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Marine and coastal activities are closely interrelated, and conflicts among different sectors can undermine management and conservation objectives. Governance systems for fisheries, power generation, irrigation, aquaculture, marine biodiversity conservation, and other coastal and maritime activities are typically organized to manage conflicts within sectors, rather than across them. Based on the discussions around eight case studies presented at a workshop held in Brest in June 2019, this paper explores institutional approaches to move beyond managing conflicts within a sector. We primarily focus on cases where the groups and sectors involved are heterogeneous in terms of: the jurisdiction they fall under; their objectives; and the way they value ecosystem services. The paper first presents a synthesis of frameworks for understanding and managing cross-sectoral governance conflicts, drawing from social and natural sciences. We highlight commonalities but also conceptual differences across disciplines to address these issues. We then propose a novel analytical framework which we used to evaluate the eight case studies. Based on the main lessons learned from case studies, we then discuss the feasibility and key determinants of stakeholder collaboration as well as compensation and incentive schemes. The discussion concludes with future research needs to support policy development and inform integrated institutional regimes that consider the diversity of stakeholder interests and the potential benefits of cross-sectoral coordination.

Keywords: trade-offs, ecosystem management, ecosystem services, cross-sectoral coordination, marine governance, multi-jurisdictional conflicts, institutions, environmental policy

INTRODUCTION

Human activities can have severe negative impacts on marine and coastal ecosystems, leading to loss of biodiversity and degradation of ecosystem services (Millennium Ecosystem Assessment [MEA], 2005). Competing uses by multiple sectors of interconnected ecosystem components that span multiple jurisdictional boundaries and ecological structures generate cross-sectoral externalities (i.e., side effects on other parties) that can impede attainment of conservation objectives (Rice, 2011). Governance systems for fisheries, power generation, irrigation, aquaculture, marine biodiversity conservation, and other coastal and maritime activities are generally organized to manage conflicts within sectors, but not across sectors (Crowder et al., 2006; Stephenson et al., 2019). Cross-sectoral conflicts typically involve heterogeneous stakeholder groups with different value systems, conflicting aims and views of the management problem, different objectives or priorities, different knowledge bases, and disagreement regarding the allocation of the costs and benefits associated with proposed solutions (Adams et al., 2003; Crowder et al., 2006; Redpath et al., 2013). These conflicts[1] are often society-wide problems, and therefore, the goal of governance regimes addressing them cannot focus solely on a particular group of resource users. Rather, solutions need to mitigate cross-sectoral externalities[2], involving both use and non-use values, while addressing environmental objectives. In addition, these governance conflicts are not necessarily limited to spatial conflicts, but can relate to tradeoffs and fundamentally different perceptions of resource values among diverse user groups.

Stephenson et al. (2019) identified the main deficiencies often encountered in sector-based governance systems when they face cross-sectoral conflicts: (1) management of diverse, interacting sectors falls under the jurisdiction of different authorities using different approaches and concepts; (2) diverse sectors have different objectives and values, and management fails to account for the full range of ecological, economic, social, and institutional dimensions that are essential for formulating successful resource management strategies; (3) explicitly identified and agreed upon objectives are lacking, which leads to the absence of evaluation of tradeoffs (or potential synergies), among objectives and across sectors, and of cumulative effects of all interacting activities, and a lack of mechanisms in place to facilitate or implement cross-sectoral coordination. Understanding how cross-jurisdictional governance systems may emerge from such situations is important in order to durably address these conflicts (Rice, 2011).

The paper discusses the results of a workshop on marine and coastal governance conflicts at the interface of multiple sectors and jurisdictions. The workshop, held in Brest France in 2019, brought together a group of 20 scholars from different disciplines to evaluate what environmental and societal factors lead to such governance conflicts and to identify policy alternatives that can better align management and stakeholders incentives to provide lasting resolution of the conflicts. Workshop participants reviewed eight case studies covering different types of cross-sectoral conflicting interactions including conflicts between fisheries and terrestrial human activities, and conflicts between fisheries and marine mammal conservation. Frameworks for evaluating and solving these types of governance conflicts were reviewed and a common analytical framework for comparing the case studies was developed. The final sessions were focused on the discussion of common themes across the case studies and identification of solutions and implementation pathways.

The remainder of paper is organized as follows. We first review the evaluation and solution frameworks discussed in the workshop and describe a novel analytical framework developed in the workshop to facilitate comparison and evaluation of the cases studies. We then summarize the case studies and apply the analytical framework to them, tabulating the characteristics of the conflicts and attempts or proposals to resolve them. Next we discuss general insights generated by review of the cases as well as the broader literature that relates to them including: the feasibility and key determinants of stakeholder collaboration; the debate over compensation and incentive schemes; and a look ahead and emerging issues associated with intensifying anthropogenic pressure on ocean ecosystems. Finally we summarize the main conclusions of the workshop and identify future research needs.

MATERIALS AND METHODS

In our analysis, we identified two broad types of frameworks for addressing cross-sectoral conflicts. First, there are evaluative frameworks that are helpful for understanding why cross-sectoral conflicts arise and what is stopping the solutions from happening. Both the Social-Ecological System (SES) framework developed by Ostrom (2007, 2009) and the transaction cost economics approaches developed by Coase (1960) and Williamson (1996, 2000) provide some insights into those questions. Notably, Ostrom and Williamson both won the Nobel Prize in the same year because their approaches were seen as complementary (Earl and Potts, 2011), and both build on the work of Coase. Second, there are frameworks oriented toward solving the problems (Pikitch et al., 2004; Armitage et al., 2008; Douvere, 2008; Stephenson et al., 2019). While these problem-solving frameworks need to be integrated with evaluation frameworks, they adopt a more practical standpoint to design durable institutions and implement effective collaborative governance. Problem-solving frameworks and many of the key concepts they build upon relate to the multi-disciplinary literature inspired by "Ostrom-type" approaches and to "Coasean-bargaining" approaches that allow for explicit exchange across sectors to compensate parties who expect to be made worse off. Below we present a synthesis of conceptual frameworks for evaluating and resolving cross-sectoral governance conflicts. We then describe a

[1]With regards to the categorization of conflict intensity, with a gradient from verbal disagreements to military acts as defined in Spijkers et al. (2018), the conflicts we focus on are typically those of lower intensity, i.e., non-violent phenomena such as verbal discords or legal proceedings resulting from differing interests.

[2]This paper is primarily focused on addressing negative externalities. However, in general, externalities can be either positive (e.g., fishing vessels switching from active to passive fishing gear lower their greenhouse gas emissions) or negative (e.g., building a dam impedes fish passage).

novel analytical framework which draws from these conceptual frameworks that we apply to the case studies to facilitate a comparison of the conflicts and solutions (or possible solutions).

Evaluative Frameworks

Evaluative frameworks are focused on understanding what environmental and societal factors lead to cross-sectoral conflicts and identifying the key heterogeneities (in stakeholders, the biophysical system, and institutions) that are barriers to resolving problems. A meticulous evaluation of the problems to be solved is a critical step providing information that will make it possible to generate appropriate solutions.

The SES framework proposed by Ostrom (2007, 2009) to analyze socio-ecological systems identifies four main components – the resource system, the resource units, the actors, and the governance system – that are inextricably linked. Interactions among these four components are affected by the broader social, economic, and political context. It is a multi-level, nested framework that organizes relevant variables for synthesizing the main features of each subsystem and evaluating the sustainability of complex systems. Ostrom's perspective is an interdisciplinary, descriptive approach that incorporates the efforts of many scholars that studied the resilience (Berkes et al., 2000), robustness (Anderies et al., 2004), and vulnerability (Eakin and Luers, 2006) of SESs.

The SES framework stresses the importance of the rules governing natural resources and the critical role of stakeholders. For instance, enforcement mechanisms depend on trust and reciprocity between stakeholders. The framework also emphasizes the importance of considering nested institutions. In a nested environment, there is an overarching set of institutions within which the subsystem institutions operate. Institutions operating at the higher level may define how rules can be changed in the lower level, and subsystems may affect the broader institutional environment within which they operate. In settings where issues are geographically contained, access to the resource is limited, and a time horizon is not too long, spontaneous, organic solutions derived from "the bottom-up" by resource users may arise. Nested institutions may increase transactions costs[3] of negotiated or cooperatively derived solutions because of friction, power imbalance, clashes of culture, etc.

The literature that follows Ostrom's work has built upon her design principles for local-scale common-pool system (Ostrom, 1990) to address multi-level, multi-layered commons arrangements, including global commons such as the open ocean beyond national jurisdictions (Dietz et al., 2003; Stern, 2011; Fleischman et al., 2014). As in the classic definition of common pool resources, two key characteristics of the conflicts considered in this literature are: (1) excluding other potential users of the ecosystem is problematic and costly, and (2) the rivalrous nature of resource use, which decreases availability to other users. In the more recent literature, there have been many applications of the SES framework to understanding conflicts in large-scale commons – e.g., Epstein et al. (2014) on the international governance of Atlantic Bluefin Tuna; Evans et al. (2014) on the governance of the Great Barrier Reef; Villamayor-Tomas et al. (2014) on the governance of pollution problems in the Rhine River in Europe. While this body of work has addressed the issues of multi-resource access and sharing, the issue of high transactions costs remains a potential obstacle to resolving conflicts.

The transaction cost framework developed by Williamson (1979; 1996; 2000) is useful to determine the source of friction that prevents one sector from negotiating with others, and what prevents solutions from emerging. The transaction cost framework suggests that cooperation is more likely when the transaction costs for seeking mutually advantageous policy agreements, bargaining over the distribution of the costs and benefits of those agreements, and monitoring and enforcing the resulting policy measures, are lower. In studies of environmental governance and public policy using a transaction cost framework, transaction costs are often considered as a source of inefficiency (e.g., waste of time, effort in conflict and litigation…) to be minimized[4]. However, transaction costs may also help explain the choice of institutional arrangements, as stakeholders and authorities prefer policies with lower transactions costs. Transaction costs are heterogeneous across institutional arrangements and depend on the adequacy of their coordination mechanism (more or less autonomy, more or less coordination) and the characteristics of the transactions. Sources of transaction costs are often non-monetary but they can be observed, which makes transaction costs theory useful to determine the best adapted form of organization to address a collective action problem (Libecap, 1994, 2014). Important factors that increase the transaction costs of addressing cross-sectoral externalities and reduce the likelihood of collective action are: scientific uncertainty regarding mitigation benefits and costs; varying preferences and perceptions across heterogeneous populations; asymmetric information[5]; and anticipation of non-compliance with agreement rules (Libecap, 2014). Multiple, differing governance and cost identification frameworks employed by intersecting agencies, further complicate the management of cross-sectoral conflicts.

Without collective action to address cross-sectoral common-pool resource[6] externalities or public good[7] provisioning problems, the constraints sectors impose on one another go

[3]Transaction costs are the costs of searching for information, bargaining, planning, policing, and enforcement associated with implementing new institutional arrangements.

[4]See for example Kuperan et al. (2008) for an application to fisheries management and Mettepenningen et al. (2011) for an application to agri-environmental schemes.

[5]Asymmetry of information relates to situations where parties do not have equal and transparent knowledge about contributions to the externality, natural system responses, and compliance.

[6]A common-pool resource is a resource available to all but which provides diminished benefits to everyone if an individual consumes it and to which access can be limited only at high cost. Classic examples of common-pool resources include fishery resources, irrigation systems, aquifers, forests, pastures, etc.

[7]A public good is a good available to all and whose use by an individual does not reduce availability to others. Examples of public goods include knowledge, flood control systems, lighthouses, etc.

unaddressed, increasing transaction costs and decreasing the opportunities for collaboration or agreement. For example, even if fungible property rights exist within sectors, they are usually not tradable across sectors, therefore opportunities to bargain over resource access are stymied. A transaction cost framework is useful to empirically analyze systems and determine why a particular action was chosen and whether it worked or did not work. Conflicts often emerge when one party perceives that they are going to be made worse off and that they will not be compensated in some manner. In a transaction cost framework, bargaining among parties typically leads to some compensation for those who are going to be made worse off (see Coasean-bargaining approach described below). But this is typically not easily achieved in a cross-sectoral context. Likewise, the game-theoretic literature on coalitions in fisheries points out that, even if cooperation among all players is expected to increase aggregate benefits greatly, there is a substantial incentive for the largest players to deviate from a cooperative solution unless side payments between players are feasible (Arnason et al., 2000; Bailey et al., 2010). Moreover, prospect theory (Kahneman and Tversky, 1979) suggests that losses are seen more negatively than similar volumes of benefits are seen as positive, which means that the overall volume of benefits (including potential compensations) may need to increase, if there is redistribution among stakeholders.

Problem-Solving Frameworks

While evaluative frameworks are essential to define and characterize the challenges posed by cross-sectoral conflicts, they do not necessarily identify solutions. The literature that has evolved from evaluative frameworks includes a body of work focused on designing effective governance systems and making multiscale governance institutions durable. Traditional top-down regulation does not facilitate negotiation or collaboration among the parties to adjust behavior in a way that would be effective to address environmental goals (Ostrom, 2005). This is particularly true when activities are regulated under different jurisdictions. Top-down regulation typically does not provide economic incentives toward solving the common-pool resource problem and is not well suited to address dynamic factors such as climate change and shifting political agendas. Moreover, top-down regulations are associated with high transaction costs. In what follows, we consider two complementary problem solving-oriented approaches which emerge from the literature above, which we label "Ostrom-type" and "Coasean bargaining," and then proceed to summarize key considerations in problem-solving frameworks. These approaches are not mutually exclusive but differ in their emphasis on the tools used to resolve the conflicts – e.g., collaborative governance and bottom-up development of use rules (Ostrom) vs. bargaining and exchange and a focus on reducing transactions costs (Coase).

Ostrom-Type Approach

An Ostrom-type approach for implementing durable institutions in SESs relies on eight design principles for collective action (Ostrom, 1990) and on the many lessons learned from the variety of cases studied over the years (including Agrawal, 2001; Berkes, 2009; Cox et al., 2010; Cinner et al., 2013). The approach begins with communities conceptualizing their world and acknowledging power dynamics (at least implicitly), and aims to fully account for system dynamics and feedbacks. The approach includes delegating regulatory authority to user groups within a setting typically characterized by limited entry, shared views, long-term commitments, proportionate distribution of costs and benefits. The resources, the community of resource users, and collective-choice rules are clearly defined.

In an Ostrom-type approach, the processes of negotiation and setting up agreements that determine the rights and responsibilities of the involved parties are intended to reduce conflicts. The reduction of conflicts is important to ensure that individuals are willing to invest in creating appropriate institutions (Ostrom, 1990). When a crisis that imperils the resource and their users arises, the user groups need to agree on the problem and on taking action for the collective interest. This can be a difficult and time consuming task that necessitates sacrifices by the users (Rowland, 2005). The ability to modify rules as the need arises is considered essential for being able to adapt management and ensure resource sustainability (Ostrom, 1990). In cross-sectoral conflicts that go beyond simple allocation of resource use, some governing body or process is likely to be needed to facilitate and oversee a solution to the conflict, though it may emerge from the bottom up rather than being imposed by the state.

Coasean Bargaining Approach

An economic solution to solving resource use conflicts, often associated with Coase (1960), emphasizes the importance of the allocation of property rights and the central role of bargaining between groups of users. Traditional, top-down approaches (e.g., "polluter pays" approach) may not be effective when there are multiple sectors (and multiple parties within sectors), multiple governing authorities providing regulation and funding, and multiple political jurisdictions. In such cases, there may not be a shared view and common objectives for resource use allocation among users, and an Ostrom-type approach might be impeded by excessive transaction costs. Collaboration can be improved by a better comprehension of stakeholder behavior and Coasean bargaining in the presence of high transaction costs (Coase, 1960). A Coasean approach in which people can expect to have a claim on long-term benefits structured by a regulatory mandate and exchange some sort of property rights among sectors does not necessarily require a shared vision of the problem and solutions across sectors (Rhoads and Shogren, 2003). Finding a way to make some sort of exchange across sectors possible could be the key to reaching a solution where nobody's welfare is made worse off (a Pareto improvement) while advancing protection of an ecosystem or species.

A Coasean, bargaining-based solution could involve exchange of regulatory benefits, rather than exchange of traditional property rights or monetary side-payments. Sectors and government agencies may negotiate the structure of regulatory mandates such that regulatory obligations/costs are not uniform across sectors. For example, a sector may agree to take some action (e.g., make habitat improvements) in exchange for

a reduction in regulatory requirements (e.g., an increase in allowable pollutant discharge for the sector). A competing sector may agree to this arrangement if the expected benefits to it, from the other sector's action, are greater than the costs of the reduced regulatory requirements. Creation of property rights in some form (e.g., legally or socially supported claims to streams of benefits over time) can make systems durable as they enable Coasean bargaining, making the systems more dynamic and self-adjusting to exogenous shocks as opposed to top-down regulations.

Coasean, bargaining-based frameworks sometimes suggest compensating parties for refraining from taking action that may harm other parties. This type of compensation might be controversial (see discussion of this issue below). However, compensation may cost less than alternative options to achieve environmental goals, especially when there may be a lot of opposition and high transaction costs.

Combining the Approaches

Both Ostrom-type and Coasean bargaining approaches delegate more responsibilities to stakeholders than traditional regulatory approaches. In fisheries, management regimes can involve both Ostrom and Coasean approaches. Individual transferable quotas (ITQs), essentially giving fishers a property right over part of a total allowable catch, are often considered Coasean solutions (Tresch, 2015; Libecap, 2016). However, in many cases, all externalities are not resolved by ITQs. For example, even if fishers were allocated individual rights, they have formed cooperatives as a way to find a cost-effective solution to deal with certain environmental problems such as bycatch (Holland, 2018). Forming a cooperative (which can be considered an Ostrom-type approach) can dramatically reduce the transaction costs of coming to a solution and allow implementing a solution in an effective way. In that case, the two approaches have been effectively combined to address ecosystem protection issues and include non-use values (Holland, 2018). However, the majority of efforts to operationalize these approaches usually display either one or the other, and rarely both, as demonstrated in the following case studies.

Operationalizing Problem-Solving Frameworks

Problem-solving frameworks that utilize one or the other of these approaches to address coastal and marine governance conflicts include ecosystem-based management (Pikitch et al., 2004), adaptive co-management (Armitage et al., 2008; Butler et al., 2015), integrated management (Stephenson et al., 2019), collaborative governance (Emerson and Nabatchi, 2015), marine spatial planning (Douvere, 2008), and others. These are somewhat distinct in their operational implementation, but all tend to consider that the various ocean uses are interconnected and that they should be managed jointly. Each of these problem-solving frameworks uses concepts and principles from multiple approaches described above, and the ultimate goal is to have durable institutions that are able to sustain human activities and achieve environmental objectives. Stephenson et al. (2019) list the following nine key features for the successful implementation of integrated management of coastal and marine activities: (1) recognition of the need for integrated management; (2) a shared vision by stakeholders and decision-makers for integrated management; (3) appropriate legal and institutional frameworks for coordinated decision-making; (4) sufficient and effective processes for stakeholder engagement and participation; (5) a common and comprehensive set of operational objectives; (6) explicit consideration of trade-offs and cumulative impacts; (7) flexibility to adapt to changing conditions; (8) processes for ongoing review and refinement; and (9) effective resourcing, capacity, leadership and tools. All of which can be utilized to examine the extent to which problem-solving frameworks both achieve resolution of the resource issue and a durable governance system to address environmental and human objectives.

A Common Framework for Evaluating Case Studies

Based on the key elements of conflicts and solutions identified during the workshop, and bridging the different evaluative and problem-solving frameworks that were assessed, a common analytical framework was developed and applied to the case studies. This novel framework (**Table 1**) is an output of the workshop and reflects workshop participants' consensual perspectives on important elements to consider in evaluating cross-sectoral conflicts. **Table 1** details how the different elements of the framework relate to the evaluative and problem-solving frameworks presented above. Brief summaries of case studies are presented in the next section. The full case studies are available in **Supplementary Material**. The subsequent discussion sections were developed based on the main lessons learned from case studies and cross-cutting discussions that were held at the workshop.

CASE STUDY SUMMARIES

Case Study 1: Moray Firth Seal Management Plan

The Moray Firth in north-east Scotland has Special Areas of Conservation (SACs) established for three marine protected species (harbor seal *Phoca vitulina*, Atlantic salmon *Salmo salar*, and bottlenose dolphin *Tursiops truncatus*). The conflict centers around the balance between the conservation of harbor seals and Atlantic salmon — both protected but with one that preys on the other, although the impact of predation at the population level was largely unknown due to a lack of objective scientific information. Consequently, views held by stakeholders about seal predation were polarized (Butler et al., 2011).

The Scottish Government issued a Conservation Order in 2002 that prohibited the killing of harbor seals, driven by declining numbers of harbor seals, the potential consequence of a Phocine Distemper Virus outbreak, and a bounty scheme whereby District Salmon Fishery Boards (DSFBs) were paying marksmen for shooting unlimited numbers of seals. With declining catches of salmon, and the imperative to protect salmon SACs, a bottom-up process triggered by salmon fishery stakeholders emerged in 2002 which aimed to balance seal

TABLE 1 | Common framework for evaluating case studies.

Case study element	Evaluation feature	Link with evaluative and problem-solving frameworks
Resources and users	Define stakeholder participation Define ecosystem services in consideration	Highest-tier variables (resource system, resource units, users) in SES framework (Ostrom, 2009)
Externalities	Identify conflict Define values (monetary and non-monetary) of stakeholder groups	Second-tier variables I4 (conflicts among users), O3 (externalities to other SESs), and RU4 (economic value) in SES framework (Ostrom, 2009)
Distributional effects and power dynamics	Identify benefits of coordination Identify beneficiaries of coordination Define political influence (in relation to stakeholder participation)	Second-tier variables I6 (lobbying activites) in SES framework (Ostrom, 2009); Proportionate distribution of costs and benefits in transaction cost framework (Libecap, 1994)
Coordination mechanisms	Define existing coordination mechanisms Define support from central authorities	Second-tier variables GS1 (government organizations) in SES framework (Ostrom, 2009); Level 3 (governance) and level 4 (resource allocation) in transaction cost framework (Williamson, 2000)
Shared objectives	Define management and stakeholder objectives Identify shared and conflicting objectives	Key features #2 (shared vision by stakeholders and decision-makers) and #5 (common and comprehensive set of operational objectives) in Integrated Management framework (Stephenson et al., 2019)
Evaluative processes	Define existing processes for scenario evaluation focused on trade-offs	Key features #6 (explicit consideration of trade-offs and cumulative impacts) in Integrated Management framework (Stephenson et al., 2019)
Solutions	Identify solutions and their type (top-down, Ostrom-type, Coasean) Characterize durability of solutions and resilience to external shocks	Ostrom-type and Coasean-bargaining approaches; Key features #7 (flexibility to adapt to changing condition) #8 (processes for ongoing review and refinement) and #9 (effective resourcing, capacity, leadership and tools) in Integrated Management framework (Stephenson et al., 2019)
Governance challenges and opportunities	Identify barriers to possible solutions Identify opportunities	Transaction costs associated with institutional changes (Williamson, 2000)

and salmon conservation. The DSFBs and Scottish Natural Heritage, the Sea Mammal Research Unit (SMRU) and the Moray Firth Partnership (a forum representing local wildlife tourism operators, conservation groups and marine fishery interests) collaborated to develop the Moray Firth Seal Management Plan (MFSMP) to resolve the conflict between seal conservation and salmon fisheries. The MFSMP allowed for a collective annual application from the DSFBs to the Scottish Government to shoot a limited number of individual seals most likely to be impacting on fisheries in confined Management Areas, away from seal pupping sites and marine tourism centers (Butler et al., 2008; Graham et al., 2011).

A number of conditions enabled the successful negotiation and implementation of the MFSMP (Young et al., 2012). The first was a local "champion" — a scientist employed by the Spey DSFB, with a background in wildlife conflict resolution and salmon management (Young et al., 2016). His facilitation enabled the integration of all relevant stakeholders on an equal footing and resulted in the MFSMP being endorsed by all stakeholders involved. The second was the involvement of the Scottish Government, which created a crisis point (in the form of the Conservation Order), resourced the process of developing the MFSMP, and endorsed any agreements reached, thereby legitimizing the outcomes. The last condition, and one that has not been fully resolved, is the provision of adequate financial and local institutional support to ensure long-term implementation of the plan. Although local DSFBs have appointed a staff member to collate seal-shooting information and to submit the annual application, this has been insufficient to fund stakeholder coordination and interaction, and hence knowledge exchange, learning and innovation has dissipated since the MFSMP's early years.

Longitudinal evaluation indicates that relative to 2004 the MFSMP has shifted from community-led adaptive co-management to government-led and instructive management (Butler et al., 2015): annual seal shooting license applications are approved by the Scottish Government but local stakeholder engagement has declined. The intervention of a new animal welfare stakeholder in recent years has caused a further crisis point for the system. This may have the catalytic effect of restoring collaborative governance, since the original aims of the MFSMP are being challenged, upsetting the status quo.

Case Study 2: Salmon Management Institutions in the Columbia River Basin

Many salmonid populations in the Columbia River Basin are at historically low levels and are listed either as threatened or endangered under the US Endangered Species Act (ESA). Major dams, which are used for power production, flood control, navigation, and irrigation, are impeding upstream and downstream migration of adult and juvenile salmonids, respectively, and blocking access to potential spawning habitats. Dam operators are tasked with optimizing multi-use operations while assuring economical and reliable power supply to the public as well as compliance with the ESA. Salmon conservation is also potentially conflicting with human harvest and with the protection of marine mammals (pinnipeds and imperiled southern resident killer whales) that prey on salmon (Chasco et al., 2017). Because salmon face a multitude of threats whose impacts are not fully understood, stakeholder groups tend to point to threats they themselves are not associated with. For example, fishers and tribes who want more salmon point to dams and habitat destruction; irrigators, loggers, and other river users allege overfishing; and all use sectors also blame predation

by marine mammals and birds, while non-use sectors criticize impactful human activities.

Hundreds of millions of dollars are spent annually on salmon habitat restoration (Northwest Power and Conservation Council [NPCC], 2020). Other conservation actions that have also been widely implemented include barging of juvenile salmon, installation of screens and bypass improvements at dams, managing dam spills and flow operations for fish, wild stock supplementation via conservation hatcheries, and leasing water rights to enhance in-stream flow (McKean and Johnson, 2019; Northwest Power and Conservation Council [NPCC], 2020). Despite these efforts, salmon populations remain in peril. Improved coordination could lead to taking other, potentially more cost-effective types of action that have not been broadly implemented, such as breaching major dams, government-supervised culling of pinniped predators, and eliminating harvest supplementation hatcheries (McKean and Johnson, 2019). Implementation of these potential solutions is generally impeded by competing stakeholder interests and entrenched interests arising from management institutions (Hanna, 2008). Improved coordination could also reduce litigation and uncertainty associated with litigation, which would benefit to stakeholders involved in ongoing legal battles. The courts play a critical role in ensuring actions to promote recovery continue but they generally do not prescribe particular recovery actions.

With potentially less favorable climate-driven environmental conditions in the future (both in freshwater and ocean environments), it is unlikely that salmon populations will meaningfully recover without considerably reducing human impacts on salmon and their habitats, returning rivers to more natural states, and addressing predator control issues (McKean and Johnson, 2019). The fact that externalities occur across different ecosystem goods (water users impact salmon production, marine mammal conservation impacts salmon survival, salmon users impact killer whale conservation which rely on salmon for prey), biomes (ocean, estuary, rivers), and across jurisdictional boundaries (multiple States, multiple sectors, multiple species) is likely to increase the transaction costs of collective action because of scientific uncertainty about externality costs, diverging preferences across parties, information asymmetry, and anticipation of non-compliance. In addition, the conflicts involve both use and non-use sectors so that solutions need to consider the important cultural values that salmon and killer whales hold in the region. This constrains the range of possible solutions as there is no straightforward way for use and non-use sectors to bargain to reduce externality losses.

Case Study 3: International Whaling Commission

The International Whaling Commission (IWC) was established 75 years ago to manage commercial harvesting of whales. Initial stakeholders were representatives of commercial whaling operations. Given today's growing range of threats that far surpass mortality from direct hunts, the IWC now has a much broader range of issues and stakeholders (Wright et al., 2016). The emerging threats to whales are externalities from sectors that are not part of the regular IWC stakeholder groups: fishing; underwater drilling and extraction; shipping noise and emissions, and other ocean pollution (plastics) (Lent, 2015). These externalities are rarely if ever *internalized* into production and consumption decisions, although regulatory processes might require impact analyses on marine mammals.

Improved coordination can lead to *pareto superior* exchanges with losses to impacted stakeholders offset by other stakeholders willing to pay for the improvements to the marine ecosystem, such as the ECHO program[8] in Vancouver BC. Marine mammal entanglement in fishing gear can lead to gear losses and therefore operators share interest in avoiding bycatch. Ecolabels can incentivize fishery stakeholders to reduce marine mammal bycatch (Lent and Squires, 2017). Examples include the Marine Stewardship Council labeling and the US Marine Mammal Protection Act (MMPA) import rule[9]. Processes for coordination must be created and nurtured. For example, development of marine mammal bycatch guidelines at the FAO Committee on Fisheries was possible due to support from key countries, IWC and other intergovernmental and non-governmental organizations, which provided the funding and the expertise to partner with FAO to get this work agreed and completed. The IWC engages with the International Maritime Organization to provide scientific and technical information geared at reducing shipping vessel speeds, noise, and emissions.

The IWC is slowly developing social media and other communication efforts in order to increase awareness of its efforts to constructively address all impediments to recovery of whale stocks and to demonstrate its ability to implement a holistic approach to its mandate through cross-institutional, cross-sectoral cooperation (International Whaling Commission, 2018). It is only through concerted efforts at cross-institutional collaboration that there can at least be an *understanding* of the different stakeholders' and institutions' objectives and values. An important impediment to more integrated management systems is the lack of complete data and understanding of population-level impacts for marine mammals. Small-scale coastal gillnet fisheries collect very little data on whale bycatch and even less is known about their population-level impacts (Temple et al., 2018). The Indian Ocean Tuna Commission estimates that 40% of the harvests under that organization is taken by gillnets, yet bycatch data collection through logbooks, observers and other means lags far behind.

Benefits to marine mammals are often non-market in nature (Wallmo and Lew, 2011), while the costs to the sector imposing the externalities are monetary and easier to estimate. For example, the increased costs to fishery operators of using ropeless gear in a pot fishery are well documented, however generating an estimate of the benefits of lower rates of marine mammal injury and mortality is extremely difficult. The IWC provides unique insights into the challenges facing an international institution whose ability to adapt over the years to changes in the

[8]https://www.portvancouver.com/environment/water-land-wildlife/echo-program/

[9]https://www.fisheries.noaa.gov/foreign/marine-mammal-protection/noaa-fisheries-establishes-international-marine-mammal-bycatch-criteria-us-imports

global governance framework and environmental context may be critical to meeting its objectives.

Case Study 4: Management of Natural and Reared Salmon Stocks in the Baltic Sea

There are very strong natural salmon stocks in the northernmost part of Baltic Sea, and their overall production is around 70% of the total salmon production in the Baltic Sea (ICES, 2020), while it was less than 10% in 1980's. The successful management of these stocks has a big impact on the whole Baltic Sea fishing (Romakkaniemi et al., 2003). The main stakeholder groups include professional off-shore and coastal fishers, and recreational river fishers. The tourism industry along the river valleys is another important player, as it is estimated that the total value of one landed salmon in river areas is much higher than in sea fishing, where the value is around 20 − 60 € for a commercial fisher. Nature conservation organizations have been active in contributing to the policy to safeguard the stocks.

In the sea, the value of the fishery is linearly linked to stocks and thereby on catches. However, for river fishing, the mechanism seems to be that the catch per unit effort must be high enough to incentivize participation in the fishery during the best river fishing season (June-August). The conflict with recovering populations of seals has been suggested by stock assessment models (Mäntyniemi et al., 2012). Now there seems to be a balance in the seal stocks and hunting is allowed by applying a quota, but technically the hunting is very difficult and the quotas are not taken. There is some evidence that gray seals gather in the river-mouths at the time when smolts leave the river and the impact on salmon stocks may be high.

Historically, the reason for poor river catches has always been claimed to be the off-shore and coastal fisheries, and the poor coastal catches have been said to be due to the off-shore fishing, etc. At the time when reared stocks were the majority of mixed stocks (up to 90 %), overfishing was not an economic risk, but now state of the stocks is different (ICES, 2020). By improving the natural recruitment, the current management system has shown its power. Historically, a key management action was an establishment of a stepwise opening of coastal fishery from south to the north in Finnish coastal waters which ensured a certain proportion of migrating spawning stock to enter the spawning rivers. This helped both Swedish and Finnish stocks, even though the political will to do something was entirely based on the Finnish fisheries minister alone. The same coastal management system is still applied in Finland and it can be seen as a biomass-independent management of fishing mortality. In all EU fisheries management the key objective is to reach maximum sustainable yield (MSY). In the case of salmon, this means that smolt production must be about 75% of the maximum (ICES, 2020).

Individual transferable quotas systems have been applied in many Baltic Sea countries. In Finland, the system was suggested by scientists a long time ago (Mickwitz and Pruuki, 1993), and both scientists and nature conservation NGOs demanded that the trade of the quota should be made possible between the different fisheries, especially river-based and at-sea fisheries. However, in the last steps of political decision-making, this option was removed from a new legislation, most likely to preserve employment in commercial fisheries.

Case Study 5: Interactions Between Seals and Commercial Fishing in Ireland

In Ireland, it is illegal to hunt or injure seals up to 12 nautical miles offshore without ministerial permission. Recent surveys in Ireland show increasing gray seal (*Halichoerus grypus*) and harbor seal (*Phoca vitulina*) populations (Cosgrove et al., 2016), and both species are considered to be of Least Concern (low risk of extinction) by the International Union for Conservation of Nature.

The gray seal is the primary species interacting with commercial inshore set net fisheries. A 2010 questionnaire to fishers suggests depredation[10] rates of 20 – 30% across gill, tangle and trammel net fisheries (Cosgrove et al., 2015). Recent research showed that averages of 18% of Pollack (*Pollachius pollachius*), 10% of hake (*Merluccius merluccius*), and 59% of monkfish (*Lophius piscatorius*) landings were depredated by seals, and these proportions have substantially increased since the 1990's (Cosgrove et al., 2015). Total loss of landings could be over 50% in both the pollack and hake fisheries, with an estimated value of €1.7 m, when the fish entirely removed from nets were taken into account. This has led to a clear conflict in interests between the fishing industry and conservation sector, particularly environmental NGOs (Cronin et al., 2016). Responsibility for seal conservation and seal/fishery interactions also involve two different government departments. The goods and services involved are principally the provisioning services from the fishery (very important in rural west Ireland), and cultural services (existence value) of the seals. The fishers want seal populations being controlled. The environmental NGOs want the populations to continue recovery from their historic lows after hunting was banned. Those responsible for conservation in the government aim to comply with national and international legislation, which broadly stipulates a stable or growing population.

Can improved coordination help here? Probably not. Legislation prevents the culling of seals, advocated by fisher's groups. The environmental NGOs are also concerned about seal bycatch in the fisheries. The best improvement would be to try to reduce depredation by the seals. Smart fishing techniques could help, such as shorter gear deployments, working gear in relation to tidal currents, and faster hauling speeds (Cosgrove et al., 2015). Acoustic seal deterrent devices have potential too. Some coordination to help both sides understand the other's views would be useful. In terms of power dynamics, neither party is particularly powerful politically, and struggles to get their points of view considered by national authorities.

There are conflicting objectives for fishers and environmental NGOs. Fishers are mainly concerned by loss of income and operational difficulties (Cosgrove et al., 2015). The NGOs promote seal conservation and protection. Thus fishers are primarily concerned with monetary values, and NGO concerns are principally non-monetary. There are no processes in

[10]Depredation is the retrieval of fish from fishing gear by animals.

place for evaluating tradeoffs and synergies, and cross-sectoral coordination mechanisms are lacking. An ad hoc group was established some years ago to bring the parties together, but this was unofficial and had no direct mandate. It was successful in the task of getting each side to understand the position of the others. It ceased to operate in recent years with the loss of some key members. The current position is not particularly durable or resilient. The depredation issue emerges periodically in the press or parliamentary questions but is quickly forgotten. None of the mitigation solutions have gone beyond the pilot phase. Lack of a single authority responsible on this subject is also likely an issue.

Case Study 6: Water Supply and Salmon in California's Central Valley

The Central Valley of California, on the Pacific coast of the United States, has long been the setting for conflicts over the allocation of scarce freshwater resources between irrigated agriculture and habitat for Chinook salmon (*Oncorhynchus tshawytscha*). Farms in the Central Valley produced over $US 50 billion in 2017. Irrigation water is an important constraint to agricultural production and can induce significant economic and social impacts during severe or prolonged droughts (Speir et al., 2015; Lund et al., 2018). The Central Valley is also home to Chinook salmon, anadromous fish that spend most of their adult lives in the ocean, then return to their natal rivers to spawn. Juveniles rear in freshwater, then emigrate to the ocean. Freshwater habitat degradation has led to long-term declines in fish populations and an increasingly large body of evidence shows that instream flow conditions are a primary driver (Michel et al., 2015; Perry et al., 2018; Michel, 2019; Friedman et al., 2019; Henderson et al., 2019).

Water supply in the Central Valley is a highly engineered system managed by multiple federal, state, and local agencies. Direct management of dams, reservoirs, and canals is done by the Federal Bureau of Reclamation (USBR) and the California State Department of Water Resources (DWR). Species protection is overseen by two federal agencies, the National Oceanic and Atmospheric Administration Fisheries Service (NOAA fisheries) and the US Fish and Wildlife Service (USFWS), and a state agency, the California Department of Fish and Wildlife (CDFW). Delivery of water to agricultural users is done by local irrigation districts. Water supply operations are subject to the ESA because some Chinook salmon and other fish are listed as endangered. The ESA requires federal agencies to ensure that actions they fund, authorize, or carry out are not likely to "jeopardize" a species or "destroy or adversely modify" critical habitat. USBR must consult with federal wildlife agencies, which then produce a "biological opinion" describing how listed species are affected and prescribing operational rules for minimizing harm to listed species.

There is a history of institutions that coordinate among stakeholders and attempt to develop water policy in the basin. CALFED was a partnership of federal, state, and interest group organizations created in 1994 after several consecutive drought years with a mandate to find collaborative solutions in four areas: water quality, water supply, levee stability, and ecosystem restoration. However, fish populations and water quality continued to decline and CALFED dissolved in 2007 (Kallis et al., 2009; Lurie, 2011; Dutterer and Margerum, 2015). By 2013, a new governance body, the Delta Stewardship Council, was established to facilitate stakeholder involvement and implement policy. There is some potential for improved coordination between sectors. For example, rice farmers have coordinated with state and national wildlife agencies and NGOs to create floodplain habitat (Katz et al., 2017). However, conflicts often play out in the form of interest group politics and litigation.

Case Study 7: St. Croix River Alewife Restoration

The St. Croix River, which forms part of the international border between Maine, United States and New Brunswick, Canada, once supported large runs of anadromous alewife (*Alosa pseudoharengus*). Alewife migrations were interrupted by dams that spanned the full river beginning about 1830, and populations were further impacted negatively by deteriorating water quality due to logging and industrial development. Attempts to facilitate recovery of this native species, which was effectively extirpated from much of its range due to human activity, have been complicated by different values placed on ecosystem services (**Table 2**) and by complex jurisdictions (Willis, 2009; Barber, 2018).

Prior to 1980, fishways on the four major dams that span the St. Croix River were either absent or ineffective. Completion of a new fishway at the lower dam in 1981 resulted in a resurgence of the alewife population in the St. Croix system, but this coincided with a drastic decline of smallmouth bass in upper lakes, which had become the basis for an active sport fishing guide sector. In response to a strong lobby from bass fishing guides, the State of Maine enacted emergency legislation to close fishways on the US side to migrating alewives. The Government of Canada consistently called for the St. Croix River to be opened

TABLE 2 | Views of major stakeholders regarding St. Croix River alewife recovery issues.

Major stakeholder/sector	Position/issue
Indigenous (Passamaquoddy) Peoples, Environmental NGOs	Alewives are critical to the ecosystem and as a food source. Recovery of alewives was being stalled to protect an introduced species of commercial (recreational) value
Businesses (paper and power companies)	The dams of the St. Croix river, while old, are still valuable in their contributions to industry and power generation
Government of Canada (Department of Fisheries and Oceans)	Alewives are a native species and should be returned to native habitat
Government of the State of Maine	Faced with conflicting objectives of Passamaquoddy Tribe who want to promote alewife recovery and bass fishing guides who have preferred to prevent alewife recovery
Bass fishing guides	Perceived a negative interaction between alewife restoration and bass productivity, so argued against restoration

to alewife passage and began trucking alewives upstream (around the closed dams) to spawn.

Saint Croix activities are governed by State/Province and Federal United States/Canada departments. There are many issues (including fisheries, recreation, industry) and several jurisdictions (including Governments of Canada, New Brunswick, United States, Maine, the Passamaquoddy people and communities). There has been no single, agreed governance structure within which this issue could be resolved. As an international boundary, the St. Croix has a bi-national Board under the auspices of the International Joint Commission which has no direct authority related to alewives, but has provided a forum for synthesis and cross-boundary discussion aimed at preventing or reducing transboundary conflict. An ad hoc cross-jurisdictional group has worked to promote alewife recovery by dispelling the concern that alewife recovery is detrimental to bass, getting consistency in management across jurisdictions, and improving fish passage at dams.

Case Study 8: Depredation by Toothed Whales in French Antarctic Toothfish Fishery

Depredation of the very valuable Patagonian toothfish (*Dissostichus eleginoides*) by sperm whales (*Physeter macrocephalus*) and killer whales (*Orcinus orca*) is generating conflicts between the French longline vessels operating in French Antarctic territories and conservation objectives for marine mammals (Guinet et al., 2015; Tixier et al., 2015). Depredation often results in socio-economic impacts, biological impacts on targeted fishes and on depredating species, but also in ecosystem impacts. In addition, sperm and killer whales are iconic protected species that have important non-use value for environmentalists and the public.

This fishery is the only commercial activity in this area and is constituted of a concentrated fleet of seven industrial vessels. At the international level, the main stakeholder involved is the Commission for the Conservation of Antarctic Marine Living Resources, which sets conservation measures that determine the use of marine living resources in the Antarctic, based on the best available scientific information. The French Government is in charge of managing the fishery. Stakeholders include scientists, environmental NGOs, and the fishing industry. Conservation objectives require minimizing depredation-type interactions by non-lethal measures, such as implementation of vessel avoidance strategies and/or development of catch protection systems (Tixier et al., 2015). Current coordination between stakeholders and sectors exists and is substantial. Several research programs are co-funded by the industry, in collaboration with the regional administration (Terres Australes et Antarctiques Francaises); depredation is taken into account in toothfish stock assessments; and the funding provided by the selling of fishing rights related to toothfish fishing are used, among other things, to support scientific activities and monitoring of authorized fisheries. Thus, at least implicitly, there is a cross-sectoral allocation mechanism.

In general, there is a political will to maintain the coordination among stakeholders. The Marine Stewardship Council certification scheme of the fishery provides an important driver for shared objectives and demonstrates that the fishing industry can be involved in biodiversity preservation (Des Clers et al., 2018). While coordination is advanced compared to other fisheries, there is still a lack of knowledge regarding the overall impact of depredation on the toothfish stock and the associated marine ecosystem. And although the conservation objectives are relatively well understood by the fishing industry, it is hard to say that protecting the whale populations is a shared objective.

To date, the distributional impacts of whale conservation are rather unknown. The governance system in place could allow for adaptive co-management, providing rapid feedbacks on the outcomes of depredation mitigation actions (Guinet et al., 2015). Proposed solutions to mitigate depredation also include a possible diversification of target species for the current toothfish fishery (Tixier et al., 2015). Key aspects to investigate further – that will help proposing effective solutions to the depredation issue – include evaluations of the non-monetary benefits of conservation, the overall ecosystem impact of depredation, and the sensibility / dependency of the fishing industry to depredation.

RESULTS – APPLYING THE COMMON ANALYTICAL FRAMEWORK

In this section, we review a series of eight illustrative case studies that were evaluated using the analytical framework introduced in **Table 1** to tabulate the key characteristics of the conflicts and solutions (or potential solutions). The case studies have been briefly presented in the previous section and additional descriptions are provided in **Supplementary Material**. This common framework aims to characterize the: conflicts (**Table 3**); distributional effects and power dynamics (**Table 4**); coordination mechanisms (**Table 5**); stakeholder objectives and processes for evaluating trade-offs (**Table 6**); solutions implemented (**Table 7**); and, the governance challenges and opportunities (**Table 8**).

The eight case studies cover different types of cross-sectoral conflicting interactions, including conflicts between fisheries and terrestrial human activities, and conflicts between fisheries and marine mammal conservation (**Table 3**). In all of these cases there are conflicts between two or more sectors that are concerned with different ecosystem services or activities that create external costs on other sectors. Most conflicts involve trade-offs between use and non-use values. Several cases involve conflicts between fisheries and conservation of marine mammals including cases where marine mammals harm fisheries and vice versa. Other cases involved activities that compromise habitat for marine species harming both resources users and conservation interests. In all of these cases, the conflict goes beyond allocation of use of a single resource and resolving them generally requires compromise between stakeholder groups with divergent interests.

All of the cases identify potential benefits from better coordination of conflicting activities or mitigation of their impacts (**Table 4**). All cases also identify jurisdictional conflicts and power imbalances that have led to costly litigation or political

TABLE 3 | Case studies – conflict characterization.

Case study	Resources and users		Externalities/conflicts
	Species involved	Sectors involved	
(1) Moray Firth Seal Management Plan	Atlantic salmon (*Salmo salar*), harbor seals (*Phoca vitulina*)	Fisheries, tourism, government, conservation, NGOs	Salmon conservation vs. protection of predators (seals) and fisheries
(2) Salmon management institutions in the Columbia River Basin	Salmon (*Oncorhynchus spp.*), killer whales (*Orcinus orca*), pinnipeds	Fisheries, hatcheries, dams, agriculture, habitat restoration, NGOs, Indian tribes	Salmon conservation vs. dams, protection of predators, and fisheries
(3) International Whaling Commission	Whales	Whaling, fisheries, offshore drilling, shipping, whale watching, NGOs	Whale conservation vs. fishing (bycatch), drilling and extraction, shipping noise and emissions, ship strikes, ocean pollution, direct takes
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Salmon (*Salmo salar*), seals (*Halichoerus grypus*)	Fisheries, tourism, hydropower dams, river water quality, NGOs	Salmon conservation vs. commercial and recreational transboundary fisheries, slight conflict with seals
(5) Interactions between seals and commercial fishing in Ireland	Gray seals (*Halichoerus grypus*), monkfish (*Lophius spp.*), other demersal fish, crawfish (*Palinurus elephas*)	Fisheries, NGOs, conservation bodies	Seal conservation vs. sustainable fisheries
(6) Water supply and salmon in California's Central Valley	Chinook salmon (*Oncorhynchus tshawytscha*)	Agriculture, fisheries, habitat restoration, dams, NGOs	Salmon conservation vs. irrigated agriculture
(7) St. Croix River alewife restoration	Anadromous alewife (*Alosa pseudoharengus*), smallmouth bass (*Micropterus dolomieui*)	Hydropower, Businesses (paper companies, bass fishing guides), NGOs and Indigenous Peoples	Blocking (native) alewife passage at dams to protect (introduced) bass productivity for recreational fishery vs. returning alewife to native habitats
(8) Depredation by toothed whales in French Antarctic toothfish fishery	Toothfish (*Dissostichus eleginoides*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*)	Fisheries, government, NGOs	Depredation: whale conservation vs. sustainable fisheries

TABLE 4 | Case studies – Distributional effects and power dynamics.

Case study	Distributional effects and power dynamics	
	Benefits of coordination	Political influence
(1) Moray Firth Seal Management Plan	Reducing litigation and transaction costs; generating innovative solutions	Government holds legal leverage over fishery interests; conservation NGOs have moral ascendancy to give seal conservation priority
(2) Salmon management institutions in the Columbia River Basin	Implementing more cost-effective recovery action, reducing litigation	Strong hydropower and agricultural interests vs. tribal interests and diffuse non-use values; fishery interests favoring hatcheries
(3) International Whaling Commission	Design and implementation of more tailored and cost-effective monitoring and mitigation measures	Fishing and processing, oil and mineral extraction, shipping.
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Improved management of a transboundary resource, support for science, higher value use of salmon	All management actions re-distribute catches, i.e., they are very political decisions
(5) Interactions between seals and commercial fishing in Ireland	Depredation and byctach of seals are likely linked, suggesting the possibility of benefits for both	Neither side are particularly strong politically, although NGOs may have slightly more influence
(6) Water supply and salmon in California's Central Valley	Reduced litigation costs, reduction in risk to ecosystem and water users.	Well-connected agricultural lobby
(7) St. Croix River alewife restoration	Overcome complex jurisdiction (Canada, United States, and Indigenous People), and inconsistent management	Bass fishing lobby; Power imbalance as one jurisdiction can take action that negatively impacts entire system
(8) Depredation by toothed whales in French Antarctic toothfish fishery	Minimizing depredation ecological and socio-economic impacts, avoiding toothfish quota reductions	Political will to maintain coordination and fight illegal fishing

maneuvering that obstructed solutions to the conflict or led to failure of attempt to resolve them. Reducing litigation costs is cited as a benefit of better governance for several cases (Moray Firth seal management, Columbia River Basin, and California's Central Valley cases). While it may be clear that better governance could increase overall benefits, win-win solutions are rare and solutions generally require compromises.

The case studies are also informative in terms of approaches for making tradeoffs and implementing durable solutions (**Table 5**). In most cases, partnerships involving government bodies and essential user groups were formed. The time period between the beginning of the crisis and the formation of a partnership with a direct mandate to address the conflict appears to increase with the number of sectors involved in the case. Likewise, the multiplicity of parties appears to decrease the likelihood of reaching agreement on solutions for mitigating the conflicts. This is illustrated by cases such as the salmon management in the Columbia River Basin and the water supply

TABLE 5 | Case studies – Coordination mechanisms.

Case study	Coordination mechanisms	
	Existing mechanisms	**Support from authorities**
(1) Moray Firth Seal Management Plan	Partnership of tourism operators, conservation groups and marine fishery interests; annual seal shooting licensing system; local "champion" for solution mechanism.	Existing but lack of mechanism to engage fisheries, tourism and conservation interests
(2) Salmon management institutions in the Columbia River Basin	Northwest Power and Conservation Council, Columbia Basin Partnership, Courts	Existing but lack of overarching institutions
(3) International Whaling Commission	Collaboration on science and stewardship at the global, regional and local levels	Still a challenge given diverging mandates and institutional silos.
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Strong link between policy and science, EU fisheries policy approaches	Existing support from managers; strong political will of Finnish fisheries minister to improve management
(5) Interactions between seals and commercial fishing in Ireland	Ad hoc discussion group with industry and NGOs, led by scientists	Minimal
(6) Water supply and salmon in California's Central Valley	Inter-agency coordination meetings, NGO and water user projects, Council established to facilitate stakeholder involvement, government grants to fund alternative habitat projects	Existing, but buy-in is voluntary and decisions often non-binding.
(7) St. Croix River alewife restoration	No existing structure that allows for coordinated action	Ad hoc group, facilitated by an international body, is trying to bring all parties together
(8) Depredation by toothed whales in French Antarctic toothfish fishery	Industry-research partnership	Coordination by a regional commission (CCAMLR) and French government

TABLE 6 | Case studies – Stakeholder objectives and processes for evaluating trade-offs.

Case study	Shared views/objectives across stakeholder groups (formally recognized)	Evaluative processes for trade-offs
(1) Moray Firth Seal Management Plan	Compromise accepted and codified in collaboratively developed Moray Firth Seal Management Plan (MFSMP)	Sophisticated trade-off analysis based on seal and salmon population assessments and predation modeling
(2) Salmon management institutions in the Columbia River Basin	Emerging and partial – long term aspirational goals but lack of clear near-term objectives	Limited evaluation and lack of mechanisms for implementing trade-offs
(3) International Whaling Commission	Limited awareness of the impacts of non-whaling threats on cetaceans	Limited but possible if open and informed public process and shared science. Need workable and practicable solutions
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Common understanding but no shared view	High quality Bayesian stock assessment estimates all individual stocks separately and their reactions to policy actions
(5) Interactions between seals and commercial fishing in Ireland	Common understanding but no shared view of objectives	No trade-off evaluation undertaken to date
(6) Water supply and salmon in California's Central Valley	Water supply and ecosystem services formally recognized as co-equal goals; but stakeholders rarely agree on specific objectives	Strong support for "no-lose" alternatives, but mechanisms for evaluating tradeoffs are lacking.
(7) St. Croix River alewife restoration	No for some time, but consensus now emerging that alewives should be returned to former distribution	No formal process for evaluation
(8) Depredation by toothed whales in French Antarctic toothfish fishery	Common understanding but no shared view	No trade-off evaluation undertaken to date

and salmon in California's Central Valley where partnerships have not yet led to broad, resolute actions needed to resolve the long-standing conflicts. Individuals can also be the key to conflict resolution (as well as disruption). For instance, the role of a facilitative leader and the political will of a minister are emphasized in the Moray Firth Seal management case and the Baltic salmon management case, respectively.

Multiple case studies highlighted the importance, and often the lack of, a shared views and objectives (**Table 6**). A common theme across several case studies is the disagreement over the allocation of costs and benefits across sectors. For instance, fishers often deplore being the only sector bearing the cost of marine mammal conservation while ocean pollution and other sectors such as shipping may also pose threats. However, stakeholders in favor of marine mammal conservation note that industry sectors often fail to take into account their impacts on marine mammals in their operating decisions. In the two US salmon conservation cases, rebuilding salmon populations will likely requires sacrifices by harvesters, industries and the broader public that degrade habitat or benefits from services generated by the hydroelectric system (e.g., irrigation, power, and flood control), but also by conservation interests that may have to consider trade-offs between marine mammal and birds conservation and salmon recovery. The lack of a governance structure that brings these disparate interests together to negotiate trade-offs has led to litigation and political maneuvering that has increased the cost of identifying and implementing solutions and slowed progress.

TABLE 7 | Case studies – Solutions implemented.

Case study	Solutions implemented to address conflicts		
	Top-down	**Ostrom-type solutions**	**Coasean solutions**
(1) Moray Firth Seal Management Plan	Government introduced legislation to force negotiation by fisheries	Partnership of diverse stakeholder representatives negotiating compromise, integrating knowledge and generating innovative solutions	Negotiation of seal shooting quotas in areas where impacts on conservation and tourism are minimized, and salmon predation most likely
(2) Salmon management institutions in the Columbia River Basin	Court orders for recover actons; amendment of MMPA allows lethal removal of pinnipeds	Partnership of diverse stakeholder representatives	Leasing water rights to balance stream flow needs for salmon and historical water uses
(3) International Whaling Commission	Bans on certain activities, such as in MPAs or bans on certain gear types, shipping zones, etc.	Collaboration on monitoring and evaluating alternatives to the activities causing the externalities such as bubble curtains, gear modifications, slower ships.	Compensation schemes ("beneficiary pays" type), e.g., ECHO Program in BC Canada
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Measures based on EU Common Fisheries Policy, supported by national restrictions	International science and policy collaboration within existing EU institutions	Individual Transferable Quotas (but not currently transferable between river-based and at-sea fisheries)
(5) Interactions between seals and commercial fishing in Ireland	Prohibition of killing or harming seals	Collective rules to mitigate impacts on both seals and fisheries	
(6) Water supply and salmon in California's Central Valley	Endangered species laws and administrative biological opinions regulate water use	Collaborative governance program and Council to facilitate stakeholder involvement	Water markets
(7) St. Croix River alewife restoration	Top-down legislation (blocking fish passage) changed in response to pressure from many groups	Emerging collaborative partnership to overcome jurisdictional complexity.	
(8) Depredation by toothed whales in French Antarctic toothfish fishery	TAC reduction imposed on fishery depending on depredation level	Partnership of diverse stakeholder representatives	Incentive scheme: quota allocation depends on fishing firm participation to research on whale conservation and solutions to mitigate depredation

TABLE 8 | Case studies – Governance challenges and opportunities.

Case study	Governance challenges and opportunities	
	Barriers to other possible solutions	**Opportunities**
(1) Moray Firth Seal Management Plan	Lack of financial support from government to maintain local coordination and research; apathy from stakeholders as a result	Decline in salmon stocks creating renewed crisis and elevating salmon conservation imperative
(2) Salmon management institutions in the Columbia River Basin	Conflicting legal mandates (under ESA, MMPA, and MSA), multiple jurisdictions (state, federal, tribal) and management agencies	Shift in norms and values may create impetus to amend the ESA to allow consideration of trade-offs between objectives
(3) International Whaling Commission	Conflicting national or treaty mandates, lack of global or regional agreements; lack of data on population level mortality impacts of different sectors	Collaboration, Memorandums of Understanding, joint development of guidelines, etc.
(4) Management of Natural and Reared Salmon stocks in the Baltic Sea	Focus of EU Common Fisheries Policy on at-sea fisheries only, differing national policies	Potential to implement ITQs between countries and between river-based and at-sea fisheries
(5) Interactions between seals and commercial fishing in Ireland	Confusion of responsibilities spread between responsible parties	Potential to reduce both bycatch and depredation with a single solution, e.g., acoustic deterrents or change in fisher behavior
(6) Water supply and salmon in California's Central Valley	Water scarcity; multiple agencies with jurisdictional conflicts and different and conflicting mandate conflicts	Water scarcity and new legal mandates (groundwater management, dam relicensing) may foster policy innovation
(7) St. Croix River alewife restoration	Complex, international jurisdictions; no consensus on priority of objectives among interested parties and ecological health of the waterway	Increasing acceptance that return of alewife would improve productivity and not negatively impact the recreational fishery
(8) Depredation by toothed whales in French Antarctic toothfish fishery	Management still focused on short-term issues, scientific uncertainty about mitigation benefits and costs, importance of non-use values	Longer-term management plans, test of new technical mitigation solutions, further inclusion of fisheries impacts on marine mammals in MSC labeling criteria

A formal evaluation of trade-offs is rarely done (the Moray Firth case is an exception). In the Columbia River Basin salmon case, a visioning process, where stakeholders envision a better world (identifying objectives, and potential paths to get there), is being employed. Even if some of the objectives are unrealistic, a visioning process can gives stakeholders a common positive goal to aspire to. This can help build empathy and trust, and to build stakeholders cooperation. In addition, the visioning

process could focus on a shared vision of the management approach, not necessarily on a shared vision about the relative importance of different objectives (Stephenson et al., 2019). Sometimes developing a shared vision between industry groups and non-governmental organizations (NGOs) can be less difficult than expected as industry groups understand that they need social acceptability (Kelly et al., 2017). In other cases, while not sharing the same values, the different stakeholders at least have a common understanding of the different values and objectives of others (e.g., Baltic salmon case, seal-fisheries interactions in Ireland, and French Antarctic toothfish fishery case). This indicates that collaboration may be beneficial even when values are not shared, despite the challenge of reaching agreement on a solution remaining.

Scientific uncertainty is also mentioned as an impediment to reaching agreement on a solution in the majority of case studies. Stakeholders are often unwilling to incur substantial costs for management measures that would have highly uncertain outcomes. Even if transaction costs are equally born, some parties perceive different odds of success. The case of Baltic Sea salmon management underscores that probabilistic decision analysis tools offer a possibility to check how precisely the objectives must be known in order to be able to provide scientific advice to a fishery. In general, scientists can estimate and work toward decreasing uncertainties, including regarding the value of ecosystem services, to help stakeholders identify the potential outcomes of alternative solutions to problems. A few of the cases discuss formal evaluations designed to better understand the cause of the problem or the efficacy of solutions. Sometimes, research may not be able to provide such knowledge. Several cases note a lack of formal evaluation of the conflict or potential solutions (e.g., seal-fisheries interactions in Ireland, St. Croix River alewife case, French Antarctic toothfish fishery case) or stress the issue of insufficient funding to ensure long-term support toward collaboration efforts in science-policy projects (e.g., Moray Firth case). Other times, while scientific information is available, it may not be understood and/or believed by some parties. For instance, the linking of multiple ecological and social components in complex models may decrease their understandability and thereby their usefulness in supporting coordinated decision-making across sectors. Uncertainty estimation is often technically difficult, and the explanation of the results to all stakeholders may be demanding.

While most of the conflicts in the case studies have yet to be fully resolved, a variety of mechanisms to facilitate solutions have been applied including top-down legislative and regulatory actions; Ostrom-type solutions involving partnerships of diverse stakeholder groups or collaborative governance; and Coasean solutions involving compensation or market solutions (**Table 7**).

Top-down solutions reliant solely on regulation may not be the most effective means of resolving many of these conflicts and may be hindered by conflicting mandates that require changes in legislation or international agreement and treaties. Nevertheless, these mechanisms are often part of the solution as they can create pressure on regulated parties to find alternative solutions that are more effective or less costly such as in the Moray Firth case.

Most of the cases involved some attempts at collaborative governance in the form of partnerships between stakeholder groups. Some are facilitated by government (e.g., Columbia Basin Partnership) while others were developed by stakeholders (e.g., case of seal-fisheries interactions in Ireland). Many of these partnerships are ongoing and evolving, making it difficult to assess their efficacy or durability.

Several case studies provided examples of Coasean bargaining solutions, though these are mostly partial solutions that mitigate but do not resolve the conflict. For instance, compensation or lower docking fees may be offered to shipping vessels reducing their speed in approaching the port, which favors whale conservation (see IWC case study). Individual fishing quota allocations can include a "participation in research activities" criterion to incentivize fisheries collaboration with scientists on issues related to marine mammal conservation (e.g., French Antarctic toothfish fishery). Technical operating measures that effectively mitigate externalities such as marine mammal bycatch may be encouraged by ecolabels which can provide incentives to industry groups seeking to demonstrate that their activities are "eco-friendly."

Markets can be viewed as an alternative mechanism to collective governance based on a shared vision; in a market, parties do not have to agree on how a resource is going to be used. However, markets may fail to address the needs of a large and diverse set of stakeholders, hence the need for incorporating them in an integrated governance approach (German and Keeler, 2009). Market mechanism were used or identified as possible solutions in several cases (water markets in two US-based case studies, individual fishing quotas in the Baltic salmon management case).

Barriers to solutions were identified in all cases, including conflicting legal mandates or treaties and complex and unclear jurisdiction over uses and activities (**Table 8**). Several case studies also stress the issue of insufficient funding to ensure long-term support toward collaboration efforts in science-policy projects (e.g., Moray Firth case). Another common problem is the perception that not everyone is cooperating. For instance, while environmental NGOs are identified as relevant stakeholders in all the case studies, they may prefer not to participate in cross-sectoral partnerships depending on their strategy as counter lobbyists. In the St. Croix River alewife case, the lack of an institution with cross-national jurisdiction and the lack of cooperation between those involved led to an aberrant situation where the State of Maine enacted legislations to close dam fishways to block alewife migration while Canadian authorities were transporting alewifes around the dams using trucks. Other recurring issues in case studies include the inertia created by high transaction costs and the lack of existing mechanisms for cross-sectoral cooperation.

Reconciling use and non-use values is critical to addressing many cross-sectoral conflicts. Conflicts between use and non-use values are illustrated in multiple case studies by the issue of predator controls. For instance, many populations of pinnipeds are recovering after bans on hunting, leading to conflicts between fishers and environmental NGOs on the issue of pinniped culling. In the case of interaction between seals and commercial fishing in

Ireland, the legislation prevents the culling of seals. Conversely, in the Moray Firth seal management and the Baltic salmon management cases, fishers have been allowed to shoot a limited number of seals. However, under EU regulations, the selling of seal products is not allowed, which prevents the use of yield for ethically unacceptable use. Likewise, in the United States, the MMPA was amended in 2018 to allow for much greater flexibility to lethally remove pinnipeds in the Columbia River and its tributaries. Another illustration of conflicts between use and non-use values is when a resource is valued for its role in the ecosystem and is impacted by human activities (e.g., IWC internal conflict with regards to whales, St. Croix alewife interacting with dams and bass recreational fisheries). Non-use values may affect the scope of tradeoff possibilities when non-use sectors are reluctant to negotiate on certain values such as existence values or animal cruelty. Consequently, non-use values are highly relevant to the likelihood of stakeholder collaboration. Non-use values are highly diffuse, accruing to broad populations not closely connected to the resource or its management. While they may be represented by NGOs or the government, their lack of direct involvement in conflict resolution can lead to lack of acceptance that can undermine agreements (like in the Moray Firth case when an animal rights group disputed the solution that had been in place). This, in turn, may undermine other parties' willingness to negotiate.

In some cases, a crisis may be an opportunity to facilitate the process of getting all stakeholders together (Young et al., 2012). In the Moray Firth case, a crisis created by a government conservation order triggered bringing diverse stakeholders to the table to develop a plan. Cross-jurisdictional collaboration can be triggered by ecological disasters (Evans et al., 2014; Villamayor-Tomas et al., 2014). However, the occurrence of external disturbances is not always sufficient to trigger or sustain cooperation among actors in large-scale systems (Fleischman et al., 2014). Some actors who are involved in multiple policy forums, sometimes referred to as "policy elites" (Jenkins-Smith et al., 2014), may play the role of facilitative leader and bridge different sectors. Local leaders can reach out to stakeholders that feel left out of the process (Young et al., 2012). Otherwise, central authorities or the courts sometimes play the role of forcing some kind of negotiation. In some instances, central authorities have the capacity to force parties together to negotiate by shutting down all activities until a solution is found[11]. This can make the cost of the conflict greater than the transaction costs associated with finding a solution. However, there might be settings where it is not acceptable politically. The two US-based case studies (Columbia River Basin and California's Central Valley cases) mention the role of litigation to arbitrate conflicts between groups or to force governments to improve their recovery plans. In cases of very intense conflict between stakeholder objectives, a new legislation may be needed, where policy-makers, instead of stakeholders, decide on the weighting of the different policy objectives.

[11]For example, Canada's DFO entirely closed the Pacific groundfish trawl fishery in 1995 to force bargaining among stakeholders. The fishery reopened months later with a new management system including 100% at-sea observer coverage and ITQs (Grafton et al., 2004).

DISCUSSION

Feasibility and Key Determinants of Stakeholder Collaboration

Governance frameworks generally prescribe getting all stakeholders together and having them agree on a comprehensive set of objectives. However, large-scale systems can involve a multitude of governmental and non-governmental actors, making this task very difficult. Ostrom's work shows that shared vision about a resource is more likely when groups are relatively small with similar production models and objectives (Cox et al., 2010), conditions which do not describe most of the cross-sector problems examined in this paper. Cross-sector collaboration efforts that address a diverse set of policy issues entail higher transaction costs (Lubell et al., 2019). First, the group of stakeholders needs to be defined and bounded to avoid institutionalizing open-access (i.e., establishing institutions with potential for new entry would likely fail to address typical open-access issues). Next, stakeholder representatives need to be identified and selected to maintain a power balance within the group. In cases involving multiple sectors and multiple constituencies within each sector (e.g., large watersheds), this might not be feasible. Lubell (2004) found that coastal watershed collaborative institutions do not change the level of collaboration among conflicting stakeholders. Advocacy actors such as environmental and economic interest groups often have conflicting policy preferences (Newig and Fritsch, 2009). Some stakeholders also may lobby for their narrow policy interests rather than have a more neutral perspective. Other potential issues include the strategy of some powerful environmental NGOs that may get involved in conflicts with a disruptive campaign but refuse to participate in collective policy forums (Redpath et al., 2013). Greater public involvement in participatory environmental planning can also help include public values into decision-making and improve trust in government agencies, though this will depend on the commitment of the lead agency to the participatory process (Beierle and Konisky, 2000). An appropriate legal framework is also important to facilitate stakeholder collaboration[12]. Consequently, the number of challenges in gaining stakeholder cooperation and collaboration are not to be underestimated.

Trust and learning among resource use sectors is critical for establishing durable management regimes and fostering system resilience. Support from central authorities is also essential. Resilience of the system and durability across political cycles require that institutions, government bodies, stakeholders, and resources have the potential to adapt to change (Folke, 2006). According to Ostrom (1998), three main elements are important in designing long-term solutions to collective action when multiple parties bring different interests: reciprocity (continually interacting institutional players may be more willing to trade), reputation, and long-term trust. In general, a proactive approach is usually a much better strategy than a reactive approach to develop all three of these elements. Legislation can support a

[12]For instance, under the US Endangered Species Act, NGOs can sue without having to negotiate beforehand.

more proactive approach to avoid crisis. The role played by central authorities in monitoring and enforcement may also be essential to build trust in the system (Singleton, 2000; Potoski and Prakash, 2004), especially in cases where there is no history of cooperation between sectors.

The question of who initiates coordinated management efforts, and at what level, is also important. Cross-sectoral collaboration can be a local effort or it can also be widespread. Who sets objectives can greatly influence the success of collaborative governance. The emergence of a widely respected leader to guide the process can be favorable to build trust among groups (Stern and Coleman, 2015; Young et al., 2016). The importance of a leader was noted in the Moray Firth case, but the role individuals play in finding or disrupting solutions is rarely documented though it may often be critical. Moreover, while evaluation of tradeoffs is necessary, a mechanism for deciding resource uses and making associated tradeoffs is also needed. The identification of mechanisms for making tradeoffs across sectors is a critical challenge for facilitating solutions. In addition, the cumulative effects of management actions are typically not evaluated. Cumulative effects are often inherent to cross-sectoral conflicts, and to some extent, the evaluation of the cumulative effects is the ultimate goal of cross-sectoral collaboration (Korpinen and Andersen, 2016; Stephenson et al., 2019). Finally, the level of complexity and the information needed, which increases with the number of sectors considered, is an important issue. In some cases, it may be more effective to solve conflicts among a subset of stakeholder groups rather than considering all sectors at once and being unable to resolve tradeoffs.

Debate Over Compensation and Incentive Schemes

Distributional impacts of institutional change are often the primary reason for the difficulty of resolving cross-sectoral conflicts. Some parties anticipate bearing more, uncompensated costs than benefits, and they have an incentive to resist. For instance, if the ecosystem service is a broad public good, but the costs are narrowly imposed, then parties are likely to oppose institutional change. Ostrom (1990) and Libecap (1994) identified that a proportionate distribution of costs and benefits are key to resolving conflicts. Ideally, the distribution of costs and benefits should be fair. However, not everybody will agree on what constitutes a fair distribution (Loomis and Ditton, 1993). In a practical way, what is important is to achieve a distribution of costs and benefits so that no group will defect; to this end, the distribution of costs and benefits should relate directly to the shared set of objectives and values. There are two main aspects to the distribution of costs and benefits: (1) the distribution once the long-term objective is met, and (2) the distribution during the transition phase (moving from status quo to a solution). Political systems, where short-term outcomes are prioritized, can be ill-equipped to meet long term objectives if stakeholders are incentivized to focus on the short term costs of transitioning. Compensation might help address issues related to redistribution that may occur in the transition phase.

Compensation and incentive schemes can be a solution to help achieve environmental objectives but may also be controversial depending on the context. In a number of countries, livestock owners are compensated for their losses due to attacks by protected wolves (Agarwala et al., 2010; Thiel et al., 2012). This mechanism intends to help achieve conservation objectives. However, in most fisheries (including many fisheries where depredation occurs), fishers are given the right to extract a common-pool resource for free. If fishers are also given the right to harm another public resource (e.g., marine mammals that might interfere with fishing operations) or paid as a result of depredation costs, then the public may perceive this as unfair. Depredation could be seen as a "cost of doing business" that fishers should bear just as they would bear any other privately incurred cost to harvest a valuable resource. On the other hand, this type of compensation is not very different from cases where successful parties in the regulatory game get benefits that they do not pay for (e.g., subsidies).

The reluctance of many to go toward market-based approaches is that incentives in some market-based fishery systems have been perceived as perverse: public resources were given for free to groups in the form of shares, which are now worth millions of dollars, which is seen as unfair from society's point of view (Bromley, 2009). Another potential issue in fisheries where rights are well defined and transferable is that the willingness to pay of recreational fishers can be higher than that of commercial fishers, and there may be cases where recreational fishers would buy out the commercial fishers (see above discussion on ITQs in the Baltic Sea salmon case). But this has not been widely allowed because it is not politically or socially acceptable to have commercial fishing disappear. The need for market instruments depends on whether social and cultural norms foster cooperation and allow for reallocations across different parties (Noussair and Tucker, 2005). Market-based approaches may be unnecessary in situations where cultural and social rules are effective in resolving cross-sectoral externalities (Shogren, 2012). In other words, good social capital may help to find acceptable solutions.

Additionally, there might be concerns about moral hazard as compensation might lead to changes in behavior of resource harvesters. If harvesters are required to bear the cost of depredation, rather than being compensated, they may devise strategies to avoid depredation events (e.g., by changing when and where they fish or with gear modifications or devices to deter or scare away predators). This also raises questions about how to organize the regulation and enforcement of the compensation system to deter cheating. For instance, in the case of depredation by seals, it may be difficult to demonstrate that a fish has been damaged by a seal. Society may be reluctant to offer compensation for damaged fish, even if the cost is relatively small. Yet, one could argue that fishers already get a lot of things that they do not pay for and compensation might be a relatively cheap option to solve a long standing problem. With regard to moral hazard, ex-ante compensation (e.g., payments for ecosystem services) may be more appropriate than ex-post compensation (e.g., fixed value per damaged fish) in order to maintain incentives for harvesters to prevent depredation events (Skonhoft, 2017).

Compensation means that rights requiring compensation have to be allocated and often these rights would be granted for free to past participants (grandfathering), which is part of why this might not be politically acceptable. This relates to the question of fairness and equity. The lesson from Coase (1960) is that if transaction costs are high, then the initial distribution of rights matters and this might affect whether you would want to have a compensation scheme or not in some cases. Moreover, in cases where resource exploitation generates negative externalities to a non-use sector, the issue of whether non-use values can be quantified is critical (Krutilla, 1967). The ability to estimate these non-use values[13] in a manner that allows a negotiation is a key factor in achieving agreement. If we cannot adequately estimate non-use values, then they may be viewed as trumping other values and may undermine collective action. They may also be implicitly assigned a value of zero, which would likely lead to socially inefficient outcomes.

Stakeholder adaptation to an external shock (resilience) and willingness to make a major change, depend on the different perceptions of the probability of an external shock and how the distribution of costs and benefits are perceived. Discount rates that people are using are important for long-term risk assessments. Discount rates and access to capital, as well as the implications of prospect theory on the redistribution of interests (Kahneman and Tversky, 1979), are relevant when a change is needed and involves costly actions for stakeholders. Compensation could take the form of low-cost financing (e.g., loans) to give users the opportunity to make a major change, which might be more politically acceptable than compensation (Rangeley and Davies, 2012).

Looking Ahead

The accelerating trend of increased ocean uses over the last 50 years is intensifying anthropogenic pressure on ocean ecosystems (Jouffray et al., 2020). The multitude of claims on ocean food, material, and space, increasingly leads to cross-sectoral conflicts such as those examined in this paper. Addressing the challenges associated with cross-sectoral conflicts requires an improved knowledge of the diversity and magnitude of claims being made and their interactions, as well as a greater consideration of trade-offs and cumulative impacts (Stephenson et al., 2019; Jouffray et al., 2020). In addition, traditional governance is often not well-adapted to mitigate these conflicts (Spijkers et al., 2018, 2019), stressing the need to consider Ostrom-type approaches and Coasean solutions more systematically to achieve a balance between sustainable use and conservation while addressing equity concerns. More research is therefore required to determine where and when each of these governance alternatives is most appropriate to manage conflicts.

An additional complication for ocean governance is that 64% of the surface of the oceans is situated beyond national jurisdictions, where human activities are regulated and managed by a multitude of disparate sectoral institutions (Wright et al., 2018), and these institutions have limited authority and enforcement capability. In particular, there is little cooperation between existing organizations and no responsibility for overarching principles for the conservation and sustainable use of biodiversity beyond national jurisdiction. To address growing threats to biodiversity in these areas, the United Nations (UN) is currently discussing a possible international legally binding instrument to conserve biodiversity and mediate between conflicting uses (Wright et al., 2019). Interestingly, ongoing discussions include the possibility of a funding mechanism to balance the distribution of costs and benefits, in particular between countries of lower and higher capacity (Österblom et al., 2020). Such a funding mechanism could for instance include side payments to a conservation fund (to support environmental sustainability) or to a capacity-building fund (to provide financial resources for operationalizing a clearing-house mechanism or help developing countries).

Coastal and marine governance conflicts are also relevant to UN 2030 Agenda for Sustainable Development and associated Sustainable Development Goals (SDGs). As pointed out by Singh et al. (2018), SDG 14 (Life under Water) that aims to "conserve and sustainably use the oceans, seas and marine resources for sustainable development" contributes to many other SDGs such as ending poverty (SDG 1), ending hunger (SDG 2), good health and well-being (SDG 3), reduced inequalities (SDG 10), and peace, justice, and strong institutions (SDG 16). A failure to develop institutions able to mitigate marine and coastal governance conflicts may therefore undermine the realization of these broader goals. Acknowledging the critical role of the ocean in achieving the SDGs, the UN has proclaimed a Decade of Ocean Science for Sustainable Development (2021–2030) to encourage the development of the frameworks and tools required for the integrated and sustainable management of the ocean (Ryabinin et al., 2019; Claudet et al., 2020; Pendleton et al., 2020). Given the need to address cross-sectoral conflicts for achieving societal goals, it appears important that the Decade of Ocean Science engages in additional social science research to support the development of more integrated, multi-sectoral governance approaches.

CONCLUSION

The successful management of cross-sectoral conflicts often requires moving beyond traditional top-down regulation. Ostrom-type approaches, which are broadly focused on cooperative management and collective-choice rules, and Coasean bargaining, which involves exchanges of some form of property rights or regulatory benefits between groups, both delegate more responsibilities to stakeholders who have more practical knowledge than managers or politicians to implement actions. Both approaches may be more responsive to dynamic factors and thus may provide more durable institutions. Ultimately, which policy option is more appropriate depends on the nature of the resources, the users and their values, and the nature of their interactions. Often some combination of top-down pressure, collaborative governance, and bargaining and exchange may be needed to resolve these highly complex and intractable conflicts.

[13]Tools to estimate non-use values include revealed-preference (Boyle, 2017) and stated-preference methods (Johnston et al., 2017).

More research is required to put forward governance alternatives that will assist in evaluating trade-offs and conflict management. Addressing marine and coastal governance conflicts at the interface of multiple sectors and jurisdictions could be approached through the effective combination of collaborative institutions and mechanisms that provide incentives to stakeholders, or compensation to parties that perceive that they are going to be made worse off by institutional change. Solutions need to ensure that non-use values are reflected in decisions, most likely through public participation in collaborative institutions if representativeness can be guaranteed. Finally and ultimately, cross-sectoral coordination for conservation is highly dependent on long-term stakeholder and political commitments.

AUTHOR CONTRIBUTIONS

MB, CS, DH, and OT convened the workshop in Brest. MB led the writing of the manuscript. MB, CS, JB, RF, SG, DH, SK, BL, RL, DR, RS, and JY developed the case studies. All authors were involved in drafting this article and approved the final version for publication.

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SUPPLEMENTARY MATERIAL

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