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Climate change increases the risk of fisheries conflict

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The effects of climate change on the ocean environment are complex and sweeping, and include three main phenomena: warming waters, ocean acidification, and sea level rise. Much work has been done to characterize how the ocean is changing, and the direct and indirect consequences for marine ecosystems and resources, including consequences for the people that use the oceans for income, food and cultural value [1-3]. This article brings insights from social science to bear on the question of overall impacts, by investigating how the effects of climate change on the ocean environment challenge the prevailing institutional frameworks for managing local, national, and internationally-managed fisheries, and in particular the ability of these institutions to prevent fisheries-related conflict. While conflicts over fisheries have always existed, climate change is already altering the locations, types, and overall prevalence of these disputes. We conclude that the ultimate result of the effects of climate change on fisheries is an increased risk of fisheries conflict and a new set of governance challenges for fisheries management (see Fig. 1). Although many of our findings apply to the communal or sub-national levels, the collective impacts of climate change have implications for inter-state and regional interactions, such that conflict may occur on multiple scales. We propose a set of policy solutions that include adaptive and polycentric institutions, coordinated multinational response teams, reforms to the law governing maritime territorial claims, and marine protected areas. Although there has been some movement towards these solutions, the current state of fisheries governance is inadequate to redress the increased risk of fisheries-related conflict.

Although this article considers conflict drivers and dynamics across scales, it has a particular focus on fisheries disputes with an international dimension. As common pool resources that often span maritime boundaries, fisheries are a relatively frequent source of interstate conflict, and these conflicts have become more frequent over the past forty years [4]. Fishers and fishing vessels, which are flagged to a particular country but are not typically under the command and control of that country's armed forces, can also become entangled in broader disputes that have a maritime component, as is the case with recurrent fisheries-related conflicts involving North and South Korea [5]. Fisheries are one of the few causes of interstate conflicts between democracies, including democracies that are military allies, such as the Cod Wars between Great Britain and Iceland [6]. While membership in the United Nations Convention on the Law of the Sea (UNCLOS) can help promote third-party management and mediation of maritime conflicts, it does not seem to help in preventing militarized maritime disputes, of which fisheries conflicts are among the most common causes [7].

Climate change contributes to an already complex set of factors that influence the risk of fisheries disputes. Recognized drivers of fisheries conflict include stagnating or declining catches, illegal and unreported fishing and related attempts at enforcement, food insecurity, and contested maritime boundaries [8-9]. Many of these processes are intensified by climate change, but the nexus between climate change and maritime security issues is under-studied [10]. In the subsequent sections, we demonstrate how climate change will affect these known drivers, explore linkages with other maritime security issues, and consider how this situation creates new challenges for existing governance and regimes.

Impact of Climate Change on Fisheries

The effects of climate change on the ocean environment impact fish populations, fisheries, and fisheries management institutions in complex ways. Although the associated changes to fisheries will produce both ‘winners’ and ‘losers’ in the ocean environment and among ocean users, the common theme is disruption and change. Ocean warming results in shifting species distributions and fuels multiscale spatiotemporal changes in fish stocks [11-12]. Warming also impacts primary productivity, growth, and distribution of fish populations, resulting in reorganized food-webs and altered yields of exploited marine species as well as the economic and social benefits they provide [13]. Ocean acidification primarily impacts calcareous organisms, which range from small phytoplankton at the base of food-chains, to coral reefs that provide vital habitat and ecosystem services, to shellfish that we directly harvest [14]. Ocean acidification also decreases the survival rate – and potentially the harvestable biomass – of some fish species by interfering with behaviors triggered by environmental cues [15-18]. Taken as a whole, warming and acidification result in significant changes to the productivity and location of fish stocks.

Climate change also results in significant changes to fish habitats, in particular coral reef systems. Both warming and acidification damage coral reef ecosystems, which are important hosts and support for fish populations [1, 19-20]. The phenomenon of ‘coral bleaching’ is well-documented, and large scale bleaching events are increasing in frequency and duration [3, 20]. Warming also slows reproduction and recruitment of corals, which impedes reef accretion and rebound from acute events. Acidification makes the calcification of corals and coralline algae more metabolically taxing [20]. These climate change impacts, often in combination with local stressors like sedimentation and nutrient runoff, can cause reefs to undergo a “regime shift,” creating new ecosystem configurations that alter ecosystem functions in complex ways [21-23].

The impacts of sea level rise are mainly felt on coastlines, though it can be challenging to separate sea level rise from other influences, such as subsidence caused by groundwater extraction, enhanced erosion processes, and melting permafrost. In most cases, the problems created by these other factors are compounded by sea level rise. In some cases, sea level rise is the main cause of changes in the coastal water level. Its overall impact on global coastlines may be much larger than previously thought [24]. These changes alter the character and shape of the reefs, shorelines, and islands on which existing territorial boundaries – and thus fisheries claims and governance institutions – are predicated [24-25]. Sea level rise can also disrupt the coastal infrastructure of fishing communities, and undermine the coastal wetland environments that serve as hatcheries and habitats for juvenile fish [26-28]. Warming and acidification also hinder the vertical growth of coral reefs, which combined with sea level rise causes fewer reefs to reach or break the surface [20]. This lessens the benefits of shallow reefs, including mitigating erosion and buffer the impacts of extreme weather events.

These changes are likely to increase the incidence of conflict at various levels of social organization: fisher to fisher, fishing community to fishing community, fishing sector to other sectors, and state to state [4, 6, 9, 29]. And they will also be exacerbated by another important climate change-related effect: increasing reliance on fishing as a livelihood strategy. The next sections review four changes to fisheries caused by climate change – increasing scarcity, shifting populations, shifting boundaries, and increasing intensity of fishing – that together increase the risk of fisheries conflict, and create new challenges for fisheries governance.

Increasing scarcity

Increases in extractive pressure on fish stocks, and the tension it often causes between users, can result from reduced supply and/or increased demand. Demand for fish and fish products is expected to continue growing, due largely to population growth and rising incomes [1, 30-31]. Although much of the growing demand will be filled by aquaculture, including inland ponds, the role of aquaculture in global food systems is often overstated, and its expansion presents ecological and socioeconomic challenges that may complicate growth [32-34]. The potential for growth in open ocean aquaculture is difficult to calculate, given the complexity of climate effects and the asymmetrical regulatory environment [35]. And even as aquaculture continues to grow, the effort level for capture fisheries is also expected to increase [31]. In this situation of growing demand and increasing effort, reductions of the supply of wild fish stocks can have particularly concerning consequences for fishers.

Ocean acidification (OA) is one of the main climate change-related contributors to changes in fishery productivity [13], because it poses serious threats to calcareous marine species including shellfish, mollusks and coral reefs, and drives ecosystems to shift toward fleshy algae dominated states [36]. Increasing acidity reduces corals' ability to build their skeletons, which erodes their resilience to other stresses including warming-associated bleaching, overfishing of herbivores, and nutrient overloading [37]. Loss of coral reef habitats leads to a reduction in reef fisheries production, which negatively impacts communities and countries highly dependent on coral reef ecosystems for their food, income and livelihoods. The economic costs due to OA-driven reduction in the fisheries production of coral reef habitats are estimated to be between $5.4 to $8.4 billion annually under a high emission scenario [38].

Ocean warming and acidification also impact more temperate marine habitats. Temperate reefs and kelp forests are currently experiencing 'tropicalization' due to warming waters, which will have different effects on overall biodiversity and productivity depending on a range of factors [39-40]. While this process may help conserve some tropical coral species and benefit certain herbivorous fish species, it also entails a decline in habitat for some juvenile commercial fish species [39-41].

The impacts of OA on calcareous species create particular challenges for shellfish fisheries, which include both capture fisheries and coastal aquaculture. The consequences of reduced shellfish production, such as mollusks, due to OA are expected to adversely affect economies and food production in shellfish-producing countries. Research has already demonstrated such effects in the northwestern United

States, British Columbia, and several European countries [42-43]. The most vulnerable are countries – including some small island states – with low adaptive capacity, rapidly growing populations, and a high dependence on mollusks. Some regions with high and increasing demand for mollusks are also the regions where expected changes in ocean acidity are the most significant [44]. Meeting future needs would require a substantial investment in mollusk aquaculture (and in particular selective breeding programs for OA tolerant traits) and increases in mollusk imports. However, aquaculture mollusks are also susceptible to OA and these investments may suppress the resources allocated to other development projects in a country. As such, OA can lead to increases in food insecurity, and conflicts over resource allocation within countries [42].

The effect of OA on marine ecosystems is enhanced in coastal upwelling zones, which are some of the most biologically productive areas of the ocean. Although these ecosystems are generally resilient to environmental fluctuations, there is strong evidence that the early-life history stages of many species in upwelling systems are negatively affected by increases in ocean-acidity [45-47]. Ecological theory suggests that this will lead to large and abrupt decreases in fisheries productivity in the future [48]. And indeed, there is some evidence that OA will impact the productivity of highly migratory fish populations, such as yellowfin tuna [49-50]. Impacts on the productivity of fish stocks will have different implications for different fishers. The most vulnerable countries to climate change driven disruptions in the supply of local fish stocks are those with a high economic or protein dependence on fisheries, and limited ability to adapt via, for example, livelihood transitions [51].

Unlike OA and warming, the impacts of sea level rise on fisheries are limited to coastal zones. Sea level rise significantly affects the character of some coastal zones, including those important to fish stock productivity and fish landing and processing. In terms of stocks, sea level rise can negatively affect important juvenile habitats like salt marshes and mangroves, potentially reducing the overall size of particular commercial fish stocks [26, 28]. These impacts will vary depending on the rate of sea level rise, and the ability of coastal wetlands to move inland without being obstructed by human development. In addition to possible habitat effects, fishers themselves are highly dependent on coastal access infrastructure [28]. Sea level rise threatens shore-based infrastructure and support industries from the material stress caused by rising seas, and the heightened destructiveness of natural disasters [26-27]. The overall result may be a decline in fishing capacity or fishing effort, although most likely only until fishers can re-establish the necessary infrastructure farther inland or elsewhere.

These negative impacts on coastal wetlands and infrastructure may or may not spur fishers to change their employment, depending on the local effects on various industries, especially agriculture, fishing, and aquaculture. Sea level rise undermines coastal agriculture through increased flooding and water salinity – this can be an inducement to migration away from the coast, but it can also increase investment in aquaculture as a source of replacement income [52]. But sea level rise can also create new obstacles for coastal aquaculture. For example, in New Caledonia, shrimp ponds – an important source of export revenue – will become more challenging to drain and dry, which are necessary processes for waste management, harvesting, and pond maintenance [53]. The impacts of sea level rise on fisheries supply and demand are therefore complex and countervailing. Existing research suggests that encroaching seas may reduce fish stock productivity, weaken fisheries infrastructure, induce migration, and spur the adoption or abandonment of aquaculture. Although the overall impact on the health of global fisheries is difficult to predict, the impacts of climate change – sea level rise, acidification, and warming – include several drivers of increased scarcity.

Shifting populations

Warming waters induce shifts in fish populations, making the same fish populations accessible in new locations and to new fishers. Depending on the accessibility of neighboring fish stocks, users may attempt to follow or locate new stocks. If doing so entails a shift between regulatory regimes, the resilience of socio-ecological fisheries systems will depend on a range of factors, and the design of regulatory institutions [54-55]. Competition and conflict can also emerge across jurisdictional boundaries. The so-called 'mackerel war' between the United Kingdom and Iceland/Faroe Islands is an example which arose because with warming, the spatial distribution of the mackerel stock shifted from UK waters to those of Iceland and the Faroe Islands [29]. These types of conflicts are expected to increase as continued emissions intensify warming and its impacts on fish distributions and productivity [29, 56]. Many existing transboundary management arrangements (e.g. between Norway and Russia for Barents Sea cod) will need to be renegotiated as species move and change the bargaining power and threat points of the parties involved [29]. Existing joint management of transboundary fish stocks may collapse as a result of changes to their distribution and productivity, with those most vulnerable to these changes being coastal communities in developing countries [11, 13, 29, 56]. Even in the situation where fish stocks shift from international to national zones, current users may see themselves as rights holders, or be economically dependent on a stock, and therefore follow the fish over this new political and legal barrier. And when national fisheries management institutions fail to rapidly adapt to new or shifting stocks, the result can include "race-for-fish" dynamics [55].

Competition to exploit unregulated fisheries may also result from polar ice melt. The Arctic experienced major melts in 2007 and 2012, and has seen a general trend of decline in ice thickness and extent. In 2017, Arctic ice hit a record winter low for the third year in a row. At the other end of the planet, the Antarctic land mass has made it more difficult to measure the extent of ice melt. In recent years, however, scientists have measured numerous major ice melts and ice calving events, which expand the scale of ice-free areas [57]. Ice free waters, combined with the general warming trend, will bring new species to both poles. In the north, this has already led to new species migration (e.g. the snow crab moving into Svalbard's waters). The increased presence and availability of commercial species may encourage a new competitive race to fish in polar seas (see Fig. 2), placing additional management pressures on the Arctic Council, which already struggles to coordinate the actions and policies of Arctic littoral states. The new Central Arctic Ocean Fisheries agreement is a positive start, through which 9 major states and the European Union have agreed to a 16 year moratorium on commercial fishing in the Arctic high seas. But this temporary agreement, which excludes Arctic coastal waters, may face challenges as Arctic waters become more accessible and more is learned about fish stocks in the region [58-59]. In the south, this has put increased pressure on the Antarctic Treaty System bodies, particularly the Convention for the Conservation of Antarctic Marine Living Resources, which has faced dissension among its members about the scientific data needed to allow commercial fishing of particular stocks [60]. In both regions, increasing interest in polar resources has historically created governance challenges, which will only be amplified as more resources become accessible.

Shifting boundaries

Sea level rise affects claims over fisheries. The negotiation of UNCLOS created a political allocation of ocean space based on the location of coastlines. Most relevant is the 200 nautical mile ‘Exclusive Economic Zone (EEZ),’ which gives coastal states control over marine resources, including fish stocks. Rising waters challenge existing maritime boundaries in two ways: by shifting the low water line from which maritime zones like the EEZ are drawn, and by submerging islands on which many claims are based. The waters most affected are EEZs generated from low-lying coasts or coral islands, which tend to contain highly productive fisheries. When the water line shifts or an island submerges, previously declared or agreed upon maritime boundaries lose their topographic foundations. This situation is likely to prompt new conflicts over fisheries resources because the text of UNCLOS is ambiguous about whether coastal submergence causes EEZs to shift landward, and whether a legal ‘island’ can become a legal ‘rock’ or ‘low tide elevation’ and therefore lose its EEZ claim altogether [61].

Although no internationally recognized maritime boundary has been challenged because of submergence, the so-called ‘regime of islands’ has been recently subject to conflicting interpretations, in part because of other challenges to its meaning and durability [62-63]. The case of Okinotorishima, a tiny and low-lying atoll, demonstrates the risks associated with uncertainty about maritime claims. Japan asserts that the feature is an ‘island’ with a Japanese EEZ, while China and Taiwan claim it is a ‘rock’ and surrounding areas are freely-accessible high seas. While no direct conflict has yet to occur, Japan has detained Taiwanese fishing vessels in the area, which Taiwan responded to in part by sending patrol vessels to support its claims [64]. Absent the emergence of clear jurisprudence or customary international law that resolves this legal ambiguity – both of which require time – there is a risk that states will seek to change facts ‘on the ground’ by sending fishing and enforcement vessels to newly-questionable boundary areas. This combination of opportunistic exploitation and legal uncertainty means that even if the fisheries themselves are not affected by sea level rise, previously settled claims over fish will become controversial, likely fueling conflicts.

Increasing intensity

Existing research suggests that the impacts of climate change on land will also increase the number of fishers, and reliance on fishing as a source of subsistence and income. Because the impacts of climate change on land will be spatially heterogeneous, so too will the related factors that encourage migration to coastal fishing communities. As terrestrial temperatures rise, anticipated outcomes include losses in agricultural production and increasing need for alternative livelihood options for people reliant on agriculture, with migration to comparatively open-access resources like fisheries, particularly in the artisanal fisheries of the developing world [65-66]. In various coastal and deltaic agriculturally dependent countries, a relationship is observed between terrestrial agricultural problems and increased local dependence on fisheries [67].

Likewise, increasing temperatures and changing water security may drive new patterns of human migration [68-69]. Recurring crop losses because of climate change add to the “push” factors that incentivize relocation [70]. Migration is understood to be an effective adaptation strategy for coping with climate change, and fishing and aquaculture livelihoods can serve as "pull" factors drawing migrants to new locations [71-72]. This may be true regardless of the health and abundance of coastal fish stocks, as this information may not be known or disseminated, or because fisheries may retain relative appeal despite scarcity.

It is not yet known what growing dependence on fishing livelihoods, and new migration to fishing economies, implies for fisheries’ sustainability, or, in the event of fishery decline, future climate vulnerability of coastal communities, but it is likely that additional fishing pressure will create tensions in fishing communities [73]. Indeed, in situations where fishing pressure increases rapidly as a result of rapid in-migration, increased fishing pressure can feed back and became a source of conflict itself [66]. This is especially true of fisheries already experiencing declining catches or catch per unit effort. However, migration out of stressed fisheries may also lead to reduced fishing pressure and a reduction in conflict, albeit at the cost of harm to local economies and demographic balance [74].

Governance Challenges, Policy Solutions

The literature linking climate to conflict is large and growing, though not entirely conclusive [75-77]. In general, findings point to increased incidence of conflict events at extreme temperatures and levels of precipitation, on a wide array of time scales. However, these studies focus overwhelmingly on terrestrial conflicts and the direct impacts of temperature and rainfall, rather than the second-order effects of these changes for ecosystems and changing livelihood strategies. Here, we discuss how the physical changes described above are likely to affect the likelihood and intensity of conflict at multiple scales, and how vulnerabilities in fisheries management regimes can be addressed to reduce the overall risk of fisheries conflict.

Fisheries Conflict Risks

The physical changes to the environment associated with climate change are likely to exacerbate interpersonal, communal, and interstate conflict over fisheries resources. While most of this competition will not be violent, the literature suggests that fisheries conflicts between fishers and fishing communities, i.e., within states, will be more prevalent where formal governance institutions and property rights enforcement are weak, incomes are low, and social marginalization of certain groups – usually along ethnic or religious lines – is high, such as in much of Sub-Saharan Africa and South and Southeast Asia [78-79].

At the interstate level, fisheries-related incidents are one of the common sources of conflict at sea, especially among otherwise more peaceful maritime neighbors, like developed democracies [8]. These disputes often arise when fishing vessels encroach on the EEZ or territorial waters of another country in pursuit of productive fishing grounds. These encroachments can lead to interdictions, or even the scuttling of vessels and exchanges of fire between navies and coast guards. While most of these fisheries-related incidents do not escalate to war, they are emblematic of the tensions that underlie current governance approaches. Moreover, they are likely to occur both in regions where fish are becoming more scarce – increasing competition – and where they are becoming more plentiful, as conflict participants either compete over a dwindling pie or compete for shares of the newly abundant resource.

The fish stocks governed by existing fisheries management institutions are changing, as marine species shift their spatial distribution, abundance, physiology and phenology due to the changes in ocean conditions under climate change [80-84]. These trends are likely to intensify and worsen the risk of international disputes over fish stocks and fisheries. To understand the potential risk of fisheries conflicts in the future, we overlaid the historical militarized interstate disputes (MID) zones involving fisheries with the projected change in maximum catch potential (MCP) of about 900 demersal and pelagic marine species under high greenhouse gas emission scenario (IPCC Representative Concentration Pathway 8.5) [80, 85-86] (Fig. 2). The MID data is obtained from the Correlates of War data project [87-89]. To determine the subset of MIDs that involved fishing, we searched the narratives for 1993-2010 to find those containing the words “fish,” “fishing,” etc. Using the location data for those events combined with estimated locations based on the narratives for MIDs that were not already geolocated, we mapped the events and clustered them within a 500 mile radius to show concentrations of MIDs related to fishing. Changes in MCP, which is the maximum theoretical catch of a species in a given ecosystem, through the 2050s from the current status are extracted from the study by Lam et al. (2016) in which the distributional shifts of exploited marine species were first investigated using a Dynamic Bioclimate Envelope Model (DBEM) [86]. Based on the current distribution, the DBEM, which is a dynamic process-based species distribution model, simulates changes in the distribution of abundance and MCP of fishes and invertebrates over time and space driven by projected changes in ocean conditions, with consideration of physiological and ecological effects of changes in ocean properties and density-dependent population growth and movement under the IPCC Representative Concentration Pathways 8.5 scenario. The details of the DBEM are described in Cheung et al. (2009) [80].

Our analysis (Fig. 2) indicates the potential for continued or increased conflicts between coastal and long distance fisheries in various regions. The opportunity and scarcity dynamics that often fuel interstate or trans-boundary fisheries conflicts suggest that these disputes may increase in areas of both increasing and declining fisheries productivity. The geographic trends in historical conflict and change in catch potential imply a large potential for fisheries conflict continuing in the South China Sea in the near term, where productivity is declining, but also increasing in the Arctic, where catch potential is forecast to increase significantly under climate change. The coastal zones of South Pacific island states are not historically a site of militarized interstate disputes involving fisheries, although their valuable pelagic fisheries are exploited by many distant water fishing nations (along with domestic commercial and artisanal fishers). This region faces both declines in catch potential and uncertainty about maritime boundaries as a result of sea level rise. Ultimately, however, if fisheries near collapse, the likely result would ultimately be a decrease in fishing effort and a concomitant decrease in hostilities. The spatial shift in the distribution of marine species will also potentially increase the risk of fisheries conflicts between countries for some transboundary fish stocks [56].

While fish would likely be one of several issues at the center of any major maritime conflict, they could incite a ‘wild card’ scenario in which competing state powers are brought to the brink of engagement by the actions of third parties – fishing vessels and, in some instances, state-sponsored maritime militias – they neither directly command nor control [90-91]. Under these circumstances, miscalculations or misunderstandings may spiral out of control [92]. Furthermore, these disputes often cluster in regions – including the South China Sea and Gulf of Aden – where multiple maritime conflict accelerants (e.g. piracy, hydrocarbon reserves, rising military powers with regional ambitions) overlap with forecasted declines in maximum catch potential. Considering that many of these accelerants are forecast to be exacerbated by climate change, an increase in fisheries conflicts is plausible, as fishers and fishing fleets adapt to changing fish distributions by following fish across maritime borders (Fig. 2).

Vulnerabilities in Existing Fisheries Management

The present model for maritime governance is a largely territorial one, which divides most of the world’s most productive fisheries into zones of national control. While warming, acidification, and sea level rise may lead to fisheries conflicts via different mechanisms, claims over fish rely on a regime that links resource access to territory. The adoption of UNCLOS enshrined two specific types of national zone relevant to fisheries management: the 12 M territorial sea, where the coastal state has complete sovereignty over fisheries resources, and the 200 M Exclusive Economic Zone, where the coastal state has sovereign rights to exploit, conserve, and manage fisheries resources. Climate change and technological advances in resource extraction are altering the “fixed” nature of territory, resulting in conflicting claims over the maritime borders that give users access to resources [93]. And if the association of a particular resource with given territory changes (due to fish migration, acidification, etc.), or the claim to the territory itself changes, these developments will strain current governance systems and institutions that continue to rely on the notion of territory to secure resource access and rights of extraction. Movement of fish between or into EEZs may be especially vulnerable to conflict, because UNCLOS technically requires coastal states to provide access for foreign fishers to “surplus” fish stocks (Article 62). And disagreements about the existence of a surplus or access to it are exempt from mandatory dispute settlement procedures (Article 297). So users following a stock as it shifts from the high seas to an EEZ may feel they have a reasonable claim to access that stock, but no institutional mechanism for asserting that right.

Fish stocks that straddle or migrate between EEZ boundaries, and those whose range falls mostly or entirely within the high seas, are managed by Regional Fisheries Management Organizations (RFMOs). But UNCLOS explicitly protects the freedom of fishing on the high seas (Article 87), and does not technically obligate non-members of RFMOs to follow the conservation and management measures they implement [94-95]. The 1995 UN Fish Stocks Agreement goes farther, and obligates flag states fishing within RFMO jurisdiction to become members or participants in the relevant RFMO, or to agree to apply the conservation and management measures established by the RFMO (Article 8). But membership in the UN Fish Stocks Agreement remains far below the number of parties to UNCLOS, in part because of continued commitment to the freedom of fishing on the high seas [96-97]. And because RFMOs are multilateral, and the stocks and areas they manage are typically far from coastal areas, enforcement is a serious challenge for these management regimes. Partially as a result of these structural obstacles, RFMOs have under-performed as fisheries management institutions [98]. However, the gradual adoption of the 1995 UN Fish Stocks Agreement has somewhat strengthened RFMOs’ ability to achieve the goals of conservation and sustainable use, by incorporating the precautionary and ecosystem approaches into management decisions, and by expanding the range of legal enforcement options [99-100].

Strengthening Fisheries Management

Several major re-imaginings of international fisheries governance have been proposed to ameliorate the intensification of fisheries conflict. While better enforcement of maritime boundaries might help by reducing uncertainty and deterring maritime border crossings, many states lack the funding and capacity for increased monitoring, surveillance, and enforcement. And unilateral efforts are likely to be provocative. Expanding the naval assets needed to effectively patrol EEZs may be interpreted as a threatening buildup of offensive capability.

A multilateral response could achieve better outcomes. Creating coordinated, multinational maritime response teams and sharing information could help prevent “wild card” conflicts. This policy has been pursued fruitfully in addressing piracy in the Gulf of Aden [101]. In general, improving capabilities for monitoring, control, and surveillance can improve governance and reduce conflict insofar as it helps authorities deter or catch violators, as opposed to other fishers taking action to protect their claims over fish stocks [102]. Adoption of more sophisticated modeling techniques – and the collection of data needed to utilize them – can improve projections of change in stock locations and abundance, thereby improving predictions of potential conflict areas [55]. Coordination and information sharing will also be essential with regard to environment and resource management. Here multinational (e.g. International Maritime Organization), regional (e.g. RFMOs), and subnational (e.g. West Coast Ocean Partnership) institutions will play a critical role in coordinating efforts between actors and providing polycentric and adaptive governance [103].

Some fisheries governance mechanisms may be more resilient to climate change than others. Irrespective of the physical impacts of climate change on the fisheries they govern, RFMOs range widely in terms of compliance and enforcement mechanisms, conservation and management measures, and institutional procedures and decision-making rules [104-105]. Variation along each dimension makes them more or less capable of effectively responding to the shifting populations, shifting boundaries, and increased fishing pressure associated with climate change. Even RFMOs with generally high compliance can be challenged by changing stock distributions [95].

How to improve resilience and effectiveness in the context of climate change depends on the individual RFMO. Some older RFMOs could improve their ability to handle emerging challenges by reforming their decision making processes and adopting dispute settlement procedures [99; 106]. Although most RFMOs have incorporated the ecosystem and precautionary approaches into their formal management frameworks – and at least one RFMO has explicitly resolved to consider the impacts of climate change – there is little evidence that doing so has shaped managerial practices to account for the uncertain effects of climate change [104, 107-108]. Climate change impacts must be more fully integrated into the assessment and decision-making functions of RFMOs in order to avoid destructive competition that may be spurred by changes and shifts in fish stocks [108]. And changes in fisheries productivity and distribution will also raise new issues related to equity and proportionality in allocation [109-110]. Protecting the legitimacy and efficacy of RFMO conservation and management measures will therefore require targeted efforts to build consensus around political questions of rights and responsibility [111-112].

Unfortunately, RFMOs face significant political and practical enforcement challenges that impede their ability to adapt to new realities in the resources they are designed to manage [104, 108]. And there is a risk that highlighting the challenges associated with climate change within RFMOs could be used to shift focus away from efforts to redress over-fishing [113]. Reform of RFMOs should focus on scaling up fisheries management approaches used more often on the national or subnational scale, such as rights-based approaches, catch sharing agreements, or increased harvest controls [54-55]. The specific context - including information deficits, monitoring capability, and stakeholder support - can help inform which of these approaches is most suitable or promising for different fisheries [114]. And although the UN Fish Stocks Agreement has already achieved a central role in high seas fisheries governance, efforts could also be made to encourage non-members such as China to formally join, and to better fulfill the obligations of the Agreement related to data sharing and cooperative management. RFMO members can also pressure non-members to comply with conservation and management measures, for example by making compliance in the high seas a condition of access to their EEZ fisheries [115]. These changes to how RFMOs manage fisheries, and how they coordinate and cooperate with one another, can make high seas fisheries management more resilient to shifts in stocks and users, and changes in relative abundance.

It is also possible to preempt some of the pathways leading to fisheries conflict by clarifying or altering rights, rules, and decision-making processes related to national coastal zones. For example, some scholars have argued for fixed baselines, and a legal regime that connects fisheries access to entitlements rather than territory, thus circumventing much of the uncertainty presented by climate change [61]. The International Law Association Committee on International Law and Sea Level Rise recently outlined two legal approaches to freezing maritime entitlements in the face of sea level rise, and identified several means through which these approaches could be formalized [116]. This process has since shifted to the International Law Commission, which is likely to contribute a detailed analysis of existing law and legal options in the coming years. Although a formal amendment to UNCLOS is very unlikely, individual states could take action to create a stable, predictable, and customary international law around maritime boundaries [62].

The creation of Marine Protected Areas (MPAs) in national waters and on the high seas offers the potential to improve the resilience of ecosystems and populations under stress from climate change-induced alterations to the ocean environment. Many RFMOs already have provisions for the creation of MPAs and MPA-like closures, but these designations are infrequently or insufficiently used [104, 114]. Ongoing negotiations to conserve and sustainably use ‘Biodiversity Beyond National Jurisdiction’ at the United Nations are formulating, among other things, a means through which high seas MPAs could be designated and implemented [117-118]. The selection of sites for MPA designation ought to consider the location of refugia from climate change stressors [119]. But this approach – protecting particular areas from human activities, including fishing – could have the unintended effect of displacing fishers to areas of weak governance and enforcement, thereby exacerbating the tensions described above [120]. It will therefore be necessary to incorporate multiple strategies to address the rising risk of fisheries conflict.

Conclusion

The disruptions associated with climate change will test existing fisheries management regimes by undermining their assumptions about the type, abundance, intensity and location of artisanal and commercial fisheries. These changes are already underway, and when combined with growing demand for fish and fish products, and existing sources of maritime conflict, the evidence suggests that climate change is likely to lead to an increase in fisheries conflicts. Because national and international fisheries management regimes are well-established (and even entrenched), change will require adopting new management approaches, new technologies, new cooperative mechanisms, and even new customary and formal international law to ensure the resilience and sustainability of fisheries in an era of climate change.

This article has made several suggestions for fisheries management institutions to better account for the impacts of climate change on fisheries, and thereby reduce the risks of fisheries conflict. These include multilateral approaches to monitoring, scaling up of existing models of fisheries management, clarifying the legal basis of maritime boundaries, and expanding MPA networks. Two more general approaches to governance -- which can be incorporated at different scales and by different institutions -- are also useful when responding to climate change. First, the use of Marine Spatial Planning (MSP) can help moderate disputes between different user groups, including new users who have shifted to coastal employment or followed fish stocks into a new jurisdiction. The most effective use of MSP would factor in expected changes in marine resources, and maximize stakeholder engagement and participation [121-122]. Second, investments in continued ecological monitoring and assessment can provide critical support to decision-making. Because it is impossible to perfectly predict the ecosystem changes caused by ocean warming, acidification, and sea level rise, management flexibility and responsiveness will be a key characteristic of successful fisheries institutions [123].

There is no single solution to managing fisheries conflict risks associated with a changing climate, but the options and approaches described here offer a useful menu of institutional responses. Because climate change is already affecting fish stocks and fisheries, institutional adaptation should be pursued in the near term.

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Fig. 1. Potential pathways between climate change and fisheries conflict.

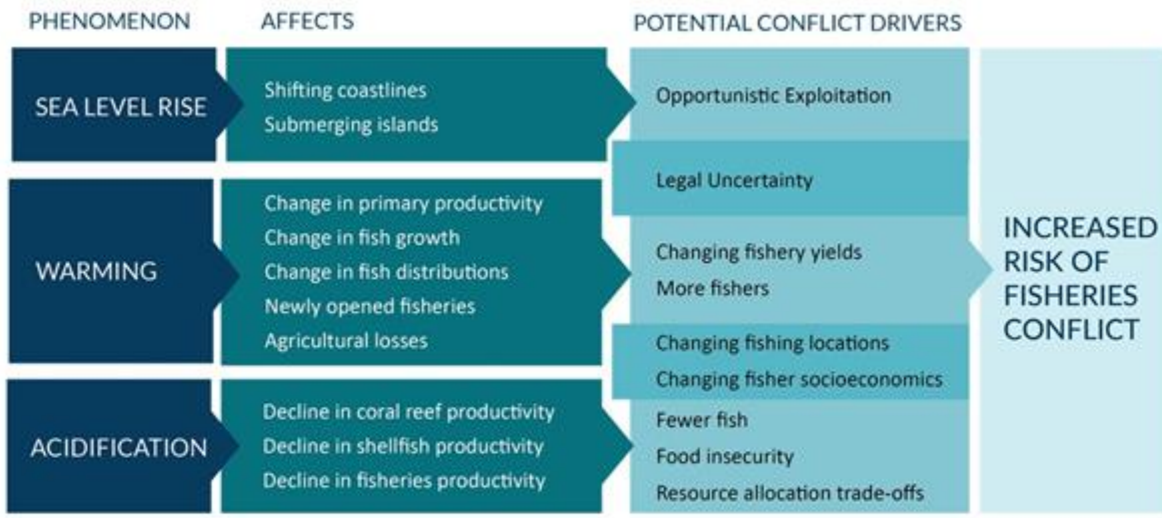

Fig. 2. Historical militarized inter-state disputes involving fisheries, overlaid on projected change in maximum catch potential.