Scotland. Anim. Conserv. 10, 48–56.

Treves, A., Wallace, R.B., White, S., 2009. Participatory planning of interventions to mitigate human–wildlife conflicts. Conserv. Biol. 23, 1577–1587.

Van Vaerenbergh, Y., Thomas, T.D., 2013. Response styles in survey research: a literature review of antecedents, consequences, and remedies. Int. J. Publ. Op. Res. 25 (2), 195–217.

Wade, P.R., 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14, 1–37.

Walkerden, G., 2005. Adaptive management planning projects as conflict resolution processes. Ecol. Soc. 11 (1), 48. http://www.ecologyandsociety.org/vol11/iss1/art48/.

White, R.M., Fischer, A., Marshall, K., Travis, J.M.J., Webb, T.J., Di Falco, S., Redpath, S.M., van der Wal, R., 2009. Developing an integrated conceptual framework to understand biodiversity conflicts. Land Use Policy 26, 242–253.

Wiek, A., Talwar, S., O'Shea, M., Robinson, J., 2014. Toward a methodological scheme for capturing societal effects of participatory sustainability research. Res. Eval. 23, 117–132.

Young, K., 1998. Seal Watching in the UK and Republic of Ireland. International Fund for Animal Welfare, Crowborough.

Young, J.C., 2010. Analysing the Implementation of Natura 2000 in Scotland: an Evaluation of Processes and Outcomes of Stakeholder Engagement in Management Plans. PhD thesis. University of East Anglia.

Young, J.C., Marzano, M., White, R.M., McCracken, D.I., Redpath, S.M., Carss, D.N., Quine, C.P., Watt, A.D., 2010. The emergence of biodiversity conflicts from biodiversity impacts: characteristics and management strategies. Biodivers. Conserv. 19, 3973–3990.

Young, J.C., Butler, J.R.A., Jordan, A., Watt, A.D., 2012. Less government intervention in biodiversity management: risks and opportunities. Biodivers. Conserv. 21, 1095–1100.

Young, J., Jordan, A., Searle, K.R., Butler, A., Chapman, D., Simmons, P., Watt, A.D., 2013a. Does stakeholder involvement really benefit biodiversity conservation? Biol. Conserv. 158, 359–370.

Young, J., Jordan, A., Searle, K.R., Butler, A., Simmons, P., 2013b. Framing scale in participatory biodiversity management may contribute to more sustainable solutions. Conserv. Lett. 6, 333–340.