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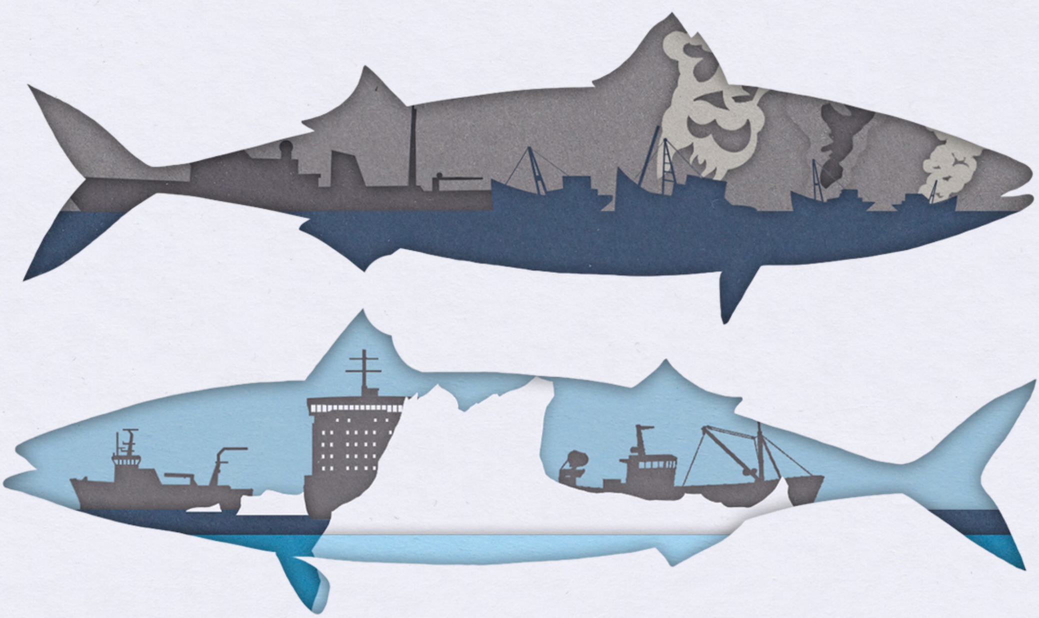
Global patterns of international fisheries conflict

Jessica Spijkers



Doctoral Thesis in Sustainability Science at Stockholm University, Sweden 2020

Global patterns of international fisheries conflict

Jessica Spijkers

Academic dissertation for the Degree of Doctor of Philosophy in Sustainability Science at Stockholm University to be publicly defended on Friday 11 September 2020 at 15.00 and digitally via conference (Zoom). Public link will be made available at https://www.stockholmresilience.org/.

Abstract

Are international conflicts over fishery resources a growing security concern? High-profile incidences of conflict, diminishing fishery resources and climate impacts on marine systems have made the international community increasingly wary of fisheries conflict. However, we lack knowledge on conflict incidences over time, as well as the contexts in which the conflicts occur, to assess if fisheries conflict is a growing security threat. To fill that gap, this thesis aims to provide a more detailed understanding of the temporal and regional patterns of international fisheries conflict – more specifically its frequency, nature, regional occurrence over time, and its drivers. Gaining insight into these patterns can aid the development of conflict management strategies and implementation of policies to ensure future ocean security.

In **Paper I**, I present a review of the literature on fisheries conflict, aimed at assessing to what degree existing studies have incorporated ideas from complexity and social-ecological systems theory. Making use of an initial scan of 803 relevant papers, and the subsequent intensive review of 31 fisheries conflict studies, I identify areas within the literature that would benefit from further development. First, precise definitions of fisheries conflict are lacking. Second, there is a narrowness in the methods used to assess the drivers of fisheries conflict, as the literature is largely populated by single cases of conflict assessed in a qualitative manner. Third, nonlinear and dynamic feedbacks, multiple causes, effects and intervening variables are often not explicitly recognized. Fourth, there is room for a more widespread extension of higher order concepts and associated terminology to describe complex system interactions, such as ‘feedbacks’ or ‘adaptive capacity’.

In **Paper II**, I present findings on the characteristics of international fisheries conflict over time drawing on a global and longitudinal database I developed that logs international fisheries conflict between 1974 and 2016. The analysis shows that the frequency of fisheries conflict increased over this time period, with substantial variation in both the type of conflict and the countries involved. Before 2000, fisheries conflict involved mostly North American and European countries fighting over specific species. Since then, conflict has primarily involved Asian countries clashing over multiple species linked to illegal fishing practices. I also consider potential response strategies for the different conflict types uncovered.

In **Paper III**, I use a multi-model approach to test for the supply-induced scarcity hypothesis (diminishing supplies of resources increases conflict) and the demand-induced scarcity hypothesis (rising demand for resources increases conflict) on international fishery conflict data. Three alternative political and economic explanatory pathways are also tested. Overall, I find that no single indicator is able to fully explain international conflict over fishery resources. For the period 1975 to 1996, I find a relationship between conflict over fishery resources and higher levels of GDP per capita. For the period 1997 to 2016, findings support the demand-induced scarcity hypothesis, with analyses also indicating that an increase in supply of fishery resources is linked to an increase in conflict occurrence.

Lastly, in **Paper IV**, I present four future fisheries conflict scenarios. The scenarios integrate longitudinal evidence on international fisheries conflict and expert data on fishery conflict trends and drivers. The scenarios take place in the years 2030 to 2060 in the North-East Atlantic (“Scramble for the Atlantic”), the East China Sea (“The Remodeled Empire”), the coast of West Africa (“Oceanic Decolonization”), and the Arctic (“Polar Renaissance”). The aim is to illuminate how different decisions made today can lead to dramatically diverging future paths, and to inspire policy makers to work with exploratory scenario processes to build anticipatory capacity to support future ocean security.

Keywords: *Fisheries, conflict, environmental security, social-ecological systems, complex adaptive systems thinking.*

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Keywords: Fisheries, conflict, environmental security, social-ecological systems, complex adaptive systems thinking

Sammanfattning

Är internationella konflikter över fiskeriresurser en växande säkerhetsutmaning? Högprofilerade konflikthändelser, minskande fiskeriresurser och klimatpåverkan på marina system har ökat det internationella samfundets oro för fiskerikonflikter. Trots det, saknar vi kunskap om konflikthändelser över tid, samt sammanhangen där konflikterna skett, vilket gör att vi inte kan avgöra ifall fiskerikonflikter är ett ökande säkerhetshot. För att fylla denna kunskapslucka, ämnar denna avhandling öka vår förståelse för tidsmässiga och regionala mönster för internationella fiskerikonflikter. Särskilt kommer fokus ligga på konflikthändelsers frekvens, karaktär, regionala förekomst över tid, samt bakomliggande drivkrafter. Nya insikter om dessa mönster kan bidra till utvecklingen av strategier för konflikthantering och implementering av politik som kan säkerställa framtida säkerhet på världshaven.

I **Artikel I** presenterar jag en genomgång av den vetenskapliga litteraturen om fiskerikonflikter. Målet med genomgången är att bedöma i vilken mån de existerande forskningsstudierna tar hänsyn till teoribildning kring komplexitet och social-ekologiska system. En inledande sökning resulterade i 803 relevanta artiklar. Utav dem valdes 31 studier om fiskerikonflikter ut för djupgranskning. Baserat på dessa studier identifierar jag följande områden i forskningslitteraturen som i behov av vidare precisering och forskning: (1) Exakta definitioner av fiskerikonflikter saknas; (2) Variationen av metoder som används för att bedöma drivkrafter bakom fiskerikonflikter är låg, då forskningslitteraturen till stor del består av kvalitativt bedömda fallstudier; (3) Icke-linjära och dynamiska återkopplingsmekanismer, flera orsaker, effekter och intervenerande variabler erkänns sällan explicit; och (4) Det finns utrymme för en bredare användning av teoretiska begrepp och tillhörande terminologi för att beskriva komplexa systeminteraktioner, så som 'återkoppling' eller 'adaptiv förmåga'.

I **Artikel II** redogör jag för typiska karaktärsdrag hos internationella fiskerikonflikter över tid. Analysen baseras på en global, longitudinell databas där jag registrerat internationella fiskerikonflikter mellan 1974 och 2016. Analysen visar att frekvensen av fiskerikonflikter ökade under denna tidsperiod, med stora variationer i både typ av konflikt och vilka länder

som var inblandade. Före 2000 omfattade fiskerikonflikter oftast nordamerikanska eller europeiska länder i konflikter över enstaka arter. Sedan dess har konflikter främst inbegripit asiatiska länder i sammandrabbningar över flera arter men kopplade till illegala fiskemetoder. Jag reflekterar även över potentiella strategier för att hantera de olika konflikttyper som identifierats.

I **Artikel III** använder jag en multi-modellmetod på data om internationella fiskerikonflikter för att pröva hypotesen om utbudsframkallad brist (att sinande tillgångar av resurser ökar mängden konflikter) och hypotesen om efterfrågansframkallad brist (att ökande efterfrågan av resurser ökar mängden konflikter). Även tre alternativa politiska och ekonomiska förklarande utvecklingsvägar prövas. Överlag finner jag inte någon enstaka indikator som ensam kan förklara förekomsten av internationella konflikter över fiskeriresurser. För perioden 1975 till 1966 finns det ett samband mellan fiskerikonflikter och högre nivåer av BNP per capita. Mellan 1997 och 2016 stöds hypotesen om efterfrågansframkallad brist, samtidigt som analyser även antyder att ökande tillgångar av fiskeriresurser är kopplat till en ökad mängd konflikter.

Till sist, i **Artikel IV**, presenterar jag fyra scenarier för framtida fiskerikonflikter. Scenarierna integrerar longitudinella data om internationella fiskerikonflikter med expertbedömningar om trender och drivkrafter. Scenarierna utspelar sig under åren 2030 till 2060 i nordöstra Atlanten (”Kapplöpningen om Atlanten”), Östkinesiska havet (”Det omdanade imperiet”), den västafrikanska kusten (”Havens avkolonisering”) och Arktis (”Polarrännessans”). Målet är att belysa hur beslut som tas idag kan leda till dramatiskt olika utvecklingsvägar i framtiden. Därigenom kan politiker och andra beslutsfattare inspireras att arbeta med utforskande scenarioprocesser för att öka sin förmåga att förutse potentiella framtider och därigenom stödja framtida säkerhet på världshaven.

Nyckelord: Fiskeri, konflikt, miljösäkerhet, social-ekologiska system, tänkande om komplexa adaptiva system

List of papers

Paper I

Spijkers, J., Morrison, T.H., Blasiak, R., Cumming, G.S., Osborne, M., Watson, J., Österblom, H., 2018. Marine fisheries and future ocean conflict. Fish Fish. doi:10.1111/faf.12291

Paper II

Spijkers, J., Singh, G., Blasiak, R., Morrison, T.H., Le Billon, P., Österblom, H., 2019. Global patterns of fisheries conflict: Forty years of data. Glob. Environ. Chang. 57. doi:10.1016/j.gloenvcha.2019.05.005

Paper III

Spijkers, J., Singh, G., Wabnitz, C.C.C., Österblom, H., Morrison, T.H. Identifying predictors of international fisheries conflict (Manuscript).

Paper IV

Spijkers, J., Merrie, A., Wabnitz, C.C.C., Osborne, M., Mobjörk, M., Bodin, Ö., Selig, E., Le Billon, P., Hendrix, C., Singh, G., Keys, P., Morrison, T.H. Anticipating the future of fisheries conflict through narrative scenarios (under review at One Earth).

Contribution

Paper I: Idea generation. Data collection. Data co-analysis. Paper preparation. Writing as lead author.

Paper II: Idea generation. Data collection. Data co-analysis. Paper preparation. Writing as lead author.

Paper III: Idea generation. Data collection. Data analysis. Paper preparation. Writing as lead author.

Paper IV: Idea generation. Workshop design, coordination and facilitator. Data analysis. Paper preparation. Writing as lead author.

Additional publications

Österblom, H., Jouffray, J.-B., **Spijkers, J.**, 2016. Where and how to prioritize fishery reform? Proc. Natl. Acad. Sci. 113, 201605723. doi:10.1073/pnas.1605723113

Spijkers, J., Boonstra, W.J., 2017. Environmental change and social conflict: the northeast Atlantic mackerel dispute. Reg. Environ. Chang. doi:10.1007/s10113-017-1150-4

Blasiak, R., **Spijkers, J.**, Tokunaga, K., Pittman, J., Yagi, N., Österblom, H., 2017. Climate change and marine fisheries: Least developed countries top global index of vulnerability. PLoS One 12, 1–15. doi:10.1371/journal.pone.0179632

Pinsky, M.L., Reygondeau, G., Caddell, R., Palacios-Abrantes, J., **Spijkers, J.**, Cheung, W.W.L., 2018. Preparing ocean governance for species on the move. Science 360, 1189–1192.

Spijkers, J., 2019. Exploring the knowns and unknowns of international fishery conflicts, in: Cisneros-Montemayor, A.M., Cheung, W.W.L., Ota, Y. (Eds.), Predicting Future Oceans: Sustainability of Ocean and Human Systems Amidst Global Environmental Change. Elsevier, pp. 387–394.

Østhagen, A., **Spijkers, J.,** Totland, O. A., 2020 Collapse of cooperation? The North-Atlantic mackerel dispute and lessons for international cooperation on transboundary fish stocks. Marit. Stud. https://doi.org/10.1007/s40152-020-00172-4

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Scope and aim

International conflict over fishery resources is considered to be a growing security concern. Ongoing, high-profile interstate fishery disputes are sparking concerns of future global fish wars (note: for the remainder of this thesis, terms such as fishery conflicts refer to *marine* fishery conflicts, excluding conflicts over fresh water species). One of those ongoing interstate disputes is the so-called 'mackerel war' between Norway, the European Union (EU), Iceland and the Faroe Islands, which erupted in 2007 when the northeast Atlantic mackerel (*Scomber scombrus*) stock shifted its distribution towards the north-west of the Nordic Seas and their surrounding waters. The conflict has had disruptive social and ecological consequences: it resulted in the overfishing of the mackerel stock, undermined the coastal states' management plans, and even contributed to Iceland withdrawing its application to become an EU member state (Spijkers & Boonstra 2017). Another prominent example is that of the South China Sea, where fishers often find themselves on the frontlines of international disputes over fishery resources as China, Vietnam, the Philippines, Taiwan, Malaysia and Brunei fail to resolve competing claims over parts of the area (Dupont & Baker 2014). Although these fisheries conflicts are linked to a larger territorial struggle in the region (with China increasingly militarizing what it has determined to be its maritime sphere of influence), the rich fishing grounds are an important, strategic commodity for surrounding states given that fisheries play a vital role in ensuring food security in the region (Dupont & Baker 2014). Some scholars even claim fish is an 'overlooked destabilizer' in the region, and that China's militarization efforts are a power move intended to dominate marine harvest (Baker et al. 2016, Thomspon 2019)

Moreover, environmental conditions that might trigger or exacerbate fisheries conflict are likely to become more widespread in the future, further heightening worries about impending security challenges for ocean governance. First, changing ocean conditions are causing shifts in fisheries resources' distribution patterns, affecting potential yields of and revenues generated from exploited marine species (Lam et al. 2016, Sumaila et al. 2011). This redistribution of resources is expected to result in more fishery disputes, as current fisheries management is predicated on the assumption that the geographical distribution of fish populations is largely static (Pinsky et al. 2018, Cheung et al. 2010). However, climate change will lead to a redistribution of resources and a loss of revenue for the global fishing industry (Lam et al. 2016, Sumaila et al. 2011). Such shifts in resources might become a particular menace for countries with a high dependence on fish protein for nutritional security with countries such as Tuvalu and Kiribati likely to experience the largest decreases in their maximum catch potential due to climate change (Blasiak et al. 2017, Lam et al. 2016). Depending on how the impacts of anthropogenic climate change play out in the global ocean, 23-35% of global Exclusive Economic Zones (EEZs) are projected to receive new transboundary fish stocks by the end of the century (Pinsky et al. 2018). In some EEZs in the already troubled maritime region of East Asia, 10 new stocks are projected to enter as a consequence of climatic changes (Pinsky et al. 2018). In summary, the changes fishery systems will undergo due to climate change are likely to cause disruption to fisheries management globally, and are feared to spark conflict.

Second, the global decline in catches, largely as a consequence of overfishing, is also considered to be an accelerating driver of conflict. The abundance of available fishery resources has decreased substantially: 33.1% of fish stocks were fished at biologically unsustainable levels in 2015 (in 1974, this was 10%), and 59.9% fished at their maximally sustainable level (FAO 2018). While effort has increased since the 1950s, catches have stagnated and then slowly declined since the late 1980s (Pauly & Zeller 2017, Pauly & Zeller 2016, Watson et al. 2013). Simultaneously, consumption of and demand for fish is steadily increasing, and the average annual increase in global fish consumption (3.2%) outpaced population growth (1.6%) between 1961 and 2016 (the average annual increase in meat consumption, for example was 2.8% during that same period (FAO 2018)). In combination with disputed maritime boundaries, this increased competition may contribute to volatile situations.

International fisheries conflicts are considered a threat to maritime security as they can have far-reaching impacts on marine safety, resource sustainability, geopolitical relations and food security. For example, geopolitical stability and marine safety (safety of seafarers and passengers (Bueger 2015)) were compromised during the infamous Cod Wars that occurred between Great Britain and Iceland during the 1950s and 1970s. The two countries were embroiled in a string of confrontations over fishing rights in the North Atlantic, where Iceland wanted to extend its fishing limit, but Great Britain did not recognize their right to do so. The consequences for geopolitical stability and, at certain stages, marine safety (Bueger 2015) were severe: flash points of the conflict included the use of military vessels to patrol the area and defend fishing boats, patrol boats cutting the nets of trawlers, ships ramming trawlers and frigates, and, ultimately, Iceland threatening to leave NATO (Bakaki 2017). An example of compromised resource sustainability due to an international fisheries conflict is the previously discussed northeast Atlantic mackerel dispute. As a result of the conflict, there are no comprehensive management plans for the stock, and the mackerel has become severely overfished. With countries setting unilateral quotas, their combined catch in 2018 was twice that recommended by the International Council for Exploration of the Sea (ICES), and the fisheries had their Marine Stewardship Council (MSC) certifications retracted (Ramsden 2019, Seamon 2018). Lastly, food security has also been jeopardized due to international fisheries conflict, as exemplified by the incidents taking place in the South China Sea. Fishermen from contending countries that operate in the troubled waters, and whose livelihoods depend on the rich fishing grounds, have at times decided to leave their occupation all together, afraid of going out into the waters without any protection (Patience 2013). Moreover, failure to address rising tensions could lead to greater regional instability and severe environmental degradation, further compromising regional food security (Zhang 2016, deLisle 2012).

Due to the pervasive impacts human activities and climate change have on fish stocks, policy makers around the world are considering conflicts over fish to be an increasing challenge. The maritime security strategies outlined by the EU and France, for example, reflect the nations' increased concern over the altered biophysics and economics of our world's fisheries and how these changes might spark or exacerbate fishery resource conflicts (Silveira 2019, Council of the European Union 2014, République Française 2015). The EU has designed a maritime security strategy as a comprehensive framework to ensure a stable and secure global maritime domain, and pinpoints interstate conflict as a threat to the EU's maritime interests (Silveira 2019). These concerns have also started to find voice in the media: *The Independent* warned of 'global fish wars' as a consequence of increased competition (Johnston 2017), *National Geographic* reported on the threat of climate change in sparking fish wars (Welch 2018), and the *Washington Post* alerted its readers that - "the fishing wars are coming" (Stavridis & Bergenas 2017). However, despite the apparent certainty with which many media pieces warn of the impeding advent of future fish conflicts, there remain many unknowns about the patterns, occurrences and drivers of fisheries conflict. For scholars to make better assessments concerning the potential gravity of the threat fisheries conflicts represent to society, and for policymakers to be able to prevent or de-escalate emerging conflicts, a more detailed understanding of the complex nature of fisheries conflict and its causes are needed.

I start by giving an overview of the theoretical background that informs my thesis, which hinges on three different literatures: complex adaptive systems (CAS), environmental security, and maritime security. First, the CAS framework, itself embedded in social-ecological systems (SES) thinking, allows me to understand the complexity and dynamics of marine SES and how conflict is embedded within that system (section 1). CAS thinking informs how I conceptualize fisheries conflict throughout the thesis. Second, the literature on environmental security embeds the issue of fisheries conflicts in the larger context of natural resource conflicts, such as those over fresh water, oil or minerals. The literature on water conflicts in particular offers important findings on the link between natural resources and conflict, which informs my understanding of, and approaches to, analyzing the drivers of fisheries conflict (section 2). The environmental security literature is, in addition to a reference literature that shapes my research questions and analytical approaches, a body of work I aim to contribute to. Last, the concept of maritime security helps me to zoom in on the security threats that exist in the maritime domain in particular, and how fisheries conflict relates to those others threats (section 3). This thesis not only uses the concept of maritime security to set the context for fisheries conflict, but it also aims to contribute to our understanding of the linkages between conflict and other security threats over time. For a conceptual view of how the three literatures are used to inform this thesis, see Figure 1. Definitions and clarifications of key terms related to the theoretical background are listed in Table 1.

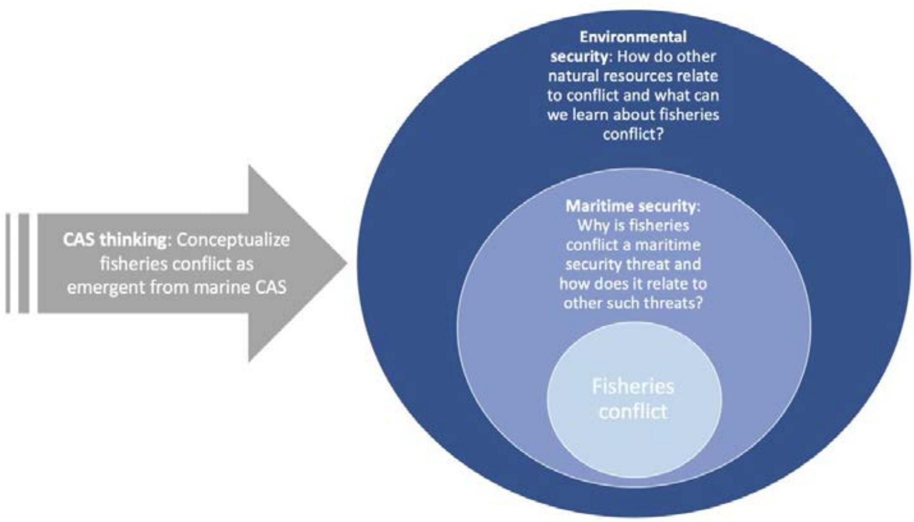

Figure 1: Theoretical background components on which the thesis hinges

Table 1: Definitions and clarifications of key terms

Key term	Definition/clarification
Environmental security	Many different conceptions exist as the literature is multidisciplinary and conceptually eclectic (Watts in Floyd & Matthew 2013). In this thesis, it is defined as "protection from environmental dangers, the lack/depletion of strategic resources and conflict over these resources" (Koff 2016, pp. 665).
Maritime security	Commonly defined by the absence of the following threats - maritime interstate disputes; maritime terrorism; piracy; trafficking of narcotics, people and illicit goods; arms proliferation; illegal fishing; environmental crimes; or maritime accidents and disasters (Bueger 2015, UN 2008). Sometimes also defined as a "stable" or "good" order at sea (Vrey 2013).
National security	Traditional conceptualization of 'security', where threats are viewed through the prism of state survival (e.g. territorial conflicts, threats to infrastructure or violent interstate conflicts) (Hameiri & Jones 2013).
Human security	Often described as a concept that transcends the traditional view of national security, as it focuses on the security of the individuals, their protection and empowerment (UNTFHS 2009).
Complex adaptive systems (CAS)	Following Preiser et al. (2018), CAS are systems exhibiting the following six features: they are constituted relationally, adaptive capacities, dynamic processes, radically open, contextually determined and novel qualities emerge through complex causality.
Social-ecological system (SES)	Interdependent human and ecological systems. SES are considered to be CAS (Levin et al. 2012, Folke et al. 2005).
Exclusive Economic Zone (EEZ)	Area 200 nautical miles off the coast over which a coastal state has sovereign rights over the exploitation, conservation and management of natural resources (living and nonliving), the seabed and its subsoil, as well as superjacent waters (United Nations 1982).

Regional Fisheries Management Organization (RFMO)	An intergovernmental organization dedicated to the sustainable management of fishery resources. RFMOs range widely in terms of institutional procedures and regulatory measures, though many of them have management powers regarding fisheries such as setting catch limits. RFMOs are comprised of member nations that share practical and financial interests in a particular region of international waters or of highly migratory species (Ásmundsson 2016).
Distant Water Fishing (DWF)	Many countries have DWF fleets, which fish great distances from their home waters (Watson et al. 2017). While some DWF fleets fish the high seas (for example for tuna), others fish in the richer inshore areas of foreign countries (Watson et al. 2017). DWF fleets are often highly subsidized (Belhabib et al. 2015).

Theoretical background

1. Complex Adaptive Systems thinking

The overarching lens that informs how I conceptualize fisheries conflict within the marine environment is complex adaptive systems (CAS) thinking (Preiser et al. 2018, Levin et al. 2012, Scheffer et al. 2012, May et al. 2008, Hartvigsen et al. 1998). CAS thinking describes the characteristics of a system as emerging from the interactions and patterns within that system, and explicitly addresses nonlinear feedbacks, multiple causes, effects and intervening variables (Preiser et al. 2018, Lubchenco et al. 2016, Levin et al. 2012, Cumming et al. 2013). CAS draws attention to how behaviors of individual processes at the local scale influence emergent properties at the regional or global scale, and how they in turn can impact behaviors of the contextual, local processes at smaller scales (Preiser et al. 2018, Levin et al. 2012). The constant mutual adaptations that take place between its components make for a constantly evolving system (Levin et al. 2012). Managing such systems requires more creativity and experimentation, as uncertainty and unpredictability is inevitable (Hendrick 2009). This line of thinking has been implemented for decades by ecologists who started applying it to understand social-ecological systems (SES) - coupled human-natural systems, and how to manage them (Hartvigsen et al. 1998).

Marine SES are CAS, as they exhibit complex and interdependent interactions between the social and ecological subsystems through activities such as fishing pressure, tourism, gear use or market dynamics (Lindkvist et al. 2017, Österblom et al. 2013, Mahon et al. 2008). Marine CAS, and the fisheries systems within them, are neither predictable nor controllable but are open systems that respond to internal and external stimuli (Mahon et al. 2008). Human activities have increasingly become embedded parts of marine CAS as a growing range of actors, operating at various scales and in different sectors, interact with marine ecosystems (Österblom et al. 2016). By viewing marine SES as CAS, I can conceptualize international fisheries conflict as a feature of marine CAS that exhibit 'systemic instability', this is "a state in which things will inevitably get out of control sooner or later" (Helbing 2013, pp. 51). Here, instability (a state of the system over which one fails to have control, such as financial crises, epidemics or breakdowns in cooperation) is the result of amplifying (positive) feedback effects that intensify changes in processes that destabilize the system (Helbing 2013, Nyström et al. 2012). Increasingly interconnected systems offer a greater number of perturbation sources, potentially rendering the system more unstable and prone to emergent conflict outcomes (Hendrick 2009). Conflict has also been described as an emergent property by Lederach (2003), who understands system properties as the context of relationships out of which conflict episodes emerge. To understand why conflict emerges, discovering the underlying, longer-term patterns of change in the system (such as dramatic shifts in conflict intensity) is important (Hendrick 2009, Lederach 2003) (**Paper II**, **Paper III**).

In particular, using the CAS lens in the thesis to understand conflict helps avoid the oversimplification of fisheries conflict in terms of its nature, its drivers and its effects. First, it allows for an explicit recognition of the different forms fisheries conflict can take (e.g. the different observable behaviors or actions that constitute conflict), but also that the nature of fisheries conflict and its drivers is likely not static throughout time (**Paper II, Paper III**). This follows from the fact that the behavior of marine CAS has a temporal dimension (Österblom et al. 2013, Liu 2007), which means the nature of the properties emerging from marine CAS, such as fisheries conflict, will too. For that reason, a longitudinal, database approach to uncover the nature of fisheries conflict can be helpful to understand the phenomenon.

Second, in terms of drivers of conflict, CAS allows me to go beyond a single-causation explanation for conflict in the thesis, and rather recognize multiple possible causal pathways and to forego the often reductionist nature of linear thinking (Preiser et al. 2018, Levin et al. 2012). I view conflict as an emergent property of a marine CAS due to many different interactive processes between, for example, high demand for fishery resources and increased pressure on the marine ecosystem; and I incorporate the idea of non-linear relationships between independent variables and conflict (**Paper III**). Through the use of CAS, fisheries conflict can then be understood as the result of nonlinear feedbacks, multiple causes, effects and intervening variables; as well as the internal randomness of the system or stochasticity (**Paper I**, **Paper III**).

Third, depicting conflict as an emergent feature of unstable CAS means conflict can not only be an outcome, it can also be a cause on its own and feed back into the system by affecting regional political processes or sustainability (**Paper IV**) (see for example Daskin & Pringle (2018) on the negative effects of conflict on wildlife populations). The concept of 'systemic risk' illustrates how risk in one domain, such as food supply, can increase risk in another domain, such as geopolitics, through complex feedbacks and interactions in interdependent systems (Galaz et al. 2017, Frank et al. 2014, Helbing 2013). International conflicts over fish can become systemic risks and create cascading ruptures in humanity's highly interconnected social systems. In the northeast Atlantic mackerel conflict, for example, the international disagreement affected the accession process of Iceland to the EU, as well as fishery sustainability and mackerel prices (Seamon 2018, Spijkers & Boonstra 2017).

2. Environmental security

The environmental security literature provides an important underlying theoretical background for my papers, as it allows me to draw inspiration from previous work on resource-conflict connections. It informs the methodological approaches I use to analyze fisheries conflict over time (**Paper II**), and it is used as a reference point to analyze what could be driving fisheries conflict (**Paper III**). Here I give a brief overview of some of the developments within the environmental security literature that inform the thesis.

Conflicts over natural resources have been an inextricable part of human history. Civil wars linked to the diamond industry in West Africa, oil-related conflicts in the Niger delta; interstate fresh water conflict between Israel and Palestine; or between Egypt and Ethiopia relating to the Nile Basin; and local forest conflicts in Indonesia are just a few recent illustrations of the social strife the presence, absence or distribution of natural resources has caused or fueled (Le Billon 2014, Peluso & Watts 2001). Growing worries about humankind's impact on the planet and its resources placed the issue of resource-related conflict at the forefront of the international policy agenda in the 1970s, where such emerging concern led to the United Nations Conference on the Human Environment in 1972 (contemporaneous important literature include amongst others Garrett Hardin's 'The Tragedy of the Commons' (1968) and Meadows et al. 'The Limits to Growth (1972)) (Floyd & Matthew 2013). Environmental security, defined as "protection from environmental dangers, the lack/depletion of strategic resources and conflict over these resources" (Koff 2016, pp. 665; see also Graeger (1996) for an early exploration of the concept), has, according to Koff (2016), subsequently emerged as a global, rights-based norm. Environmental security threats are best described as a form of 'soft security threat' that stands separate from more traditional security threats, as they spill across national borders and conventional single-state action often does not suffice when attempting to address them (Koff 2016, Hameiri & Jones 2013, Graeger 1996). The emergence of environmental security as a concept is important to this thesis as it recognizes the role of environmental resources in transnational conflicts (Koff 2016, Floyd & Matthew 2013).

The Brundtland report, produced in 1987, set much of the agenda for research on the links between natural resources and security (Dabelko 2008), now labelled the 'environmental security literature'. Both renewable and non-renewable resources, such as oil, diamonds, minerals or water, have been identified as having a possible role in driving conflicts, with the literature possibly most developed with respect to freshwater resources such as river basins - in which surface freshwater is shared between two or more states (Bernauer & Böhmelt 2020, Bernauer & Böhmelt 2014, Devlin & Hendrix 2014, Brochmann 2012, De Stefano et al. 2010, Yoffe et al. 2003, Wolf et al. 2003). In the early years of the literature's development, the main focus was on the concept of 'eco-scarcity', holding that a shortage of resources is the sole/main driving factor of (violent) conflict (Theisen 2008). This thinking has its roots in neo-Malthusian thought, the idea that environmental degradation of natural resources sparks conflict as population growth and consumption approach natural limits (Fischer et al. 2018, Devlin & Hendrix 2014).

After nearly three decades of scholarly interest in links between the environment and security, the field has not evolved to become a homogenous literature, but rather includes many different analytical and theoretical approaches (Floyd & Matthew 2013). It is beyond the scope of this kappa to provide a full overview of this broad literature (see for example Floyd & Matthew 2013), with the aim rather to focus on giving a very succinct summary of the scholarship on natural resources and conflict within the environmental security literature. The early literature, which proposed a direct, linear causal relation between natural resources and conflict, attracted much critique. Political ecology scholars claimed it failed to account for the complexities and dynamics of processes of social-ecological change (Fischer et al. 2018, Spijkers & Boonstra 2017, Peluso & Watts 2001, Gleditsch 1998), and that changes in natural resources alone seldom lead to conflict. Rather, there are strong interactions with other political, economic, and social factors. The environmental security scholarship started identifying the many variables that mediate the pathway from natural resources to conflict, with development, state strength, poverty, migration or dysfunctional institutions drawing substantial attention (Ide 2015, Theisen 2008, Barnett & Adger 2007, Humphreys 2005). Moreover, not only scarcity but also the abundance of resources has been linked to outbreaks of conflict, sometimes linked to the argument of the 'resource curse' where resource abundance can lead to local corruption and conflict (Floyd & Matthew 2013, Collier & Hoeffler 2005). Although the debate has generally become more nuanced, still much of the academic work, particularly on fisheries conflict, emphasizes how environmental change, and in particular competition over increasingly scarce resources, will *directly* trigger conflict in the future (Mendenhall et al. 2020, Cook 2020, Glaser et al. 2018, Pomeroy et al. 2007).

In later years, much of the scholarship evolved to take on an explicit climate-security framing (Dalby 2009). The focus on the security impacts of climate change was reflected in global security debates, as exemplified by Conference of Parties to the United Nations Framework Convention on Climate Change (COP21), which heavily focused on this issue (Koff 2016). Within the environmental security literature, several papers used correlations attempting to establish a causal relationship between climate change and conflict, at different scales (see overview paper by Salehyan 2014). Some scholars have made the case for a direct link, with warmer temperatures thought to increase the risk of many types of conflict (Hsiang 2013), though such work has been critiqued as suffering from bad sample selection and poor analytical coherence (Buhaug et al. 2014, Nordås & Gleditsch 2007). While research on climate and conflict has produced mixed and inconclusive results, and the causal link between climate change and conflict remains a point of discussion, most experts agree that climate change's role in triggering (violent) conflict cannot be generalized: when, and how, climate influences conflict is highly dependent on social, economic and political contexts (Adams et al. 2018, Abrahams & Carr 2017, Buhaug et al. 2014, Scheffran et al. 2012, Barnett & Adger 2007).

I use the theoretical and empirical developments made within the environmental security domain not only to as a reference literature to inform how I analyze fisheries conflict (for example, I consult the literature to gather which variables have been commonly analyzed for their potential causal relationship with resource conflict), but also with a view to contribute to the literature itself. As summarized above, although the existing body of work showcases a great deal of progress in how we view the links between natural resources and conflict, the debate about the role of resource scarcity in particular has not been settled and remains a topic of discussion. Moreover, fisheries conflict has not been researched as extensively nor with the same analytical rigor as other resource conflicts have (see aforementioned fresh water studies, or Rustad et al. 2008 for forest resources; further arguments provided in **Paper I**). For that reason, analyzing if some of the drivers commonly linked to conflict over other resources also play a significant role in predicting fisheries conflict (**Paper III**) could offer valuable insights for that literature as a whole.

3. Maritime security

Fisheries conflict is considered a threat to maritime security. Though it still lacks a widely agreed upon definition, maritime security has become a much-used term in both the realm of international politics and within the research community. As reported by Bueger (2015), a leading scholar in mapping out the meaning and usage of maritime security, the concept is mostly applied as an umbrella term that includes the following range of activities (many of them illegal) occurring at sea: "(…) maritime inter-state disputes, maritime terrorism, piracy, trafficking of narcotics, people and illicit goods, arms proliferation, illegal fishing, environmental crimes, or maritime accidents and disasters" (Bueger 2015, pp. 159). The rising academic and policy awareness surrounding maritime security threats is largely a consequence of oceanic changes attributable to anthropogenic impacts as well as our increased usage of and demand for maritime space and resources (Jouffray et al. 2020) (see for example Germond & Mazaris 2019, Song et al. 2019, Aleskerov & Shvydun 2018, Belhabib et al. 2018, Zervaki 2018, Pinsky et al. 2018, Pomeroy et al. 2016, Warner & Schofield 2012; see also Stephenson Ocean Security Project launched in 2018). There are different aspects of maritime security that scholars focus on: those threats relating to living and non-living oceanic resources (fish, oil or minerals for example); the activities that take place within the maritime space (such as transport, tourism or seabed mining); or the threats produced by a weakened 'protective function', which the ocean fulfills in the earth's climate system. Many of these recent works focus on oceanic change and climate change as the possible ultimate culprits of insecurity in the maritime space.

Although slow in their uptake of the concept, maritime threats are also starting to be acknowledged in official national and regional strategic documents (Germond & Mazaris 2019). In particular 'sea-locked nations', such as the Small Island Developing States (SIDS) in the Pacific, have highlighted illegal fishing as a maritime threat due to the problems it poses for the development potential of their maritime domain (Malcolm 2017). Larger developed nations such as the USA have also started to recognize the maritime security implications of climate change and its effects on the ocean, and have commenced planning military policies, investments and actions (Ayyub & Kearney 2012) according to the recognition of climate change as an explicit security concern. In 2009, the US Navy established Task Force Climate Change, assigned with assessing climate change implications for strategy, policy and plans (Warner & Schofield 2012). While the US Navy puts heavy emphasis on an increased presence in the Arctic, for example, due to the region's rapidly changing environment, other threats such as "changing fish stocks in Asia" and "more intense hurricanes in the Atlantic Ocean" are also on their radar (Ayyub & Kearney 2012, pp. 41).

This thesis focuses on the first maritime threat highlighted by Bueger: maritime interstate disputes. Particularly, this thesis explores interstate disputes that center around the ownership or management of marine fishery resources. Those conflicts are considered threats because they challenge both more classic forms of national security (this is, sovereignty over delineated territory) through, for example, emerging sovereignty claims, disputes or military activities between states as consequences of maritime inter-state disputes. Additionally, fisheries conflicts can jeopardize many aspects of human security such as food, economic and personal security through, for example, a decline in access to food or revenue (Germond & Mazaris 2019, Krampe & Mobjörk 2018). I apply a specific definition of international fisheries conflict in this thesis. An international fishery conflict is a dispute:

(a) actualized through 'conflict events', which are actions or behaviors ranging from an exchange of statements to severe military involvement and casualties (as defined by the 'intensity of observed behavior' scale, see Table 2).
(b) occurring between two or more states and/or vessels that fly their flag;
(c) related to the access to a fishery resource or management of a fishery resource;
(d) potentially occurring in the larger context of a maritime territorial conflict, where the fishery resource contributes to some degree to that territorial conflict;
(e) spanning over any length of time.

Table 2: Intensity of observed behavior/action. Source: Spijkers et al. 2018 (Paper I).

Intensity of observed behaviour/action	
Intensity	**Description**
5	Military acts causing death
	Attack of foreign vessels, crew members or Coast Guards, with resulting deaths
4	Military acts
	Attack of foreign vessels, crew members or Coast Guards, no death toll
3	Political-military hostile acts
	Sending out police vessels/warships
	Seize vessel and/or crew
	Gear destruction
	Reinforcing borders
2	Diplomatic-economic hostile acts
	Breaking or not adhering to existing agreement
	Lawsuit
	Trial in court
	Seeking international arbitration
	Trade ban
	Fishing ban
	Landing ban
	Monetary penalties
	Close ports
1	Verbal expressions displaying discord or hostility in interaction
	Failing to reach an agreement
	Making threatening demands and accusations
	Threatening sanctions
	Condemning specific actions, behaviours or policies
	Requesting change in policy
	Civilian protests
0	Non-significant acts

International fisheries conflict can co-occur or be triggered by other maritime security threats. First, fisheries conflict often co-occurs with ongoing interstate territorial disputes. The Scarborough Shoal, for example, is claimed by China as a traditionally Chinese fishing ground, and touted to be an important part of China's territorial integrity. Simultaneously, the Philippines claims the area, yet Filipino fishers are often prevented from fishing in the area, with reports indicating harassment by Chinese coastguard vessels (for example by ramming vessels or using water cannons) (Beech 2020, Fabinyi 2020, Bloomberg 2018, Zhang 2016). The Philippines filed a case against China through the UN in 2013, but despite the Court's ruling in favor of the Philippines in 2016, China never recognized the process nor the outcome (Fabinyi 2020). Second, international fisheries conflict can be triggered by (repeated) instances of illegal, unreported or unregulated (IUU) fishing. In Somalia, for example, illegal fishing by foreign vessels has been causing violent outbreaks of conflict with the domestic fishing sector for decades (Glaser et al. 2019). In the Yellow Sea, repeated illegal incursions by Chinese fishing vessels into the South Korean EEZ has led to numerous instances of conflict (Zhang 2016, Carolin 2015). South Korean coast guard officers as well as Chinese fishermen have lost their lives in several confrontations, and at-sea incidents have led to diplomatic tensions between China and South Korea (Zhang 2016, Kim 2012). There also exists a direct connection between territorial disputes and IUU, as pending sovereignty disputes and maritime delimitation conflicts lead to difficulty in defining IUU fishing (Li & Amer 2015)).

It should be noted that within the recent literature on maritime security, one finds several connections amongst the other security threats outlined previously (Bueger 2015). For example, in Somalia, research shows that conflicts over space and fish stocks (which can be a consequence of reduced fishing opportunity) can trigger instances of piracy (Belhabib et al. 2018). Fish stock collapse, which can be driven by high levels of illegal fishing, in Senegal has spurred the trafficking of people, illegally crossing over borders into Europe to flee economic hardship (Belhabib et al. 2018). However, discussing all such ties not directly related to fisheries conflict goes beyond the scope of this thesis.

Overall, the literature on maritime security is useful to this thesis both because it outlines how fisheries conflict can compromise security at sea, and because it situates fisheries conflict in relation to other maritime threats. However, although there is a recognition that fisheries conflict can be inextricably linked with both territorial disputes and IUU, there is very little evidence of how often fisheries conflict is in actuality triggered by IUU, nor does existing literature provide information where and how often conflicts occur in the grander scheme of ongoing territorial disputes.

The database presented in **Paper II** outlines the prevalence of those relationships over time, and indications of where those co-occurring threats are most prevalent.

International fisheries conflict, a growing security threat?

Is international fisheries conflict a growing security threat? From the literature on maritime security, we understand that, due to the implications such conflict holds for different facets of national and human security, as well as due to its links to other maritime security threats, fisheries conflict can indeed be considered a threat to multiple conceptions of security (national, human and maritime). Moreover, some of the intellectual tenets offered by the environmental security literature, including the idea of increased resource scarcity as a driver of conflict, might also lead us to conclude that fisheries conflict is indeed a *growing* security risk as global fishery resources dwindle. However, to more rigorously understand if fisheries conflict can be labeled a growing security threat, we lack systematically collected data on the phenomenon. As opposed to data that is available on water conflicts, we do not have large-scale datasets that can help us understand the prevalence of fisheries conflicts over time, what might be driving the patterns we are seeing, and what might be the nature of potential future fisheries conflict. The methodological and theoretical gaps in our understanding of fisheries conflict are outlined in more detail in **Paper I**.

This thesis contributes to those unknowns by addressing the following research questions:

1. **What are the gaps in the fisheries conflict literature from the CAS and SES perspective, and how might one improve on the existing literature?** Paper I
2. **How prevalent has international fisheries conflict been over time and space?** Paper II
3. **What has driven past fisheries conflict?** Paper III
4. **While exploring the future for fisheries conflict, what governance insights can be gained for conflict mitigation?** Paper IV

In combination, the questions are designed to provide information on whether or not international fisheries conflict should be considered a growing security threat.

Answering these four research questions can also contribute to broader ongoing debates discussed in the previous two sections, and provide new analytical and theoretical insights for broader applications in the fields of environmental security and maritime security.

First, this thesis can contribute to the ongoing debate pertaining to the drivers of resource conflict, with particular attention to the resource scarcity hypothesis (i.e. the declining availability of natural resources causes conflict), which remains contested yet is ubiquitous, including in the fisheries conflict literature (see **Paper I**). Fishery resources have not been researched as extensively nor rigorously compared to other resources for their links to conflict (see **Paper I**) and therefore analyzing the drivers of fisheries conflict can offer some additional evidence to refine the resource scarcity hypothesis (**Paper III**). Moreover, exploring these research questions present us with some insights to debate whether some resources are more prone to lead to conflict than others.

Second, the CAS lens informs how I conceptualize conflict and consequently informs my methodological choices to analyze conflict emergence. Those methodological choices could be of interest for application to other environmental security questions and the field as a whole. I dive deeper into these two additional contributions to the environmental security literature in the discussion section. Third, though the maritime security literature offers important insights on the linkages between recognised key maritime security threats, there is little data available on those relationships over space and time. **Paper II** offers specific insights on the spatial and temporal dimensions of IUU, territorial conflict and their relationship to fisheries conflict.

Data collection and methodology

This thesis uses both qualitative and quantitative approaches to answer the four research questions outlined above.

In **Paper I** I employed a broad and in-depth literature review to make a theoretical contribution to the fisheries conflict literature. The broad literature review consisted of a text mining process where, through a broad title–abstract keyword search of the Scopus database, relevant fisheries conflict articles were identified and analyzed using data mining tools. This process allowed for the identification of the geographic focus of those papers. I then performed an in-depth literature review of 31 papers, a number I came to when including only those articles within the subject areas of social sciences and economics (excluding papers from disciplines with a less clear connection to conflict) and only those that directly dealt with the causes of past or ongoing conflict over a specific marine fish or fishery.

Those papers were analyzed to understand the degree to which integrative SES thinking is applied in the fisheries conflict literature by assessing four criteria: 1) clarity in definitions and applications of key terms; 2) consideration of feedbacks, thresholds and nonlinearity; 3) use of comparative approaches and suitably integrative methodologies; and 4) use of higher order systems concepts, as indicated by the presence of associated terminology such as ‘feedbacks’ or ‘vulnerability’. The conflict intensity scale I present in that paper was built by drawing on the work of Yoffe et al (2003) and Wolf et al (2003) in their development of the BAR Scale of Intensity of Conflict and Cooperation. Their categories were re-interpreted to make sense in an international fisheries context.

In **Paper II**, the data collection consisted of developing a database currently containing 542 reported international fisheries conflict events between 1974 (the first year for which we retrieved conflict event data from LNA) and 2016. Labelled the

International Fishery Conflict Database (IFCD), the database was set up to explore international conflicts over fishery resources by using event data, i.e. conflict events. Those conflict events, linked to a scale of conflict intensity presented in Paper I (see Table 2 above), were identified through the LexisNexis Academic (LNA) database, the world's largest repository of media reports. From the results returned in the search queries, I collected data on the following variables for each conflict (event): number of countries involved; the species mentioned; date; the intensity of the observed behavior or action; whether a specific territory under dispute was mentioned; and whether or not it was linked to IUU fishing.

To understand the patterns of the frequency, occurrence and nature of international fisheries conflict over time, several analyses were conducted. First, descriptive statistics were employed to identify the frequency of conflict (events) over time. Second, to distinguish between different types of fisheries conflict, non-metric multidimensional scaling complemented with hierarchical cluster analysis was used to categorize different types of fisheries conflict based on the variables that characterize the conflicts (i.e. the characteristics described above, except for the event date). Third, a time series analysis of the clusters was undertaken to understand when in time the clusters were more or less present. When combined with the place-specific conflict data (i.e. continents), it was possible to discern which combination of continents is most represented in the conflict clusters.

Additionally, three analyses were run to understand if the IFCD was biased by the media sources I extracted data from. To explore if there was a relationship between the number of reported conflict events and the level of English media output in different countries, two regressions were conducted against reported conflict events with two different sets of data: 1) the media output dataset (extracted from the LNA website); and 2) the Press Freedom Index. Applying robust regression with downweighed outliers and heteroscedasticity-corrected standard errors, I found no evidence that recorded conflict within and among countries were the result of national differences in media reporting. Third, to analyze if the conflict data per year is correlated to the level of English media coverage per year, I ran a cross-correlation after making the conflict data stationary. There was no significant relationship between conflict and media coverage.

In **Paper III,** I use a multi-model approach to identify significant predictors of conflict (see Table 3 for predictors). The model ensemble consists of three models: boosted regression trees (BRT), a zero-inflated negative binomial generalized linear model (ZINB GLM), and a generalized linear mixed model (GLMM). BRT is a nonparametric tree-based model, which recursively fits multiple trees with samples randomly drawn from the original data set. Importantly, BRT can capture nonlinear relationships. ZINB GLM, is a two-component model where the first component is a count model and the second a zero-inflation binary model. The ZINB GLM can account for situations where countries were not able to experience fisheries conflict at a given point in time. GLMM, an extension to GLM, allows for the incorporation of random effects in addition to fixed effects, so that I can account for any non-independence within a country (i.e., within-country correlation due to, for example, unaccounted for political or cultural factors).

Table 3: Hypotheses and linked predictors tested in Paper III.

Hypothesis	**Predictor**	**Predictor description**
Demand-induced scarcity	Protein supply quantity	The apparent consumption is calculated as production minus non-food uses and fish exports. Fish imports are added, and changes in stocks taken into account. Measured in grams per capita per day of protein consumed from fish products.

	Employment in the fishing sector	This variable includes all commercial, industrial and subsistence fishers, operating in freshwater, brackish water, and marine waters to catch and land any aquatic animals and plants. Because the dataset was only available from 1995, we only tested this predictor for the second time period. Measured in numbers of persons.
	Annual population growth	Measured in percentage (percent growth rate).
Supply-induced scarcity	Domestic supply quantity	The quantity of fishery products for domestic utilization is calculated by adding the production of fisheries products to imports of fisheries products, subtracting fishery exports and taking into account the changes in stocks. Fisheries products encompass both wild caught fish as well as cultured fish. Measured in tons.
Democracy	Level of democracy	Scale ranging from 0-10 where 0 is least democratic and 10 most democratic, covering both procedural (e.g. electoral process) and structural (e.g. rule of law) element of democracy.
Macroeconomic development	GDP per capita	Measured in value, USD.
Military expenditure	Military expenditure	Measured in percentage of GDP.

I used three models to avoid misleading results. Fisheries conflicts occurs in complex SES and have been described with numerous predictor variables attributed to the individual cases. Fisheries conflict has yet to be explored with quantitative methods, however, and selecting a single 'best' model can lead to high uncertainty (i.e. parametric uncertainty about what variables to include in a model, and structural uncertainty related to choosing model design). Moreover, individual model approaches incorporate different elements of critique common to positivist approaches to understanding conflict. BRT can model non-linear relationships between the independent and dependent variable; the ZINB GLM helps incorporate instances where countries don't experience conflict instead of only looking at years when they do experience conflict to find predictors; and the GLMM allows us to account for country-specific characteristics that we do not have data for that might influence their propensity for conflict.

Lastly, in **Paper IV,** I build four future fisheries conflict scenarios by integrating longitudinal evidence on international fisheries conflict and expert data on fishery conflict trends and drivers. The longitudinal data originates from the IFCD, and was used as an axis in case study selection. The expert data was drawn from a workshop on fisheries conflict, where eleven participants identified key drivers and conditions that contribute to conflict. The expert data was complemented with findings from the scientific, technical and policy literature to validate conflict drivers and conditions resulting from the workshop, and to identify the trends for all drivers in each of the four case study areas. Additionally, one regional expert for each scenario was selected to review the narrative to enhance its validity and robustness, as well as asked to identify 1-3 points in the narrative where the scenario would, or could have, taken a different path. This was done to enhance the breadth of scenario diversity and to gain insight into key leverage points in the trajectories.

Results

RQ1: What are the gaps in the fisheries conflict literature from the CAS and SES perspective, and how might one improve on the existing literature?

The results presented in **Paper I** constitute a theoretical contribution to the field of fisheries conflict by identifying four substantial scientific gaps from the perspective of SES and CAS in the existing literature that need to be addressed to improve our understanding of the nature and drivers of fisheries conflict:

1. The literature lacks fishery conflict definitions that are precise, that distinguish among degrees of conflict intensity and that specify which actions or behaviors are indicative of different levels of conflict intensity;
2. There is an absence in the literature of (large sets of) comparative conflict data, and consequently there is a lack of diversity in the methods used to assess the drivers of fishery conflict;
3. There is a lack of theoretical framings in the literature that explicitly recognize nonlinear and dynamic feedbacks, multiple causes, effects and intervening variables; and that are translated into appropriate methodologies for complexity;
4. There exists a much wider scope in the literature to use higher order concepts and associated terminology.

I also make concrete suggestions as to how scholars can address certain gaps, such as through the fisheries conflict intensity scale (for international conflict) (Table 2).

RQ2: How prevalent has international fisheries conflict been over time and space?

In **Paper II**, through analysis of the IFCD, I find that international fisheries conflict increased between 1974 and 2016. Intra-continental conflict (65.7% of all conflict events) was more common than inter-continental conflict (34.3% of all conflict events) during the entire time period. Many of the countries most frequently involved in conflict are large industrial fishing powers known to dominate global fishing efforts (McCaulley et al 2018). The USA was involved in most conflicts over time, followed by Canada, Japan, China and the EU. The conflicts collected in the database fall into eight distinct types of fisheries conflict, which vary in their intensity distribution, whether or not the conflict centred around a given species or multiple species, whether it was linked to illegal fishing, and whether or not it was connected to a larger territorial dispute (see Figure 2).

For the entire time period, I find that fisheries conflicts shifted largely from occurring between and amongst countries within North America and Europe to countries within Asia. Before approximately 2000, fisheries conflict involved mostly North American and European countries fighting over specific species. Since then, 43.0% of all international fisheries conflict events primarily involved Asian countries clashing over non-specific species, with conflicts often linked to illegal fishing practices. A notable exception includes Europe, where fishery disputes surrounding the northeast Atlantic mackerel (*Scomber scombrus*) and Atlanto-Scandian herring (*Clupea harengus)* are ongoing. We also discuss six foundational and specialized risk mitigation strategies that have proven useful for resolving certain international fisheries conflicts.

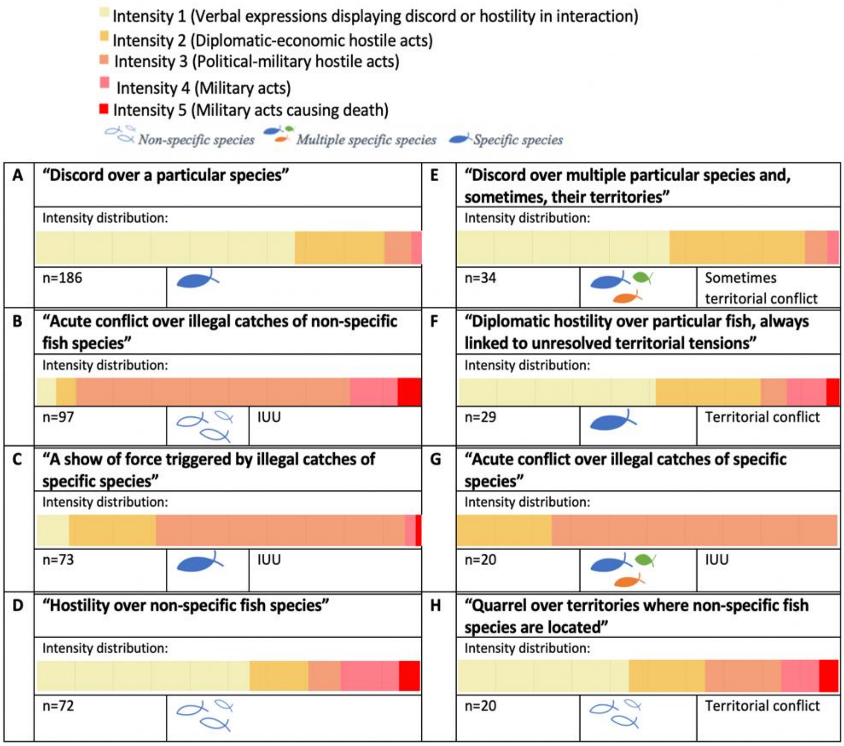

Figure 2: Eight conflict event types, their narrative descriptions, intensity distribution throughout the database and number of records (events) under each type

RQ3: What has driven past fisheries conflict?

In **Paper III,** I find that no single indicator (Table 4) is able to fully explain historical international conflict over fishery resources. For the first time period (1975 to 1996), I find no evidence that any type of scarcity, neither demand-nor supply-induced scarcity, is a significant predictor for increased conflicts over fishery resources. Rather, the results indicate that during this time, higher macroeconomic development of a country was a strong predictor for it to experience more conflict. For the second time period (1997 to 2016), over which the global availability of wild fishery resources leveled off and then declined, I do find support for the demand-induced scarcity hypothesis, which postulates that increased demand drives conflict over resources. I also find evidence counter the supply-induced scarcity hypothesis, indicating that higher domestic supplies of fishery resources (i.e. the quantity of fishery products available for domestic utilization) are linked to an increase in conflict occurrence. In the paper I discuss how to make sense of these findings. Briefly, it is possible that, although total national-level supply of fish is increasing, a decline in availability of marine, wild-caught fish in combination with growing demand is spurring on conflict, which would confirm the scarcity hypothesis. However, as discussed in the paper, the relationship between availability of fishery resources and conflict might be more complex than represented in some fishery conflict studies. Additionally, for both time periods, experiencing conflict in the previous year is a significant predictor for experiencing more conflict in the following year.

Table 4: Summary of the findings for time period 1 (1975-1996) and time period 2 (1997-2016).

Predictor	Level of support		Relationship	
	Time 1	**Time 2**	**Time 1**	**Time 2**
Domestic supply	Low	Moderate	Positive	Positive
Protein quantity	None	Strong	None	Positive
Fishery employment	NA	None	NA	None
Population growth	None	Low	None	Positive
GDP per capita	High	None	Positive	None
Democracy level	None	None	None	None
Military expenditure	None	Low	None	Positive
Lagged conflict	High	High	Positive	Positive

RQ4: While exploring the future for fisheries conflict, what governance insights can be gained for conflict mitigation?

In **Paper IV** I develop four exploratory scenarios to build an understanding of potential futures for fisheries conflict taking into account context-specific dynamics in complex systems in a way that is not possible with current modelling approaches. These scenarios incorporate findings from both the expert workshop and the scientific, technical and policy literature. I showcase the 23 economic, social, political and environmental drivers and conditions that participants in the expert workshop identified as linked to the onset of fisheries conflict. The importance of those underlying drivers and immediate conditions for conflict vary across time and space, as regions exhibit varying levels of vulnerability to fisheries conflict. Although conflict is not always the outcome of biophysical triggers, we stress that pervasive and often unpredictable impacts from climate change could increase the likelihood of conflict in least-likely cases, but it can also be a catalyst for positive transformation (such as bottom-up policy development). I find that the combination of participatory elements with imaginative approaches can boost the utility and relatability of future scenarios as well as provide a different platform for the engagement of a diversity of actors.

Discussion

In this section, I touch on a few important discussion points related to my thesis. I first examine how my thesis can inform policies for conflict mitigation and prevention. This is followed by a discussion of some of the limitations of my work and the implications for how one interprets the results. I then discuss my findings related to the nature and drivers of fisheries conflict in the context of the environmental security literature. I finish off with some recommendations for future research, and a personal reflection on my PhD process.

Contributions to policy

The research questions addressed in this thesis aim to provide information on whether international fisheries conflict constitutes a growing security threat. From developing and analyzing the IFCD I found that international fishery conflict events did increase over time, in particular during the last decade in Asia. There are indications it might be in part driven by growing demand for fish, indicating conflict may become a bigger issue in the future as demand grows, yet, particularly by incorporating cultured fish into the analysis, the picture is likely more complex. Aside from providing a first assessment of the nature, driver and future for fisheries conflict, this thesis also offers some insights in terms of conflict prevention and mitigation strategies for policy makers.

I provided an overview of historical strategies used for conflict mitigation and prevention (**Paper II**), which can provide policy-makers with recommendations for action, dependent on the type of conflict. I pinpoint six strategies, all related to strengthening fisheries management: building a shared scientific understanding, shared enforcement activities, side payments, long-term management plans, provisional fishery agreements, and stringent IUU policies. Some of those strategies, such as side-payments and coordinated scientific efforts, are deemed to also be useful conflict mitigation strategies in the context of shifting species' distributions due to climate change (Mendenhall et al. 2020, Pinsky et al. 2018). Recent studies have especially emphasised the importance of international cooperation related to scientific collaboration (collecting and sharing information and data) (Mendenhall et al. 2020, Pinsky et al. 2018). Regional Fisheries Management Organizations (RFMOs) are often put forward as the primary administrative bodies to implement some of the suggested strategies, for example the deployment of flexible mechanisms such as tradable rights schemes to address catch allocation conflicts between states (Mendenhall et al. 2020, Pinsky et al. 2018, Cox 2009). However, much rests on the will and power of the nation state, which ultimately has control over critical resources (Morrison et al. 2017).

Aside from suggesting ways to strengthen fisheries management for conflict mitigation, knowing what predictors might be linked to conflict can be useful for policy makers. Understanding what might be driving conflicts can give policy makers indications regarding which stressors they might want to pay close attention to to avoid conflicts. Particularly the finding that increased demand for fish is significantly linked to increased conflict over fish could, if confirmed by further studies, offer interesting insight into conflict prevention. It could indicate that focusing primarily on fisheries management from the production and supply side (such as tougher penalties for IUU) might not be enough to curb fisheries conflict (Zhang 2016). It is promising that aquaculture might increasingly meet the rising demand for fishery resources, taking some pressure of wild capture fisheries and potentially diffusing conflict. However, shifting the bulk of fish supplies from being produced by wild capture fisheries to aquaculture could be meaningless to diffuse conflict if: a) the aquaculture sector continues to rely heavily on wild-caught fish; or b) aquaculture does not (fully) replace or supplement those marine fishery resources for which there is a high demand; or c) aquaculture impacts consumer demand in such a way that it exacerbates conflict.

On the first point, current developments seem positive. Although dependency on protein from wild-caught fish, primarily small pelagic fish for fishmeal and fish oil, is still a challenge for aquaculture, a declining, proportion of world fisheries production is processed into fishmeal and fish oil (FAO 2018). Moreover, novel aquaculture feeds such as microbial seaweed and insect sources are being developed (FAO 2018). On the second point, squid (families Gonatidae, Loliginidae, Ommastrephidae, Onychoteuthidae) is a good example of how aquaculture might not meet demand for certain species, resulting in (continued) conflict over the wild-caught variant. Squid is in high demand in China and Japan, for example, and is heavily exploited by China's Distant Water Fishing (DWF) fleet (Mallory 2013). Global catches of the three major squid species (jumbo flying squid (Dosidicus gigas), Argentine shortfin squid (Illex argentinus) and Japanese flying squid (Todarodes pacificus)) declined by 26, 86 and 34 percent, respectively, between 2015 and 2016 (FAO 2018). Currently, about 14 percent of global squid production is recognized as sustainable or improving (Sustainable Fisheries Partnership 2019). In the last few decades, squid fisheries have grown to play an increasingly important role in the global seafood market and this trend is likely to continue (Arkhipkin et al. 2015). There is currently no substantial cephalopod aquaculture production to alleviate this demand-supply gap (Cai & Leung 2017). The IFCD includes numerous conflict events related to squid, triggered by illegal fishing, and such conflicts seem unlikely to diminish if consumer demand for these products is not curbed, although consumer preferences may change. On the third point, there are examples of aquaculture successfully being able to meet demand in terms of volume, yet increasing demand for the wild-caught version of a species exacerbates overfishing. Successful aquaculture production of the large yellow croaker (*Larimichthys crocea*), for example, created a large price difference between the rarer and more preferred wild-caught version, which motivated more fishermen to go after the wild croaker (Zhang 2016, Liu & Mitcheson 2008). Yellow croaker conflicts between China and Japan, for example, date back decades (Muscolino 2008), with recent high demand for the wild variant encouraging illegal fishing for the species off the coast of West Africa and prompting conflicts (BBC News 2016). To summarize, my work can help to inform a debate amongst policy makers on how shifting demand, rather than managing supply, might be a conflict mitigation tool as it can help reduce incentives for overfishing and illegal fishing, shown in **Paper II** to trigger conflict.

Last, the narrative scenario approach I used in the last paper can be useful to policy makers to identify contextual factors that contribute to conflict, but that might showcase high regional variability. This method allows one to consider the different proximate and remote drivers of fisheries conflict and to parse out how different interventions can lead to diverging future scenarios for conflict (inspired by the approach in Merrie et al. 2017). Replicating this exercise, where one discusses the drivers of a system and their potential future pathways together with regional experts, can provide valuable insights for intervention in geographical areas that are particularly vulnerable to future fisheries conflict, such as the coast of West Africa or the Arctic.

Considerations and limitations of my work

First, there are a limitations related specifically to using media as the source of conflict events to set up the IFCD. The data on conflict events was extracted from news reports, which can be prone to misreporting. All news searches were conducted in English, which means there can be bias in the coverage of conflict events. For example, I have very limited data for South American and African countries, although Belhabib et al. (2018) do report that perhaps there are less conflicts involving African nations due to lower levels of enforcement and easier access for foreign vessels to obtain licences due to corruption. Nonetheless, there is likely underreporting of (minor) conflicts in regions with non-English speaking news media, particularly during the early part of the period covered. To counter this availability bias, conducting searches in other languages and producing collaborative research with experts from other regions would help gain a broader perspective and understanding of trends.

Second, I employ a very specific definition of an international fisheries conflict. While this is not a limitation *per se*, it does frame the manner in which to interpret the results. Conflict can be conceptualized in different ways, and studied from a multitude of scales. Conflicts vary widely in their form and intensity, and, consequently, scholars have taken different approaches to defining what conflict over natural resources means in their work. In studies on forestry disputes, 'forestry conflict' has been defined as :'where one group impairs the activities of another by restricting their access to the resource or excluding them from the decision-making process' (Yasmi 2007); 'a context of different approaches in setting forest management or caused by conflicting forestry legislation on one side and environmental and nature protection legislation on the other side' (Vuletić et al. 2013); and as 'conflicts of interest (…) [such as between] conservation and local people's livelihood' (Hares 2009). In fresh water research, conflict has been conceptualized as 'a conflict of interest' (Giordano et al. 2005), while others exclude all but violent conflict incidences from their analysis (Sawyer 2004). Many scholars study only armed conflict, and its relation to different natural resources (Le Billon 2001, Welsch 2008). Some of the disparate findings on the links between resources and conflict are attributable to differences in operationalizing conflict, both regarding the intensity of conflict as well as the scale of analysis scholars select for their study (Devlin & Hendrix 2014).

Consequently, it is important that conflict scholars make their definition, and its implications for findings, clear. I follow the FAO in its conceptualization of conflict, this is that natural resource conflict is based on disagreements and disputes regarding access and management of the resources (which can manifest itself in a multitude of ways) (FAO 2000). I operationalized that definition by linking it to a scale of actions and behaviors, inspired by Yoffe et al. (2003) and Wolf et al. (2003) (Table 2). I find it important to use a full spectrum of interactions (from militarized conflict to a failed negotiation), because all of those interactions have social and/or environmental repercussions, and can indicate hampered cooperation around fishery resources. Using such a wide scale of how international fisheries conflict can manifest itself, however, means that there is a range of events that are included in the IFCD. As a consequence, all three terms in the concept of 'international fisheries conflict' include a spectrum (Figure 3).

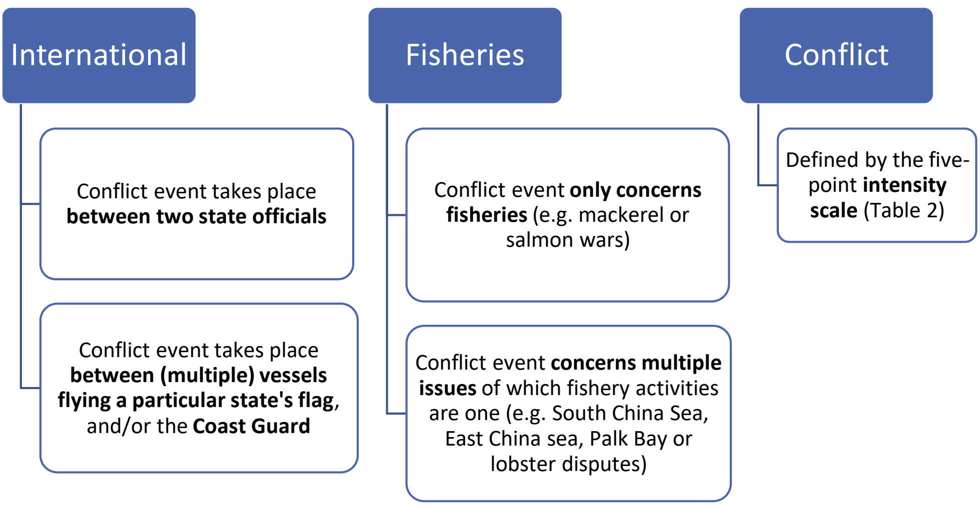

Figure 3: Range of events in the International Fishery Conflict Database

This particular definition is not a limitation, but a consideration, as it needs to be made clear that the results related to what drives conflict (**Paper III**) ultimately rest on how one *defines* conflict. There is a genuine debate to be held on whether or not it makes sense, for example, to aggregate violent and non-violent fisheries conflict; or to aggregate disputes over access to a resource with conflicts over how to manage a resource. It is possible that these different kinds of conflict have their own unique driver sets rather than being produced by the same mechanisms.

Third, in **Paper III**, it can be argued I use a positivist approach to understanding what drives conflict, and this approach, in particular large-N quantitative studies, has attracted (valid) criticism in the environmental security literature (Selby 2014, Vivekananda et al. 2014). The goal here is not to list them all, yet I want to offer a few common criticisms that are relevant for the work I present in this thesis, and provide some of my own thoughts on them. First, the predictive value of large-N quantitative studies is often questioned on theoretical grounds. It is argued that, because environmental change repeatedly creates new context for social behavior, the future is never like the past (Ide 2015, Selby 2014, Floyd & Matthew 2013). Moreover, it is argued that positivist causal conflict studies are focused on what or why something is happening rather than on what *should* happen, and that they therefore do not advance a comprehensive case for why one set of policies should be adopted over another (Floyd & Matthew 2013). On the first point, I agree as far as that the future will remain fundamentally unknowable. However, an alternative viewpoint would be that analyzing historical data (be it in a quantitative or qualitative manner) is likely to remain our only way to make assumptions about future risk and to derive valuable lessons that are still likely to bear impact. On the second point, I find that this can in fact be a strength: a desirable outcome or 'what *should* happen' is inherently contested, and ever-changing. Presenting data on the phenomenon up for discussion can provide a starting point to reboot more normative discussions of what is desirable, and how to work towards that.

Aside from more theoretical considerations; positivist, large-N conflict studies are often criticized on methodological grounds. For one, scholars usually employ linear models to explain what causes conflict, which is pinpointed as being at least partly responsible for the non-replicability of results within the environmental security literature (Le Billon & Duffy 2018, Ide 2015, Selby 2014, Floyd & Matthew 2013). Because I use the CAS perspective to conceptualize marine SES and conflict as a phenomenon embedded within that framework, I find this criticism legitimate and agree that the methodologies typically used do not reflect the likely non-linear relationships between cause(s) and conflict. I tried to address this methodological issue in my own work (**Paper III**), which I discuss in more depth in the next subsection. Second, studies connecting climate change and conflict often are questioned for deriving predictions from correlations alone (Selby 2014). I would indeed not want to be making any *predictions* about future fisheries conflict solely based on the outcomes of **Paper III**. For that reason, I use a non-positivist approach in **Paper IV** to explore a diversity of potential future pathways for fisheries conflict that combine findings from my previous, more positivist work, with more qualitative findings from an expert workshop. Third, the significant issues around temporal and spatial assumptions are often raised (Le Billon & Duffy 2018, Selby 2014). Much of the quantitative work on the resource-conflict connection, as well as the climate-conflict connection more specifically, makes assumptions in regards to the temporal and spatial connections between cause and effect. Oftentimes this translates into analysing connections between cause and effect within the same year and within the same spatial location (e.g. decrease or increase in precipitation in a particular year gets linked to conflict in that same year), an approach I use in **Paper III**. This is an assumption that would benefit from more theoretical and analytical exploration, because it is conceivable that those connections operate on much longer temporal scales and wider geographical areas.

The final limitation of my thesis up for discussion here relates to climate change as a potential (future) cause of fisheries conflicts. Although I discuss climate change as a potential cause of fisheries conflict in all the papers (and in this kappa), I do not directly test for its causal links to conflict in **Paper III** in the same way I do test for other common hypotheses, such as resource scarcity. This means climate change as a predictor feels somewhat absent from the quantitative, analytical side of this thesis. This is mainly due to the lack of data to actually test this hypothesis. To test in detail if spatial changes in stock distribution are linked to conflict, I need access to a large amount of historical data on the spatial locations of different fish stocks and link them to conflicts over those same fish stocks (although one supposedly could take a more general approach and build a non-stock specific, global map of the rate of species distribution changes overall in certain oceanic areas and overlay it with a map of conflict, but that would certainly be less informative). Moreover, although climate-driven stock redistribution is a phenomenon that is already being observed (Cheung et al. 2015), the speed and extent of the phenomenon is expected to increase strongly in the future depending on the degree of warming, which diminishes the value of testing the hypothesis on historical conflict data (Pinsky et al. 2018, Cheung et al. 2015). For that reason, I only explicitly incorporate climate change as a future driver of fisheries conflict in **Paper IV**, where the methodology of narrative scenario building allows me to bring in more qualitative aspects of fisheries conflict. I do think, however, that **Paper III** delivers relevant insights for the climate change-fisheries conflict connection, as it allows us to consider how climate change might impact those predictors that are significantly linked to increased fisheries conflict, such as a rise in demand. Moreover, although it is not a paper featured in this thesis, I did contribute to research on the climate change-fisheries conflict connection led by Dr. Malin Pinsky (see Pinsky et al. 2018).

Insights for the environmental security literature

The first contribution my thesis can make to the larger environmental security literature relates to the critiques laid out in the previous section. I addressed some of the methodological limitations through my CAS-informed perspective on fisheries conflict, and my methodological choices in **Paper III** may be relevant for the wider environmental security literature. First, the methodology I employ explicitly recognizes that drivers of conflict might change over time (CAS adapt over time in response to feedbacks) by examining if my dependent variables, international fisheries conflict, had a continuous trend over time (by running a piecewise regression model). I did find breakpoints in the data, indicating that fisheries conflict might not be a static phenomenon throughout time with constant, time-invariable drivers; and thus I examine the time periods separately. Second, the method used in

Paper III incorporates the notion that conflict likely has multiple causes, and that interactions exist between them. Not only do I test for multiple social, political and ecological driving variables to uncover their relationship with conflict over time, but BRT also allows me to quantify the relative interaction strength between the predictors. Third, the methodology used incorporates the possibility that the relationships between cause and effect (conflict) might be marked by non-linearity and stochasticity. This is done by pooling together linear models such as GLM with BRT, a tree-based model which, by using only a random subset of data to fit each new tree (controllable by the 'bag fraction' parameter), introduces randomness in the process (which is why the final model is slightly different each time you run it) (Elith et al. 2008). However, some challenges remain, mainly related to incorporating cross-scale spatial and temporal interactions (such as time lags), a feature of CAS. Overall, although the approach of taking a multi-model ensemble is in some ways more advanced than the methodological approach usually taken to investigate causal resource-conflict links, I would also note that it remains correlation-based which, when it is used for *direct prediction*, as discussed, has been criticized.

The second contribution this thesis can make to the wider environmental security literature is less direct, but can provide food for thought. It relates to the conflict potential different natural resources may hold, and much of what follows is largely based on questions and points of confusion that have arisen at multiple times during my PhD while reading some of the environmental security literature. As discussed, the answer to whether or not a particular (set of) driver(s) is causally linked to conflict likely depends on one's particular conceptualization and definition of conflict. That definition includes different facets, such as the scale of the conflict (i.e. who is the conflict between, for example between communities or states), an intensity (i.e. what are the actions/behaviors observed in this conflict, for example a verbal disagreement or violence), and the object under conflict (i.e. what is the issue creating the conflict, e.g. a particular resource such as water or fish). It *could* be nonsensical to aggregate across different conceptualizations and definitions of conflict to find a set of drivers for all of them (although perhaps some intensities, scales or subjects of conflict might have similar drivers connected to them). In particular, reading through works in the environmental security literature, it seems the *object* under conflict (such as a particular resource) sometimes is spoken of in general terms (e.g. just 'natural resources' all together), and I do not find many studies that explicitly discuss how characteristics of different resources might affect the likelihood of conflict. Nonetheless, it is likely that questions such as "will fewer resources lead to more conflict?" might warrant very different answers depending on the resource one looks at. Therefore, I think a more detailed, theory-informed discussion juxtaposing different characteristics of resources and how they might influence conflict propensity can be useful.

First, a note on the *mobility* of different renewable natural resources and how it plays in to conflict is warranted. Changes in the access to natural resources such as fresh water, fish, forest or agriculturally productive land (which can happen for many reasons, such as climate change impacts) can cause conflict in certain contexts, as it could create incentives for communities to physically secure access over valuable resources (e.g. looting of resources on land or illegal fishing) (Bowles et al. 2015). More dynamic, mobile renewable resources might be of even more cause for concern in that regard as changes in relative access might be more abrupt and geographically extensive for such resources. Moreover, as the mobility of the resource increases, the number of actors that could find themselves in conflict over the resource could also be larger and more variable, and might therefore more easily cause regional instability. Fisheries conflicts, for example, can play out between multiple countries in a region, as was the case with the northeast Atlantic mackerel or the conflicts in the East and South China Seas. The latter point is particularly important in light of climate change, as climate change is set to trigger large geographic shifts in distribution for highly mobile resources such as fish (Cheung 2018). Global warming also impacts other natural resources such as fresh water greatly as it will reduce their availability, potentially increasing the likelihood of conflict (Bowles et al. 2015). However, the mobility of fishery resources means climate change not only reduces the total availability of fishery resources (due to effects on the physiology and biology of marine organisms, affecting, for example, their growth or reproduction (Cheung 2018)), but also impacts strongly on the geographical locations of the resources. Moreover, higher mobility hampers our ability to easily monitor and manage the resource which increases the potential for conflict. It is, for example, much more technically feasible to measure water stocks and flows than it is to estimate the number of fish, solely due to their high mobility (Cox 2009).

Second, it might also be valuable to consider which natural resource can become largely *substitutable* through (future) technological developments. There are those scholars that hold there is little evidence to suggest natural resources are even becoming scarce globally as there are various forms of technology that can displace them, and there have been many examples of that during human history (e.g. natural fibers being replaced by synthetic materials such as plastic) (Floyd & Matthew 2013). Wild-caught fish, for example, could be substituted, or at the very least supplemented, by cultured fish (Crona et al. 2016), which might diffuse conflict potential over dwindling marine fishery resources. Similarly, although oil, coal and natural gas remain the primary energy sources for now, renewable sources of energy are in a rapid growth phase and are forecasted to continue their market expansion. Fresh water, however, is a unique and vital resource for which there is no substitute at the current time. For that reason, the future potential for conflicts over water could perhaps be considered greater. From the results of **Paper III**, however, I find that scarcity of resources does not fully explain conflict. It can therefore nonetheless be true that, despite technological developments and increased availability of resources through technological means, we might still witness conflicts over natural resources (as exemplified by the price difference example between wild-caught fish and cultured fish), or that we shift potential conflicts to other types of valuables resources or possessions. The latter option seems especially realistic if we continue to conceptualize nature through a traditional capitalistic lens and regard it as free and inexhaustible.

Suggestions for future fisheries conflict research

I have a few suggestions for future research on fisheries conflict which relate to further methodological improvements and increased data collection efforts in particular. First, fisheries-related conflict occurs at different geographic scales, from conflict between fisherpeople located in the same village to conflict between states. The different environmental pressures that affect the ocean (such as climate change), and by consequence fish stocks, might very well lead to an increase in more localized conflicts rather than international conflicts. Therefore, there is a need to expand our data collection efforts to cover those conflicts as well and monitor their frequency. Aligning data-gathering methods and compiling larger datasets across those scales will greatly improve our understanding of conflict drivers across time, scales and geography.

Second, the IFCD currently does not include cooperative events over fishery resources, which is an important aspect if we truly wish to understand if fisheries conflict is a security risk. This thesis offers no quantitative evidence on the prevalence of international fisheries cooperation (it is possible, for example, that international cooperation over fishery resources has increased over time as well, and perhaps even more rapidly than conflict), nor what conditions might promote it. However, the options for conflict transformation and consequently deepened cooperation is explored in different geographic regions in **Paper IV** by using narrative scenarios as a tool. Indeed, previous work on environmental peacemaking shows cooperation can occur in the face of environmental change and resource scarcity, though likely this is contingent on contextual factors (Ide 2019, Conca & Dabelko 2002). Particularly the literature on fresh water conflict (which has found there are comparatively more cooperative water events internationally than conflict-ridden ones (Yoffe et al. 2003)) can again be consulted to set up data collection efforts on (international) cooperative fisheries events (Yoffe et al. 2004).

Third, looking in-depth at characteristics of different fishery resources themselves and how they might influence conflict is an unexplored avenue. Characteristics such as the fish species' value, its spatial mobility, or its substituteability by other produce could be informative for its relationship to conflict and can help move us further beyond simply scarcity narratives. Working hypotheses could for instance include: the higher the consumer demand for a particular species, the more likely conflict over that species is; or the more spatial mobility a species exhibit, the more likely conflict over that species is. Exploring such hypotheses would require data on a more granular level than aggregated 'conflicts over fish', as one would need to compare 'conflicts over tuna' with 'conflicts over whitefish', for example. That level of granularity is in part limited in using media reports as the source of information, as the reports can vary widely in the amount of detailed information supplied. Addresing such questions can provide us with more nuanced insight into what drives conflicts over fish, and if certain species are linked to greater conflict than others, and in light of that, if such conflicts have the potential to become more widespread in the future.

Personal reflection on the PhD process

Finally, I briefly reflect on how this thesis has contributed to my academic development. When I made the decision to pursue a PhD degree, I wanted it to be difficult and challenging. I had wanted to acquire more analytical and methodological skills ever since I did my Master's at the Stockholm Resilience Centre; and in particular I wanted to learn how to put together and analyze large datasets. I enjoy writing data-driven papers, and in some strange way I like the suffering involved in figuring out analyses and coding problems because it signals: "You are learning something!". However, there have been a few times where I felt that by choosing to build a PhD around the emerging topic of fisheries conflict, using methods I had not used before, and putting together a first database on the matter, the thesis was in fact too challenging. The IFCD went through several iterations, reflecting my winding thought process whilst setting it up and the numerous times I changed my opinion on what types of conflict events should be included in the database and which ones fell outside of its scope. To claim that I now have the exact same idea of how to set up the database and what to put in it as I did even a mere year ago would be false. In particular, choosing the exact definition of fisheries conflict and deciding what characteristics to gather data on felt particularly challenging at times as there was not much literature on the topic to guide me. When it came to analyzing the dataset, there were many grand ideas at the start of the PhD that have remained just that: unexecuted ideas.

However, I am pleased that I have acquired analytical and methodological skills in the process of making the thesis, and that I have developed an understanding of what certain approaches can in reality provide you with. Perhaps the most important lesson I learnt from analyzing the database is: results provided through statistical analyses are not black and white. Dig deep into the data, combine different ways to analyze the data, and be conservative in what you think the data can actually tell you. Those insights may well be obvious to experienced academics, but they are important lessons to be learnt by students. Additionally, from hosting the workshop and writing the last paper, I was somewhat stunned to find out that you can be an expert in the same subject area as other academics and still hold wildly diverging opinions in the same arena. However, discussing where the divergence comes from, being engaged in constructive conflict, has led to real knowledge creation and tangible improvements for the field.

The PhD process was also special for me as it involved a lot of travel and personal development due to the cotutelle. I feel I am very lucky to have been admitted as a

PhD student at two different universities, and to have access to supervisors from both locations with different yet complementary skill-sets. The cotutelle PhD was not always straightforward though, and not only because of the practicalities involved in living, studying and travelling between two geographical regions that are on opposite sides of the world (and with the most dissimilar climates imaginable). Balancing the expectations and obligations of two universities, maintaining strong communicative ties with the whole supervisory team, and ensuring I hit all of the milestones in a timely manner has been challenging. Nonetheless, because of the strong support I have received from both my JCU and SRC supervisory team and the many networks and opportunities the cotutelle has provided me with, I am very grateful for the experience.

Conclusion

Is international fisheries conflict a growing security threat? In a nutshell, from building the International Fishery Conflict Database, I find that the number of conflicts has increased between 1974 and 2016, with a more rapid increase in recent years particularly between Asian states. Those more recent conflicts are often linked to illegal fishing, and have a tendency to become more intense in nature. According to my analyses, conflicts from 1997 onwards are in part driven by increased demand for fishery resources, which, in light of prospected continued growth in demand for seafood, might confirm concerns that we will witness more conflicts over fishery resources in the future. However, the latter finding needs to be critically examined, particularly considering the growth of aquaculture as a potential substitute for wild-caught fish. Overall, this thesis is a first attempt at examining the nature and drivers of international fisheries conflict over time by use of comparative, large scale data on fishery conflict events. However, more work is needed both methodologically and theoretically to confirm or dispute some of the findings presented here, and to form a more detailed understanding of the potential for fisheries conflict to become a security threat. For that reason, I hope to continue the development of the IFCD in such a way that it increasingly accurately reflects trends and patterns in international fisheries conflict, so its analysis can aid both theoretical explorations as well as policy making.

Moreover, I find that integrating large-scale, quantitative data and modeling on conflict with more context-specific information on particular spatial areas (gathered through, for example, an expert workshop) can offer more nuanced and policy-relevant insights. Though analyzing historical data is likely to remain our only way to make assumptions about future risk, predicting with precision the future by use of quantitative historical data can seldomly be done, even when such data has the most robust empirical backing. The future remains fundamentally unknowable, particularly when it comes to social-ecological CAS, so there is unlikely to be a silver bullet for mitigatating conflict. Perhaps variables such as fisheries scarcity seem to have had limited, or at the very least contested, influence in producing the conflict events I compiled and analyzed, yet this does not mean those factors will not play a big role in sparking future conflict. It is for that reason that imaginative scenarios that bring together stakeholders have an important role to play in understanding and preparing for possible futures for complex systems. Focusing on potential geographical hotspots for continued and future fisheries conflict such as the Arctic or the East and South China Seas can be of particular interest to policy makers in that regard. Although shedding light on the nature and prevalence of conflict and the (relative) effect of certain mechanisms producing such trends might not lead to perfect decision-making to avoid, de-escalate or transform future fisheries conflict; I hope it can help us think more critically about conflict drivers and appropriate management interventions.

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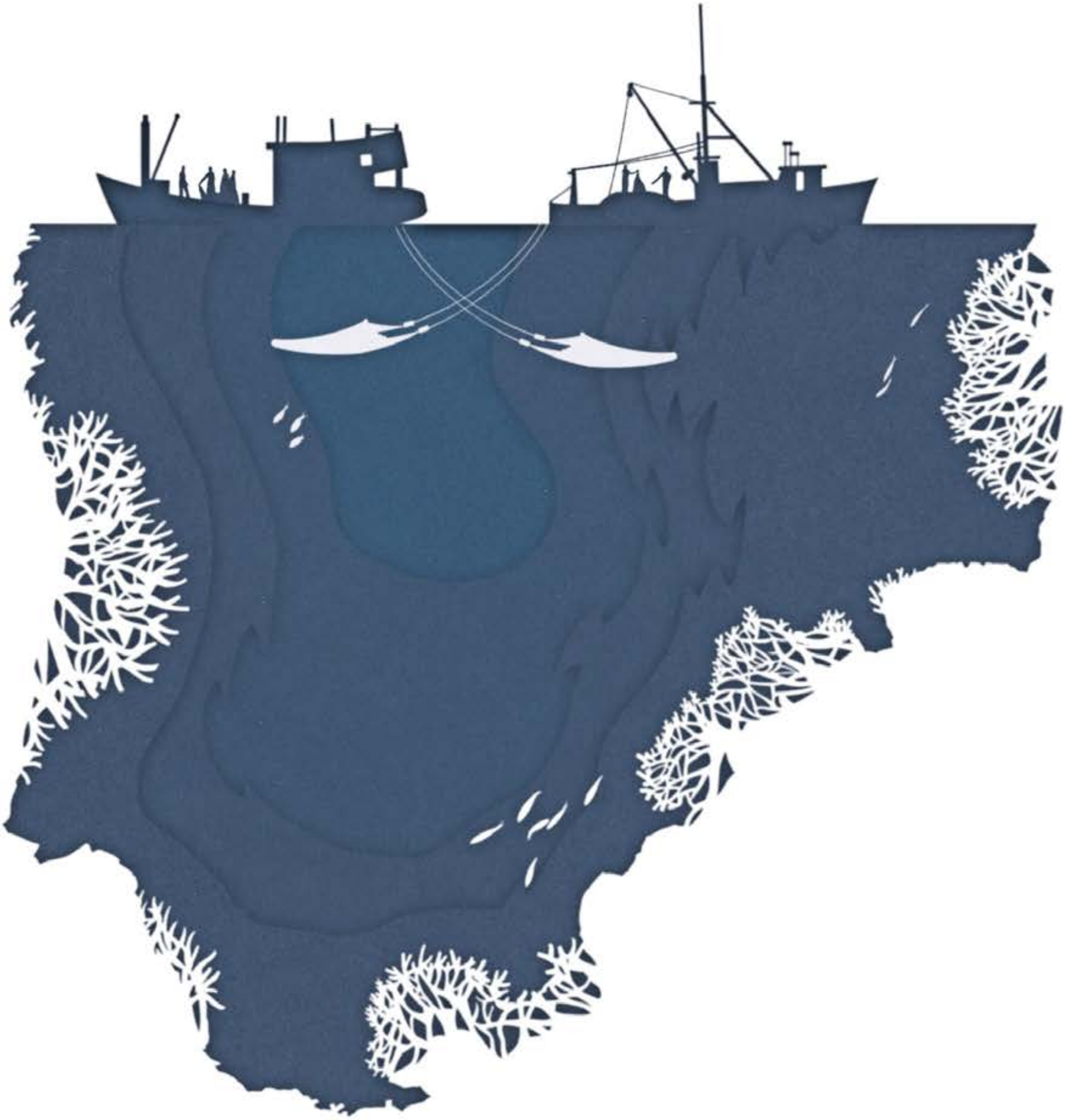

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GHOTI

WILEY FISH and FISHERIES

Marine fisheries and future ocean conflict

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Abstract

Conflict over marine fishery resources is a growing security concern. Experts expect that global changes in our climate, food systems and oceans may spark or exacerbate resource conflicts. An initial scan of 803 relevant papers and subsequent intensive review of 31 fisheries conflict studies, focused on subnational and international conflicts, suggests that four substantial scientific gaps need addressing to improve our understanding of the nature and drivers of fisheries conflict. First, fisheries conflict and levels of conflict intensity are not precisely defined. Second, complex adaptive systems thinking is underutilized but has the potential to produce more realistic causal models of fishery conflict. Third, comparative large-scale data and suitably integrative methodologies are lacking, underscoring the need for a standardized and comparable database of fisheries conflict cases to aid extrapolation beyond single case-studies. Fourth, there is room for a more widespread application of higher order concepts and associated terminology. Importantly, the four gaps highlight the homogenized nature of current methodological and theoretical approaches to understanding fishery conflict, which potentially presents us with an oversimplified understanding of these conflicts. A more nuanced understanding of the complex and dynamic nature of fishery conflict and its causes is not only scientifically critical, but increasingly relevant for policymakers and practitioners in this turbulent world.

KEYWORDS
climate change, complex adaptive systems, disputes, fishery resources, scarcity, security

1 | INTRODUCTION

Policymakers are growing increasingly concerned about conflicts overfishery resources (Germond, 2015; Hassani-Mahmooei & Parris, 2013). Wild capture fisheries production has stagnated over the last 20 years (FAO, 2014; Pauly et al., 2003, Worm, 2016), and climate change is expected to alter the distributions and potential yields of exploited marine species (Cheung et al., 2010; Miller, Munro, Sumaila, & Cheung, 2013; Sumaila, Cheung, Lam, Pauly, & Herrick, 2011; UNEP, 2015). Meanwhile, global demand for marine protein is growing (Béné

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Etymology of Ghoti

George Bernard Shaw (1856–1950), polymath, playwright, Nobel prize winner, and the most prolific letter writer in history, was an advocate of English spelling reform. He was reportedly fond of pointing out its absurdities by proving that 'fish' could be spelt 'ghoti'. That is: 'gh' as in 'rough', 'o' as in 'women' and 'ti' as in palatial.

et al., 2015), particularly in vulnerable regions that depend on fish for food security (Allison et al., 2009; Blasiak et al., 2017; Taylor et al., 2015). A number of militarized international post-World War II conflicts have already been driven by disagreements overfishing quotas and maritime boundaries (Mitchell & Prins, 1999), including many ongoing, high-profile disputes (Box 1). The occurrence of conflicts overfisheries is thus expected to become more common (EFARO, 2012).

However, there is still limited consensus on the fundamental causes or mechanisms connecting natural resources to conflict, and linkages between changing climate conditions and security issues remain unclear (Gemenne, Barnett, Adger, & Dabelko, 2014). Efforts to describe such linkages in the case of fishery resources have been criticized as overly simplistic (Penney, Wilson, & Rodwell, 2017). This growing criticism stems from the increased understanding that marine social–ecological systems (SESs) are complex adaptive systems (CAS), characterized by nonlinear dynamics and multiple possible outcomes (Hughes, Bellwood, Folke, Steneck, & Wilson, 2005; Morrison, 2017; Österblom et al., 2013), and that conflict over marine resources can itself be an outcome as well as a driver within those systems (Pomeroy, Parks, Mrakovcich, & LaMonica, 2016). In this review, we test the validity of the claim of simplicity (Penney et al., 2017) by assessing the degree to which the fisheries conflict literature, encompassing both subnational and international conflict, has incorporated ideas from complexity theory and SESs theory and identifying areas within this literature that would benefit from further development.

Box 1 Examples of current, unresolved fishery disputes

South China Sea: China, Vietnam, the Philippines, Taiwan, Malaysia and Brunei currently have competing claims over parts of the South China Sea, including the Paracels and Spratlys, and dozens of rocky outcrops, atolls, sandbanks and reefs (BBC News, 2016a; Song & TØnnesson, 2013). In the 1980s and 1990s, Vietnamese and Chinese fatalities occurred in battles over the Paracels and Spratlys. The rich fishing grounds that supply the livelihoods of people across the region are a significant part of the wealth of the South China Sea, although fisheries are often ignored by conventional narratives which focus on the large reserves of natural resources such as minerals and oil that the area under dispute is estimated to harbour (BBC News, 2016a; Dupont & Baker, 2014). In 2016, the Philippines countered Chinese claims through a tribunal of the United Nations Convention on the Law of the Sea (UNCLOS), which ruled in favour of the Philippines (BBC News, 2016a,b). However, China continues to regard these fishery resources as critical to its food security and thus as a strategic commodity (Dupont & Baker, 2014).

Northeast Atlantic: The “mackerel dispute” between Norway, the European Union (EU), Iceland and the Faroe Islands erupted in 2007 when the northeast Atlantic mackerel (*Scomber scombrus*) stocks began spawning further towards the north-west of the Nordic Seas and their surrounding waters (Gänsbauer et al., 2016, ICES Advisory Committee, 2014; Nøttestad et al., 2014). Iceland (which now finds mackerel within its Exclusive Economic Zone) did not originally include mackerel in its coastal state management plans. The migration not only resulted in increased overfishing of the stock, but the subsequent dispute also eroded the legitimacy and functioning of existing management plans (ICES Advisory Committee, 2014, Spijkers & Boonstra, 2017, World Ocean Review, 2016). A few years after the shift in mackerel distribution, the relevant parties attempted, but failed, to include Iceland in the agreement negotiations. At the time of writing, Iceland has still not been formally involved in the agreements on the Total Allowable Catch (TAC) and quota allocations per country.

2 | METHODOLOGY

We used a broad title–abstract keyword search of the Scopus database to identify 1,941 relevant articles, which were analysed using data mining tools provided by the R package tm using the search phrases: “fish” OR “fishery” AND “conflict” OR “dispute” or “war” (Feinerer & Hornik, 2017). This data mining process was executed to understand the geographic focus of the papers (Figure S1). We then narrowed the scope of the analysis by including only those articles within the subject areas of social sciences and economics and excluding papers from disciplines with a less clear connection to conflict (e.g., health sciences). This resulted in a set of 803 articles. We reviewed the abstracts of these articles and selected those dealing with the roots of past or ongoing conflict over a specific marine fish or fishery (excluding, for example, theoretical papers on fishery conflict or papers discussing potential future conflicts). For each of the resulting 31 papers, we extracted information on their geographical focus, species, methodology, data sources and theoretical framing (Appendix S1).

Given the concerns raised by Penney et al. (2017), we approached the review with an a priori interest in the degree to which integrative SES thinking is applied in understanding fisheries conflict. The SES literature deals with questions around sustainable development and promotes the idea of holism rather than fragmentation (Hjorth & Bagheri 2006, Levin et al., 2012). The literature therefore provides a potentially useful integrative lens for a more holistic understanding of fisheries conflicts. SES outcomes result from complex interactions between social and ecological variables; the literature on SESs strives to reflect this complexity through its choice of methodologies, theories and data sources. Work on SESs seeks to unveil and understand the complexity of social–ecological change overtime, accounting for feedbacks and path dependency, and uses empirical data to do so (Österblom et al., 2013). Taking an integrative SES approach helps us understand the diverse social and biophysical outcomes we observe in the world, of which conflict over resources is one.

To identify gaps in the application of SES concepts and complex systems approaches to the fisheries conflict literature, we evaluated existing studies against the following a priori criteria: (i) clarity in definitions and applications of key terms; (ii) consideration of feedbacks, thresholds and nonlinearity; (iii) use of comparative approaches and suitably integrative methodologies; and (iv) usage of higher order systems concepts, as indicated by the presence of associated terminology (e.g., resilience, vulnerability, and emergence).

3 | RESULTS

3.1 | Clarity in definitions and applications of key terms

Comparison of articles on conflict suggested that current fishery conflict typologies often conflate conflicts overfish as a resource with general conflicts taking place within the fisheries space, leaving the concept "fishery conflict" poorly defined. According to one typology, for instance, "types of fisheries-related conflicts" encompass both conflicts overfish stocks as well as maritime crime and general civil unrest (Pomeroy et al., 2016). Another typology (Bennett et al., 2001) does not distinguish between ownership/management conflicts overfish and conflicts between different users of the fisheries space. It therefore could include conflicts between fishermen and the tourist industry over access and use of coastal areas, although such disputes are not necessarily triggered by fish as a resource. These typologies may reflect the complexity of conflicts in marine areas, but differentiating between conflicts overfish as a natural resource and conflicts that simply occur in the same place where fishing is happening is useful if we wish to better understand the root causes of conflict. Such distinctions are possible for common pool resources: access rights refer to "the right to enter a defined physical property," while withdrawal rights describe "the right to obtain the 'products' of a resource (e.g., catch fish)" (Schlager & Ostrom, 1993, pp. 14–15; see also Bavinck, 2005). Using the insights from the common pool resource literature in marine environments, "physical property" relates to the sea space or territory, whereas "products" include fish stocks (Bavinck, 2005). Making this distinction is important when analyzing the different types and potential causes of fishery conflict, as conflicts overfish as a resource could have drivers (such as the value of a particular stock) that would be largely independent of conflicts within the general marine space, where territory represents the resource.

Second, the term "fishery conflict" is applied to diverse case-studies, without explicitly recognizing the differing intensities of conflict. Three papers provide typologies of fisheries conflict (Bennett et al., 2001; Charles, 1992; Pomeroy et al., 2016), and two of these suggest that different intensity levels of conflict exist. But none of these typologies explicitly distinguishes among different intensity levels of conflict, nor how such levels could be identified despite the fact that the existence of a "violence gradient"' has been emphasized "[c]onflicts of this type do not necessarily have to be violent nor highly disruptive, in fact many conflicts that arise as a result of differing interests are low-level, non-violent phenomena" (Bennett et al., 2001, pp. 366). Distinguishing between the different amplitudes and impacts of fisheries conflicts would help determine whether there are separate drivers of conflict leading to different "intensity outcomes." For example, extremely violent conflicts may exhibit very different causal patterns than non-violent disagreements, and cooccur more frequently with certain variables, or contextual conditions. Such an intensity scale would also facilitate differentiation among various levels of conflict and explore patterns and cycles causing non-violent disputes to transform into violent conflict (Hsiang, Burke, & Miguel, 2013; Salehyan, 2008). Likewise, it could aid the identification of variables that have a determining impact on feeding or mitigating conflict, causing co-operative/peaceful systems to shift into "fishery conflict regimes" exhibiting hostility and even violence. A scale of conflict intensities would enable analysis of conflict and cooperation across a gradient, where certain variables could be "tipping points" for a system to shift back into a lesser state of conflict. Researchers dealing with other types of natural resource conflicts have already identified such conflict gradients, for instance for freshwater resources (Wolf, Yoffe, & Giordano, 2003).

Current conceptual typologies of fishery conflict (Bennett et al., 2001; Charles, 1992; Pomeroy et al., 2016) could be enhanced by adding several components that would facilitate comparability in the identification and characterization of fishery conflict. These include (i) a precise definition of what constitutes a fishery conflict; (ii) a gradient or categorization of conflict intensity; (iii) a specification of which actions and behaviours indicate different levels or types of conflict intensity. In Table 1, we propose a new and more generally applicable typology of potential fishery conflict intensities, expanded from examples from the environmental security literature on freshwater resources (e.g., "the BAR Scale of Intensity of Conflict and Cooperation" in Yoffe, Wolf, & Giordano, 2003; Brochmann, 2012; Bernauer & Bohmelt, 2014). Drawing on reviewed case-studies of fisheries conflicts, we linked five different intensities to observable behaviours and actions within international fishery conflicts. The South China Sea conflict (Box 1), for example, has seen many military interventions with displays of violence (Delisle, 2012), while the mackerel dispute has not seen this same level of hostile acts, yet is marked by diplomatic–economic hostile acts such as termination of agreements and trade/landing bans (Spijkers & Boonstra, 2017).

3.2 | Consideration of feedbacks, thresholds, and nonlinearity

Few of the reviewed papers explicitly address causal complexity by comprehensively assessing multiple potential conflict drivers and intervening variables that are empirically derived. Several shed light on the issue of fishery conflict through the theoretical framings of international or customary law, for example (5 of 31). In these papers, the focus generally lies on understanding the use and importance of certain legal measures within disputes, not explicitly identifying potential causes or contributing factors outside of that

TABLE 1 Categorization of fishery conflict intensities, linked to their observable actions and behaviours. Developed as an example for applicability to international fishery conflicts

Intensity of observed behaviour/action	
Intensity	**Description**
5	Military acts causing death
	Attack of foreign vessels, crew members or Coast Guards, with resulting deaths
4	Military acts
	Attack of foreign vessels, crew members or Coast Guards, no death toll
3	Political–military hostile acts
	Sending out police vessels/warships
	Seize vessel and/or crew
	Gear destruction
	Reinforcing borders
2	Diplomatic–economic hostile acts
	Breaking or not adhering to existing agreement
	Lawsuit
	Trial in court
	Seeking international arbitration
	Trade ban
	Fishing ban
	Landing ban
	Monetary penalties
	Close ports
1	Verbal expressions displaying discord or hostility in interaction
	Failing to reach an agreement
	Making threatening demands and accusations
	Threatening sanctions
	Condemning specific actions, behaviours or policies
	Requesting change in policy
	Civilian protests
0	Non-significant acts

realm of study (Appendix S1). Framing an analysis around a particular concept or variable can result in a linear representation of cause and effect, not explicitly recognizing potential feedbacks, thresholds and nonlinearity. In some cases, however, these authors point to the complex causal reality of conflict; Silk (2001), for instance, uses an international law framing, noting that "the issues underlying even a single-species fishery dispute are often complex, ranging from legal issues, biological issues, and economics, to politics" (Silk, 2001, pp. 792). Many papers reference a multitude of variables throughout the text including poor governance (e.g., DuBois & Zografos, 2012; Muawanah, Pomeroy, & Marlessy, 2012) and declining resource abundance (e.g., van Herten & Runhaar, 2013; Perez, 2009; Song, 1997), but these papers never set out to empirically derive these variables nor to test for their relationship with conflict.

Another example of a linear and potentially oversimplified idea of fishery conflict is the concept of eco-scarcity, according to which the scarcity of fishery resources leads to increased competition, which in turn leads to conflict. Little empirical evidence currently exists within the fisheries conflict literature to support claims of eco-scarcity as the driver for conflict (Penney et al., 2017). Yet, it is an a priori assumption underpinning much of the work on fisheries conflict, including the "fish wars cycle" described by Pomeroy et al. (2016). Other scholars have also remarked that "conflicts within fisheries can be oversimplified by resource scarcity narratives" (Penney et al., 2017, pp. 46) and have called for an investigation of more complex and multidimensional causes of conflict.

The two studies of fisheries conflict that have assessed multiple potential conflict drivers (Muawanah et al., 2012; Pomeroy et al., 2007) generated a deeper and more nuanced understanding of how conflict emerges, and how multiple factors have influenced observed conflicts. However, these papers are focused on conflict at the subnational scale. At the regional and international scales, the primary focus has seldom been to assess the relative importance of an array of variables, but instead to tell the story of how the dispute emerged and changed over time. Moreover, scholars who have focused on international fisheries cooperation have generally based their empirical analysis on a single variable, for instance, the maximization of economic incentives in game theoretic applications (Bailey, Sumaila, & Lindroos, 2010; Hannesson, 2011). Attempting to retroactively understand conflict or to predict it with such approaches, especially on international scales, reduces the complexity that underlies such conflicts and can result in simplistic conclusions.

We argue that the scholarship could benefit from explicitly addressing causal complexity. This would require comprehensively assessing multiple potential conflict drivers (biophysical, sociopolitical, institutional and economic) that are empirically derived, and the relationships between them. Moreover, conflict should not be seen as solely the outcome of a process, but also as a variable that can feed back into the system. Complex adaptive systems thinking can be a useful framing tool, as it recognizes nonlinear feedbacks, multiple causes, effects and intervening variables that are linked by interactive, synergistic and nonlinear causation that can also operate across different timescales (Cumming, Olsson, Chapin, & Holling, 2013; Folke, Hahn, Olsson, & Norberg, 2005; Levin et al., 2012; Lubchenco, Cerny-Chipman, Reimer, & Levin, 2016). Researchers dealing with other types of renewable and non-renewable resource conflicts have applied elements of CAS thinking to varying degrees in contexts characterized as complex and dynamic. In the freshwater literature, for example, emphasis has shifted from trying to identify single causes to instead explore environment-conflict connections that are substantially caused or affected by political and socio-economic factors (Homer-Dixon, 2001; Selby & Hoffmann, 2014; von Uexkull, Croicu, Fjelde, & Buhaug, 2016; Yoffe et al., 2004).

Addressing complexity more explicitly will allow us to distinguish between "necessary" and "sufficient" causes of fishery conflict, and the interactions between the two. In the case of necessary causes, the observed outcome of conflict would not have happened in the absence of the cause in question; for sufficient causes, the observed conflict outcome might have been the same regardless of the cause in question (Mahoney, 2008). Translated to the world of fisheries conflicts, in some cases, perhaps a decline in the resource is a necessary factor to produce a conflict condition, while an ongoing jurisdictional boundary conflict could be a sufficient one. Understanding the distinction between these two types of causes is pertinent for assessing, the growing concern that climate change will influence the likelihood of conflict overfishery resources.

3.3 | Use of comparative approaches and integrative methodologies

From the 31 papers that we reviewed in depth, only four offered an analysis across multiple conflict case-studies and only two of these used quantitative methods. This means that most papers have analysed single cases of conflict in a qualitative manner, and that little has been done to systematically compile quantitative, historical evidence of fisheries conflict. Although single, qualitative case-studies on fishery conflict are valuable, comprehensive quantitative studies on fishery conflict could help us understand linkages and dynamics across multiple case-studies and over time.

The lack of comparative data and analysis has restricted understanding of the prevalence and geography of fishery conflicts around the world. The majority of the studies assessed here deal with conflicts among states in the North Pacific and North Atlantic; for instance between the US and Canada (8 of 31) or, more recently, conflicts involving Asian actors such as Japan (Appendix S1). Such trends are also apparent from the text-mining analysis applied to the larger set of 1,941 conflict articles. We found that the majority of work has focused on the world's most industrialized countries, with few studies in the least developed countries, a trend that seems to be continuing (Figure 1).

Second, the lack of large sets of comparative data means scholars have not been able to test if certain relationships between variables that have been anecdotally connected to fishery conflict exist across a larger set of cases. Case-studies of fishery conflict (e.g., in Box 1) suggest general patterns, but empirical analysis of (large) comparable datasets is necessary to resolve questions of causality. Obtaining such data can help to validate the robustness of the relationships suggested by case-studies on fisheries conflicts, and to investigate new potential relationships that would inform a realistic model for fisheries conflict. The predominance of qualitative single case-studies has generated depth and richness but also represents a lack of comprehensiveness in methodologies available to understand

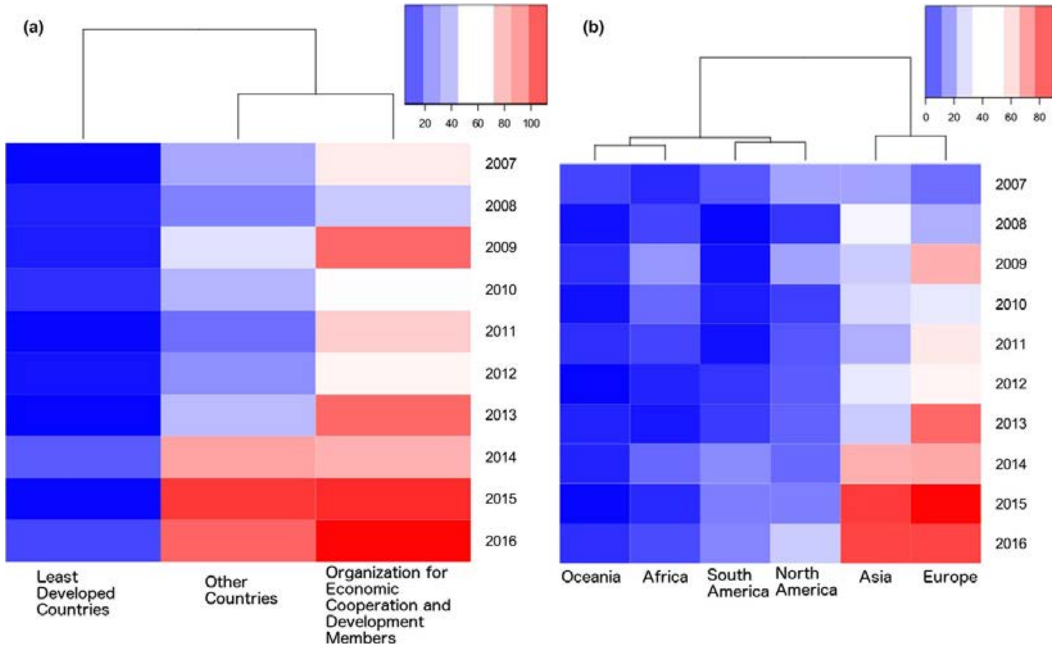

FIGURE 1 Frequency with which the fishery conflict literature from 2007 to 2016 referred to countries within specific (a) socio-economic groupings; (b) regional groupings. The United Nations has identified 47 Least Developed Countries (LDCs), characterized by low levels of socio-economic development; conversely, the 35 members of the Organization for Economic Cooperation and Development (OECD) are among the world's most highly industrialized countries. Hierarchical clustering and color-coded frequency (blue representing the lowest frequency and red the highest) are provided at the top of each heatmap. Data source: Scopus 2016 [Colour figure can be viewed at wileyonlinelibrary.com]

and explain fishery conflict. Expanding the methodological toolbox to include Structural Equation Modelling (SEM) or agent-based computer simulations could advance efforts to understand the variables associated with fishery conflict (Helbing, 2013).

A global database of fishery conflicts would provide the large-scale comparative data needed to (i) get an understanding of the geography and prevalence of fishery disputes over time; (ii) test for relationships between conflict variables across multiple cases; and (iii) open the door for a more diversified repertoire of methodologies. Research on other forms of natural resource conflicts provides useful guidance in this respect. The systematic collection of data on conflict over freshwater resources (Transboundary Freshwater Dispute Database), for example, resulted in a framework for quantitative, global-scale assessments of the relationship between freshwater resources and international cooperation and conflict (Yoffe et al., 2004). Here, the approach was to use a standardized event database to move beyond the case-study approach to include large sets of GIS and contextual data. This theoretical and empirical foundation enabled scholars to use forecasting methods to assess the predictive power of selected explanatory factors (Bernauer & Bohmelt, 2014). Drawing on some of these tested approaches could provide promising avenues for expanding our knowledge of fishery conflicts.

3.4 | Usage of higher order systems concepts and associated terminology

In SES research, higher order concepts and terminology are used to describe pattern–process dynamics that emerge from complex system interactions and dynamics. Scheffran, Brzoska, Kominek, Link, and Schilling (2012) have argued that debates describing links between the climate system, natural resources, societal stability and human security lack complexity. In trying to inject some of that missing complexity back into the research, they use higher order systems terminology to describe the links between natural resources, the climate and conflict, that is the terms “resilience,” “adaptation/adaptive capacity,” “vulnerability,” “sensitivity,” “feedbacks,” “tipping points” and “thresholds.” We searched our selected review articles to determine whether the literature on conflict overfishery resources had implemented this terminology in their analyses.

Twenty of the 31 reviewed papers did not use higher order systems terminology, and the large majority of those not using any such terms are papers from disciplines such as law and international relations. Within those scientific communities, it is not often explicitly recognized that there is a complex set of interactions between the climate system, natural resources, human security and societal stability, as they often approach the topic of fishery conflicts to understand a single variable such as the effectiveness of a particular international regulation. However, several fishery conflict scholars have used higher order systems terminology such as “vulnerability” and “adaptive capacity” to reflect their recognition of complexities in the relationships between natural resources, the climate system and conflict; here, we describe a few of these usages.

The first to explicitly acknowledge the complexity of marine SES, and conflict as a component within that system, through the usage of higher order systems terminology was Charles (1992): “In any bio-socio-economic system as complex and as dynamic as a fishery, with its many interactions amongst natural resources, humans and institutions, it is hardly surprising that conflict tends to be prevalent”. In that same year, Mirovitskaya and Haney (1992) also recognized the complexity of marine SES and threshold within those and explicitly mentioned the interconnectedness of conflicts overfishery resources. However, the use of higher order systems terminology was restricted to terms merely describing marine systems as complex and interconnected, not yet using concepts such as “vulnerability,” “resilience” or “adaptive capacity” to describe the internal properties of the marine SES.

From 2000, Miller (co)-authored four papers that at first applied the terms “sensitivity,” “resilience,” and later on used the terms “vulnerability,” “adaptive capacity,” and “thresholds” in the context of conflict within marine SES. In the latest paper, for example, “resilience” and “adaptability” are used by the authors to connect changing dynamics of fishery resources induced by the climate to emerging conflict: they argue that to effectively govern shared fisheries in the face of changing environmental conditions “(…) mechanisms to improve the resilience and adaptability of cooperative management arrangements to environmental perturbations” are needed (Miller et al., 2013, pp. 326). After Miller, a few authors used the term “vulnerability” (albeit exclusively in papers approaching fishery conflict from a natural resource management perspective) to describe the links between overfishing, vulnerability to climate impacts and conflict.

An important contribution in the usage of higher order systems terminology comes from a paper by Gänsbauer, Bechtold, and Wilfing (2016), where it is explicitly recognized that there is a “necessity to acknowledge [the current international fishery management] as a complex adaptive system”. They introduce new concepts such as “emergent properties” and “nested hierarchies” into the description of marine SESs and the role of conflict. However, the terms are used only a single time as a descriptor of the system and not as tools for analysis. Nonetheless, the paper marks a shift into a deeper scientific understanding of the characteristics of marine SESs that can help us to understand conflict overfishery resources.

4 | CONCLUSION: THE FUTURE OF FISHERIES CONFLICT RESEARCH

A rapidly expanding body of research dealing with fisheries conflict suggests a growing interest and concern over the potential for increased conflict overfishery resources. This concern is justified from a historical perspective, as fisheries have been connected to conflict through an array of potential mediating variables such as climate variability, rapid population growth, social inequality and the expansion of economic zones around coastal nations. All of these factors are projected to remain or even intensify in future years. Greater understanding of the risk potential of commonly cited drivers such as climate variability will depend on filling in gaps in the fisheries conflict literature. The four gaps that we have identified are:

1. The lack of fishery conflict definitions that are precise, that distinguish among degrees of conflict intensity and that specify which actions or behaviours are indicative of different levels of conflict intensity.
2. The absence of (large sets) of comparative conflict data, and consequently narrowness in the methods used to assess the drivers of fishery conflict.
3. The lack of theoretical framings that explicitly recognize nonlinear and dynamic feedbacks, multiple causes, effects and intervening variables; and that are translated into appropriate methodologies for complexity.
4. Although the complexity of marine SES and conflict's role within that system is recognized through the use of terms such as "adaptive capacity" and "vulnerability," there is room for a more widespread extension of higher order concepts and associated terminology.

As the topic of fishery conflict becomes increasingly salient and considering the well-documented importance of fisheries for human well-being, researchers focused on fisheries conflict are well-positioned to make a practical contribution to more sustainable and cooperative use of fisheries resources. Doing so will require supplementing individual case-studies with more generalizable approaches to develop a deeper understanding of the complex interaction between drivers of fisheries conflict and how to avoid or mitigate them. This will enable more precision and a deeper understanding that is not only scientifically significant, but increasingly important for policymakers and practitioners operating in a turbulent world.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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Supplementary information Paper I

APPENDIX 1: REVIEWED PAPERS

CASE STUDY & CONFLICT SCALE	***DATA SOURCES & METHODOLOGY***	***THEORETICAL FRAMING***	***REFERENCE(S)***
Atlantic lobster fishery, France vs Brazil *International*	*Secondary sources* *Historical explanation, single case*	*International law*	*Azzam 1964*
North Pacific Ocean *International*	*Secondary sources* *Historical explanation, single case*	*International law*	*Park 1989*
Salmon fishery on Canada's Pacific coast & *Groundfish fishery on Canada's Atlantic coast* *Sub-national & international*	*Secondary sources* *Historical explanation, single cases*	*Natural resource management*	*Charles 1992*
North Pacific Ocean *International*	*Secondary sources* *Historical explanation, single case*	*Natural resource management*	*Mirovitskaya & Haney 1992*
Pacific salmon stocks of North America (Canada vs USA) *International*	*Secondary sources* *Historical explanation, single case*	*History*	*Rogers & Stewart 1997*
Turbot fishery in Northwest Atlantic (Canada vs EU) *International*	*Secondary sources* *Historical explanation, single case*	*International law*	*Song 1997*
Pacific salmon stocks of North America (Canada vs USA), *Norwegian Spring Spawning Herring* *International*	*Secondary sources* *Historical explanation, single case*	*Natural resource management/economics*	*Miller 2000, 2007, Miller & Munro 2004, Miller et al. 2013*

Ghana, Bangladesh and the Turks and Caicos Islands (TCI) in the Caribbean *Sub-national*	*Semi-structured questionnaires, focus group discussions, and contextual and conflict map building* *Comparative analysis of multiple case studies*	*Natural resource management*	*Bennett et al. 2001*
Turbot fishery (Canada vs Spain), Native American Fisheries Disputes in the USA, southern Bluefin tuna *Sub-national & international*	*Secondary sources* *Comparative analysis of multiple case studies*	*International law*	*Silk 2001*
Saury fishery (Russia vs South Korea vs Japan) *International*	*Secondary sources* *Historical explanation, single case*	*International relations*	*Valencia & Lee 2002*

CASE STUDY & CONFLICT SCALE	***DATA SOURCES & METHODOLOGY***	***THEORETICAL FRAMING***	***REFERENCE(S)***
South India (Coromandel Coast) *Sub-national*	*Participant observation, focused interviews, case studies of events, analysis of court cases, survey* *Historical explanation with legal pluralist perspective, single case*	*Customary law*	*Bavinck 2005*
Lobster fishing in the Gulf of Maine (Canada vs USA) *International*	*Secondary sources* *Historical explanation, single case*	*Political ecology*	*Cook 2005*
Flying Fish (Trinidad & Tobago vs Barbados) *International*	*Secondary sources* *Historical explanation, single case*	*Natural resource management*	*Blake & Campbell 2007*
Indonesia, the Philippines, Thailand and Vietnam *Sub-national*	*Fisher questionnaires* *Comparative analysis of multiple case studies,*	*Natural resource management*	*Pomeroy et al. 2007*

	using descriptive and inferential statistics		
Sapodilla Cayes Marine Reserve, Belize vs Guatemala vs Honduras *International*	*Participant observation, key informant interviews & collection of secondary data*	*Natural resource management*	*Perez 2009*
Tuna fishing in Atlantic Ocean, Japan versus Taiwan *International*	*Interviews, archival research* *Historical explanation, single case*	*International relations*	*Chen 2011*
Indonesia *Sub-national*	*Fisher questionnaires* *Comparative analysis within one geographical case study but at different times, using descriptive statistics and regression analysis*	*Natural resource management*	*Muawanah et al. 2012*
Senegal *International*	*Participant observation, semi-structured interviews, focus group discussions, direct observation & archive content analysis* *Historical explanation, single case*	*Political ecology*	*DuBois & Zugrafos 2012*

CASE STUDY & CONFLICT SCALE	***DATA SOURCES & METHODOLOGY***	***THEORETICAL FRAMING***	***REFERENCE***
Dutch eel fishery *Sub-national*	*Secondary sources, interviews* *Argumentative discourse analysis, with elements from the ACF framework & Toulmin's structural model of argument, single case*	*Natural resource management*	Van Herten & Runhaar 2013

Palk Bay (India vs Sri Lanka) *International*	*Participant observation, in-depth interviews* *Historical explanation, single case*	*International relations*	Stephen et al. 2013
China's behavior in the East and South China Sea *International*	*Secondary sources* *Historical explanation, single case*	*International relations*	Dupont & Baker 2014
Philippines *Sub-national*	*Semistructured & unstructured interviews, participatory observation* *Historical explanation, single case*	*Anthropology*	Segi 2014
Northeast Atlantic (Iceland vs Faroe Islands vs Norway vs EU) *International*	*Secondary sources* *Game theory (non-cooperative), single case*	*Economics*	Jensen 2015
East China Sea (Taiwan VS Japan) *International*	*Secondary sources* *Historical explanation, single case*	*Political ecology*	*Yeh et al. 2015*
Northeast Atlantic (Iceland vs Faroe Islands vs Norway vs EU) *International*	*Secondary sources, interviews with one party* *Q methodology, single case*	*Anthropology*	*Gansbauer et al. 2016*
Salmon fishery (Japan VS Russia) *International*	*Secondary sources* *Historical explanation, single case*	*International relations*	*Ferguson-cradler 2016*
China's behavior in the East and South China Sea *International*	*Interviews, secondary sources* *Historical explanation, single case*	*International relations*	*Zhang 2016*
Chinese industrial fleet in local Ghanaian fisheries *International*	*Semi-structured interviews & informal group discussion*	*Political ecology*	*Penney et al. 2017*

SUPPLEMENTARY MATERIAL FOR FIGURE 1

```
library(igraph)
library(linkcomm)
library(RColorBrewer)
library(tm)
library(SnowballC)
library(proxy)
library(network)
library(ggplot2)
library(cluster)
library(FactoMineR)
library(GMD)
library(gplots)
library(MASS)
cname <- file.path("~/PROXY") # Specify path name
cname
docs2 <- Corpus(DirSource(cname))
summary(docs2)
docs2 <- tm_map(docs2, removeWords, stopwords("english"))
docs2 <- tm_map(docs2, removeNumbers)
toSpace <- content_transformer(function(x, pattern) {return (gsub(pattern, " ", x))})
docs2<- tm_map(docs, toSpace, "-")
docs2<- tm_map(docs, toSpace, "—")
docs2 <- tm_map(docs2, removePunctuation)
docs2 <- tm_map(docs2, content_transformer(tolower))
docs2 <- tm_map(docs2, stripWhitespace)
docs2 <- tm_map(docs2, stemDocument, language = "english")
adtm2 <- DocumentTermMatrix(docs2)
myterms <- c("PROXY", "PROXY", "PROXY", "ETC")  # self-selected terms
adtm2.selected <- DocumentTermMatrix(docs2, list(dictionary = myterms)) #matrix of just
these terms
inspect(adtm2.selected)  #shows frequency of terms
m1 <- as.matrix(adtm2.selected)
heatmap.2(m1, Rowv = NULL, density.info="none", col=bluered(256), hclustfun=function(d)
hclust(d, method="ward.D2"), margin=c(6,6), trace="none", main = "Conflict")
```

II

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Global patterns of fisheries conflict: Forty years of data

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ABSTRACT

International fisheries conflict can cause crises by threatening maritime security, ecosystems and livelihoods. In a highly connected world, the possibility for localized fisheries conflict to escalate into 'systemic risks', where risk in one domain such as food supply can increase risk in another domain such as maritime security and international relations, is growing. However, countries often choose hard-line actions rather than strategies initiating or repairing fisheries cooperation. To design, prioritize and implement more effective responses, a deeper understanding of the temporal and regional patterns of fisheries conflict is needed. Here, we present novel findings from the first global and longitudinal database of international fisheries conflict between 1974–2016. We explore the characteristics of conflict over time and develop a typology of eight distinct types of conflict. Fisheries conflict increased between 1974 and 2016, with substantial variation in both the type of conflict and the countries involved. Before 2000, fisheries conflict involved mostly North American and European countries fighting over specific species. Since then, conflict primarily involved Asian countries clashing over multiple and nonspecified species linked to illegal fishing practices. We use this empirical data to consider potential response strategies that can foster maritime security and thereby contribute to broader societal stability.

1. Introduction

Fisheries conflict has the potential to reshape global international relations by threatening maritime security, ecosystems and livelihoods. Conflict over fisheries in the 1960s and 1970s triggered the establishment of Exclusive Economic Zones (EEZs) for coastal states in the 1980s. A single fishery offense over halibut (*Reinhardtius hippoglossoides)* escalated into serious tensions between Canada and Spain in the mid-1990s (Sullivan, 1997). More recently, conflict over fisheries in the EU has fuelled British nationalist sentiments and the successful "Leave" campaign to withdraw the United Kingdom from the European Union (EU) (Appleby and Harrison, 2017). Prolonged shifts in the distribution of the northeast Atlantic mackerel *(Scomber scombrus)* in the Atlantic triggered an international dispute over the stock's management, resulting in unilateral import embargos, vessel seizures and access restrictions, which in turn played a role in Iceland's decision to withdraw its application for EU membership (Spijkers and Boonstra, 2017). Repeated Chinese fishing fleet incursions into foreign waters have sparked diplomatic and military tensions between China and countries both near (e.g. Philippines), and far (e.g. Argentina) (Zhang, 2016). Incursions by foreign trawlers into the Somalian EEZ incited conflict between Somali and foreign fishers, and, according to some scholars, contributed to the emergence of piracy in the region (Sumaila and Bawumia, 2014, Belhabib et al. 2019, for a different view on this link, see Hansen, 2011). Even seemingly unobtrusive or 'subdued' international fisheries conflicts, characterized by hostile verbal interactions and the failure to reach management agreements, threaten transboundary fish stocks (Ishimura et al., 2014).

These examples show how international conflicts over fish can, and have, created cascading ruptures in humanity's highly interconnected social systems (Helbing, 2013). Fisheries conflict is often the outcome of interdependent failures within our global system due to interactions between conditions such as climate change, fragile states, food security concerns, extractivist logics, and unresolved territorial disputes, and

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can escalate to become so-called "systemic risks" (Pomeroy et al., 2007; Helbing, 2013; Galaz et al., 2017). Systemic risk is here defined according to Helbing (2013,pp.51) as "the risk of having not just statistically independent failures, but interdependent, so-called 'cascading' failures in a network of *N* interconnected system components". The potential for fisheries conflict to escalate into systemic risk in the future and trigger cascading shocks throughout the global system is an important concern for policy makers. Potential developments include, for instance, that increasing domestic demands for fish in combination with collapsing stocks could be met with increasingly aggressive resource grabs and open conflict between states (Higgins-Bloom, 2018). Alongside oil and mineral resources, fisheries have already proven to be a common source of international conflict (Mitchell and Prins, 1999). Although the particular focus in this paper is interstate conflict, significant disputes over marine resources also occur regularly between communities and individuals within states (McClanahan et al., 2015; Morrison, 2017).

Conditions known to trigger fisheries conflict are likely to become more widespread and interactive in the future (Pinsky et al., 2018). Through altered water temperatures, changing ocean currents and coastal upwelling patterns, climate change is affecting the distribution and potential yield of marine species (Cheung et al., 2010; Sumaila et al., 2011; Jones and Cheung, 2017). Shifts in abundance and distribution are increasingly understood as a security threat, as those changes are expected to disrupt management of fish stocks (Spijkers and Boonstra, 2017; Pinsky et al., 2018). Additionally, overfishing and resulting declines in catches (Pauly and Zeller, 2016) are also considered to be potential security threats and may directly result in increased levels of Illegal, Unreported and Unregulated (IUU) fishing (Österblom et al., 2011). Security threats might then arise due to an increase in frontier-related incidents involving transboundary poaching and IUU fishing (Boonstra and Österblom, 2014; Yeh et al., 2015; Hughes et al., 2012). Climate change, increased resource scarcity, illegal activity and territorial disputes are just some of the worrying global conditions and trends that increase the possibility of international fisheries conflict becoming a systemic risk in the future, causing disruptions to propagate through global networks (Pomeroy et al., 2007; Pinsky et al., 2018; Zervaki, 2018, Belhabib et al. 2019). Maritime security scholars are increasingly recognizing this potential risk, and have identified that fishery conflicts cannot be grasped in isolation, but are embedded within broader and often synergetic relations including vulnerability, poverty, adaptation, and resilience (Germond and Mazaris, 2019; Pomeroy et al., 2016).

Hard-line and crisis-driven actions characterizing many international fisheries conflicts show us that, currently, governance institutions often lack an efficient, swift and peaceful approach to detect and respond to conflict in fisheries. Actions range from vessel seizures, to port closures and even the attack of vessels, and can prolong disputes to the detriment of international relationships and raise concern for the sustainability of fishery resources (Spijkers and Boonstra, 2017). Prolonged conflict and insecurity can open up areas to increased fishing efforts by third parties as physical control of the territory wanes (Hendrix and Glaser, 2011), while the potential for conflict can result in accommodation, co-optation or corruption on the part of enforcement forces, thereby undermining sound management of fisheries (Sumaila et al., 2017; Belhabib et al., 2018a,b).

For governance systems to adequately respond to fisheries conflict and systemic risks in the face of environmental and societal change, scholars have called for the increased monitoring of system dynamics (Helbing, 2013; Galaz et al., 2017; Frank et al., 2014) and the collection of 'big data' to develop realistic explanatory models to ultimately better understand the occurences and drivers of systemic risks (Helbing, 2013; Spijkers et al., 2018). Monitoring systems and scanning for trends to detect early warning signals of risks are vital to increase the necessary institutional capacity to adequately respond, for example by developing appropriate conflict mitigation measures (Galaz et al., 2017; Boyd et al., 2015). There has, however, been little monitoring of occurences of fisheries conflict, and large, comparative datasets have been nonexistent. As a result, we have little knowledge of the diversity, geography and frequency of international fisheries conflict (Spijkers et al., 2018), which raises the risk of leaving these potentially systemic risks undetected. Moreover, being unaware of the different types of conflict that might occur raises the risk of implementing ineffective governance strategies (as strategies tend to be appropriate only for specific kinds of conflicts (Slimani et al., 2006)).

In this study, we provide the first longitudinal analysis that uses a large comparative dataset to scan for global patterns and trends in international fisheries conflict. We answer the following questions:

1) What is the frequency of international fisheries conflict over time?
2) What types of fisheries conflict events exist internationally and what actors are involved?
3) What strategies are used to respond to different types of conflict?

To answer these questions, we apply descriptive statistics, ordination and cluster techniques on novel data from the International Fishery Conflict Database (IFCD), which was developed from media reports of fisheries conflict to explore international conflicts over fishery resources between 1974 and 2016, n = 531 fisheries conflict events (see Materials and Methods). In that database, we tracked six variables: the countries involved in the conflict event, the species mentioned, the date of the event, the intensity of the observed behaviour or action in the event (based on the scale from Spijkers et al. (2018), see Table 1), whether the event mentioned a specific territory under dispute, and whether the event was linked to IUU fishing or not. Those variables are used to analyze which types of conflicts have occurred.

Table 1
Intensity of observed behaviour/action. Source: Spijkers et al., 2018.

Intensity of observed behaviour/action	
Intensity	**Description**
5	**Military acts causing death** - Attack of foreign vessels, crew members or Coast Guards, with resulting deaths
4	**Military acts** - -Attack of foreign vessels, crew members or Coast Guards, no death toll
3	**Political-military hostile acts** - Sending out police vessels/ warships - Seize vessel and/or crew - Gear destruction - Reinforcing borders
2	**Diplomatic-economic hostile acts** - Breaking or not adhering to existing agreement - Lawsuit - Trial in court - Seeking international arbitration - Trade ban - Fishing ban - Landing ban - Monetary penalties - Close ports
1	**Verbal expressions displaying discord or hostility in interaction** - Failing to reach an agreement - Making threatening demands and accusations - Threatening sanctions - Condemning specific actions, behaviors or policies - Requesting change in policy - Civilian protests
0	**Non-significant acts**

2. Materials and methods

2.1. The international fishery conflict database

The IFCD contains 531 reported conflict events between 1974 and 2016. It was set up to explore international conflicts over fishery resources by using event data, i.e. detailed records of interactions between actors (countries) (Shellman, 2004). An international fishery conflict is a dispute:

(a) actualized through ‘conflict events’, which are actions or behaviors ranging from an exchange of statements to severe military involvement and casualties (as defined by the ‘intensity of observed behavior’ scale, see Table 1).
(b) occurring between two or more states and/or vessels that fly their flag;
(c) related to access to a fishery resource or management of a fishery resource;
(d) potentially occurring in the larger context of a maritime territorial conflict, where the fishery resource contributes to some degree to that territorial conflict;
(e) spanning any length of time.

Event data were identified through the LexisNexis Academic (LNA) database, the world's largest repository of media reports, using the following search terms: “trade ban”, “seize AND vessel”, “close w/5 ports”, “no w/5 agreement”, “sanction”, “attack w/5 vessel”, "conflict AND tribunal" in combination with 28 specific fish species, as well as the general term of “fish” (w/5 means ‘within five words’). The search terms were used to detect the actions and behaviors from the intensity scale (see Table 1 displaying the scale developed by Spijkers et al. (2018), based on reviewed fishery as well as fresh water conflict literature). The 28 specific species were selected based on the commercial groups within the SeaAroundUs database (Pauly & Zeller, 2015) (see SI Table S1). We entered into the database those results that were relevant based on our definition of a conflict event. We tracked the following event characteristics: number of countries involved, the species mentioned, the date, the intensity of the observed behaviour or action (Table 1), whether a specific territory under dispute was mentioned, and whether or not it was linked to IUU fishing. We tracked territorial disputes and IUU because those variables spark much concern among scholars in terms of future maritime security (45), and because they are maritime security threats that can be a feature of a larger fisheries conflict. In contrast, we did not track maritime security threats such as human trafficking or smuggling (Bueger, 2015), because they are not a direct feature of a fisheries conflict that centers primarily around the ownership or management of fish. Once the database was assembled, we grouped different conflict events together that were continuations of the same conflict over time, which are those that happened between the same countries or the same species (see SI Methods: IFCD for further details).

We ran several analyses to understand if the IFCD was biased by the media sources we extracted it from. Firstly, to analyze if the conflict data within the IFCD was correlated to the level of English media output in different countries (see SI Figure S2 for further details on coverage by LNA), we extracted the content list from the LNA website (from the European region) for analysis. This content list is available for download through the database’s webpage and contains information, amongst others, on the date of addition of all news sources, their coverage start/end, the geographical region covered, and the language of the news source. This allowed us to assess to what extent media coverage of a given country or year in LNA affects the frequency of conflict events for that given country or year within the IFCD. We also extracted the Press Freedom Index scores for the countries in the IFCD (Reporters Without Borders, 2018). After using robust regression (downweighing outliers) with heteroscedasticity-corrected standard errors, we did not find that either the media coverage in the LNA or the press freedom score of a country had a significant relationship with conflict frequency in the IFCD for that country. We tested this relationship for all countries in the IFCD, but also looked more closely into that relationship for those countries in the database where the primary de facto spoken language or de jure language is English, and ran an analysis for the USA in particular (as it was an outlier in the previous analyses) (see SI Results: Media Bias). None of the analyses showed a consistent relationship between media coverage in the LNA and conflict frequency in the IFCD. Secondly, to analyze if the conflict data per year is correlated to the amount of media coverage per year, we extracted the list of publishers from the LNA website (the European region). Using cross correlation analysis, we found no significant correlation between conflict and media coverage, even when taking into account time lags (see SI Figure S4). Although we found no evidence of undue influence of media coverage on country or yearly conflict frequency within the IFCD, we note that this does not mean the database is free of any bias as a result from searching English media: we warn for the likely underreporting of (minor) conflicts in regions with non-English speaking news media within the IFCD, such as countries located in South America and Africa. For a more elaborate discussion on the media bias analyses, see SI Results: Media Bias.

2.2. Conflict event categorization

To distinguish between different types of fisheries conflict, we use non-metric multidimensional scaling (NMDS) complemented with hierarchical cluster analysis to categorize different types of fisheries conflict based on the variables that characterize the conflicts (including potentially causal correlates) (Chatfield, 2018; Dixon, 2003). First, we use NMDS to visualize conflict event groupings based on multivariate dissimilarity, and we determined the variables that explain the spread of conflict events across groups. We chose to conduct our NMDS along three axes because this was the minimum number of axes where a computationally stable result was generated with low stress. Our resulting NMDS plot had a stress value of 0.085, indicating low distortion from 7-dimensional space to 3-dimensional space (see SI Figure S9).

Second, we use hierarchical cluster analysis to determine the grouping of conflict events and complement the NMDS. For the hierarchical clustering, we use scree plots of the dissimilarity between clusters versus the number of clusters to determine a number of clusters that forms a natural break where there is comparatively not much more dissimilarity difference by adding an additional cluster (Henry et al., 2005). We conducted each of the analyses using three widely used dissimilarity measures (Jaccard’s, Bray-Curtis, and Gower’s), and found all three to generate the same clusters. We use the results from the Gower’s dissimilarity as this dissimilarity measure is best suited for mixed-data situations (Legendre and Legendre, 2012). All categorical data with two states (IUU fishing and whether an event was part of a larger territorial dispute) was converted to a binary variable, and categorical variables with three states (the type of fishery) was converted to dummy variables for the analysis.

We then ran a time series analysis of the clusters to understand when in time the clusters were more or less present, and combined this with the place-specific data (i.e. continents) to understand which combinations of conflict between continents are most represented in the clusters (see SI Figure S10). We used the R package vegan for NMDS and clustering analysis (Oksanen et al., 2018). We used the R packages MASS (Venables and Ripley, 2002) and lmtest (Zeileis and Hothorn, 2002) for the regression analysis. From that, we also got the frequency of continent configurations per conflict cluster (see SI Table S2).

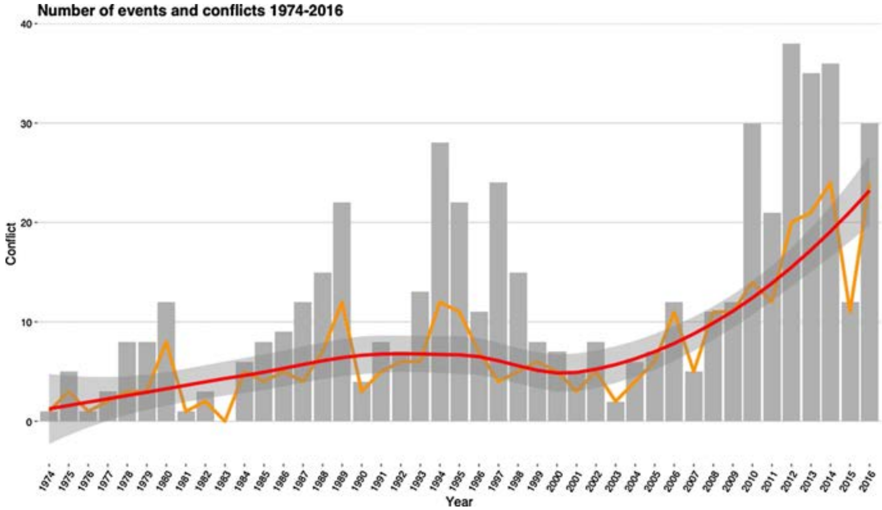

Fig. 1. Conflict events (bars) and conflicts (orange line), 1974–2016. Conflicts are aggregated events part of the same overall conflict (see Materials and Methods). LOESS smoother (red line) added for visual interpretation of growth in conflicts (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

3. Results

3.1. Fisheries conflict increases over time

The frequency of conflict has increased since 1974, although there was a period of lower reported conflict between approximately 1998–2007 (Fig. 1). Intra-continental conflict (64.8% of all conflict events) was more common than inter-continental conflict (35.2% of all conflict events) during the entire time period. The USA was involved in most conflict over time, followed by Canada, Japan, China and the EU; all of these high-conflict countries have been predominantly in conflict with countries located within the same continent (see SI Figure S1). As discussed above, we ran analyses, but found no evidence that the dataset we developed was biased due to national differences in media coverage, the degree of press freedom, nor a reflection of the amount of media coverage per year (Materials and Methods).

3.2. Changes in fisheries conflict types over time

The non-metric multidimensional scaling and cluster analysis (Materials and Methods) identified eight different types of fisheries conflict events (Fig. 2).

Despite the eight types of fisheries conflict, there are overarching general trends across all conflict events. Firstly, Type A (discord over a particular species), has been the most commonly occurring conflict event between countries over time (35.0% of all conflict events). Secondly, almost all deadly conflict events have occurred over non-specific species (84.6% of all deadly conflict events). Finally, for all types it was rare for events to take place between more than two countries, yet if this did occur, the event was most likely to be conflict Type A (21.0% of Type A events take place between more than two countries).

The occurrence of the eight different conflict event types within and between continents are illustrated in Fig. 3. Three different constellations of conflict were particularly frequent: intra-North America conflict, intra-Europe conflict, conflict between Europe and North America and intra-Asia conflict, which collectively represent 74.8% of all conflict events. In the following, we examine the conflict trends across each of those four constellations over time (Materials and Methods).

3.3. Intra-continental conflict in North America and Europe

Conflicts between North American countries (19.2% of all events) and between European countries (17.1% of all events) have been similar in types observed throughout time. Discord over a particular species (conflict event Type A) is the main kind of conflict occurring among North American countries and among European countries, such as over cod (*Gadus morhua)*, salmon (*Salmo salar*) or Albacore tuna *(Thunnus alalonga)*. Those conflicts largely occurred in the past for North America, while Europe is currently dealing with fishery disputes surrounding the northeast Atlantic mackerel and Atlanto-Scandian herring (*Clupea harengus)*. Besides these low intensity discords over a particular species, North American actors have also been involved in some shows of force triggered by illegal catches of specific species (Type C conflict events), which can have a higher intensity. However, those are no longer very common.

3.4. Europe-North America conflict trends

European and North American countries have often been involved in international fisheries conflicts (11.5% of all conflict events). Similar to the intra-Europe and intra-North American conflicts, the conflict is generally associated with a particular species (Type A conflict events) such as cod or, more recently, American plaice *(Hippoglossoides platessoides)*. These events occur relatively consistently throughout time. A type of conflict event that frequently occurred between European and North American countries before the turn of the century is the diplomatic hostility over a particular fish linked to unresolved territorial tensions (Type F conflict events). That type is exemplified by the cod dispute between France and Canada linked to disagreements around the extent of the maritime jurisdiction of St-Pierre and Miquelon.

3.5. Intra-Asia conflict trends

Intra-Asia conflicts occur most frequently (26.9% of all conflict events) and the region is most diverse in the types of conflict events

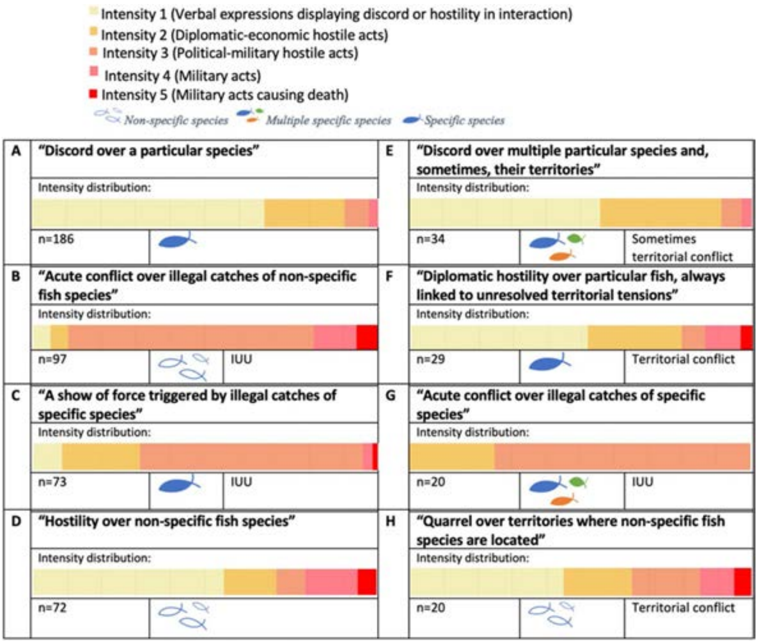

Fig. 2. Eight conflict event types and their narrative descriptions.

documented (all different types have occurred for intra-Asia conflict). Since 2000, 43.0% of all international fisheries conflict events occurred between Asian countries. The most violent events have also taken place between Asian countries (sometimes resulting in the death of fishermen or Coast Guard officials). The most common kind of intra-Asia conflict event is the acute conflict over illegal catches of non-specific fish species (Type B conflict events), which have increasingly occurred since 2004. The second most common type is hostility over non-specific fish species (Type D conflict events), which became more frequent over the past decade. Quarrels over territories with general fish biomass is the third most frequently occurring conflict event between Asian countries (Type H events). Those disputes include competing claims for fishery rights around the islands off eastern Hokkaido (the Kuril Islands, claimed by both Russia and Japan), the Senkaku Islands (disputed by Japan, China, and Taiwan) and the Scarborough Shoal (claimed by both China and the Philippines). These conflicts events have been most common from 2007-2016.

4. Discussion

4.1. Examining changing patterns of international fisheries conflict

Our analysis suggests that the nature of, and countries engaged in, fisheries conflict have changed substantially over the past 40 years. Many of the countries most frequently involved in conflict are large industrial fishing powers known to dominate global fishing efforts, but they have engaged in conflict at different points in time (Teh and Sumaila, 2015; Tickler et al., 2018). Spain and the UK, for instance, dominate European fishing effort along with Russia (Anticamara et al., 2011), and are among the ten countries with the largest number of fisheries conflict events. In Asia, Japan was long the dominant fishing power in terms of fishing effort, but has more recently been surpassed by China and South Korea (Tickler et al., 2018). All three are also among the ten countries most frequently involved in conflict. The USA and Canada are responsible for the majority of North/Central American fishing effort, again often engaged in conflict in the past. Some countries have large Distant Water Fishing (DWF) fleets that have continually expanded their geographical presence and have been cited for engaging in illegal or unreported fishing (such as the DFW fleets of certain European countries and China, see (Belhabib et al., 2015; Carolin, 2015)); which could be a reason for their frequent engagement in conflict with other nations.

Type A, C and F conflict events involving North American and European actors (related to single species, mostly characterized by low conflict intensity and sometimes territorial disputes), were relatively common particularly before the turn of the century. This echoes findings by Daniels and Mitchell (2017) that advanced democracies regularly have conflict over maritime issues (with the Americas in particular exhibiting high rates of maritime conflict). They suggest that this is likely the consequence of being more able and thus active to pursue claims, and having relatively high levels of economic activity in their maritime domains (Daniels and Mitchell, 2017). After the turn of the century, conflict involving North America and European states became less common, as many conflicts were resolved through negotiated agreements. Important changes to the system's institutional architecture were made through agreements over boundaries, such as the decision by the International Court of Justice in 1984 on the Georges Bank delineation; and agreements over fisheries management, such as the Pacific Salmon Interception Treaty in 1985 for the Pacific Northwest, revised in 1999 (Rogers and Stewart, 1997), and the Transboundary Resource Assessment Committee for the Gulf of Maine in 1998 (Pudden and Vanderzwaag, 2007). Those institutional changes contributed to de-escalating fisheries conflict and preventing them from cascading throughout the system. In addition, it is also conceivable that conflict among and between North American and European actors has subsided in part due to a relatively high rate of species collapse in the higher latitudes (Watson and Pauly, 2013), potentially leaving less to argue over after the year 2000.

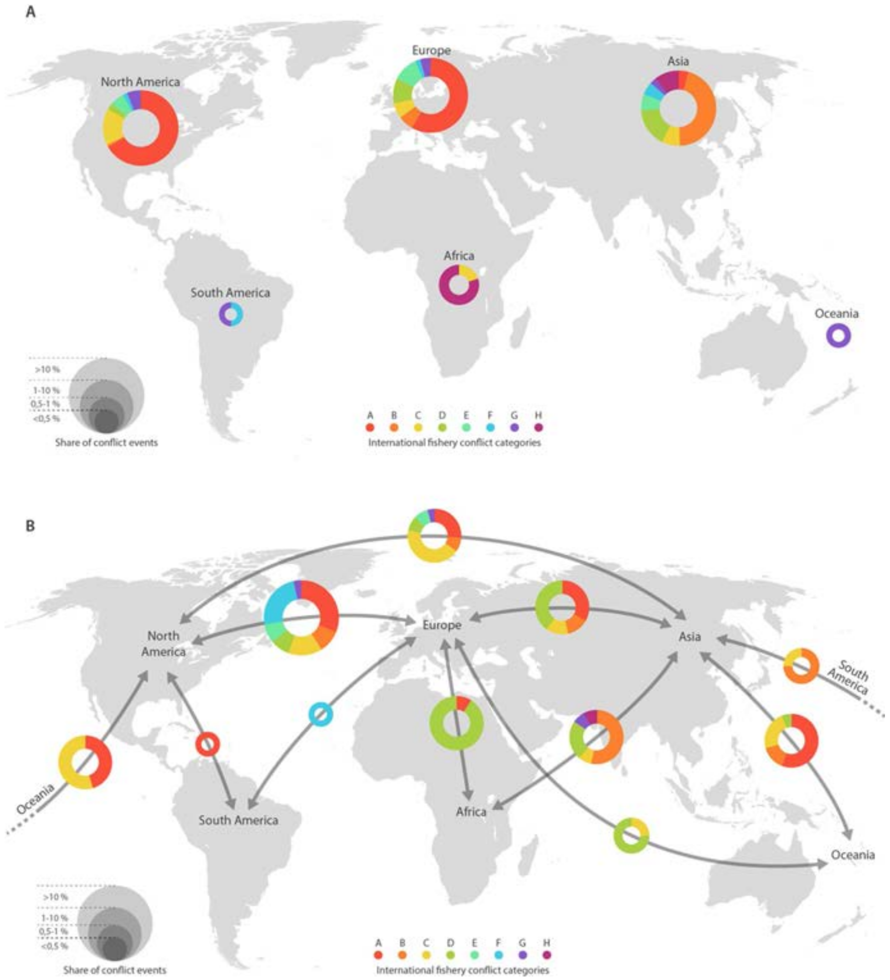

Fig. 3. Distribution of intra-continental (A) and inter-continental conflict events (B).1974–2016.

The frequency of Type B, D and H conflict events between countries in East and Southeast Asia (focused around non-specified fish species) can be explained by the multispecies fisheries common to tropical and highly diverse marine ecosystems. The increase in fisheries conflict between Asian actors might be a consequence of overfishing of major fisheries in temperate northern waters, and subsequent displacement of conflict risk to other regions by relocating the locus of fishing effort (Watson and Pauly, 2013; Worm and Branch, 2012), combined with subsequent overfishing within the Asian region. The conflict events are often characterized by illegal fishing and higher intensity actions, which likely reflects the rapid expansion of fishing effort by East and Southeast Asian fleets, such as those from China (Rogers and Stewart, 1997; Blasiak et al., 2015) and South Korea (Anticamera et al., 2011). Competition for control of resources with other states, as well as illegal activities and (violent) conflicts, ramped up since 2007 (Carolin, 2015). Low intensity disputes over specific species also occur between Asian countries, such as the ongoing conflict over Pacific saury (*Cololabis saira*) where Japan has proposed setting catch limits for the stock but has seen its proposal blocked by China (Kyodo, 2018). Our analyses show that disputed territories in Asia currently present grave security concerns for fisheries. As fleets venture farther out, crew risk entering off-limits or disputed waters and engaging in fishing potentially unauthorized due to ongoing territorial rivalry (Mallory, 2013).

4.2. Response strategies

There are historical precedents for strategies that have been effectively put in place by countries to respond to certain conflict types we have considered, and we outline those below. We distinguish between foundational and specialized risk mitigation strategies for the different conflict types (Table 2). Foundational strategies are those that have proven generally helpful in resolving conflict of any kind, whereas specific strategies are those that can help prevent particular types of conflict from escalating. We note that these strategies are mostly technical and legal in nature, and might not efficiently address issues that have deeper social, political or economic roots requiring much

Table 2
Selection of foundational and specific response strategies for the different conflict types.

	A	B	C	D	E	F	G	H
Foundational strategies	Scientific collaboration Shared enforcement							
Specific strategies	Side payments Long-term management plans				Side payments Long-term management plans			
						Provisional fishery agreements		Provisional fishery agreements
		IUU policies					IUU policies	

broader solutions.

For all conflict types, creating a **shared scientific understanding** of stocks and aquatic ecosystems more generally has historically proven valuable as a first step to conflict mitigation.

Scientific collaboration, through shared monitoring and coordinated data collection, often provides a basis for negotiation. The establishment of the Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM), for example, was crucial as it served as a platform for a non-threatening political exchange between the Soviet Union and the other Baltic states. The literature on transboundary cooperation over fresh water resources underscores the importance of joint fact-finding among nations as an important catalytic tool to move from conflict to cooperation, where information disclosure through data-sharing and monitoring is regarded as a first and key step in conflict management (Xie and Jia, 2017; Mitchell and Zawahri, 2015; Uitto and Duda, 2002). However, scientific collaboration on fishery issues is not implemented in certain areas with high conflict risk, with substantial constraints existing in the volatile South China Sea (Zhang, 2018), although it could be initiated by an existing regional governing body (such as the Southeast Asian Fisheries Development Center (SEAFDEC)).

The establishment of **shared enforcement activities**, especially in areas where conflict relates to IUU, is another important foundational strategy to reduce conflict risk. The Joint Fisheries Commission between Russia and Norway, for example, is an arena where countries exchange observers on each other's control vessels or coordinate satellite tracking systems, which has aided in creating a coordinated response to rampant IUU (Stokke, 2009). The lack of joint enforcement actions not only leads to an uneven marine space where areas of high enforcement and monitoring create spaces with high fishing pressure but no enforcement; it can also result in violent, militarized conflict responses to IUU between countries. However, in fisheries conflicts where not only IUU is an issue but also overlapping territorial claims, addressing territorial boundary tensions is a pre-requisite, and one not easily fulfilled. For example, being a party to UNCLOS encourages the use of third-party dispute settlement techniques, but it does not reduce militarized tensions over contested maritime spaces between states (Nemeth et al., 2014).

Side payments, or compensating transfers in the form of monetary or in-kind compensation from one party of a conflict to another, provide incentives to stay in a coalition where otherwise payoffs between countries would differ (Cole et al., 2014). This kind of conflict mitigation tool requires some form of an established institution for the purpose of collaborative management (such as a Regional Fisheries Management Organization (RFMO)). Side payments in the form of contributions to a conservation fund helped resolve a number of conflicts surrounding specific species, such as the Pacific salmon conflict between the USA and Canada (Pinsky et al., 2018; Miller and Munro, 2004). More recently, side payments have been put forth as a tool to resolve the northeast Atlantic mackerel dispute, where access to or quota for other species such as Atlanto-Scandian herring could be used to increase the scope for bargaining and forego conflict.

Long-term management plans that allow for changes in stock distributions have proven to be essential in creating successful fisheries management plans for specific stocks, if territorial issues and IUU fishing are largely absent (Bundy et al., 2017). The revised Pacific Salmon Treaty (1999), for example, replaced short-term management regimes with a longer-term plan where harvest shares were defined on stock abundance indices (Rogers and Stewart, 1997), avoiding frequent renegotiation of catch allocation. Coupled with side payments, the revised long-term management plan significantly enhanced collaboration between the parties.

Provisional fishery agreements that explicitly recognize territorial disputes will be essential in avoiding fisheries conflict in areas with overlapping territorial claims. Taiwan and Japan, for example, recognized this issue and forged in 2013 a fisheries agreement designating the waters around the Diaoyutai/Senkaku Islands a 'non-specific area', thereby treating territorial sovereignty as a separate issue (Yeh et al., 2015). This agreement reduced tensions and helped to promote stability in the East China Sea, as fishermen have been able to avoid detention or penalties from the opposing claimant country (Yeh et al., 2015).

Stringent IUU policies are necessary to avoid conflicts events characterized by IUU. There are a few effective, non-belligerent IUU policies that can be implemented by coastal states, such as banning transshipment (or the transfer of fish between boats) at sea or requiring a vessel monitoring system (VMS) tracking the vessel's location. Both policies were implemented recently by Indonesia, with great success (Cabral et al., 2018). Market states that are major consumers of fish can demand stricter traceability standards to combat IUU in foreign waters. The EU, for example, requires catch documentation for imported seafood. Modifying the policies and procedures of financial services in the insurance sector in such a manner that it denies benefits to those that engage in IUU fishing, could greatly reduce conflicts related to this illegal practice (Miller et al., 2016). Other measures should include preventing the reflagging of fishing vessels to tax havens, removing subsidies from fishing fleet owners and investors tied to IUU activities, and more comprehensively listing vessels, companies, and beneficial owners involved in illegal fishing activities (Belhabib and Le Billon, 2018).

4.3. Response gaps

There are historical examples of successful strategies for fishery conflict de-escalation. However, there is no standardized, swift procedure for dealing with conflict situations in a non-escalatory manner yet, and it often takes years for governments to agree on an effective strategy to end conflicts that have already damaged international relations and fish stocks. Moreover, the two foundational strategies are not applied in certain conflict-prone areas: to our knowledge, scientific collaboration between South-East Asian countries, for example, has only been initiated in a few areas (such as the Coral Triangle Initiative for Coral Reefs, Fisheries and Food Security between six Asian countries in the Coral Triangle (Weeks et al., 2014)) despite an increase in Type D events. This is problematic as, depending on the extent of warming, certain EEZs in East Asia are projected to receive up to 10 new stocks by the end of the century (Pinsky et al., 2018), and new entrants into already saturated territories are more likely to spark disagreement (Blasiak et al., 2015). These response gaps increase the possibility for conflicts to become systemic risks. To promote wider and swifter implementation of the strategies discussed, deep changes to the current international governance framework for fisheries will be necessary (through, for example, revisions of RFMO competences and operations (Pinsky et al., 2018)).

Besides responding swiftly to conflict once it has erupted, countries also need to manage the incremental stressors that either drive conflict to erupt in the first place, or that push fisheries conflicts to become systemic risks. For this, more region-specific research is needed into underlying and proximate drivers of conflict, and how they interact to produce wider systemic risks. We suggest three specific topics for attention: the impacts of climate change as a driver (so as to better identify conflicts likely to result from unprecedented rates and magnitudes of change) the key drivers of conflict in Asia (so as to better prevent even more widespread and severe conflicts that could result in systemic risks) and the importance of fish abundance as a driver of conflict (so as to better understand the role of responsible fisheries management for conflict prevention). Research on conflict drivers within fisheries can also further facilitate a discussion on indicators of potential imminent fishery conflict and how policymakers might use those to develop responses. For instance, it might be possible to simplify the eight conflict types according to appropriate policy prescriptions. Finally, we advise continued monitoring of the occurrence and types of fisheries conflict that occur globally to follow-up trends and gain greater accuracy.

5. Conclusion

The world has become highly interconnected, and as a result, a crisis in one part of the global system can trigger cascading shocks in other sectors. In certain instances, international fisheries conflict has already negatively affected international relations and fishery sustainability. Conflicts need to be swiftly and peacefully addressed to avoid escalation into globally extensive, systemic risks with unforeseeable consequences. To design effective response strategies and prioritize them geographically, the regional frequency and nature of fisheries conflict has to become clearer. For that purpose, we developed and analysed the International Fishery Conflict Database and show that international fisheries conflict increased between 1974 and 2016, shifted largely from occurring between and among countries within North America and Europe to countries within Asia, and included eight distinct types of fisheries conflict events. More recent conflict types involve greater severity, nonspecific species, IUU, and territorial disputes. We discussed foundational and specialized risk mitigation strategies for the different conflict types, and highlighted existing response gaps.

Many international fisheries conflicts have been successfully resolved in the past, but often only after much damage to both international relations and fish stocks. In some parts of the world where conflict has been increasing, even the most foundational procedures for dealing with conflict situations in a non-escalatory manner do not exist, increasing the possibility for localized fisheries conflicts to escalate into systemic risks. In the face of climate change impacts, resource scarcity, illegal activity and territorial disputes, conflict management across political borders becomes essential for environmental sustainability, human health and maritime security. Fisheries conflicts, their impacts and their drivers need to be considered more rigorously by scientists and government.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.gloenvcha.2019.05.005.

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Supplementary information Paper II

Supplementary Information (Figures)

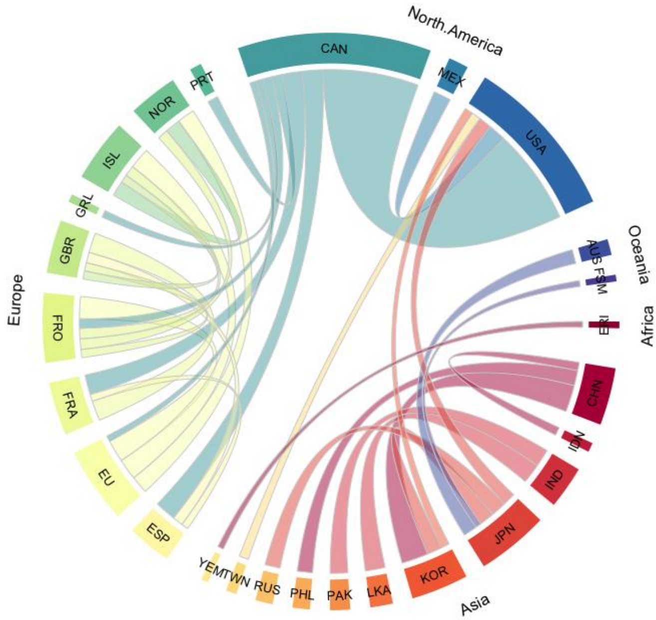


Figure S1: Diagram representing countries involved in more than 4 international fisheries conflict events with each other, 1974-2016. The width of the link represents the number of conflict events between the connected countries. Colors hold no meaning but to distinguish between the different connections. Abbreviations clockwise, followed by the top 5 ranking of countries in conflict overall: CAN (2)= Canada, MEX= Mexico, USA (1)= United States of America, AUS= Australia, FSM= Federated States of Micronesia, ERI= Eritrea, YEM= Yemen, CHN (4)= China, IDN= Indonesia, IND= India, JPN (3)= Japan, KOR= South Korea, LKA= Sri Lanka, PAK= Pakistan, PHL= Philippines, RUS= Russia, TWN= Taiwan, ESP= Spain, EU (5)= European Union, FRA= France, FRO= Faroe Islands, GBR= United Kingdom, GRL= Greenland, ISL= Iceland, NOR= Norway, PRT= Portugal. We use the R package circlize to create circular visualizations (Gu et al. 2014).

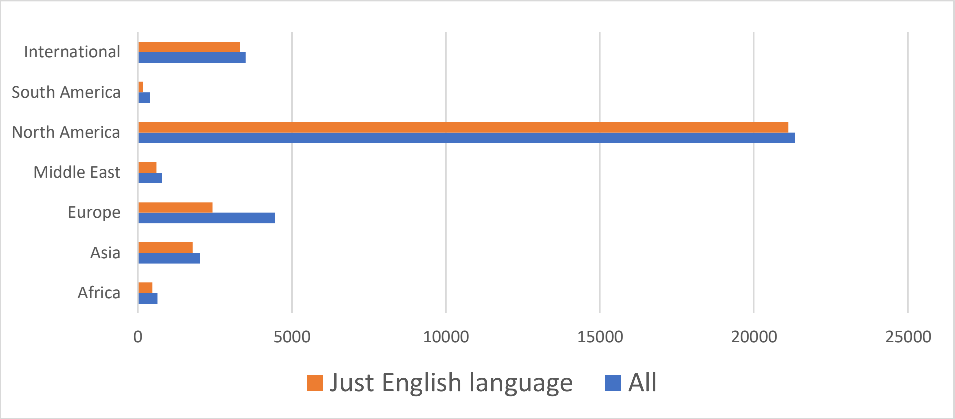
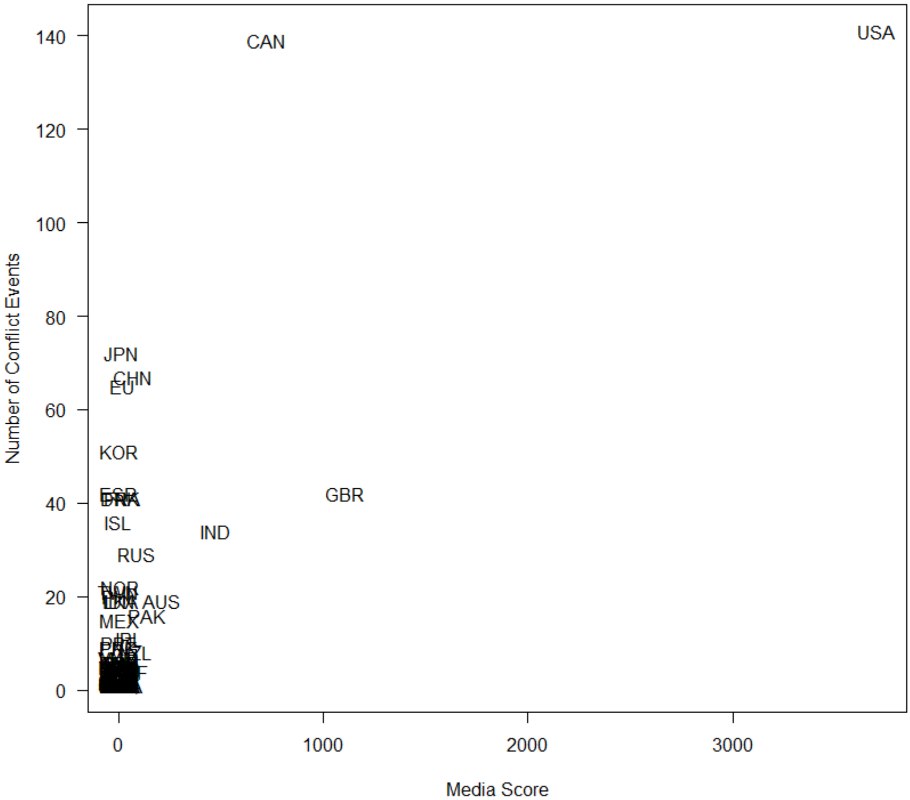


Figure S2: Coverage of LNA sources using the English language by continent


Number of Conflict Events
Media Score
0
1000
2000
3000
0
20
40
60
80
100
120
140
USA
CAN
JPN
CHN
EU
KOR
GBR
ISL
IND
RUS
AUS
PAK
MEX

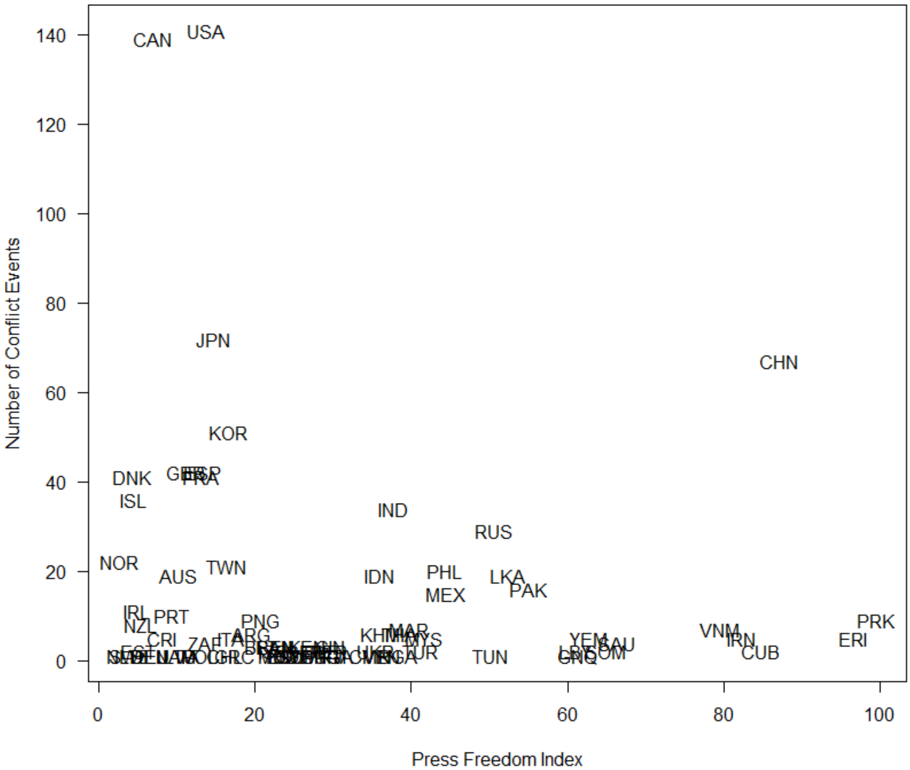


Figure S3: Correlations between number of conflict events and media output. First plot shows the media count analysis, second plot the analysis using the Press Freedom Index.

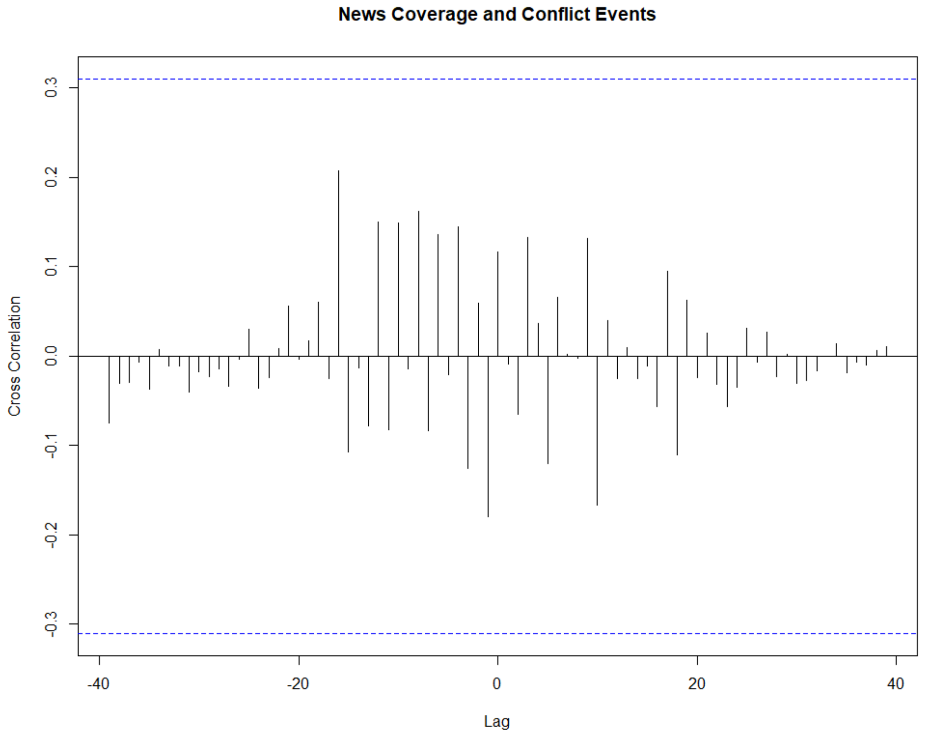


Figure S4: Crosscorrelation between conflict events in the IFCD and media coverage per year from LNA. The horizontal dotted lines above and below 0 indicate significant correlations.

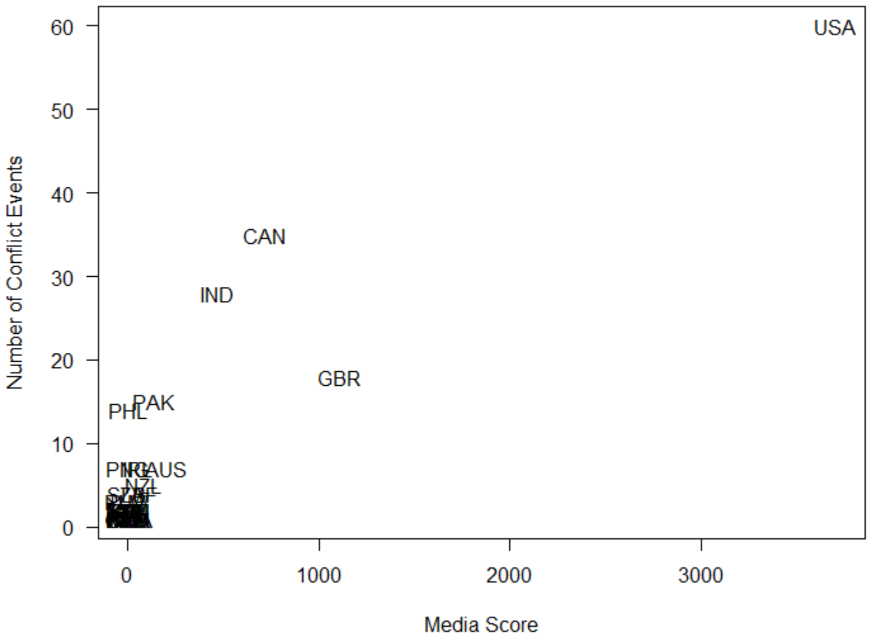


Figure S5: Correlation between the number of conflict events for countries with English as the de facto primary spoken language and English as a de jure language, and media output.

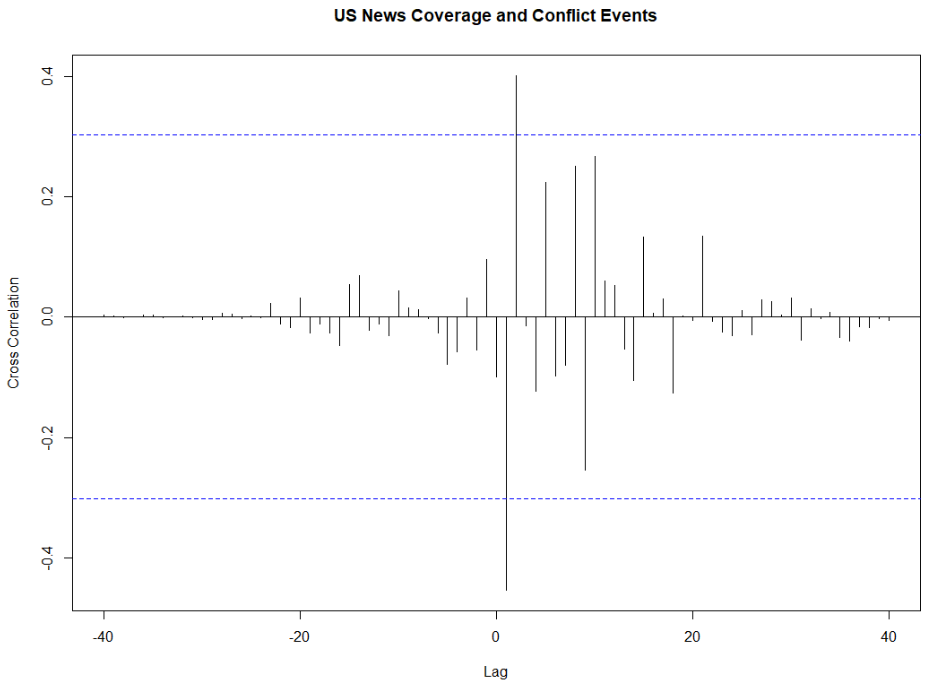


Figure S6: Crosscorrelation between conflict events in the IFCD involving the USA and media coverage per year for the USA from LNA. The horizontal dotted lines above and below 0 indicate significant correlations.

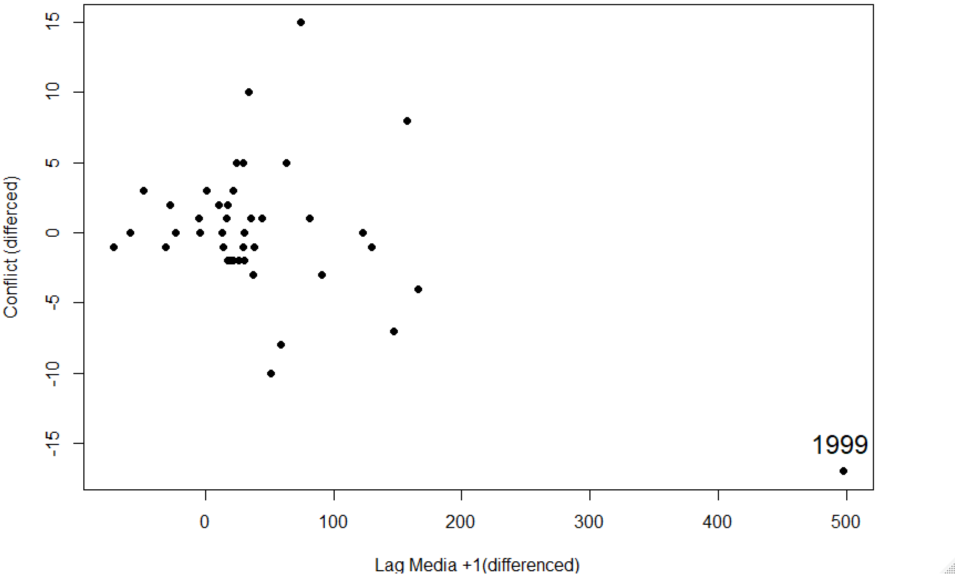


Figure S7: Relationship between conflict events in the IFCD involving the USA per year and media coverage per year lagged one year for the USA from LNA.

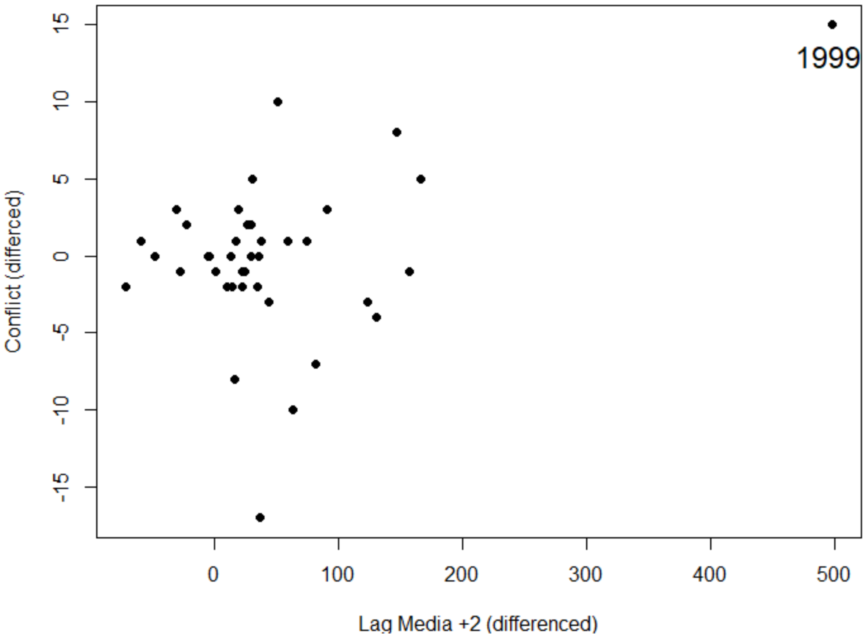
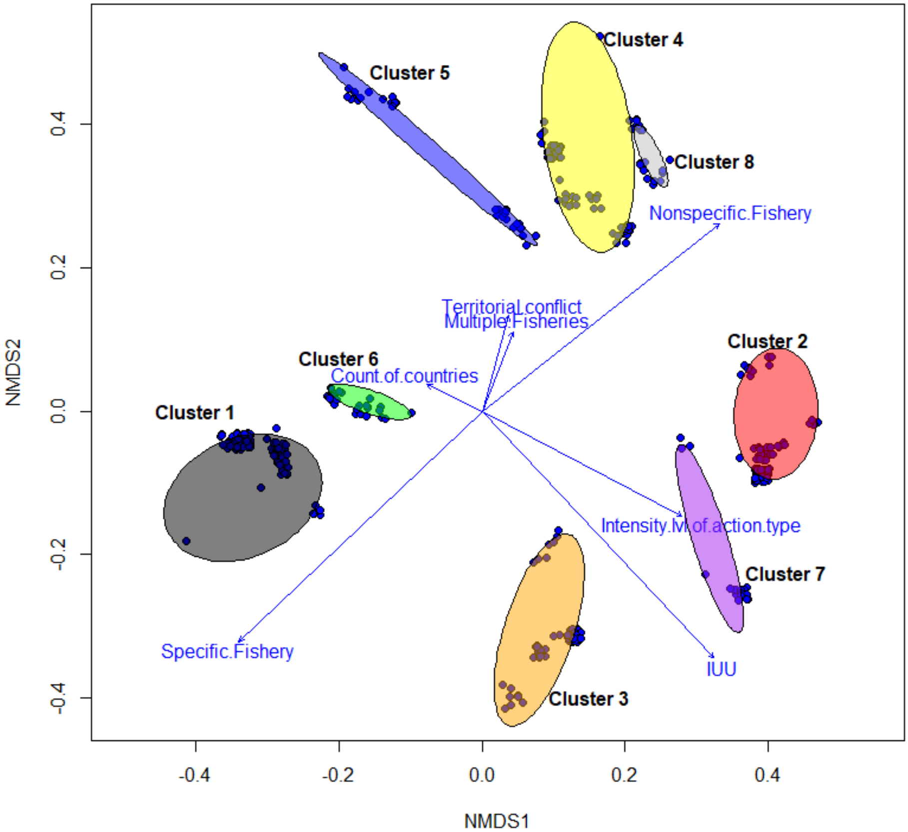
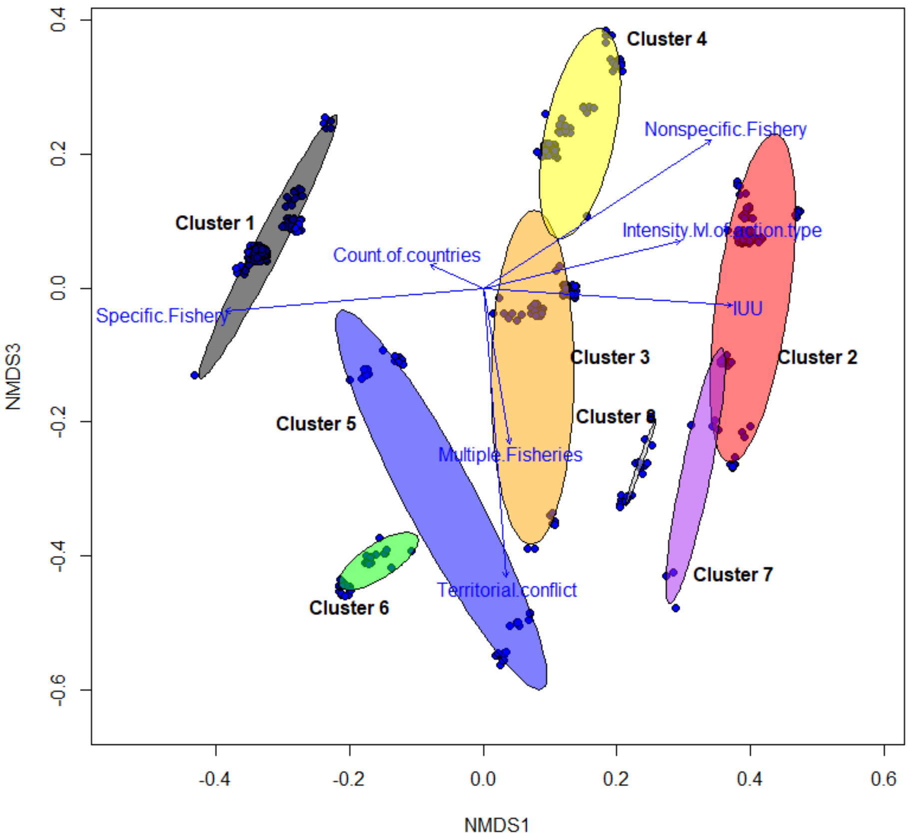


Figure S8: Relationship between conflict events in the IFCD involving the USA per year and media coverage per year lagged two years for the USA from LNA.



Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Cluster 7
Cluster 8
Nonspecific.Fishery
Territorial.conflict
Multiple.Fisheries
Count.of.countries
Intensity.lvl.of.action.type
Specific.Fishery
IUU
NMDS1
NMDS2
-0.4
-0.2
0.0
0.2
0.4



Cluster 1
Cluster 2
Cluster 3
Cluster 4
Cluster 5
Cluster 6
Cluster 7
Cluster 8
Nonspecific.Fishery
Intensity.lvl.of.action.type
Count.of.countries
Specific.Fishery
IUU
Multiple.Fisheries
Territorial.conflict
NMDS1
NMDS3
-0.4
-0.2
0.0
0.2
0.4
0.6
-0.6

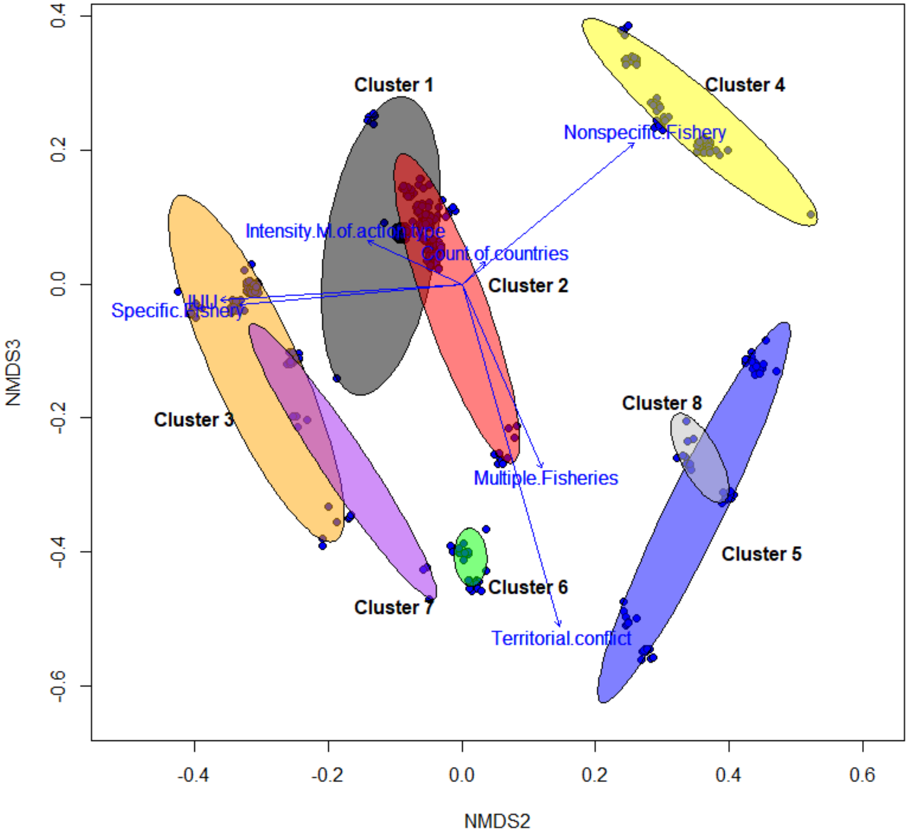


Figure S9: The three dimensions of the three-dimensional NMDS plot showing eight clusters of conflict events within the IFCD. Stress for NMDS plot: 0.08471569, indicating reasonably good fit. The clusters were later renamed with letters (Cluster 1 became cluster A and so forth).

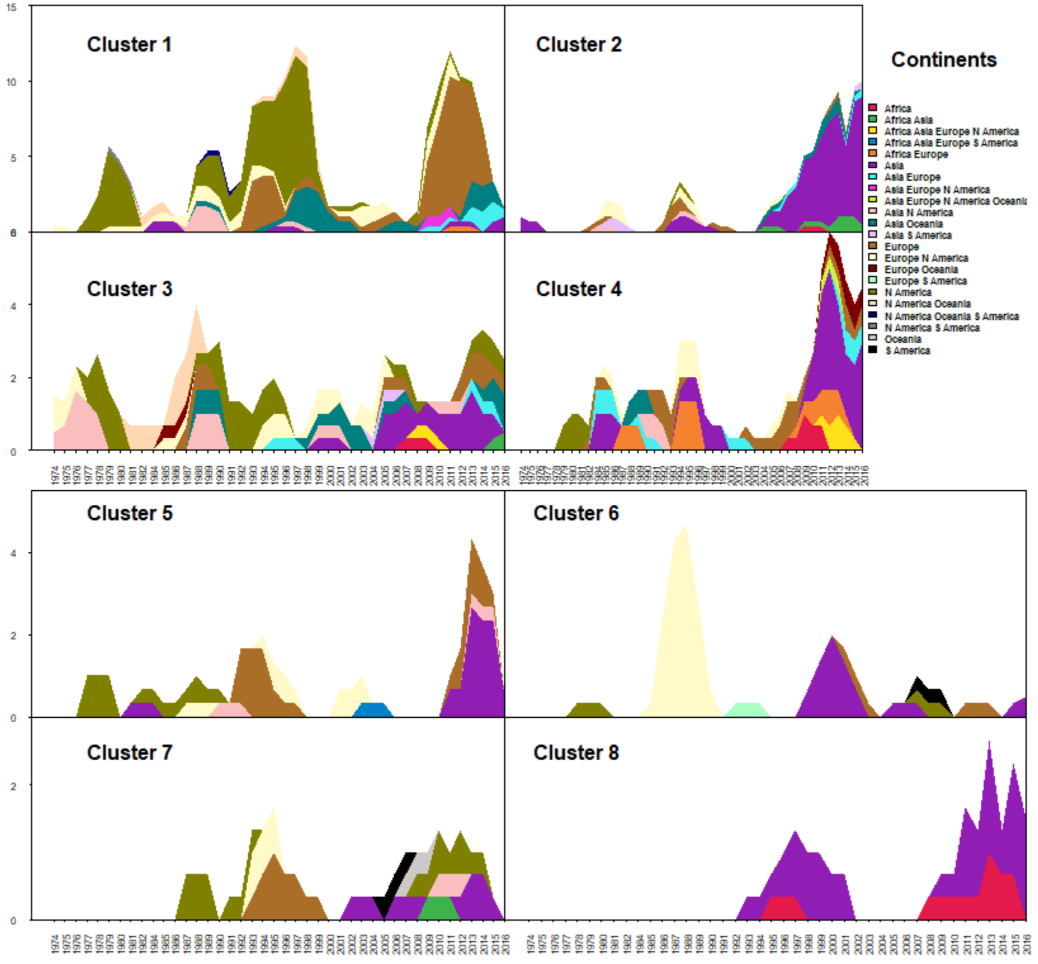


Figure S10: The occurance of the eight conflict clusters overtime, plotted using 3-year rolling averages (Cluster 1 = Cluster A and so on). The colors within this time series represent (combinations of) continents. That visualizes the proportion of conflict between countries located in the same or different continent(s) within the eigth clusters.

Supplementary Information (Tables)

	Commercial group (SeaAroundUs)	*Selected taxa common name*	*Selected taxa scientific name*	*Search terms*
/	/	/	/	Fish
1	Perch-likes	Jacks, pompanos Chilean jack mackerel	Carangidae Trachurus murphyi	Mackerel
2	Cod-likes	Atlantic Cod Alaska Pollock	Gadus morhua Theragra Chalcogramma	Cod Pollock
3	Herring-likes	Pacific sardine Atlantic herring	Sardinops sagax Clupea harengus	Sardine Herring
4	Anchovies	Anchoveta European anchovy	Engraulis ringens Engraulis encrasicolus	Anchovy
5	Crustaceans	Marine crabs, shrimps, lobsters	Miscellaneous marine crustaceans	Shrimp Crab Lobster
6	Tuna & billfishes	Skipjack tuna Yellowfin tuna	Katsuwonus pelamis Thunnus albacares	Tuna
7	Molluscs	American cupper oyster Clams	Crassostrea virginica Bivalvia	Oyster Clams
8	Salmon, smelts etc.	Capelin	Mallotus villosus	Capelin

		Pink salmon	Oncorhynchus gorbuscha	Salmon
9	Flatfishes	American Plaice Tonguefishes	Hippoglossoides platessoides Cynoglossidae	Plaice Tonguefish
10	Scorpionfishes	Redfishes Flatheads	Sebastes Platycephalidae Platycephalidae	Redfish Flathead
11	Sharks & rays	Stingrays Sharks, rays, skates	Rajidae Elasmobranchii	Shark Ray
12	Other fishes & inverts	Japanese flying squid True jellyfishes	Todarodes pacificus Scyphozoa	Squid Jellyfish

Table S1: Fish species search terms included in the IFCD

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Africa	0	1	1	3	0	0	0	5
Africa Asia	0	6	1	0	0	0	1	0
Africa Asia Europe N America	0	0	1	3	0	0	0	0
Africa Asia Europe S America	0	0	0	0	1	0	0	0
Africa Europe	1	0	0	10	0	0	0	0
Asia	6	65	11	24	10	8	4	15
Asia Europe	5	2	2	6	0	0	0	0
Asia Europe N America	2	0	0	0	0	0	0	0
Asia Europe N America Oceania	0	0	0	1	0	0	0	0
Asia N America	6	2	10	2	2	0	1	0
Asia Oceania	19	5	8	2	0	0	0	0
Asia S America	0	3	1	0	0	0	0	0
Europe	53	6	6	10	10	2	4	0
Europe N America	19	6	9	5	5	15	2	0
Europe Oceania	0	0	1	3	0	0	0	0
Europe S America	0	0	0	0	0	1	0	0
N America	68	1	16	3	6	2	6	0

N America Oceania	5	0	6	0	0	0	0	0
N America Oceania S America	1	0	0	0	0	0	0	0
N America S America	1	0	0	0	0	0	0	0
Oceania	0	0	0	0	0	0	1	0
S America	0	0	0	0	0	1	1	0

Table S2: Frequency of continent configurations per conflict cluster (1-8)

z test of coefficients:					
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	4.4675248	0.5317751	8.4012	< 2.2e-16	
media coverage	0.0374248	0.0054086	6.9194	4.534e-12	

Table S3: Robust Regression of total media score vs media derived conflict count (including USA)

z test of coefficients:					
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	3.872938	0.732384	5.2881	1.236e-07	
media coverage	0.061362	0.041921	1.4637	0.1433	

Table S4: Robust Regression of total media score (excluding USA) vs media derived conflict count

z test of coefficients:					
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	8.166357	2.098671	3.8912	9.975e-05	
media coverage	-0.025059	0.045077	-0.5559	0.5783	

Table S5: . Robust Regression of press freedom index vs media derived conflict count

z test of coefficients:					
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	2.6044029	0.4310791	6.0416	1.526e-09	
media coverage	0.0156847	0.0019572	8.0140	1.110e-15	

Table S6: Robust Regression of media score for English countries vs media derived conflict count (including the USA)

z test of coefficients:					

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	1.877706	4.435362	0.4233	0.6720	
media coverage	0.042532	0.509604	0.0835	0.9335	

Table S7: Robust Regression of media score for English countries (exclusing the USA) vs media derived conflict count

Coefficients				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	1.190765	0.819271	1.453	0.15410
media coverage	-0.026010	0.008173	-3.183	0.00286
Residual standard error: 4.667 on 39 degrees of freedom (1 observation deleted due to missingness)				
Multiple R-squared: 0.2062		Adjusted R-squared: 0.1858		
F-statistic: 10.13 on 1 and 39 DF				

Table S8: OLS regression of conflict events in USA vs lagged media score (+1 year), including 1999 data point

Coefficients				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.602951	0.844996	0.714	0.480
media coverage	-0.005162	0.013197	-0.391	0.698
Residual standard error: 4.503 on 38 degrees of freedom (1 observation deleted due to missingness)				
Multiple R-squared: 0.00401		Adjusted R-squared: 0.0222		
F-statistic: 0.153 on 1 and 38 DF				

Table S9: OLS regression of conflict events in USA vs lagged media score (+1 year), excluding 1999 data point

Coefficients				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-1.047728	0.863804	-1.213	0.2326
media coverage	0.023069	0.008514	2.709	0.0101
Residual standard error: 4.856 on 38 degrees of freedom (2 observations deleted due to missingness)				
Multiple R-squared: 0.1619		Adjusted R-squared: 0.1399		
F-statistic: 7.341 on 1 and 38 DF				

Table S10: OLS regression of conflict events in USA vs lagged media score (+2 years), including 1999 data point

Coefficients				

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	0.602951	0.844996	0.714	0.480
media coverage	-0.005162	0.013197	-0.391	0.698
Residual standard error: 4.503 on 38 degrees of freedom (1 observation deleted due to missingness)				
Multiple R-squared: 0.00401		Adjusted R-squared: -0.0222		
F-statistic: 0.153 on 1 and 38 DF				

Table S11: OLS regression of conflict events in USA vs lagged media score (+2 years), excluding 1999 data point

z test of coefficients:					
	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.844557	0.615527	1.3721	0.17004	
media coverage	-0.029181	0.015428	-1.8915	0.05856	

Table S12: Robust Regression of media score per year for the USA vs media derived conflict count per year for the USA

Supplementary Information (Text)

SI Methods: IFCD

The source we used to obtain data on international fisheries conflicts is the LNA database. The content type we opted for is ‘newspapers’, which means we excluded law reviews, company profiles and state and federal cases as those would not provide the data needed. Within the LNA database, we searched for a combination of fish- related search terms (e.g. ‘ fish’ or selected fish stocks such as ‘tuna’ or ‘pollock’) and conflict-related terminology such as ‘conflict’ or ‘disagreement’. The combination of species search terms and conflict terms result in searches such as salmon AND (no w/5 agreement), shrimp AND sanction, capelin AND tribunal AND conflict and so on. This resulted in 184 different search queries, which were performed over the time period 12/12/2016 – 27/07/2017. Also, within LNA, using the singular word form will retrieve the singular, plural, and possessive forms of most words. For example, fish would find fish, fishes, fish’, and fishes’.

Using LNA, we searched for specific fish species which were selected based on the 12 commercial groups within the SeaAroundUs database (Pauly & Zeller 2015). SeaAroundUs defines ‘commercial’ as all marine fish or invertebrate species that are either reported in the catch statistics of at least one of the member countries of the Food and Agriculture Organization of the United Nations (FAO), or are listed as part of commercial and non-commercial catches (retained as well as discarded) in country-specific catch reconstructions. We selected the top 2 species that were targeted most in terms of tonnage for each commercial group (see Table S1), and used (part of) their taxa common name as search terms.

We scrutinized all the results LNA returned for a given search query, and entered into the database those results that were relevant based on our definition of a conflict event. From the event, we recorded:

- The year and month of the event;
- The fish species the event centred on**.** If it was not ONE specific species, but multiple species, then we recorded it as ‘multiple’ and recorded the multiple species of interest in a different column**.** If it was not one nor multiple specific species, but rather non-specific fish in general, we recorded it as Unspecified;
- The countries involved in the event;
- The count of countries involved in the event (which is not the total amount of countries mentioned in an article or generally active in the dispute, but those in actuality involved in the event);
- Which of the actors was the one to take action, and which one was the one afflicted by the action;
- Because of an interest to know if and how often conflicts are linked to instances of illegal fishing, we tracked which events were directly the result of illegal fishing and which of the actors committed the illegal fishing act;
- Because of an interest to understand the connection between fish and territorial disputes, we tracked whether the event mentioned a specific territory under dispute linked to the fish conflict in question. If there was a disputed territory mentioned, we recorded which territory that is;
- The action type based on the ‘severity of observed behavior’ categorical scale, see Table 1;
- The source of the event description.

Based on the above, it is important to note that we excluded events that might have been triggered by or linked to fisheries, but were detached from issues of fisheries ownership or management. For example, if country A entered into a dispute with country B over fish, but centered around other policy areas such as food safety measures (which, due to the complex nature of domestic and international politics, is not uncommon), those events will no longer be registered in the database. It is also important to note that some events (such as the boarding of a vessel and detaining it) are not always comparable: sometimes the event would involve several boats, sometimes just one. We did not take note of any quantities involved in conflict events.

After entering all the data into the excel file, we went through all the individual events to remove those that are duplicates (an event is sometimes reported multiple times by different institutions), though these instances were relatively rare. In case two institutions reported on the same event but gave different information, the event reported in most detail was retained. We also grouped different conflict events together that were continuations of the same conflict over time. This means we grouped events together if events happened between the same countries (the EU can represent countries part of the EU in the database because fishery policy is a competence of the EU), the same species (or part of the same nested species grouping, e.g. albacore tuna and tuna were clustered together, but not yellowfin tuna and albacore tuna).

There are a number of limitations to the method used to set up the IFCD. First, the data on conflict events was extracted from news reports (not official reports), which are more prone to misreporting. Secondly, as we used English as the only language to search for news, there may be some bias in the coverage of conflict events (due to potential underreporting of conflicts in the IFCD in regions with non-English speaking news media and lower journalistic capacity). LNA includes a number of international press agencies (e.g. International Reports by BBC Monitoring and Al Jazeera) which should ensure global coverage even when limited to the English language (see SI Figure S2 for further details on coverage). However, overall there is less reporting in the early period of the database (e.g. entries from BBC Monitoring start in 1979), and international news agencies will be most focused on events judged of interest to an international audience. That might also be dependent on the strategic interests of the reporting country, such as whether the conflict event involves an English-speaking country, whether it involves a region that is of interest to the English-speaking world, or whether the event has serious implications for food supply for English-speaking markets. Overall, we warn for the likely underreporting of (minor) conflicts in regions with non-English speaking news media within the IFCD, and even more so in the early part of the period covered (1970s in particular). For example, we have limited data for South American and African countries, though the low amount of data for those regions can also reflect the lower enforcement capacity (e.g. negligible or non-existent enforcement capacity, weak institutional capacity and capabilities and even corruption). Nonetheless, we intend for this database to become more inclusive of conflicts occurring in for example South America by conducting searches in Spanish. Lastly, it is plausible that in certain countries especially ridden with co-optation and corrupt arrangements conflicts might not be reported by the coast guard or news agencies (Galaz et al. 2017).

SI Results: Media Bias
We ran three analyses to understand if the IFCD was biased by the media sources we extracted it from. Firstly, to analyse if the conflict data within the IFCD was correlated to the level of English media output in different countries (see SI Figure S2 for further details on coverage by LNA), we extracted the content list from the LNA website (from the European region) for analysis. Second, we also extracted the Press Freedom Index scores for the countries in the IFCD (Reporters Without Border 2018). We took an average press freedom index over the maximum time frame that the data was available (from 2002-2018). The resulting data did not fit the assumptions of standard linear models (both datasets had probably influential outliers according to leverage plots with Cook's distance and heteroscedastic variance), so to explore if there was a relationship between 1) media output and reported conflict events and 2) press freedom and reported conflict events, we used robust regression (downweighing outliers) with heteroscedasticity-corrected standard errors (Mackinnon & White 1985, Rousseeuw & Leroy 2005) (see SI Figure S3).

Initially, we found a significant positive relationship between total media count from LNA and conflict count (see SI Table S3), but further investigation into the leverage of each country showed that the USA still had an outsized influence on the analysis (with a Cook's distance measure an order of magnitude above the second most important country, Canada). Removing the USA from the analysis resulted in the finding of no significant relationship between total media score and conflict count (see SI Table S4). The combination of high influence and a

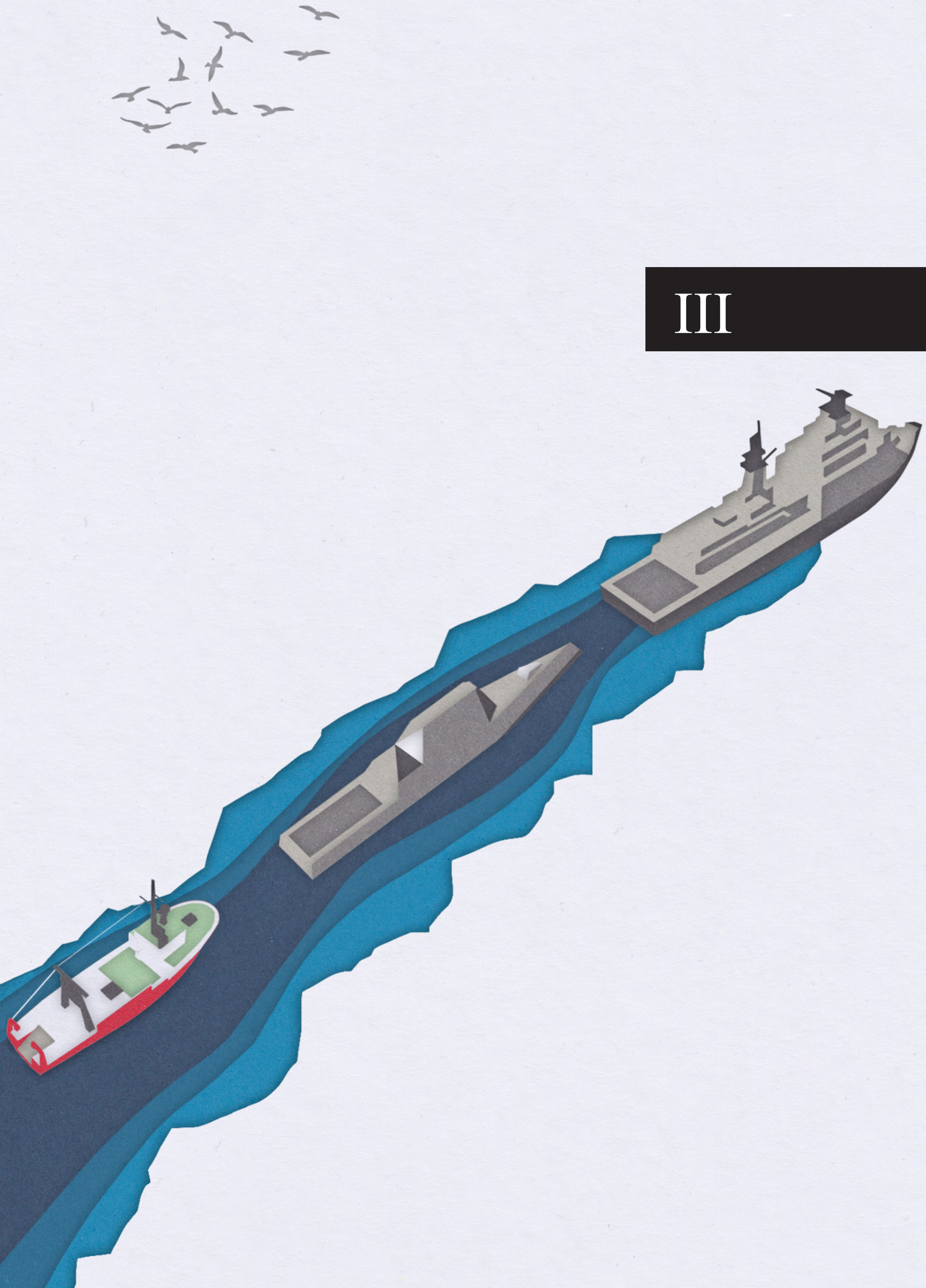
relationship being dependent on a single data point led us to conclude that there is no reliable relationship between media output and database's count of conflict events.
Secondly, we determined no significant relationship between the Press Freedom Index and the count of conflict events (see SI Table S5). Though press freedom is less directly related to our concern of media bias, and data only exists on this metric for a small period of time, it does corroborate our previous analysis which fails to find evidence of media bias in reported conflicts.

As we used English media as our source, we performed additional analysis investigating media bias for countries in the database where the primary de facto spoken language or de jure language is English. Because the assumptions of standard linear models were violated (according to leverage plots with Cook's distance and heteroscedastic variance), we used robust regression with heteroscedasticity-corrected standard errors (Mackinnon & White 1985, Rousseeuw & Leroy 2005). We found a significant relationship between conflict and media output for these English-speaking countries (see SI Table S6). Further investigation into the influence (leverage) of each country showed that the USA, again, had an outsized influence on the analysis (leverage over an order of magnitude more than the second most influential country, Canada) (see SI Figure S5). Removing the USA from the analysis resulted in the finding of no significant relationship between total media score and conflict count (see SI Table S7). Because the relationship we found initially was dependent on the inclusion of a single data point, we conclude that the relationship is spurious.

Because the USA was an outlier that influenced both previous analyses, we performed additional analyses to determine whether there is a strong relationship between media output covering the USA in LNA and the frequency conflict events involving the USA in the IFCD in a given year. To do so, we ran a cross-correlation over the entire time period for the USA (see SI Figure S6). Media output covering the USA correlated significantly with conflict count for the USA at two time points (though the correlations indicated that media output lagged behind conflict: one time point had a relationship with a media time lag of two year, and one time point had a relationship with a media time lag of one year). However, the correlations for those two time points ran in opposing directions, suggesting that the correlations may not have been meaningful (see SI Figure S6). We relied on regression analysis to explore these potential relationships. However, after running an augmented Dickey-Fuller test (which tests if a time series has a unit root) we learned that because the data was not stationary (time series data is not independent as each data point is related to the previous time step), and needed to 'stationarize' the time series to remove the autocorrelation. Then, running Ordinary Least Squares (OLS) regressions, we found both lagged correlations were dependent on the inclusion of data for the year 1999 (see SI Figure S7 and SI Figure S8). The year 1999 was a very influential outlier in both cases, with leverage values 2 orders of magnitude higher than the next most influential year (for lag of one year, see SI Table S8 and S9, for lag of two years see SI Table S10 and S11). Conducting OLS regression without the year 1999 led to the conclusion of no significant relationship in either case. Because this case also involved influential outliers and some heteroskedasticity, we also performed robust regression (downweighing the influence of outliers) with heteroskedastic corrected errors. This analysis showed no significant relationship

(see SI Table S12). This led us to conclude there is no consistent relationship between media output and conflict count for the USA.
Lastly, to analyze if the conflict data per year is correlated to the amount of media coverage per year, we extracted the list of publishers from the LNA website (the European region) every year. We cleaned that data (filling in empty end dates and deleting irrelevant dates) and ran a cross-correlation with the count of conflict per year. However, after running an augmented Dickey-Fuller test (which tests if a time series has a unit root, meaning it is not stationary) we learned that because the data was not stationary (time series data is not independent as each data point is related to the previous time step), and needed to 'stationarize' the time series to remove the autocorrelation. Once the data was stationary, we found no significant correlation between conflict and media coverage, even when taking into account lag (see SI Figure S4).
Though these analyses do not determine that our database is free from bias, they do provide early indication that our database is reflective of actual historical and geographical trends and not simply media bias of reporting location, country as reporting subject, the national freedom of the press to report on issues, or the range of news outlets that can report on conflict.

III



Identifying predictors of international fisheries conflict

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Abstract
Marine capture fishery resources are declining, and demand for them is rising. These trends are suspected to incite conflict, but their effects have not been quantitatively examined. We applied a multi-model ensemble approach to a global database of international fishery conflicts between 1974 and 2016 to test the supply-induced scarcity hypothesis (diminishing supplies of fishery resources increase fisheries conflict), the demand-induced scarcity hypothesis (rising demand for fishery resources increases fisheries conflict), and three alternative political and economic hypotheses. While no single indicator was able to fully explain international conflict over fishery resources, we found a positive relationship between increased conflict over fishery resources and higher levels of per capita GDP for the period 1975-1996. For the period 1997 to 2016, we found evidence supporting the demand-induced scarcity hypothesis, and the notion that an increase in supply of fishery resources is linked to an increase in conflict occurrence. By identifying significant predictors of international fisheries conflict, our analysis provides useful information for policy approaches for conflict anticipation and prevention.

Introduction
Natural resources have long been studied for their role in sparking conflict. Historical narratives recognizing the interdependence between natural resources and the security of the individual as well as societies date back to antiquity, yet more formal analysis of the role of resources in conflict emerged out of the environmental movement of the 1960s and 1970s (see works by Hardin (1968) and Ehrlich (1968)) (Floyd & Matthew 2013).The early environmental security literature (developed during the late 1980s and early 1990s) proposed an analytical framework that identified resource scarcity as the primary reason for conflict over land or fresh water (Homer-Dixon 1991, 1994). The 'scarcity hypothesis' holds that a decreased availability of resources, either through increased demand or diminished supply, heightens the likelihood of conflict – henceforth referred to respectively as the demand and supply-induced scarcity hypotheses (Homer-Dixon 1991, 1994). Conflict triggered by scarcity was often linked to a Malthusian perspective, where resource scarcity is seen as the result of population growth and rigid limits on supply are

assumed (Finkbeiner et al. 2017, Ehrlich & Ehrlich 1996, Renner 1996). Later studies linked resource abundance and environmental change, driven by natural variability or climate change, to conflict (Brunnschweiler & Bulte 2009, Welsch 2008). Many scholars, often from the field of political ecology, disputed these environmentally deterministic accounts of conflict, and instead documented the complex relationship between resources and conflicts, and in particular contextual factors such as vulnerable livelihoods, institutional failures or weak states (Le Billon & Duffy 2018, Dalby 2014, Le Billon 2001, Peluso & Watts 2001). Some scholars even propose that environmental changes (such as increased scarcity or availability of resource) can at most be aggravators of pre-existent social conditions (Mehta et al. 2019, Salehyan 2008). Results from studies of linkages between the environment and conflict have varied widely, in part because researchers define conflict in many different ways: some studies consider conflict to solely be expressed in violence, while others consider conflict broadly, including diplomatic reprimands. Moreover, analyses cover different time periods and geographic scales, complicating the analysis of general links between resources and conflict (Bernauer & Böhmelt 2020). Despite this inconsistent evidence base, the narrative of resource conflicts associated with rapidly increasing demand for raw materials and growing resource shortages is common in policy and is included in many briefs for decision makers (for example, UNFT 2012) (Dalby 2014).

The scarcity hypothesis is also common within the literature on fisheries conflict (although some studies flag the indirect role of scarcity and importance of other variables; Mendenhall et al. 2020, Jiminez et al. 2019, Glaser et al. 2018, Dupont & Baker 2014, Bavinck 2005). The emphasis on the scarcity hypothesis must be interpreted in the context of global fisheries dynamics, where global catches increased from the 1960s to the 1990s and then levelled off and declined (Pauly and Zeller 2016, Garibaldi 2012). In addition to declining catches, climate change has been suggested as a potential instigator of fishery conflict (Mendenhall et al. 2020, Pinsky et al. 2018). Climate change is leading to increases in sea temperature as well as changes in salinity, ocean currents, pH and oxygen, impacting stock dynamics and altering depth and geographical distributions (Free et al. 2019, Cheung 2018, Poloczanska et al. 2013). Recent projections of the shifting distribution patterns of commercially important marine species under climate change have led researchers to suggest that conflict might be more likely in the future as species enter into new Exclusive Economic Zones (EEZ) (Oremus et al. 2020, Pinsky et al. 2018, Spijkers & Boonstra 2017). In this sense, climate change can be conceptualized as a rendition of the scarcity hypothesis, where a change in the relative access of different groups to a resource causes conflict. The concern is that an absolute decline in fish, due to overfishing or mismanagement, or redistribution in catch brought on by climate change, are intensifying the risk of future conflict. The scarcity hypothesis has, however, not yet been rigorously tested on marine fishery conflict data (contrary to fresh water conflict datasets; see Dinar et al. 2015, Bernauer & Böhmelt 2014, Yoffe et al. 2004). Moreover, no studies have employed such data sets to test other hypotheses, such as whether social or economic factors regulate fisheries conflict.

Here, we provide the first such analysis by testing five different hypotheses from the environmental security literature that link natural resources to conflict. In addition to the demand and supply scarcity hypotheses, we include three alternative hypotheses that consider economic and political conditions:

H1. Demand-induced-scarcity. As national demand for fishery products (both wild catch and aquaculture) increases, the number of conflicts over fishery resources a country engages in with another country increases.

H2. Supply-induced-scarcity. As the domestic supply of fishery products (both wild catch and aquaculture) decreases, the number of conflicts over fishery resources a country engages in with another country increases.

H3. Democracy level. As the level of democracy of a country increases, political stability is enhanced, creating a pacifying effect on international relations, and the number of conflicts over fishery resources a country engages in with another country decreases.

H4. Macroeconomic performance. As the economic development and macro-economic performance of a state increase, the number of conflicts over fishery resources a country engages in with another country decreases.

H5. Military expenditure. As the military expenditure of a country increases, it is able to engage in more policing, and the number of conflicts over fishery resources a country engages in with another country increases.

Because conflicts can extend over multiple years, we use conflict at a previous time point as a predictor of conflict (Hauge & Ellingsen 1998). Although not connected to a specific hypothesis, we therefore also account for **lagged conflict**.

By testing these five hypotheses and identifying which variables are significant predictors of historical international fisheries conflict, we seek to parse out what might be driving fisheries conflict – a necessary step to develop knowledge that can support adequate approaches for conflict anticipation and prevention.

Materials and methods

We evaluated how a set of seven predictors was related to the number of fisheries conflicts a country engaged in with another country in a given year. The seven variables were proxies for the five hypotheses laid out previously (Table 1). These five specific hypotheses were chosen as they have often been tested for in previous academic work on conflict over other natural resources, and because these are the hypotheses we could test given available predictor datasets. We used the International Fishery Conflict Database (IFCD) (Spijkers et al. 2019) as our response dataset. We first discuss the response dataset and structure, then lay out the rationale behind the 5 hypotheses and the chosen predictors, and finally discuss how we used a multi-model approach to establish which variables are significant predictors of fisheries conflict despite uncertainty in model structure and the complexity of international conflict.

Table 1: Hypotheses and linked predictors and their data sources. For a more elaborate description of all the predictor variables, see SI: Data sources.

Hypothesis	Predictor	Predictor description	Predictor source
Demand-induced scarcity	Protein supply quantity	The apparent consumption is calculated as production minus non-food uses and fish exports. Fish imports are added, and changes in stocks taken into account. Measured in grams per capita per day of protein consumed from fish products.	FAO, food balances
	Employment in the fishing sector	This variable includes all commercial, industrial and subsistence fishers, operating in freshwater, brackish water, and marine waters to catch and land any aquatic animals and plants. Because the dataset was only available from 1995, we only tested this predictor for the second time period. Measured in numbers of persons.	OECD
	Annual population growth	Measured in percentage (percent growth rate).	World Bank, world development indicators
Supply-induced scarcity	Domestic supply quantity	The quantity of fishery products for domestic utilization is calculated by adding the production of fisheries products to imports of fisheries products, subtracting fishery	FAO, commodity balances

		exports and taking into account the changes in stocks. Fisheries products encompass both wild caught fish as well as cultured fish. Measured in tons.	
Democracy	Level of democracy	Scale ranging from 0-10 where 0 is least democratic and 10 most democratic, covering both procedural (e.g. electoral process) and structural (e.g. rule of law) element of democracy.	Quality of Governance database
Macroeconomic development	GDP per capita	Measured in value, USD.	World Bank, world development indicators
Military expenditure	Military expenditure	Measured in percentage of GDP.	Quality of Governance database

Response variable data source: International Fishery Conflict Database
Our response variable was the number of international fishery conflict events a country engages in per year. We use the IFCD as our data source, which was set up to explore international conflicts over marine fishery resources by using detailed records of interactions between countries (Spijkers et al. 2019). The IFCD currently contains 542 reported international fishery conflict events that occurred between 1974 and 2016 of five differing intensities (see SI: Table 1). We removed the EU from our analysis as it did not fit the country-level predictor datasets. We also removed Palestine, Western Sahara and the Falkland Islands (Islas Malvinas) from out dataset as there were no data available for these regions for any of the predictor variables.

In freshwater conflict studies, country dyad data is commonly used (Dinar et al. 2015, Bernauer & Böhmelt 2014), where a conflict dyad consists of two conflicting parties, of which at least one is the government of a state. However, close to 11% of the fishery conflicts in IFCD occur between more than two countries, where dyad-level analysis would not be informative. For that reason, exploring how national characteristics might predict conflict is a more valid and interesting avenue to explore. Finally, we are interested in exploring if national characteristics (related to supply and demand of fish, and additional economic and social conditions) influence the amount of conflict that a country experiences, and thus use country-level conflict data as the level of observation, precluding the use of dyad analysis to explore causes of conflict.

Details on hypotheses and predictor data sources

We first tested the demand-induced-scarcity hypothesis (H1) by looking at the relationship between demand and conflict (see Pomeroy et al. 2016, Seter et al. 2016, Brashares et al. 2014, Yoffe et al. 2003). Specifically, we tested whether increased demand for fish was linked to fisheries conflict through three different aspects of demand for fishery products. The first aspect is demand for fish as a source of food, measured through the 'protein supply quantity' variable. The protein supply quantity reflects 'apparent consumption', which is the per capita food fish supplies available for human consumption, and it includes both cultured and wild fish in the data. The second aspect is demand for fish as a source of income, measured through the 'employment in the fishing sector' variable, which includes all commercial, industrial and subsistence fishers. The third aspect is increased demand for fish due to domestic population size increase (the Malthusian hypothesis) (Table 1).

Second, we tested the supply-induced-scarcity hypothesis (H2) by looking at the relationship between supply and conflict (see Pomeroy et al. 2016, Seter et al. 2016, Brashares et al. 2014, Homer-Dixon 1991, 1994) through the variable 'domestic supply quantity' (Table 1). If H2 is supported, we would expect to see that as the domestic supply of fishery products decreases, the number of conflicts over fishery resources a country engages in with another country increases.

Third, we tested the democracy level hypothesis (H3) by looking at the relationship between the level of democracy in a country and conflict (see Bernauer & Böhmelt 2020, Bodea et al. 2016, Van Holt et al. 2016, Mcclanahan et al. 2015, Brochmann & Hensel 2009, Salehyan 2008, Wolf et al. 2003, Brochmann & Gleditsch 2012, Hauge & Ellingsen 1998). We tested this using the 'democracy level' variable (Table 1). The link between democracy levels and conflict has been analyzed from a variety of analytical angles (often from a dyadic perspective, testing for example if pairs of democracies experience less violent conflict), with studies on their link reaching differing conclusions (Hegre 2014, Quackenbush & Rudy 2009, Boehmer 2008). Nonetheless, a significant body of research indicates some pacific benefits from democracy on the monadic level (i.e. on the level of the individual country) (Boehmer 2008, Oneal & Russett 1997, Fukuyama 1992). The hypothesized relationship is that domestic institutions influence foreign policies, making democracies less likely to initiate conflicts, thus more democratization has a pacifying effect on international interactions (Daniels & Mitchell 2017, Quackenbush & Rudy 2009). Note, however, that previous studies specifically on maritime conflict have shown that democracies are significantly more likely to experience conflict than dictatorships (Daniels & Mitchell 2017, Mitchell & Prins 1999).

Fourth, we tested the macroeconomic performance hypothesis (H4) by looking at the relationship between the country's macroeconomic performance and conflict (see Bernauer & Böhmelt 2020, Bodea et al. 2016, Brochmann 2012, Yoffe et al. 2003, Hauge & Ellingsen 1998) (Table 1). Lower GDP per capita is reportedly one of the most robust predictors of social conflict, where higher income levels lead to less conflict (Bernauer & Böhmelt 2020). The working assumption here is thus that as the development and macro-economic performance of a state increases, the number of conflicts over fishery resources a country engages in decreases. However, a previous study specifically on maritime conflict have shown that states with higher levels of economic development are more prone to conflict (Daniels & Mitchell 2017).

Last, we tested the military expenditure hypothesis (H5) by looking for a relationship between military expenditure and conflict (see Bodea et al. 2016, Hauge & Ellingsen 1998) (Table 1). Particularly for fisheries conflict, military expenditure can be linked to a country's strengthened naval presence to protect strategically important waters by conducting military exercises or building military outposts on disputed islands (Wirth 2016, Song 2015). This could therefore suggest that greater capacity and amount of policing would lead to a greater number of international conflicts.

We also acknowledge that conflict in the previous year may be an important predictor for experiencing it in the next year, a variable we call *lagged conflict.* Indeed, in studies parsing out drivers of conflict, conflict occurring in the previous year is often a strong predictor for experiencing conflict in the next year (Ciccone 2011, Theisen 2008, Hauge & Ellingsen 1998). To test this, we use the conflict dataset lagged by one year, and dropped the first time point (year 1974) from our conflict dataset (Salehyan 2009, Hauge & Ellingsen 1998). We also used conflict of the previous time point as a predictor to account for temporal autocorrelation. We used Auto Correlation Function (ACF) plots to assess whether temporal autocorrelation had been removed from our dataset with the inclusion of this variable. We ran separate ACF plots for each country per model, and found the residuals from time T-1 were not correlated with the residuals from time T.

To assess the potential effects of multicollinearity in our models, we used pairwise relationship correlation coefficients (Pearson correlations, no coefficient greater than $|0.7|$, see SI: Figures 3-4) and variance inflation factor (VIF) estimates (scores lower than 2.5). Based on previous literature, we also considered population size and more precise measures of governance quality (the World Governance Indicators) as predictors. However, population size (source: World Bank) violated the Pearson correlation criterion (high correlation with the employment dataset), so it was excluded as a predictor. Additionally, the World Governance Indicators (source: World Bank) were excluded as predictors as they violated the Pearson correlation criterion (high correlation with democracy level and GDP per capita).

Analysis

Establishing time periods for analysis

Based on previous research, we suspected that over time there might be two different periods within the data with different underlying dynamics. There are two qualitative reasons to analyze the history of fisheries conflict in two periods. First, the conflict trends in Spijkers et al. 2019 suggest that conflict has not had a continuous trend over time, showing a more rapid increase in conflict from around the year 2000. Moreover, Spijkers et al. (2019) concluded that, before the turn of the century, fisheries conflict involved mostly North American and European countries fighting over specific species, with conflicts being characterized largely by low-intensity events of a diplomatic nature (see SI: Table 1) (Spijkers et al. 2019). The nature of the conflict events altered markedly, as fisheries conflict then primarily involved Asian countries (encompassing nearly half of all conflict events after the year 2000) clashing over multiple and non-specified species, with conflict often triggered by illegal fishing and more often exhibiting violent interactions (Spijkers et al. 2019).

Second, because we have a primary interest in exploring how the available supply of fishery resources might influence the likelihood of international fisheries conflict (scarcity hypothesis), it is important to take into consideration the global trends in available fishery resources. Global fisheries catch patterns show a clear peak in the mid-1990s (Pauly & Zeller 2016 specifically report year 1996) and visible declines since. This break in the trend (with increasing global supplies of wild-caught fish up to around 1996, and declining supplies thereafter) suggests that breaking the dataset up into two periods allows us to explore how such a change in the global resource-base may have influenced incidences of conflict. The changed nature of international fisheries conflict, the faster rate of increase in conflict over fishery resources in recent years, and the altered availability in global supply of fish catch signal the importance of examining different time periods of fisheries conflict.

To determine whether there are statistical breakpoints in the IFCD to confirm our qualitative intuitions, we run a piecewise regression model (r package: segmented (Muggeo 2008)) on the number of conflicts between 1974-2016. Using the raw conflict data over time, 1997 and 2000 emerge as breakpoints (see SI: Figure 1 and SI: Table 2). After applying a rolling mean of three years over the data, 1997 and 2002 emerge as breakpoints in the dataset (see SI: Figure 2 and SI: Table 3). As both models suggest 1997 as a clear break, and because 1997 coincides with a change in trend in available supply of fishery resources (a predictor of interest), we split the dataset that year and explored whether the different time periods (before and after 1997) might be driven by different predictors. To visualize both time periods and the countries experiencing most conflict, we built two world maps showing the count of conflict for each country in the analysis (r package: ggplot).

Identifying important predictors: a multi-model approach
Exploring complex systems, where there are multiple potential predictors, often precludes the search for a single 'best' model because of the high uncertainty regarding what combination of variables are important (Gregr & Chan 2015). Determining a single best model can bias resulting inference or generate misleading results (for example, variables not included in the selected model are deemed unimportant where they may be influential in reality) (Lukacs et al. 2010, Raftery et al. 1993). Beyond the parametric uncertainty about which variables to include in a model, there is considerable uncertainty in choosing model design (sometimes referred to as 'structural uncertainty' (Gregr & Chan 2015, Tebaldi & Knutti 2007)). To address parametric and structural uncertainty, we used a multi-model approach which allowed us to benefit from individual model strengths and guard against their limitations, while explicitly acknowledging different model structures and determining results robust to high uncertainty. In short, we used a multi-model ensemble to determine signals that cut through deep uncertainty in complex systems and model assumptions. We used three different approaches to identify significant predictors of conflict.

1. *Boosted regression trees*

Our first model, boosted regression trees (BRT), is a nonparametric tree-based model which recursively fits multiple trees (i.e. it combines multiple models or 'trees' where a single tree relates a response to their predictors by recursive binary splits) with the samples randomly drawn from the original data set. It predicts the averaged outcome based on the predictions from these multiple trees (r packages: dismo (Elith et al. 2008), gbm (Ridgeway 2013), and ggBRT (Jouffray et al. 2019)) (Elith et al. 2008). Because our response variable (conflict count per country per year) is a discrete count, we used a Poisson distribution. Within the BRT models, one can control the tree complexity (i.e. how many levels of interactions are fitted), learning rate (which determines the contribution of each new tree to the model) and bag fraction (which specifies the proportion of data to be randomly selected while fitting each single decision tree) (Jouffray et al. 2019, Elith et al. 2008). The optimal parameter settings were elected based on explained deviance.

For BRT, we assessed the cross-validated percent deviance explained. The cross-validated percent deviance explained is calculated as 1 – (cross-validated deviance/mean total deviance) (Jouffray 2019), and is a measure of goodness of fit - where 100% would indicate a perfect model. We also used BRT to explore the relative importance of each predictor. The relative importance of each predictor is a ranking metric based on how often it was used in the tree for splitting, weighted by the improvement to the model as the result of each split and then scaled so the values sum to 100 (Colin et al. 2017). We considered only the predictors with a relative influence above that expected by chance (100/number of variables) as significant (Jouffray 2019). For significant predictors, we provide partial dependence plots (PDP) showing the marginal effect on the predicted outcome for a given value of the predictor (i.e., the instantaneous effect that a change in the predictor variable has on conflict when the other variables are kept constant). The x-axis shows the distribution of the data points, and the PDP flattens in regions where there is no change, or where there is no data available. The y-axis is on the log scale. PDP's show whether the relationship between conflict and a predictor is linear or more complex.

The BRT approach offers some important advantages over other statistical models. First, it can capture nonlinear relationships, something different conflict scholars have advocated for to incorporate in models (Selby & Hoffman 2016), and which parametric models (i.e. models where the shape of the functional relationships between the response and the explanatory variables are predetermined) cannot. Second, BRT accommodates missing data by using surrogates, meaning that, if a variable is missing in a data point, the decision defers to another variable that is highly correlated with it. Third, it is robust against outliers. Last, it automatically incorporates interaction effects between predictors (Elith et al. 2008). BRT also has some important drawbacks: it depends heavily on the sample of data, and even small changes in training data can result in very different series of splits, introducing uncertainty into their interpretation; and it can be prone to overfitting (Elith et al. 2008).

2. *Generalized linear model*

Second, we used a zero-inflated negative binomial generalized linear model (GLM), or ZINB GLM. The ZINB GLM (r package: pscl (Jackman 2012, Zeileis et al. 2008)) is a two-component model. The first component is a count model that predicts some zero counts, with zeros representing instances where countries *could* have experienced conflict but did not. The second component is a zero-inflation binary model, where the zeros represent countries which *could not* have experienced fisheries conflict in that year. Because the ZINB GLM has two components, we deemed a predictor significant for the overall model if it is significant for at least one of the two components. We chose to run a ZINB GLM instead of aggregating conflicts across time to reduce the zeros in the conflict dataset, because we wanted to explicitly incorporate instances where conflict does *not* occur in our models; a limitation of many causal studies on natural resources and conflict (Adams et al. 2018, Hendrix 2018). The GLM approach offers a number of advantages. Its output is relatively easy to interpret, and offers clear understanding of how predictors influence the outcome. It is also not prone to overfitting. It can, however, show sensitivity to outliers. The ZINB GLM model in particular can account for excess zeros, which encompasses situations in which countries in our dataset at a given point in time: (a) did not have the means to protect their fishing interests (Daniels & Mitchell 2017) and therefore could not engage in conflict; or (b) could experience conflict, but there was no reporting on occurring conflicts. We use the model to assess significance of the predictors, using a p-value of < 0.05 as cut-off. We provide the pseudo r-squared as a goodness-of-fit measure, as the usual r-squared is not provided for GLM (r-squared is calculated by ordinary least-squares regression, while GLM uses the maximum likelihood estimator). The pseudo r-squared is obtained using McFadden's method.

3. *Generalized linear mixed model*

Third, we used a generalized linear mixed model (GLMM), which is an extension to the GLM in that it can contain random effects (i.e. effects that vary among individuals) in addition to fixed effects (i.e. effects that are constant across individuals). In our GLMM (r package: lme4 (Bates et al. 2015)), we used the negative binomial distribution and the country ID as a random effect to account for any non-independence within a country (i.e., within-country correlation). This model includes the possibility that important country-specific characteristics may influence the number of conflicts a given state engages in, but which we do not have predictors for. We used the model to assess significance of the predictors, with a p-value of < 0.05 as cut-off. We provide the pseudo r-squared as a goodness-of-fit measure, as the usual r-squared is not provided for GLMM (r-squared is calculated by ordinary least-squares regression, while GLMM uses the maximum likelihood estimator). The pseudo r-squared is obtained using the delta method and considers the variance by both the fixed and random effects.

Cross model evaluation

For time period 1 (1975-1996), we used the three models (BRT, ZINB GLM and GLMM) to evaluate which predictors are most robust. We included all predictors listed above except for employment in the fishing sector, as data was not available for time period 1. For time period 2 (1997-2016), we ran the same three models for all predictors, with and without employment, as data were limited to only OECD countries as well as Argentina, China, Indonesia, Thailand and Chinese Taipei. We assessed robust predictors across those six models for time period 2.

To evaluate which of the predictors carried the most weight across models, we used the following scale:

- Strong support: significance of the predictor across all models (i.e. 3/3 for time period 1 or 6/6 models for time period 2).
- Moderate support: significance of the predictor across the majority of models (i.e. minimum of 2/3 models or 4/6 models).
- Low support: significance of the predictor across less than half of models (i.e. less than 2/3 of 3/6 models).
- No support: no significance of the predictor in any of the models.

When assessing multicollinearity through the VIF scores, we found that the GLM model showed VIF scores estimates much greater than 2.5 (see SI: Table 4), but all VIF scores were no greater than 2.2 within the GLMM (see SI: Table 5) and no greater than 2.2 within the BRT (see SI: Table 6). Despite multicollinearity in the GLM, focusing on results that are consistent among all the models suggests that our results are sound. We analyzed the standardized residual plots of all models (for time periods 1 and 2) to confirm that they did not show evidence of heteroscedasticity or trends that would violate model assumptions. We also analyzed the performance of our models by comparing model predictions with our actual conflict data, to confirm a monotonic relationship between actual and predicted in our models.

Results

Time period 1 (1975-1996)

During this time period, the USA was involved in the greatest number of conflict events (n=98), followed by Canada (n=97) and Spain (n=35) (Spijkers et al. 2019) (Figure 1). The cross-validated percent deviance explained from the BRT model for this time period was 40.2%. The pseudo r-squared for the ZINB GLM is 0.36 and the pseudo r-squared for the GLMM model was 0.30. Across the three models, lagged conflict and GDP per capita emerged as influential predictors (Table 2). However, in the GLM model, decreased GDP per capita was significantly associated with lower levels of conflicts (zero-inflation model), while in the other two models, increased GDP per capita was associated with more conflicts.

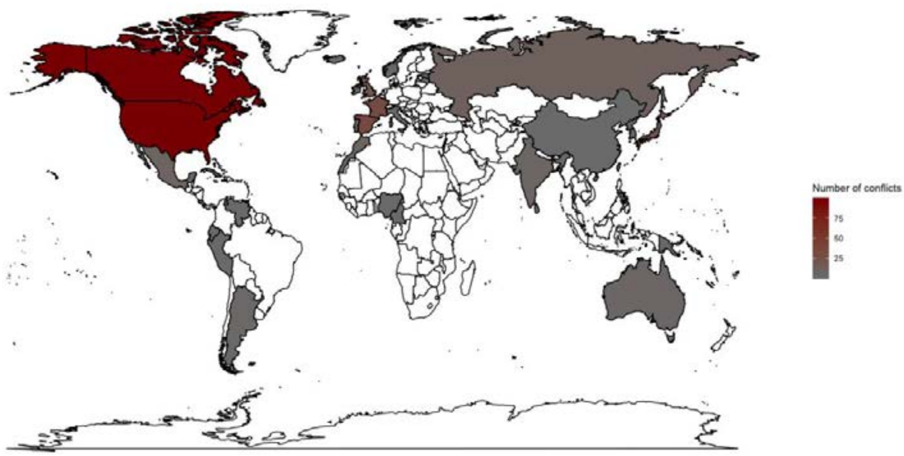

Figure 1: Map of countries experiencing conflict over fishery resources for time period 1 (1975-1996).

Predictor	**BRT**	**ZINB GLM**		**GLMM**
		Count model	Zero-inflation	
	Relative influence	*Coefficient*	*Coefficient*	*Coefficient*
Lagged conflict	**48.430055**	**1.53617**	**-4.13908**	**1.5205**
GDP per capita	**21.850888**	-0.20168	**-6.22271**	**3.0714**
Domestic supply	9.167361	1.20459	**-3.22221**	2.4764
Population growth	7.692897	-0.42474	2.22541	-2.6453

Protein from fish	5.454625	-1.86071	2.83389	-2.4212
Democracy level	3.960203	1.18338	1.40043	0.2996
Military expenditure	3.443970	-1.19697	1.71233	-2.6367

Table 2: Model comparison for time 1 (1975-1996). Bold variables are significant for the model and highlighted variables are those that have moderate to strong support across all models (as per our evaluation scale). Significant for the ZINB GLM and the GLMM mean the predictor has a p-value of < 0.05. For the BRT model, significance indicates that the predictor crossed the relative influence cut-off in order to not be expected by mere chance (14.3%). Note: the relative influence does not indicate if the relationship is positive or negative. See SI: Tables 7- 9 for raw output from all three models.

From the PDP, we can see that a country has an increasingly higher probability of experiencing conflict as the amount of conflicts it engaged in during the previous year increases (Figure 2). The same relationship holds for GDP per capita (Figure 2).

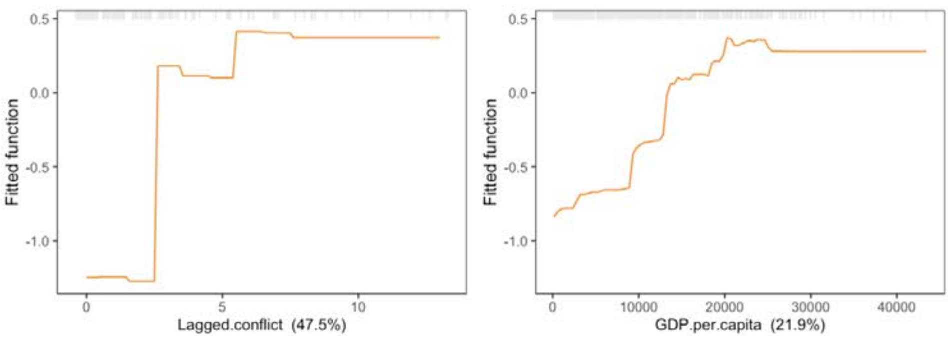

Figure 2: PDP for time period 1 showing the marginal effect on the predicted outcome for a given value of the predictor. Relative influence of each predictor in is reported between parentheses. Grey tick marks along the x-axis indicate observed data points. Values along the y-axis indicate count of conflict on a log scale.

Time period 2 (1997-2016)

Spijkers et al. 2019 found a greater number of conflicts in Asia during time period 2, mainly involving China (n=70), followed by Japan (n=53), and South Korea (n=44) (Figure 3). The cross-validated percent deviance explained from the BRT model for time period 2, including fisheries employment as a predictor, was 31.8%. The pseudo r-squared for the ZINB GLM with fisheries employment as predictor was 0.68, and for the GLMM model the pseudo r-squared was 0.23. Protein supply emerges as an influential predictor across the three models (see Table 3). Lagged conflict emerged as significant in the BRT and ZINB GLM, while population growth was significant in both ZINB GLM and GLMM.

Due to limited data availability for 'fisheries employment', we also ran the three models without that variable as a predictor (see Table 4). The cross-validated percent deviance explained from the BRT model was 33.2%. The pseudo r-squared for the ZINB GLM became 0.33, and the pseudo r-squared for the GLMM model remained unchanged. The three models without fisheries employment as predictor found convergence on the importance of three predictors: lagged conflict, domestic supply quantity and amount of protein consumed from fish (see Table 4).

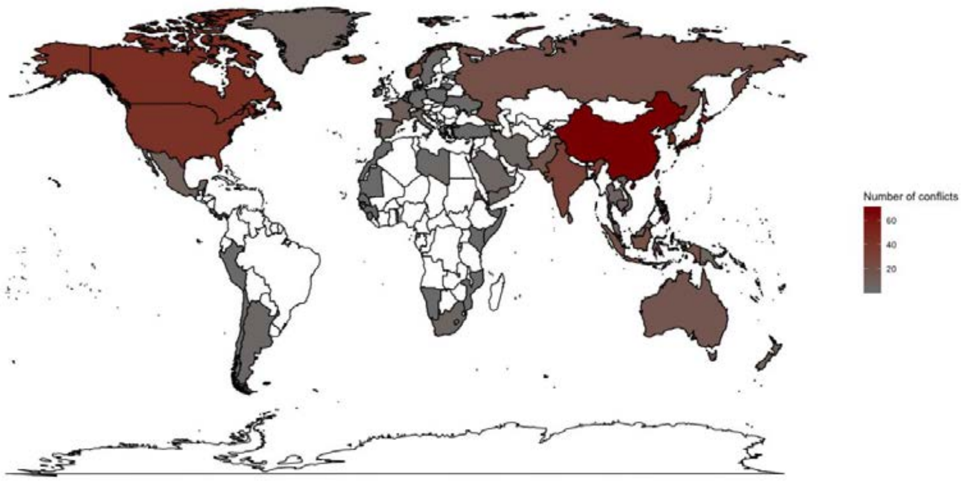

Figure 3: Map of countries experiencing conflict over fishery resources for time period 2 (1997-2016).

Predictor	**BRT**	**ZINB GLM**		**GLMM**
		Count model	Zero-inflation	
	Relative influence	*Coefficient*	*Coefficient*	*Coefficient*
Lagged conflict	**31.122203**	**4.9257**	42.969	1.8789
Domestic supply	**28.485425**	3.5428	2.402	1.2808
Protein from fish	**14.416985**	**2.6083**	20.893	**3.2177**
Population growth	4.631676	**7.4385**	-455.880	**8.4098**
GDP per capita	8.245806	0.4451	3.259	0.8056
Democracy level	3.149263	-0.8000	54.044	-1.4527
Military expenditure	3.877867	**12.9729**	824.609	4.1042
Fisheries employment	6.070774	0.8768	78.641	0.9417

Table 3: Model comparison for time 2 (1975-1996), the three models with fisheries employment as predictor. Bold variables are significant for the model and highlighted variables are those that have moderate to strong support across all models (as per our evaluation scale), including the models without fisheries employment as a predictor (see Table 4). Significant for the ZINB GLM and the GLMM mean the predictor has a p-value of < 0.05. For the BRT model, significance indicates that the predictor crossed the relative influence cut-off in order to not be expected by mere chance (12.5%). Note: the relative

influence does not indicate if the relationship is positive or negative. See SI: Tables 10-12 for raw output from all three models.

Predictor	BRT	ZINB GLM		GLMM
		Count model	Zero-inflation	
	Relative influence	*Coefficient*	*Coefficient*	*Coefficient*
Lagged conflict	**30.766761**	**5.08320**	**-45.3797**	**4.98655**
Domestic supply	**28.598450**	**3.95801**	**-71.5552**	**3.79510**
Protein from fish	**16.238776**	**1.19910**	1.4120	**2.17422**
Population growth	7.393651	-0.34175	-1.9172	-0.9966
GDP per capita	9.217082	0.16370	-1.7705	0.71646
Democracy level	3.780293	0.02571	0.6737	-0.27826
Military expenditure	4.004987	4.38959	8.6029	-2.89693

Table 4: Model comparison for time 2 (1975-1996), the three models without fisheries employment as predictor. Bold variables are significant for the model and highlighted variables are those that have moderate to strong support across all models (as per our evaluation scale), including the models with fisheries employment as a predictor (see Table 3). Significant for the ZINB GLM and the GLMM mean the predictor has a p-value of < 0.05. For the BRT model, significance indicates that the predictor crossed the relative influence cut-off in order to not be expected by mere chance (14.3%). Note: the relative influence does not indicate if the relationship is positive or negative. See SI: Tables 13-15 for raw output from all three models.

From the PDP, we can see that a country has an increasingly higher probability of experiencing conflict as the amount of conflicts it engaged in during the previous year increases, yet that probability remains the same from about four past conflict events onwards (Figure 4). The same relationship holds for domestic supply. We also found that as the quantity of protein derived from fish consumption in a country increases, so does the occurrence of conflict over fishery resources. The PDP shows that this relationship mainly holds true for higher levels of protein consumption from fish. The findings for both time periods are summarized in Table 5.

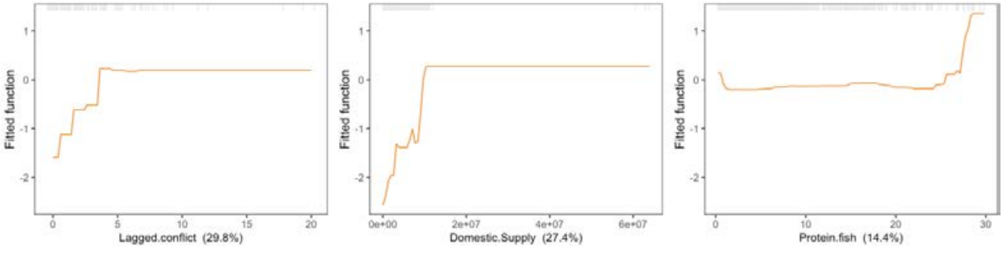

Figure 4: PDP for time period 2 showing the marginal effect on the predicted outcome for a given value of the predictor. Relative influence of each predictor in is reported between parentheses. Grey tick marks across the top of each plot indicate observed data points (along the x-axis). Values along the y-axis indicate count of conflict on a log scale.

Predictor	Time period 1		Time period 2	
	Level of support	Relationship	Level of support	Relationship
Domestic supply	Low	Positive	Moderate	Positive
Protein quantity	None	None	Strong	Positive
Fishery employment	NA	NA	None	None
Population growth	None	None	Low	Positive
GDP per capita	High	Positive	None	None
Democracy level	None	None	None	None
Military expenditure	None	None	Low	Positive
Lagged conflict	High	Positive	Moderate	Positive

Table 5: Summary of the findings for time period 1 and time period 2. The findings for time period a are based on 3 models, and the findings of time period 2 are based on 6 models (3 with and 3 without the employment variable). High and moderate support findings are highlighted.

Discussion

We did not find a single hypothesis that could fully explain increases in international fishery conflict. The results show that the nature of international fisheries conflict has changed over time (supporting previous findings by Spijkers et al. 2019) and that the predictors of the phenomenon are not generalizable from any of the tested hypotheses. Only one predictor, lagged conflict, remained significant across both time periods. Particularly during time period 1, lagged conflict was a strong predictor. During this time, many of the fisheries conflicts were prolonged, low intensity events between the same set of countries (Spijkers et al. 2019). For time period 2, experiencing conflict in the previous year remained an important predictor for conflict in a given year, but the predictor had less predictive power than for time period 1 in the BRT model. This is likely due to international fisheries conflicts not lasting as long during time period 2, but being more intense (Spijkers et al. 2019).

Aside from lagged conflict, the time periods exhibited different significant predictors for conflict. From 1975 to 1996, a time in which marine fisheries catch as well as fishing effort steadily increased, lagged conflict and high levels of GDP per capita had a significant relationship with conflict. From 1997 to 2016, when more conflict occurred in Asia and global yields from fishing had started to stabilize and decrease, we found evidence that increased demand and an increase in supply of fishery resources is linked to an increase in conflict occurrence. For a discussion on the predictors with no to low evidence for either time period, see SI: Low evidence predictors.

Findings for time period 1 (1975-1996)

During time period 1, marine fisheries catch as well as fishing effort steadily increased, and global catches peaked in 1996 at 86 million tonnes (Pauly & Zeller

2016, Worm & Branch 2012, Anticamera et al. 2011). Conflicts mainly involved North American and European countries, often occurred around a single species and were mostly characterized by low conflict intensity (such as hostile verbal expressions or hostile diplomatic acts) (Spijkers et al. 2019). Examples include the Pacific salmon dispute between Canada and the USA or the Cod wars between France and Canada (Spijkers et al. 2019).

We found that GDP per capita was a significant predictor for fisheries conflict conflicts in time period 1 (see Table 5). Studies linking natural resources such as fresh water to conflict find that decreasing levels of GDP per capita (a general indicator of the development and macro-economic performance of a country) are significant predictors of conflict (Bernauer & Böhmelt 2020, Yoffe et al. 2003, Hauge & Ellingsen 1998). However, focusing on maritime conflict, Daniels and Mitchell (2017) report that that *more* economically developed states have greater opportunities to make maritime claims, and thus engage in more conflict. Economically developed states started to delimit their maritime spaces in the late 1970s to early 1980s, triggering conflict over access to fishing areas (such as the Turbot Wars between Canada and Spain, or the fish wars between the USA and Canada over the maritime boundary at the Dixon Entrance) (Daniels & Mitchell). Our findings support this hypothesis for time period 1, although with some nuance. From our GLM model, we find that lower GDP per capita is a predictor for *not* being able to engage in conflicts. This could indicate that countries with a lower GDP per capita in this time period did not have the economic capacity necessary to actively participate in activities related to fisheries to the same degree as more developed states. Fisheries in developing countries have only gradually been integrated into international markets, yet now contribute a significant proportion of fish traded on such markets (Crona et al. 2015, FAO 2018). Being initially isolated from regional and global dynamics may have shielded them from the low intensity international conflicts common to this time period.

Findings for time period 2 (1997-2016)

We found strong support for the demand hypothesis, more specifically for demand for fish as food (see Table 5). We found moderate support for the significance of domestic supply (significant across 4 out of 6 models), however because the relationship between fish supply and conflict is a positive rather than negative (i.e. as supply of fish increases, so does conflict), this does not confirm the supply-induced scarcity hypothesis. During time period 2, more conflict arose in Asia (Spijkers et al. 2019) (Figure 3). The three countries that experienced most conflict during this period, China, Japan and South Korea, operate some of the largest Distant Water Fishing (DWF) fleets globally (Pauly et al. 2014, Mallory 2013). During this period that the number of areas open to new fisheries exploitation declined (McClanahan et al. 2015, Swartz et al. 2010) and yields from fishing started to stabilize or potentially even decrease (Pauly & Zeller 2016 report a peak in catches in 1996). However, fishing effort continued to rise, leading to a global decline in catch-per-unit-effort

(Pauly & Zeller 2016, Mcclanahan et al. 2015, Watson et al. 2013, Worm & Branch 2012). Between 1997 and 2016, a shortfall in supply from collapsing stocks within the EEZ of developed countries was increasingly replaced by fish harvested from tropical waters, where fisheries are often minimally managed (Mcclanahan et al. 2015). China became the largest producer and exporter of fishery products worldwide, while the USA became the largest importer (FAO 2018).

In time period 2, the quantity of fish available for domestic consumption had a positive relationship with conflict. The finding that an increase in supply of fishery resources to a given country is linked to increased conflict for that country goes against the supply-induced scarcity hypothesis, which postulates that conflict increases when resources decline. It is, however, possible that despite a decline in the wild capture of marine fish, total supply of fishery resources has increased, potentially masking the effect of degrading ecosystems on the incidence of conflict. We illustrate this with the example of China, the country most in conflict for time 2. As discussed previously, global yields from wild fish capture had started to stabilize or potentially even decrease during time period 2 (Pauly & Zeller 2016). For that same time period, reports indicate that some regions have been able to rebuild certain fish stocks, while others have experienced stock depletion and overfishing (Béné 2015). China is a good example of the latter, as 30 percent of its domestic fisheries are reported to have collapsed, and a further 20 percent to be overexploited (Blomeyer et al. 2012). Thus, China has increasingly turned to distant water fishing and aquaculture to satisfy its domestic demand (Pauly & Zeller 2016, Pauly et al. 2014, Watson et al. 2012, Anticamara et al. 2011). While both of these strategies have allowed China to maintain its domestic supply quantity (which is made up of both catch of wild fish and production of cultured fish) growing despite local stock collapses, it has potentially also led to a greater number of conflicts over fish. In the 2000s, China's growing DWF fleet operated in the EEZs of over 90 countries worldwide (Pauly et al. 2014). As of 2014, China's estimated DWF fleet encompassed nearly 4000 vessels and is supported by a number of governmental tax relief policies and subsidies (for comparison, the USA's DWF fleet consists of roughly 200 ships (Mallory 2013, 2016). It is possible that China has increasingly experienced conflicts because of the geographic expansion of their DWF vessels, even operating in foreign EEZs such as those of Japan and South Korea, to maintain their catches (Pauly et al. 2014). Declines in fish caught in its own EEZ push China to source its domestic supply of fish through distant water fishing and aquaculture (which also still relies in part on wild caught fish for feed (FAO 2018)). Consequently, a greater number of conflict incidences could be the end result of *local* scarcities that are masked in the domestic supply variable.

For time period 2, we also found that as the quantity of protein derived from fish consumption in a country increased, so did the occurrence of conflict over fishery resources. The PDP shows that this relationship mainly holds true for higher levels of protein consumption from fish (over 20g/capita/day) (Figure 4), suggesting that countries whose populations rely heavily on fish for food experience more conflict to ensure demand for fish is met. Fish, derived from both wild capture fisheries and aquaculture, are an important source of protein: In 2015, they accounted for about 17 percent of the global population's intake of animal protein (note that this percentage also includes consumption of *inland* catches, though they only represent about 12.8 percent of total catches) (FAO 2018). Moreover, per capita fish consumption is growing. It averaged 9.9 kg in the 1960s, grew to 20.2 kg in 2015, and preliminary estimates indicate further growth (FAO 2016). This growth in demand is reportedly due to urbanization and increasing living standards in developing countries (Béné 2015). The rising demand for fish is an important driver for the expansion of the Chinese DWF industry (Mallory 2013), and is reported to make IUU fishing profitable (Sumaila et al. 2006).

Evaluating the evidence for scarcity-induced conflict

For the first time period, we found no evidence that any type of scarcity, neither demand-nor supply-induced scarcity, is a significant predictor for increased conflicts over fishery resources. For the second time period, we did find evidence for the demand-induced scarcity hypothesis and evidence that goes against the logic of the supply-induced scarcity hypothesis. Support for the demand-induced scarcity hypothesis suggests that countries whose populations rely heavily on fish for food experience more conflict to ensure demand for fish is met. However, the demand-induced scarcity hypothesis only holds if this rise in demand is combined with an insufficient rise in supply. As discussed previously, despite an escalation in global fishing effort, global wild catch volumes are shrinking, suggesting there is not enough supply for the demand. For example, it is reported that China (the country in most conflict during this time period) has experienced declining returns of wild catch from its own EEZ while simultaneously demand for fishery resources is increasing (FAO 2018, Li & Amer 2015, Blomeyer et al. 2012, Agnew et al. 2009). Nonetheless, largely due to the increased availability of cultured fish, global supply of fish continues to increase. Would this increase in supply of cultured fish fulfill demand and buffer against conflicts over wild-caught, marine fish? This is a complex issue to be considered more rigorously by fisheries conflict scholars. We offer two reasons why an increase in supply from aquaculture might not (yet) act as a buffer.

First, perhaps fish supplied by aquaculture does not fully substitute certain popular and highly valuable or culturally sought-after marine species obtained through wild capture, so aquaculture might not prevent conflicts over such stocks. For example, squid (families Gonatidae, Loliginidae, Ommastrephidae, Onychoteuthidae) are in high demand in countries such as Japan and China. Because cephalopod aquaculture production is not significant enough to meet demand (Cai & Leung 2017), pressure on major squid species remains high (about 14 percent of global squid production is deemed sustainable or improving, see Sustainable Fisheries Partnership 2019). The IFCD has tracked conflict events related to squid, triggered by illegal fishing. Second, aquaculture itself still in part relies on supply from wild catch. Fish oil and fishmeal, produced from marine fish, are regular inputs into aquaculture systems. All in all, it is still possible that, though the total supply of fish is increasing, the decline in availability of marine, wild-caught fish in combination with growing demand is spurring conflict. These findings indicate that the relationship between availability of fishery resources and conflict might not be as straightforward as represented in some fishery conflict studies. Rather, it is possible that variables such as the value of, or cultural preferences for, particular species play a more important role in the occurrence of conflict than overall resource availability.

Limitations and recommendations

There are a few important limitations to our study. First, the IFCD does not include cooperative events over fishery resources. To better understand how often states collaborate on fishery issues rather than experience conflict over them, we need comprehensive longitudinal data on existing transboundary fishery treaties (Mitchell & Zawahri 2014, Brochmann 2012, Yoffe et al. 2004). This could also clarify whether there are shared predictors between conflict and cooperation. Second, there is a need to better understand if certain predictors would have a stronger relationship with conflict if they were lagged over a certain amount of time, indicating delayed effects of certain predictors. Finding the correct time lags for conflict research is a persistent issue (Selby & Hoffman 2014, 2016). Third, the domestic supply data set, which includes wild capture and cultured products as well as fish imports, could be masking actual declines in local resources. Efforts are therefore needed to look further into the supply-induced scarcity hypothesis, and particularly how supply and demand for specific species might interact with monetary value or cultural demand to produce conflict. Fourth, predictors such as the democracy and military expenditure here might not have shown a significant relationship with conflict occurrence, but they might be better predictors of conflict *intensity* (Daniels & Mitchell 2017, Hegre 2014, Hauge & Ellingsen 1998). Last, we find unexplained variance in the data across all models, which could indicate that we are missing (important) predictors. Possible other predictors are discussed below.

First, more precise indicators of state capacity other than the traditional democracy level indicator could have strong relationships with conflict (Homer-Dixon 1999). The World Governance Indicators could be a good starting point, but they have limited temporal coverage (from 1995 onwards) and, when we incorporate them into our analysis for time 2, the dataset exhibits a high level of collinearity with the democracy level variable. Similarly, more granular variables of economic development (and dependence) might also be a promising avenue. Second, the number of shared rivers has been used as an important predictor for dyad-conflict in the fresh water conflict literature (Brochmann 2012). Preliminary findings of analyses looking into shared fish stocks indicate that this variable could be an important indicator (Palacios-Abrantes et al., submitted), but as of yet no long time series dataset is available. Third, fleet size and fishing effort are likely to be important determinants for conflict occurrence, but only limited data on fleet size is available (source: the OECD), precluding their inclusion in our analyses.

We recommend four avenues of inquiry to guide future work on fisheries and conflict. First, greater disaggregation (higher analytical resolution) of explanatory variables and better recognition of local circumstances, including explicit consideration of geographic location and context, may make patterns clearer and easier to understand. Exploring spatial aspects associated with international fisheries conflict is an important next step (e.g., to test the 'distance and contiguity' argument, which specifies that countries in closer proximity will experience more conflict), and for which the literature on water conflict provides important insights (Bernauer & Böhmelt 2020, Wolf et al. 2003). Second, gathering more data on fisheries conflict from local to international scales, and establishing international teams that can align data-gathering methods and compile large datasets, will greatly improve our understanding of conflict drivers across time, scales and geography. Third, looking at characteristics of fishery resources themselves and how they influence conflict is an unexplored avenue. Characteristics such as the fish's value, or its spatial variability, could be informative for their relationship to conflict. Last, we suggest further research is conducted not only on the predictors found to be significant, but also those predictors that had less support for their relationship with conflict in our analyses, such as measures of democracy, employment or militarization, particularily as potential mediators of conflict intensity.

Conclusion

The role of natural resources in sparking conflict is contested. Particularly for fishery resources, declines in abundance are often assumed to incite increased competition over valuable, dwindling stocks. In this paper, we aimed to identify which variables are significant predictors of historical international fishery conflict to parse out what might be driving fisheries conflicts to help inform approaches that might anticipate and prevent them. Though we did not find a relationship between decreased availability of fish and increased conflict, we cannot entirely discount this hypothesis. Instead, we argue that reality is more nuanced and complex. Conflict might still result from local declines in wild catch, and an increase in global fish supplies (largely attributable to gains from aquaculture and increased DFW activities) might mask this reality. However, this does leave the literature to grapple with the role that cultured fish might play in mediating the relationship between declining wild fish supplies and conflict. As discussed, increased fish supplies from aquaculture could in theory act as a buffer for conflicts over wild-caught fish, yet some wild-caught species might not be substitutable by cultured species (such as, perhaps, certain wild fish of high monetary value or of cultural importance). Indeed, paying attention to the effects of cultural preferences and traditions in mediating the fishery resource-conflict pathway is an important next step in understanding what drives conflicts over fish. Overall, parsing out more nuanced pathways between changes in available fish supplies and conflict will be an interesting avenue for future scholarship.

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Supplementary Information Paper III

SI: Data sources
GDP per capita (value, USD).
Source: World Bank, World Development Indicators

Domestic supply quantity (tonnes)
Source: FAO (commodity balances)
Domestic supply quantity is calculated as the production of fisheries products (in terms of live-weight; covering catch and culture of all fish, crustaceans, molluscs and aquatic organisms, excluding mammals and aquatic plants) + imports - exports + changes in stocks (decrease or increase) (FAO 2018).

For territories that are part of another country (Faroe Islands (Denmark), Greenland (Denmark) and Gibraltar (Great Britain)), we did not use the values of the governing country as fish production differs greatly between the areas. We did not find specific values for any of them, and noted them as missing values.

Protein supply quantity (g/capita/day)
Source: FAO (food balances)
The apparent consumption of protein from fish is based on estimates of the per capita amount of food available for human consumption. The apparent consumption is calculated as production (capture fisheries and aquaculture) minus non- food uses (including amount used for reduction into fishmeal and fish oil), minus fish exports, plus fish imports, plus or minus stocks (FAO 2018). This variable represents apparent consumption, not actual consumption, as the numbers could be higher than actual average food intake due to for example waste and losses. Moreover, records of production from subsistence and recreational fisheries, as well as cross- border trade between some developing countries, may be incomplete, which could lead to underestimation of consumption (FAO 2018). This variable is used by the FAO to report on consumption patterns.

For territories that are part of another country (Faroe Islands (Denmark), Greenland (Denmark) and Gibraltar (Great Britain)), we did not use the values of the governing country as fish consumption differs greatly between the areas. For the Greenland, we used values reported specifically for the territory for the years 2000 and 2010-2013 and noted other values as missing values (FAO n.d.). For the Faroe Islands, the value reported for fish consumption per capita per year approximated that of the values for Greenland (FAO 2005). Because the territories are close in geography and both part of Denmark, we used the same four reported values for the Faroe Islands as we did for Greenland and kept the years as missing values. We did not find specific values for Gibraltar, and noted them as missing values.

Employment in fishing sector (number of persons)

Source: OECD
The 'fishing population' includes all commercial, industrial and subsistence fishers, operating in freshwater, brackish water, and marine waters in economically inspired efforts to catch and land any of the great variety of aquatic animals and plants, should be included. People working on fish farms, hatcheries, and employed in shell fish culture operations, should also be included. The term 'fisher' should include not only those operating from fishing vessels of all types, but also those operating land-based fishing gears and installations from the banks of rivers, lakes, canals, dams etc., and from beaches and shores which do not require the use of auxiliary boats. Where possible a breakdown by the type of activity should be included. The crews on fish factory ships, mother ships to fishing fleets, and on auxilliary craft such as, fish carriers, and fish transport craft should be included. Foreign fishers working on foreign vessels landing in national ports should be excluded from the data. However the data should show, preferably separately, the national fishers working on foreign vessels chartered to national companies.
The crews of state-operated fishery patrol vessels, fishery protection vessels, hospital ships, etc. should be excluded from the fishers' statistics.

Data were available from 1995 onwards, but for OECD countries only as well as Argentina, China, Costa Rica, Indonesia, Chinese Taipei and Thailand. For territories that are part of another country (Faroe Islands (Denmark), Greenland (Denmark) and Gibraltar (Great Britain)), we did not use the values of the governing country as employment within the fisheries sector differs greatly between the areas. For the Greenland, we used values reported specifically for the territory for the years 2010, 2012 and 2013 and noted other values as missing values (FAO n.d.). For the Faroe Islands, we took values reported specifically for the territory for the year 2002 and kept the other years as missing values (FAO 2005). We did not find specific values for Gibraltar, and noted them as missing values.

Population growth (annual %):
Source: World Bank, World Development Indicators

Level of democracy:
Source: Quality of Governance database. variable fh_ipolity2 (Freedom House/Imputed Polity)
The scale ranges from 0-10 where 0 is least democratic and 10 most democratic. The value was created by taking the average of the Freedom House political rights (i.e. electoral process, political pluralism, participation categories and functioning of government categories) and civil liberties (i.e. freedom of expression and belief, associational and organizational rights, rule of law, and personal autonomy and individual rights categories) scores transformed to a scale of 0-10; and Polity scores (transformed to a scale 0-10). The imputed version has imputed values for countries where data on Polity is missing by regressing Polity on the average Freedom House measure.

For territories that are part of another country Faroe Islands (Denmark), Greenland (Denmark) and Gibraltar (Great Britain)), we used the values of the governing country.

Military expenditure (% of GDP)
Source: Quality of Governance database. Military expenditures data from SIPRI are derived from the NATO definition, which includes all current and capital expenditures on the armed forced, including peacekeeping forces, defense ministries and other government agencies engaged in defense projects; paramilitary forces, if these are judges to be trained and equipped for military operations; and military space activities (SIPRI n.d.). For territories that are part of another country (Faroe Islands (Denmark), Greenland (Denmark) and Gibraltar (Great Britain)), we used the values of the governing country.

Lagged conflict
Temporal dataset, have to consider temporal autocorrelation. It is common to use conflict of previous time point as a predictor (Hauge & Ellingsen 1998). To do this, we had to drop the first time point (year 1974) from our conflict dataset as a response variable.

SI: Low evidence predictors

1. Population growth
For time period 2, population growth shows a significant relationship with conflict across 2 out of 6 models. The relatively low evidence for the significance of population growth as a predictor of conflict could be because, overall, the global supply of wild captured (as above, this also includes inland catches) and cultured fish for human consumption has outpaced population growth in the past five decades (FAO 2018). Global supply of fish has increased at an average annual rate of 3.2 percent over the period 1961 to 2013, double that of population growth over the same time period (FAO 2018). As mentioned above, increased demand for fish has been attributed to urbanization and increasing living standards in developing countries than increases in total population size (Béné 2015).

2. Military expenditure
For time period 2, military expenditure shows a significant relationship with conflict for one of the models. The relatively low evidence for the significance of military expenditure as a predictor for conflict occurrence is likely due to the fact that few conflicts in the IFCD are military conflicts involving navy vessels. Moreover, military expenditure might be a more meaningful predictor for particular intensities of conflict rather than conflict occurrence (Hauge & Ellingsen 1998). The importance of this predictor may change in the future as seas become increasingly militarized

(Wirth 2016, Wirth 2012), particularly in regions with territorial disputes (Spijkers et al. 2019).

3. Democracy level

In contrast to previous studies, we did not find significantly greater conflict occurrence for more democratic countries for any of the two time periods (Spijkers et al. 2019, Daniels & Mitchell 2017). However, similar to the military expenditure variable, it could be that democracy level is a better predictor of conflict intensity than occurrence, as Daniels & Mitchell (2017) report that democracies do experience more diplomatic conflicts than non-democratic countries over fish.

4. Employment in the fisheries sector

We only test this variable for time period 2 due to the datasets limited time coverage. None of the three models showed a significant relationship between employment and conflict. This could be explained by the decrease in proportion of those employed in capture fisheries, declining from 83 percent in 1990 to 68 percent in 2016 (FAO 2018), potentially decreasing the opportunity for at-sea confrontations. Nonetheless, 85 percent of the global population employed in the fisheries and aquaculture sectors is in Asia (FAO 2018), which is where most conflicts occurred during this time period.

Supplementary Information (Figures)

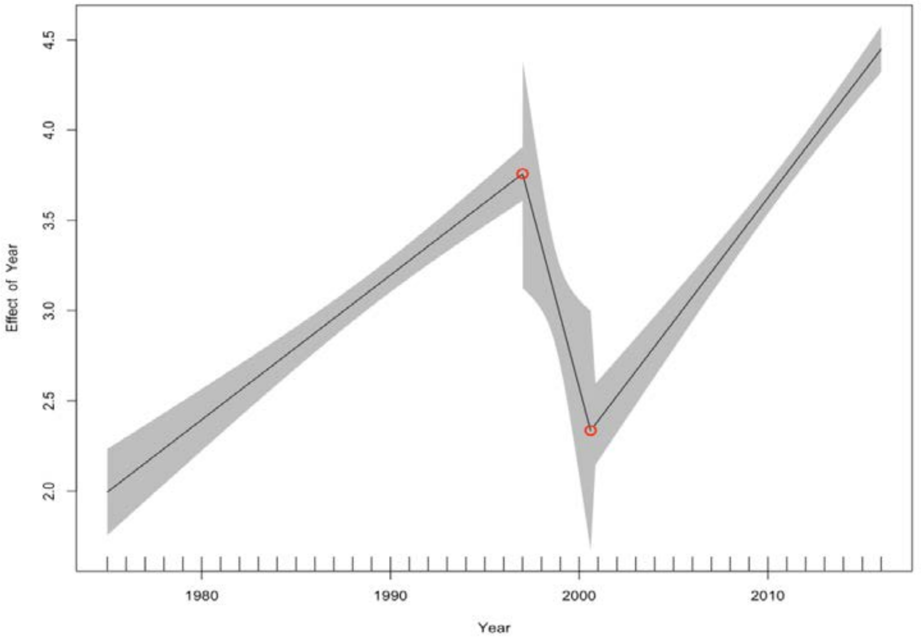

Figure 1: Piecewise regression model (non-smoothed conflict data) with estimated breakpoints year 1997 and year 2000

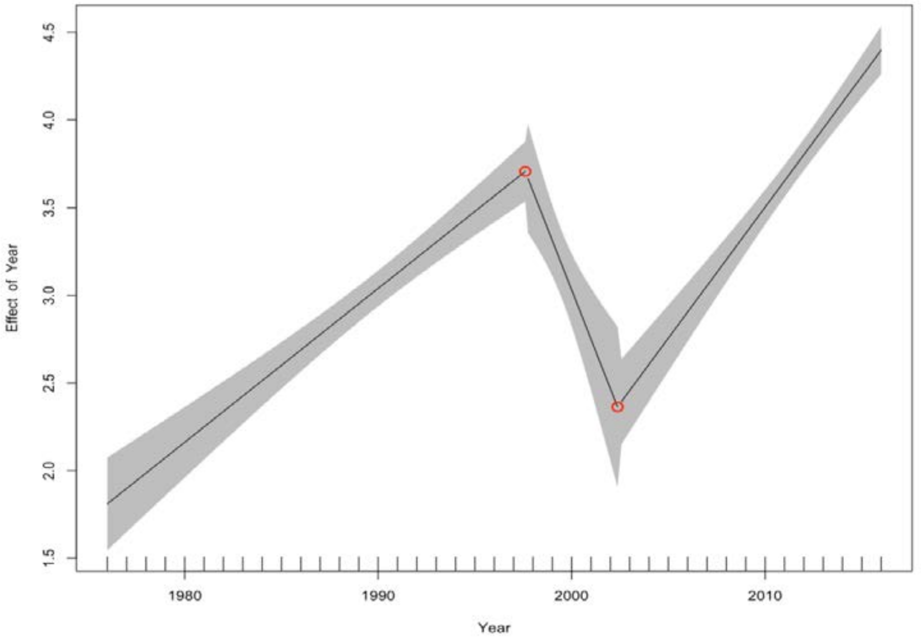

Figure 2: Piecewise regression model (smoothed conflict data, rolling mean of 3 years) with estimated breakpoints year 1997 and year 2002

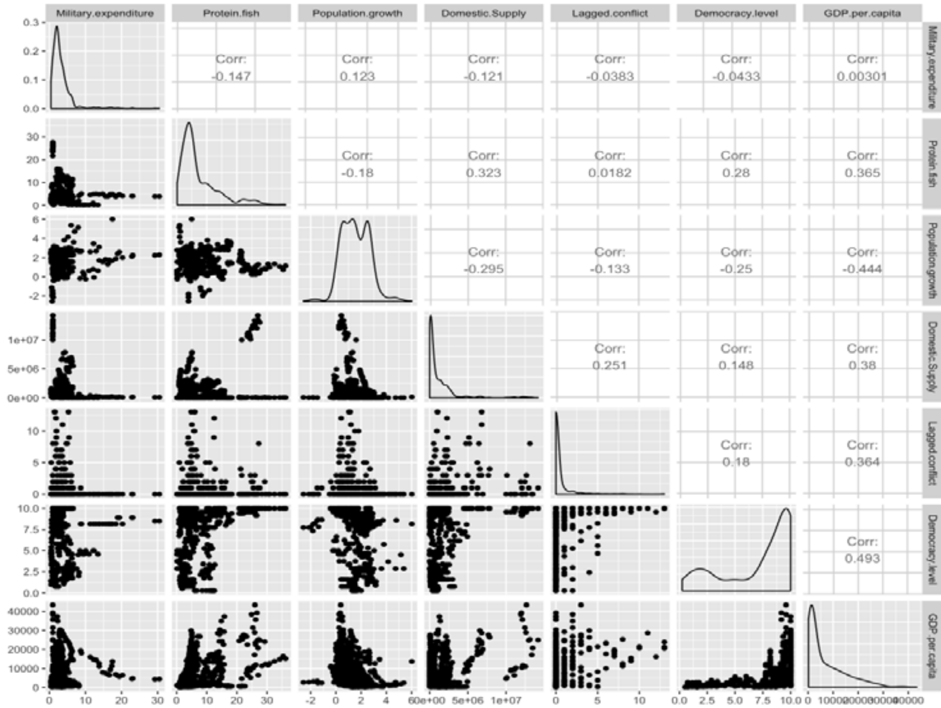

Figure 3: Collinearity matrix of all predictors used in time 1. Scatterplots of each pair of variables are drawn on the left part of the figure. Pearson correlation is displayed on the right. Variable distribution is available on the diagonal.

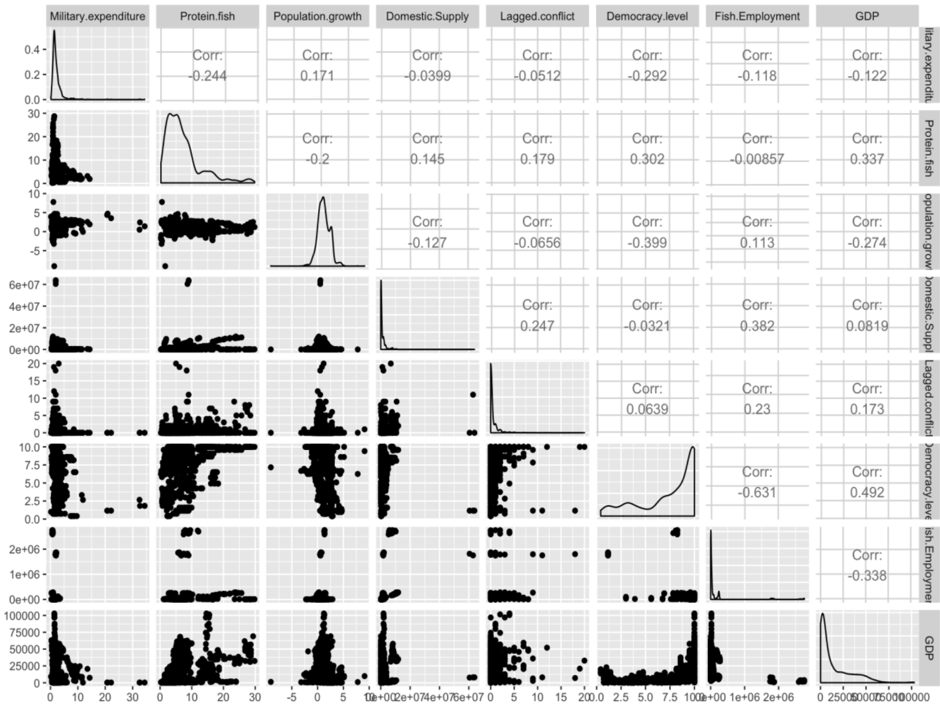

Figure 4: Collinearity matrix of all predictors used time 2. Scatterplots of each pair of variables are drawn on the left part of the figure. Pearson correlation is displayed on the right. Variable distribution is available on the diagonal.

Supplementary Information (Tables)

Table 1: Categorization of fishery conflict intensities, linked to their observable actions and behaviors. From Spijkers et al. (2018).

Intensity of observed behavior/action	
Intensity	**Description**
5	**Military acts causing death** - Attack of foreign vessels, crew members or Coast Guards, with resulting deaths
4	**Military acts** - Attack of foreign vessels, crew members or Coast Guards, no death toll
3	**Political-military hostile acts** - Sending out police vessels/ warships - Seize vessel and/or crew - Gear destruction

	- Reinforcing borders
2	**Diplomatic-economic hostile acts** - Breaking or not adhering to existing agreement - Lawsuit - Trial in court - Seeking international arbitration - Trade ban - Fishing ban - Landing ban - Monetary penalties - Close ports
1	**Verbal expressions displaying discord or hostility in interaction** - Failing to reach an agreement - Making threatening demands and accusations - Threatening sanctions - Condemning specific actions, behaviors or policies - Requesting change in policy - Civilian protests
0	**Non-significant acts**

Table 2: Model output for piecewise regression (non-smoothed conflict data).

Estimated Break-Point(s):			
	Estimate	Standard error	
psi1.Year 1997	.001	0.665	
psi2.Year 2000	.592	0.640	
Meaningful coefficients of the linear terms:			
	Estimate	Standard error	Pr(>|z|)
Year	0.08235	0.00729	<2e-16 ***

Table 3: Model output for piecewise regression (smoothed conflict data).

Estimated Break-Point(s):			
	Estimate	Standard error	
psi1.Year 1997	.600	0.492	

psi2.Year 2000	.372	0.595	
Meaningful coefficients of the linear terms:			
	Estimate	Standard error	Pr(>|z|)
Year	8.781e-02	8.688e-03	<2e-16 ***

Table 4: VIF GLM time 1 and time 2

VIF GLM time 1				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
11.985440	10.570221	14.645303	12.439507	54.733523
Lagged.conflict	Population.growth			
2.712484	61.190335			

VIF GLM time 2				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
4.786557	2.442451	7.336159	7.536486	34.796513
Lagged.conflict	Population.growth	Fish.Employment		
1.572068	440.609532	2.910195		

Table 5: VIF GLMM time 1 and time 2

VIF GLMM time 1				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
1.583126	1.932557	2.189199	1.039492	1.387835
Lagged.conflict	Population.growth			
1.145170	1.371484			

VIF GLMM time 2				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
1.412520	1.159574	1.211319	1.149163	1.788539

Lagged.conflict	Population.growth	Fish.Employment		
1.133511	1.188923	1.880709		

Table 6: VIF BRT time 1 and time 2

VIF BRT time 1				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
2.06961963046066	1.89199108660472	2.19863849629937	1.05238756675354	1.69385341229303
Lagged.conflict	Population.growth			
1.25528003013157	1.63734984395398			

VIF BRT time 2				
GDP.per.capita	Domestic.supply	Protein.fish	Military.expenditure	Democracy.level
1.45891694175485	1.3812874889229	1.35083780098208	1.12635084669414	1.9960401343546
Lagged.conflict	Population.growth	Fish.Employment		
1.25478797932616	1.21507779326884	1.94009719147059		

Table 7: BRT results time 1

Model parameters: a tree complexity of 3, a learning rate of 0.001, number of trees set at 800 and a bag fraction of 0.75.

Total.Deviance	2.0601176
Residual.Deviance	0.8616932
Correlation	0.8280932
AUC	0.0000000
Per.Expl	58.1726208
cvDeviance	1.2323207
cvCorrelation	0.5996819
cvAUC	0.0000000
cvPer.Expl	40.1820195

Table 8: ZINB GLM results time 1

Count model coefficients (negbin with log link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-0.01828	1.30310	-0.014	0.98881
GDP.per.capita	-0.20168	0.79031	-0.255	0.79858
Domestic.supply	1.20459	0.92643	1.300	0.19351
Protein.fish	-1.86071	1.35763	-1.371	0.17051
Democracy.level	1.18338	0.77723	1.523	0.12787
Military.expenditure	-1.19697	3.42074	-0.350	0.72640
Lagged.conflict	1.53617	0.47588	3.228	0.00125 **
Growth.population	-0.42474	1.82226	-0.233	0.81570
Log(theta)	0.37867	0.31946	1.185	0.23589
Zero-inflation model coefficients (binomial with logit link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.07414	1.41816	0.052	0.958307
GDP	-6.22271	1.69162	-3.679	0.000235 ***
Domestic.supply	-3.22221	1.46331	-2.202	0.027666 *
Protein.fish	2.83389	1.93507	1.464	0.143061
Democracy.level	1.40043	0.94796	1.477	0.139593
Military.expenditure	1.71233	3.06762	0.558	0.576711
Lagged.conflict	-4.13908	1.66194	-2.491	0.012756 *
Growth.population	2.22541	2.00704	1.109	0.267515
Theta = 1.4603				
Number of iterations in BFGS optimization: 28				
Log-likelihood: -409.7 on 17 Df				

Table 9: Results of GLMM time 1

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation)				
AIC	BIC	logLik	deviance	df.resid
878.3	921.5	-429.2	858.3	542
Scaled residuals:				
Min	1Q	Median	3Q	Max
-0.6446	-0.3899	-0.3090	-0.2306	0.2292
Random effects:				
Groups	Name	Variance	Std.Dev.	
X	(Intercept)	0.5963	0.7722	
Number of obs: 552	groups: X, 28			
Fixed effects:				

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.5244	0.7474	-2.040	0.041394 *
GDP	3.0714	0.8773	3.501	0.000463 ***
Domestic.supply	2.4764	1.3486	1.836	0.066331 .
Democracy.level	0.2996	0.7024	0.426	0.669765
Protein.fish	-2.4212	1.7904	-1.352	0.176257
Military.expenditure	-2.6367	2.3191	-1.137	0.255572
Lagged.conflict	1.5205	0.6758	2.250	0.024450 *
Population.growth	-2.6453	1.7593	-1.504	0.132683

Correlation of Fixed Effects:

	(Intr)	GDP	Dmstc.	Dmcrc	Prtn.f	Mltry.	Lggd.c
GDP	0.025						
Dmstc.spply	0.066	-0.156					
Demcrcy.lvl	-0.749	-0.264	0.030				
Protein.fsh	-0.290	-0.162	-0.612	-0.062			
Mltry.xpndt	-0.227	-0.010	-0.001	-0.029	0.065		
Lggd.cnflct	0.094	-0.286	0.043	-0.066	-0.014	0.104	
Ppltn.grwth	-0.650	0.106	-0.059	0.320	0.218	-0.102	-0.112

Table 10: BRT results time 2

Model parameters: a tree complexity of 5, a learning rate of 0.001, number of trees set at 900 and a bag fraction of 0.75.

Total.Deviance	1.8253158
Residual.Deviance	0.7885975
Correlation	0.8440961
AUC	0.0000000
Per.Expl	56.7966527
cvDeviance	1.2442513
cvCorrelation	0.4356522
cvAUC	0.0000000
cvPer.Expl	31.8336411

Table 11: ZINB GLM results time 2

Count model coefficients (negbin with log link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-5.6450	1.9748	-2.858	0.004257 **
GDP.per.capita	0.4451	0.5517	0.807	0.419854
Domestic.supply	3.5428	1.9415	1.825	0.068034 .
Protein.fish	2.6083	0.6561	3.975	7.03e-05 ***
Democracy.level	0.8000	0.5763	-1.388	0.165075
Military.expenditure	12.9729	5.5463	2.339	0.019335 *
Lagged.conflict	4.9257	1.3211	3.729	0.000193 ***
Growth.population	7.4385	3.5087	2.120	0.034008 *
Fish.Employment	0.8768	0.6174	1.420	0.155551
Log(theta)	-0.1757	0.2254	-0.780	0.435557
Zero-inflation model coefficients (binomial with logit link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	114.820	78.766	1.458	0.145
GDP.per.capita	3.259	16.268	0.200	0.841
Domestic.supply	2.402	10.464	0.230	0.818
Protein.fish	20.893	14.936	1.399	0.162
Democracy.level	54.044	35.815	1.509	0.131
Military.expenditure	824.609	522.340	1.579	0.114
Lagged.conflict	42.969	31.626	1.359	0.174
Growth.population	-455.880	-455.880	-1.543	0.123
Fish.Employment	78.641	50.861	1.546	0.122
Theta = 0.8388				
Number of iterations in BFGS optimization: 2887				
Log-likelihood: -395.3 on 19 Df				

Table 12: GLMM results time 2

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation)				
AIC	BIC	logLik	deviance	df.resid
839.4	884.4	-408.7	817.4	429
Scaled residuals:				
Min	1Q	Median	3Q	Max
-0.8278	-0.4920	-0.3672	0.0173	8.6270
Random effects:				
Groups	Name	Variance	Std.Dev.	

X	(Intercept)	0.2665	0.5162	
Number of obs: 440	groups: X, 26			
Fixed effects:				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.3755	0.9317	-1.476	0.139872
GDP	0.8056	0.7576	1.063	0.287632
Domestic.supply	1.2808	1.1220	1.141	0.253664
Democracy.level	-1.4527	0.8401	-1.730	0.08358 .
Fish.Employment	0.9417	0.8313	1.133	0.257324
Protein.fish	3.2177	0.9302	3.459	0.000542 ***
Military.expenditure	4.1042	8.3194	0.493	0.621778
Lagged.conflict	1.8789	1.2283	1.530	0.126108
Population.growth	8.4098	4.1423	2.030	0.04233 *

Correlation of Fixed Effects:								
	(Intr)	GDP	Dmstc.	Dmcrc	Fsh.Emplymn	Prtn.f	Mltry.	Lggd.c
GDP	-0.023							
Dmstc.spply	-0.073	-0.050						
Demcrcy.lvl	-0.821	-0.218	0.117					
Fsh.Emplymn	-0.546	0.263	-0.159	0.490				
Protein.fsh	-0.125	-0.211	-0.207	-0.126	-0.138			
Mltry.xpndt	-0.541	0.139	0.032	0.163	0.245	-0.068		
Lggd.cnflct	-0.116	-0.102	0.204	0.179	-0.100	-0.173	0.014	
Ppltn.grwth	-0.177	-0.209	0.037	-0.053	-0.207	0.244	0.154	0.007

Table 13: Results of BRT without employment

Total.Deviance	1.8253158

Residual.Deviance	0.8457307
Correlation	0.8039740
AUC	0.0000000
Per.Expl	53.6666105
cvDeviance	1.2184492
cvCorrelation	0.4469995
cvAUC	0.0000000
cvPer.Expl	33.2472135

Table 14: Results of ZINB GLM without employment

Count model coefficients (negbin with log link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.05653	1.12824	-0.936	0.3490
GDP.per.capita	0.16370	0.51997	0.315	0.7529
Domestic.supply	3.95801	1.01323	3.906	9.37e-05 ***
Protein.fish	1.19910	0.53838	2.227	0.0259 *
Democracy.level	0.02571	0.36412	0.071	0.9437
Military.expenditure	4.38959	2.97046	1.478	0.1395
Lagged.conflict	5.08320	0.98114	5.181	2.21e-07 ***
Growth.population	-0.34175	1.82244	-0.188	0.8513
Log(theta)	-0.37807	0.16168	-2.338	0.0194 *
Zero-inflation model coefficients (binomial with logit link):				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	1.0755	2.1692	0.496	0.62002
GDP	-1.7705	1.6184	-1.094	0.27395
Domestic.supply	-71.5552	25.4029	-2.817	0.00485 **
Protein.fish	1.4120	1.6591	0.851	0.39471
Democracy.level	0.6737	1.0032	0.672	0.50186
Military.expenditure	8.6029	5.2797	1.629	0.10322
Lagged.conflict	-45.3797	21.7630	-2.085	0.03705 *
Growth.population	-1.9172	3.2316	-0.593	0.55300
Theta = 0.6852				
Number of iterations in BFGS optimization: 105				
Log-likelihood: -832.8 on 17 Df				

Table 15: Results of GLMM without employment

Generalized linear mixed model fit by maximum likelihood (Laplace Approximation)

AIC	BIC	logLik	deviance	df.resid
1702.8	1752.6	-841.4	1682.8	1069
Scaled residuals:				
Min	1Q	Median	3Q	Max
-0.7734	-0.4349	-0.3192	-0.2710	7.7907
Random effects:				
Groups	Name	Variance	Std.Dev.	
X	(Intercept)	0.6242	0.7901	
Number of obs: 1079	groups: X, 58			
Fixed effects:				
	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-1.73487	0.51524	-3.367	0.00076 ***
GDP	0.71646	0.67789	1.057	0.29056
Domestic.supply	3.79510	1.32148	2.872	0.00408 **
Democracy.level	-0.27826	0.50339	-0.553	0.58041
Protein.fish	2.17422	0.85789	2.534	0.01127 *
Military.expenditure	-2.89693	3.46971	-0.835	0.40376
Lagged.conflict	4.98655	1.06101	4.700	2.6e-06 ***
Population.growth	-0.9966	1.9691	-0.506	0.61277

Correlation of Fixed Effects:

	(Intr)	GDP	Dmstc.	Dmcrc	Prtn.f	Mltry.	Lggd.c
GDP	0.185						
Dmstc.spply	-0.006	0.001					
Demcrcy.lvl	-0.382	-0.220	-0.210				
Protein.fsh	-0.753	-0.415	0.010	-0.010			
Mltry.xpndt	-0.547	-0.036	0.039	0.119	0.221		
Lggd.cnflct	-0.022	0.029	0.115	-0.131	-0.023	0.099	
Ppltn.grwth	-0.355	0.003	0.063	0.121	0.147	-0.030	0.028

IV

Anticipating the future of fisheries conflict through narrative scenarios

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Abstract
Recent studies suggest that global climate change and subsequent shifts in fish species distribution could dramatically increase the likelihood of fisheries conflict. However, existing ecological projections often neglect wider economic, social and political trends when assessing the likelihood of, and influences on, future conflict trajectories. In this paper, we build four future fisheries conflict scenarios by integrating longitudinal scientific evidence on international fisheries conflict with expert data on fishery conflict trends and drivers. The scenarios take place in the years 2030 to 2060 in the North-East Atlantic (“Scramble for the Atlantic”), the East China Sea (“The Remodeled Empire”), the coast of West Africa (“Oceanic Decolonization”), and the Arctic (“Polar Renaissance”). The scenarios illuminate how the different decisions made today can lead to dramatically different future paths. Moreover, they aim to inspire policy makers to work with exploratory scenario processes to build anticipatory capacity in the pursuit of future ocean security.

Introduction
Global changes in our climate, and as a consequence, in our oceans and related food systems, are projected to spark or exacerbate fisheries conflict. Fisheries conflicts are here defined as disagreements between two or more actors that center on the ownership or management of marine fishery resources (Nyman 2013, Pinsky et al. 2018, Spijkers et al. 2019). Climate change is leading to changes in the ocean’s water temperature, ocean currents and coastal upwelling patterns, which in turn alters the distribution and potential yields of marine species (Cheung et al. 2010, Sumaila et al. 2011, Costello et al. 2016, Wabnitz et al. 2018). Shifts in species’ abundance and distribution, and consequently their catch potential, can spur conflict and compromise security, for example through disrupting the management of fish stocks (Pinsky et al. 2018, Spijkers & Boonstra 2017). Other stressors such as habitat

destruction, pollution and overfishing exacerbate the negative impacts on marine species and their catch potentials (Wabnitz et al. 2018). Overfishing has resulted in declining catches, species collapse and even extinction (Pauly & Zeller 2016, Cabral et al. 2018, McCauley et al. 2015). In 2015, the percentage of stocks fished at biologically unsustainable levels was 33.1 percent, up from 10 percent in 1974 (FAO 2018). Aside from reducing fish catches and inciting further competition, overfishing can also directly increase instances of Illegal, Unreported and Unregulated (IUU) fishing (Österblom et al. 2011), which has led to an increasing array of conflicts, ranging from diplomatic spats to violent clashes (Kim 2012, Spijkers et al. 2019).

Scholars and policy makers are warning of a possible increase in fisheries conflicts due to such pervasive changes in our global ocean and fisheries (Nyman 2013, IPCC 2014, Glaser et al. 2018, Pinsky et al. 2019, Spijkers et al. 2019), yet climate conflict scholarship reminds us that there is no consistent, direct connection between climate change, natural resources management and conflict (Hendrix 2018, Buhaug et al. 2014, Gemenne et al. 2014). Instead, climate change can increase the risk for conflict through multiple pathways. To what degree these risks manifest as conflict within marine social-ecological systems (SES) is dependent on a diverse set of inter-related socio-political factors (Mach et al. 2019, van Baalen and Mobjörk 2018, Hegre et al. 2016), such as vulnerable livelihoods (see Theisen 2008, Barnett & Adger 2007), weak states (see Barnett & Adger 2007) or institutional design failures (see Penney et al. 2017, Dinar et al. 2015, Theisen 2008). Our understanding of the impacts of these contextual factors is important to integrate with knowledge on pervasive ecological changes in marine ecosystems if we are to gain more detailed insights into possible future trajectories for fisheries conflict.

Due to the inherent uncertainty and complexity associated with human-climate connections, integrating such contextual factors with patterns of environmental change so as to forecast when and where conflicts can arise within marine SES is challenging. Achieving accurate forecasts is a notorious problem for complex SES particularly due to difficulties in predicting human behavior and social systems (Lade & Niiranen 2017, Müller-Hansen et al. 2017). Long-term security planning, for example, has been repeatedly criticized for employing conventional quantitative analyses that downplay the subjectivity and interpretative elements of assessing risk (Bostrom and Cirkovic 2008, van Asselt and Renn 2011). Such conventional analyses have also been critiqued for their linear approach to cause and effect (Buhaug et al. 2014, Frank et al. 2014, Jore et al. 2018). Qualitative scenarios can assist in overcoming these challenges by allowing for the examination of a broader range of intervening variables. They are therefore an important tool to help policy makers think through uncertainties about the future, and decide on strategic directions that are robust to a variety of outcomes (Vervoort & Gupta 2018). Moreover, they can be used not only to identify emerging trends, but also to actively magnify or subvert different trends and to consider implications of the multiple futures generated (Boenink 2013, van Baalen & Mobjörk 2018). This feature caters to the fact that many trends that appear inevitable end up having negligible impacts ('non-events'), while minor trends or nearly invisible 'slow variables' that operate outside of established governance structures can have a much bigger influence in shaping the future (e.g. 'femtorisks') (Frank et al. 2014).

Exploratory scenarios are one of a range of tools that have been widely used to consider different futures related to complex socio-environmental problems (Riddell et al. 2018). Exploratory scenarios can help escape deterministic forecasts of the future and provide more creative and complex narratives about future developments, which are essential if we are to explore the robustness of decision-making strategies (Riddell et al. 2018, Lord et al. 2016). However, exploratory scenarios have also been critiqued for their lack of creativity and underdeveloped communicative qualities, prompting more researchers to incorporate story-telling, creative narration and imagination into scenario building (Goulden & Dingwall 2012, Burnam-Fink 2015, Merrie et al. 2018). Marrying scientific fact and a systematic methodological approach with story-telling techniques is also imperative for the expansion of the scientific process and the engagement of a wider audience (Goulden & Dingwall 2012, Burnam-Fink 2015, Merrie et al. 2018, "Learn to tell science stories" 2018).

Here, we explore different future scenarios for fisheries conflict by combining scientific evidence with creative story-telling techniques. The scientific evidence base for the scenarios consists of:

i. An expert workshop on fisheries conflict (identifying key drivers and conditions which contribute to conflict and potential case studies);
ii. Conflict trend data from the International Fishery Conflict Database (Spijkers et al. 2019) (validating final case study selection);
iii. Scientific literature on fisheries conflict cases; and scientific, technical and policy literature related to conflict drivers (validating conflict drivers and conditions, and identifying driver trends for each case study).

Using this evidence base, we built four fisheries conflict narrative scenarios for the years 2030 to 2060 in the North-East Atlantic ("Scramble for the Atlantic"), the East China Sea ("The Remodeled Empire"), the coast of West Africa ("Oceanic Decolonization"), and the Arctic ("Polar Renaissance"). In addition to the expert workshop, external regional experts reviewed each narrative to enhance its validity and robustness. To enhance scenario diversity and account for different leverage points in the trajectories described, experts identified alternative discrete events or longer trends where the scenario would, or could have, taken a different path.

Results

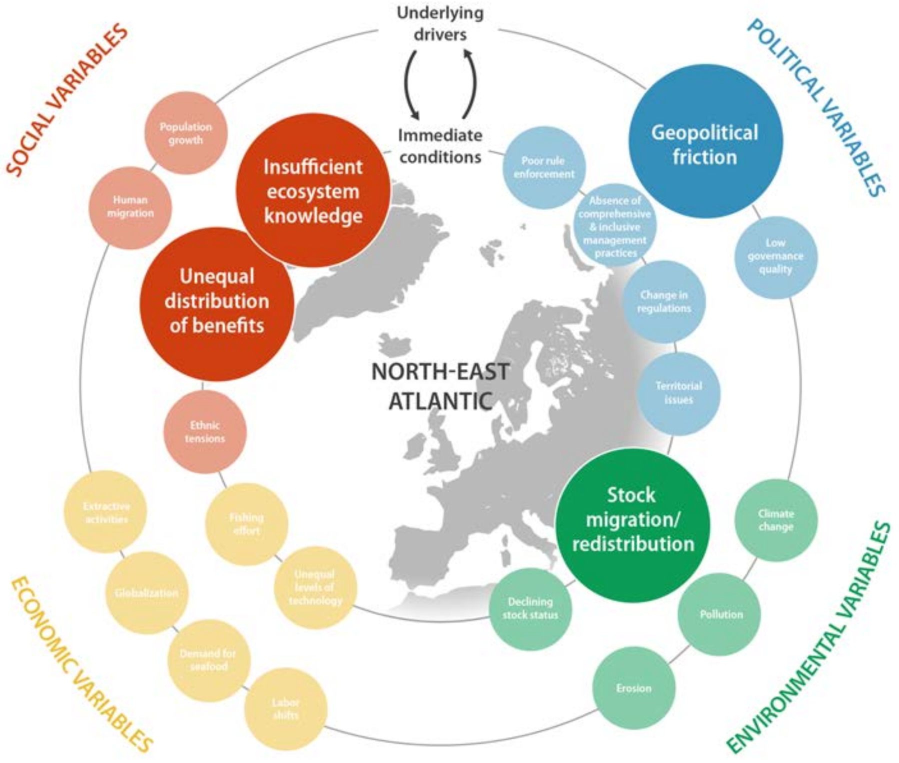
We found that 23 economic, social, political and environmental drivers and conditions have been linked to the onset of fisheries conflict (Table 1). Climate change is not the only driver of future fisheries conflict. Rather, it is a specific configuration of underlying drivers and immediate conditions that causes systemic instability in marine SES from which conflict episodes emerge (Boxes 1-4). Underlying *drivers* are forces operating at local, national or global levels that may shape situational factors in such a way that conflict becomes more likely, while *conditions* are explicitly linked, both spatially and temporally, to the conflict (Geist & Lambin 2002, Helbing 2013).

Table 1: Political, social, economic and environmental drivers and conditions that have triggered fisheries conflict. The relationship between the variables listed here and fisheries conflict are positively correlated. Case study examples for each variable are listed in SI Tables 1-4.

	Underlying drivers	Immediate conditions		Underlying drivers	Immediate conditions
POLITICAL VARIABLES	Geopolitical friction (changing power dynamics/unstable international context) Low quality of governance (high levels of corruption, low press freedom)	Poor rule enforcement/ patrolling Absence of comprehensive and inclusive management practices Change in international/national/local regulations/rules (in relation to access to fishery space/EEZ, fishery resources, or participation rights) Territorial issues (e.g. maritime boundary delimitations, disputed islands)	**ECONOMIC VARIABLES**	Extractive activities (e.g. oil, gas) Globalization (increased connectivity, trade) Demand for seafood Labor shifts from agriculture to fisheries	Fishing effort (the number of boats and the cumulative power of their engine) Unequal levels of technology available
	Underlying drivers	**Immediate conditions**		**Underlying drivers**	**Immediate conditions**
SOCIAL VARIABLES	Human migration/ displacement Population growth	Unequal distribution of benefits (real or perceived) Ethnic tensions Insufficient ecosystem knowledge	**ENVIRONMENTAL VARIABLES**	Climate change Pollution Soil erosion	Stock migration/ redistribution Declining stock status (abundance/health of stock)

Scenario development revealed that the underlying drivers and immediate conditions for conflict vary across time and space. Different drivers and immediate conditions can become amplified in different regions at different times. For example, the East China Sea and West Africa scenarios feature eight magnified drivers and conditions, while the Arctic scenario features six. The North East Atlantic scenario features four distinct drivers and conditions. The variable 'unequal distribution of benefits' is the main point of commonality across the four scenarios (Boxes 1-4).

Box 1. The North-East Atlantic: “Scramble for the Atlantic”

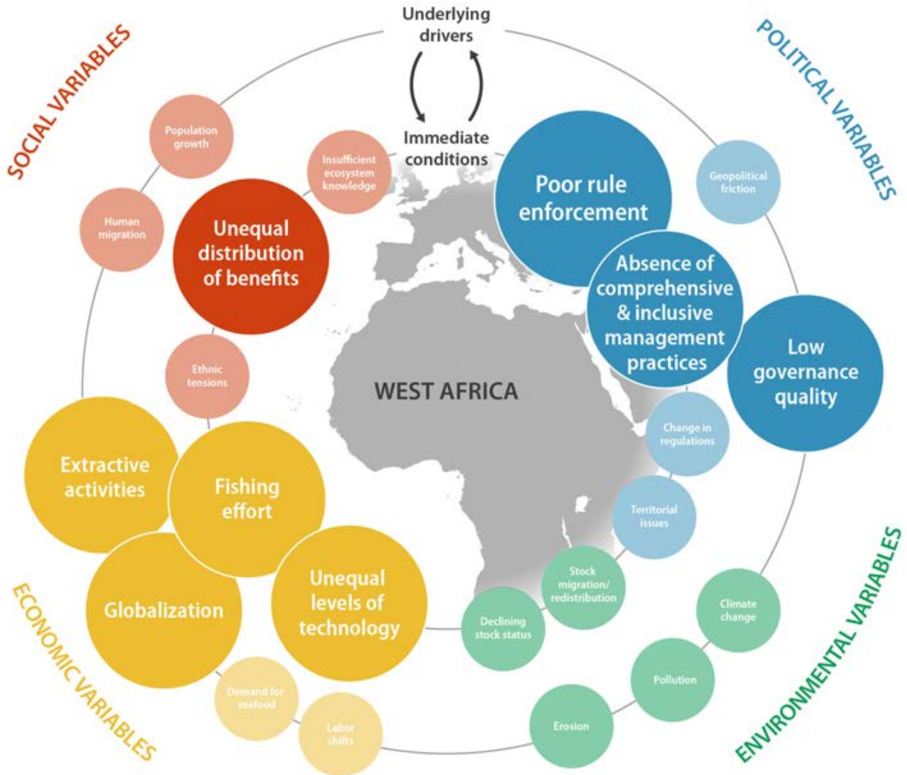


It is 2030. Climate change has been left unchecked, and fish stocks have migrated north. Great Britain, now no longer part of the EU, is attempting to negotiate with the New Nordic Alliance (Iceland, Greenland and the Faroe Islands) to regain access to fish it traditionally has rights to, but no longer has direct access to. The fish have migrated north, and Great Britain has not managed to negotiate any access agreements with other states. Current stock extent and stock abundance are both subject to intense debate and misinformation. Scientific and political cooperation and neutrality between states has broken down, obstructing any deal from being realized. Regional Fisheries Management Organizations are powerless, and with no functioning sanctions or dispute mediation tools in place, international law has become ineffective. The Ministers responsible for Great Britain's fisheries have called a diplomatic meeting with fisheries Ministers in the ‘New Nordic Alliance’ in an attempt to resolve escalating tension (read the full scenario in SI: Narratives).

Box 2. The East China Sea: “The Remodeled Empire”

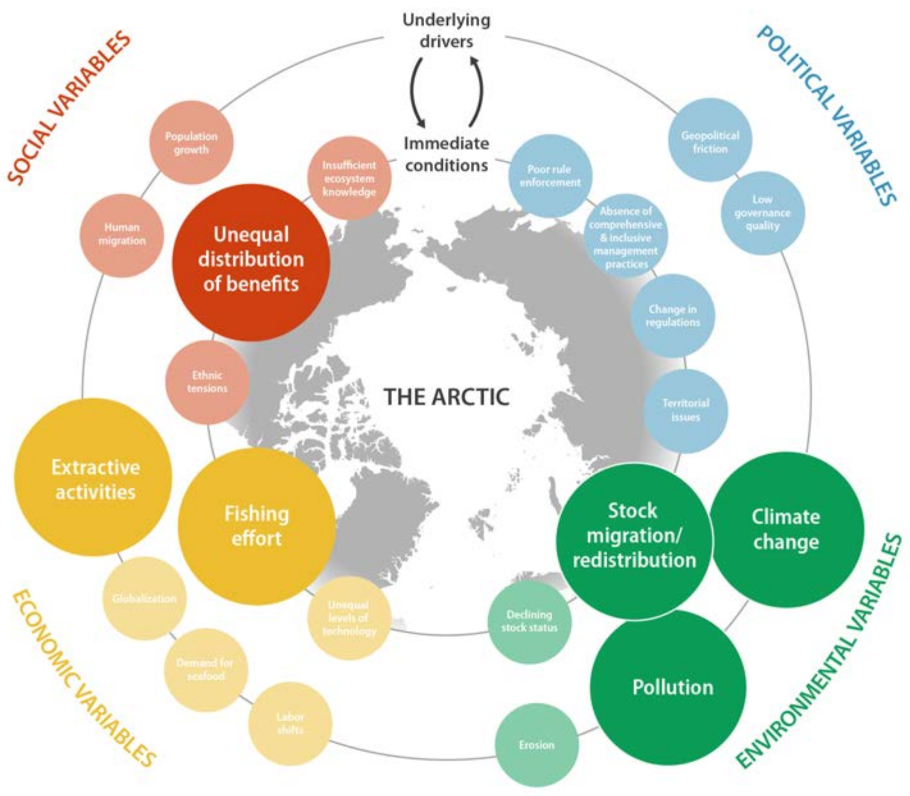
It is 2045. After countless confrontations at sea, full-blown military conflict has now broken out in the East China Sea. The triggering incident was a seemingly accidental confrontation between a Chinese nuclear-powered ballistic missile submarine and a Japanese fishing vessel. Numerous vessels have been seized and sunk, citizens are being illegally detained in both countries, and more than 200 people have already lost their lives. Many ASEAN members have lost their trust and patience after decades of illegal fishing, undermining of peaceful conflict resolution processes, territorial disputes, and at-sea aggression from China. Japan and different ASEAN countries are beginning to signal that they no longer support the diplomatic approach of the United Nations (UN) and the European Union. The conflict is set to escalate further as new countries enter into open conflict. The United States of America has sent navy vessels to its ally, Japan, and the conflict is on the brink of spilling over into the South China Sea. A UN Security Council meeting has been set up in New York to call for concrete action and prevent further escalation (read the full scenario in SI: Narratives).

Box 3. The coast of West Africa: "Oceanic Decolonization"



It is 2045. After a deadly confrontation between small-scale fishers and massive international trawlers, fishers across West Africa have banded together to take back control of their fisheries and infrastructure in a movement called 'Ocean Decolonization'. Using the judicial system, they are overturning decades of foreign overexploitation and control of marine resources and local infrastructure, which for decades had been enabled by debt traps and systemic corruption. Growing regional unity and international and local political support has empowered them to fight for the renegotiation of access agreements and the reclaiming of infrastructure and resources. West African fishers are looking forward to a future free from foreign ocean exploitation with an abundance of opportunities to grow and harvest seafood. Beyan Boakai, the representative of Liberia for the West African Fishing Fleet, has become a local hero, celebrated for his fight in the Ocean Decolonization movement (read the full scenario in SI: Narratives).

Box 4. The Arctic: "Polar Renaissance"



It is 2060. A decade ago, climate change and hunger for resources in the Arctic had pushed the region to the brink of military conflict. Retreating sea ice had allowed untapped expansion into remote Indigenous lands in pursuit of fossil fuels and boreal fish. At first, a new economic opportunity beckoned for young Yakuts, the Russian people, industrial fishers and energy companies. However, Russian military presence and competition over fish increased political tensions and led to numerous at-sea confrontations between Russia and other Arctic states. Then, on the brink of full-blown armed conflict, the carbon bubble finally burst. Oil and gas prices collapsed and Russia, a long-time petrostate, became saddled with skyrocketing debt. Indigenous communities suffered rapid socio-economic decline. The International Monetary Fund (IMF) used this opportunity to force Russia to stop its military build-up in the Arctic. The initial conflict and economic downturn also catalyzed a region-wide process of Arctic reconciliation and Indigenous empowerment. International climate reparations enabled the development of a joint Arctic trust fund to support Indigenous-led transformation. Sardana Nikolaev, an indigenous Yakut and CEO of Sakha Fishing, emphasizes the importance of Arctic unity at the fifth anniversary celebration of the historic Arctic reconciliatory meeting (read the full scenario in SI: Narratives).

We also found, through the alternative pathways provided by the expert reviewers (SI: Alternative pathways), that key drivers could drastically change the trajectory of the scenarios, thus illuminating possible policy interventions that could be part of a plan for conflict mitigation or de-escalation. For example, alternative pathways for the North-East Atlantic and Arctic scenarios elucidated the importance of building fishery management agreements and partnership networks that are robust to volatile geopolitics and changes in the environment brought on and/or exacerbated by climate change. The East China Sea scenario revealed the importance of more effective Chinese domestic policy regarding fisheries management. Similarly, for the West Africa focal area, it is the future direction of West African fisheries management, and how the region as a whole decides to tackle the tension between foreign fleets and local fishers, that shapes the direction (Boxes 1-4; SI: Narratives; SI: Alternative pathways).

Discussion

Fisheries conflict is characterized by multiple drivers that interact and intervene between cause and effect, and different regions exhibit varying levels of vulnerability to fisheries conflict. However, low-intensity, non-escalatory conflict can also unlock stronger modes of cooperation, and climate change in particular increases the likelihood of both conflict and transformation. We examined potential pathways for future fisheries conflict through the generation of four distinct science-based narrative scenarios that explore the implications of ongoing trends in conflict-prone regions of the world. Exploratory scenarios are a promising tool to investigate how different decisions made today can lead to dramatically different future paths, and how one can build anticipatory governance capacity in the pursuit of future ocean security. We highlight four key lessons.

‘Priming the pump’ for conflict

The sheer volume and complexity of conflict drivers reflects the reality that fisheries conflict is embedded as part of a complex, social-ecological system (Spijkers et al. 2018, Levin et al. 2013). The unequal distribution of benefits, real or perceived, is generally the social condition that ultimately triggers conflict (see Coulthard et al. 2011 - ‘disparate cost/benefit outcomes’), unless an intervention mitigates it. As shown, the unequal allocation of resources, or access to them, is not always the outcome of biophysical triggers (such as absolute resource scarcity), but also of certain configurations of political economies that govern modes of appropriation and distribution (Le Billon 2015). However, the intersection of biophysical changes (such as shifting species distributions prompted by climate change) and existing political economic realities can supercharge inequalities and 'prime the pump' for conflict.

Conflict vulnerability awareness

Different regions exhibit varying levels of vulnerability to fisheries conflict, as some systems are exposed to a wider range of socio-economic, environmental and political pressures (Jiminez et al. 2019). However, the message of the scenarios is not that West Africa is more vulnerable to conflict than the Arctic for example, and thus requires more immediate attention, as by using different input variables the picture could look different. Rather, the scenarios create awareness around the differential vulnerability across regions when there are more pressure points that can collectively act as a catalyst for sparking or entrenching fisheries conflict. Low quality governance, pre-existing ethnic tensions or increasing (local) demand for seafood are just some of the pressures that can shape a region's socio-political and economic profile so as to increase the propensity for fisheries conflict (see Scholtens & Bavinck 2018, Pomeroy et al. 2016).

The transformative role of climate change

Pervasive and often unpredictable impacts from climate change could increase the likelihood of conflict in least-likely cases. There is increasing evidence of climate change impacts on marine systems (Cheung et al. 2010, Sumaila et al. 2011, Costello et al. 2016, Wabnitz et al. 2018), however the degree of exposure to these impacts varies greatly across countries and regions, especially when one takes into account differences in both sensitivities and adaptive capacities (Blasiak et al. 2017). Nevertheless, climate change is projected to disrupt fisheries management even in well-organized, good governance areas (Pinsky et al. 2019), making fisheries conflict more likely in areas that otherwise exhibit fewer social, economic and political stressors, as has been the case in the northeast Atlantic mackerel conflict (Spijkers & Boonstra 2017). Climate change is increasingly framed as a growing security threat due to its overwhelming capacity in driving vulnerabilities through multiple pathways. It is worth noting, however, that a higher number of drivers and conditions may also offer more potential pathways for taking advantage of windows of opportunity (Chapin et al. 2009). We should therefore consider if the most volatile regions could in fact be arenas for transformation.

Productive conflict

Fisheries conflict does not always lead to undesirable societal outcomes. Low-intensity, non-escalatory conflict can even be productive by pushing forward public debate, incubating social justice movements, breaking down path dependencies, generating new norms and institutional structures, and thus contributing to stronger cooperation (Scholtens & Bavinck 2018, Larsen & Nilsson 2017, Scheidel et al. 2017). For instance, fisheries conflicts in the 1960s and 1970s led to the establishment of EEZs, proving that conflict can be transformative and lead to stronger institutions for fisheries management. Likewise, conflict between fisherpeople of Sri Lanka and India has been a catalyst for bottom-up policy development (Scholtens & Bavinck 2018). Our scenarios explore the transformative capacity of conflict, and we specifically articulate this potential in the Arctic and West Africa scenarios. In both narratives, initial conflict and breakdown led to a renewal process, better regional cooperation, stronger institutions, and more accountability to the regions' inhabitants. In the West Africa scenario, local resource-users banded together to collectively face the perceived shared threat of foreign overfishing (see social identity theory on how this 'banding together' could unfold, Tajfel & Turner 1979). In the Arctic scenario, the IMF used its leverage as a global regulatory institution to coerce non-cooperative states into adopting structural adjustment policies with great political implications for regional peace. Both scenarios exemplify how conflict can be short-circuited by either social or institutional mechanisms, especially when precipitated by disruptive environmental change, to unlock stronger modes of cooperation.

Building anticipatory governance capacity through narrative scenarios

The conflict narrative scenarios are not only scientifically valid articulations of four conflict futures in which conflict drivers are magnified to consider the implications in the futures being created, they also function as accessible, science-based communication tools for articulation of complex sets of interactions leading to emergent outcomes.

Exploratory scenarios in general allow us to build an understanding of potential futures of context-specific issues, and provide insights into future vulnerability of complex systems in a way that is not possible with current modelling approaches. Combining participatory elements with imaginative approaches also boosts the utility of the scenarios in multiple ways (Selin 2015, Bell et al. 2013). First, the participatory approach, which here took the form of an expert-led process to generate a set of conflict drivers, allows the creation of more robust future scenarios. Engaging more deeply with regional experts also helps to further illuminate the inherent radical uncertainty of social-ecological change and legitimizes possible policy interventions for conflict mitigation. Second, the storytelling approach can increase engagement with a more diverse audiences, and can help inspire readers to work towards desirable change (Pereira et al. 2019, Merrie et al. 2018, Milkoreit 2016, Burnam-Fink 2015). Indeed, because of the transformative role that imagination can play, imaginative approaches are now finding their way into the international policy arena (such as the 'Nature Futures' work within the context of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Pereira et al. 2019)). We hope that continued creative and participation-led scenario development can enable the dialogical and imaginative policy experimentation space that is necessary to pre-empt and short-circuit conflict, and build anticipatory capacity in service of fostering future ocean security.

Materials

The materials that make up the scientific evidence base for the four fishery conflict scenarios stem from:

a) The results derived from an expert workshop comprised of 11 participants hosted at the facilities of the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, USA (October 2018). Participants included 11 researchers with expertise in environmental governance, peace and conflict studies, ecology, fisheries, socio-ecological systems, human geography, law and political science. During the workshop, participants discussed what constitutes fisheries conflict; what the drivers of current and potential future conflicts are; and which governance mechanisms could ensure conflict prevention or mediation. The data resulting from this workshop is used in this paper as a scientific foundation to support the selection of case studies and conflict drivers (SI Methods: Workshop).
b) The International Fishery Conflict Database (IFCD) (Spijkers et al. 2019). The IFCD contains 531 reported international fishery conflict events between 1974 and 2016 (Spijkers et al. 2019). The last ten years of conflict events in the IFCD were used as an additional axis for case study selection.
c) Secondary literature. Academic papers in Scopus were used to validate the drivers of fisheries conflict with case studies. To understand the expected future trends for those drivers, we relied on academic literature where possible, and also extracted information from technical literature (e.g. reports from NGOs considered authorities in the subject matter, as well as media reports from established sources) retrieved through Google searches.

Methods: Building the scientific evidence base

First, we defined fisheries conflict based on the most recent literature. Fisheries conflicts are disagreements between two or more actors that center on the ownership or management of marine fishery resources (adapted from Spijkers et al. 2019). They can occur between different stakeholders, over varying geographical scales, and be of different intensities, ranging from an exchange of statements to severe military involvement and casualties (Spijkers et al. 2018). We use an inclusive concept of fishery conflict that encompasses, for instance, not only disputes over fish among fisherpeople but also disputes over access to ocean space between the fishery sector and other maritime industries.

Second, we selected four regions in which to set the narratives, based on the latest trends in the prevalence of fisheries conflict and maritime security issues more generally. Such geographical conflict trends (areas where fisheries conflict and maritime security more generally is a current and future concern) were drawn from the expert workshop and the IFCD (Spijkers et al. 2019) (Table 2). The following case study regions were selected:

1. North-East Atlantic. This scenario features actors from the European Union and some of its member states, as well as surrounding nation states. The nations involved in the scenario are the Faroe Islands (Denmark), Great Britain, Iceland and Greenland (Denmark).
2. East China Sea. This scenario features actors from China, Japan, and the United States of America, as well as surrounding South-East Asian states such as South Korea and Malaysia.
3. Coast of West Africa. This scenario features actors from a number of Western African countries spanning Mauritania to Nigeria.
4. Arctic. This scenario involves actors from the Arctic Council members, which are Canada, Greenland (Denmark), Iceland, Norway, Finland, Sweden, the Russian Federation and the United States of America.

Table 2: Selected case studies of fisheries conflict

Region	Narrative title	Selection justification	IFCD supporting events
North-East Atlantic	Scramble for the Atlantic	Multiple fisheries conflicts have already erupted and are ongoing; diplomatic conflict (no at-sea violence).	Iceland, Faroe Islands, Norway & EU conflicts (Mackerel, *Scomber scombrus*). Event timing 2009-2013. Flagged at workshop.
East China Sea	The Remodeled Empire	Multiple fisheries conflicts have already erupted and are ongoing; high likelihood of further escalation due to territorial tensions and economic development.	Japan versus Taiwan and China. Disputes over territory and fishing rights such as Senkaku Islands, and fish (Pacific Saury, Cololabis *saira*). Event timing 2010-2013, 2016. Flagged at workshop.
Coast of West Africa	Oceanic Decolonization	Some fisheries conflicts have already erupted and are ongoing; fisheries important for local livelihoods; important incidences of illegal fishing and unequitable fisheries access.	A few events such as Guinea versus China on IUU (e.g. shark). Event timing 2017. Flagged at workshop.
Arctic	Polar Renaissance	No fisheries conflicts have erupted yet; severe climate change impacts expected to trigger conflict.	Few specific Arctic events (2016). Also tensions over Northern Shrimp quotas between Canada, Denmark and Faroe Islands (2010). Flagged at workshop.

The third step consisted of identifying variables that have already, and could continue to, accelerate the occurrences and/or intensity of conflict. The drivers were drawn from the expert workshop, and identified as political, social, economic and environmental. Later in the workshop the variables were separated into underlying drivers and immediate conditions. This distinction is key for the appropriate design of mitigation policies and measures. As conflict can occur between a multitude of stakeholders on different scales, the drivers are a mix of those relevant for sub-national as well as international/regional contexts. To ensure the validity of the underlying and immediate driving variables, we only retained those variables linked to a peer reviewed fisheries conflict case in which the variable in question was described as having importance in causing conflict (SI Tables 1-4). We did not compile an exhaustive list of all available fisheries conflict cases, but provide a multitude of examples for each considered driver or condition (SI Tables 1-4).

Fourth, we extracted the likely future trends for each of the drivers and conditions in each selected case study region from the latest scientific, technical and policy literature (SI Tables 5- 8), capturing more recent and emerging trends. We selected current (not before 2014) reports from NGOs considered authorities in the subject matter, as well as media reports from established sources, to find trends for the different drivers. For some of the drivers, no trend data could be found. For those drivers where multiple, conflicting trends were reported, we selected the most established authority. The drivers, conditions and their trends were used to build the core of the scenarios, where some were given a dominant role in the narrative by amplifying them. The amplified drivers, conditions and their trends differ among scenarios as specific variables will be more important in certain cases, based in part on the initial conditions within the region (including cultural considerations, history and environmental conditions). Selected variables for amplification were chosen based on a combination of the significance of the trend for the region (to ensure the scenario is plausible), narrative cohesion and scenario diversity. The amplified trends are indicated in schematic representations alongside each scenario.

Finally, we selected an expert reviewer for each region to ensure scientific, socio-economic and cultural validity (increasing the robustness and validity of the scenario), as well as to obtain alternative scenario storylines based on regional in-depth knowledge (SI: Alternative pathways). The alternative storylines not only enhance the diversity of our scenarios, but also ensure that they spanned a wider scope of relevant uncertainty while gaining insight into key potential leverage points in the trajectories. Reviewers were selected based on academic experience in the domain and were asked to identify 1-3 inflection points (discrete events or longer trends) in the narrative where they find the scenario would, or could have, taken a different path.

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Supplemental Information Paper IV

Supplemental Information (Text)
SI: Narratives

For an overview of the additional sources used to build the narratives aside from the scientific evidence base, see SI: Additional sources for narratives.

1. **Scramble for the Atlantic - North-East Atlantic**

Our story begins sometime during the latter half of Earth's so-called twenty-first century. Most of humankind has been working diligently to ignore actually doing anything about the impacts of climactic change except when they can opportunistically take advantage of it. That worked for a while, until it didn't. We deal with a period chiefly labeled as the post-truth era, a time marked by the use of non-knowledge and ignorance as important political forces, where facts are irrelevant and emotion and prejudice rule. With science, and unity out the door, the full consequences of this global experiment escaped nearly all governments and their people. Here is a recording of one such event that occurred at the onset of the period known as The Disintegration.

Great Britain: Good evening

The New Nordic Alliance (NNA): Good evening, we are all here. Can you hear us?

GB: Who is us?

NNA: All of us. The fisheries ministers of Iceland, Greenland, and the Faroese. We have business representatives of the New Nordic Alliance in the room, as well as two of our top scientists. Now. You wanted to once again discuss our fishing in the north-east Atlantic?

GB: Well, as we have previously made clear, Great Britain demands the right to exert the sovereign authority bequeathed to us under international law and to claim the marine resources that are rightfully ours.

NNA: You say Great Britain, but Scotland is eager to leave the UK, your biggest fishing industry, not least because they are fearful for the implications on their shellfish sales. Even Northern Ireland and Wales are ready to jump ship. Hardly 'Great Britain.'

GB: Please do not resort to disparagement and ill-formed suppositions. It is our right to claim the resources that are lawfully ours, and support the rebuilding of our fishing industry.

NNA: Listen. You don't have any fish, they moved North, they are ours now and we have processed most of them already. Our negotiators have been over this countless times, perhaps you should have invested time and money in building vessels and processing facilities for anchovies, our scientists say they're coming in to your waters next.

GB: Forgive us, but that is simply not true. Our scientists, respectable people that do excellent research, tell us they are not all gone from our territory. Our Navy vessels even saw you entering our waters, targeting our fish!

NNA: It is impossible for us to confirm or deny that accusation. Navigation malfunctions of course happen, and that cannot be helped. Why did you not take the opportunity to apprehend the vessel, if you felt it was violating your sovereignty? Why did you not take the opportunity to apprehend the vessel, if you felt it was violating your sovereignty?

GB: Well… We petitioned the European Union for assistance, but they refused to intervene to assist us in enforcing our fishing regulations. This was clearly a retaliatory tactic for the British people deciding to re-establish their sovereign authority. This was most especially the case as we were, regrettably, forced to ban them from our waters after we expelled their fleet… This seemed to have particularly provoked Holland and Belgium who then petitioned the European Commission, supported by France and Denmark to refrain from supporting us in our hour of need.

NNA: Don't be disingenuous. Great Britain left the union without having a fishing agreement in place, and of course Norway is too politically aligned with the EU to discuss any agreement without the EU. You must remember our altercation with regards to EU accession? At the very least, you could have taken a hard look at the numbers – your people don't even want to eat the fish you worked so hard to reclaim. Horse mackerel and chips? Please. You just forced yourself into a situation where buying the fish your people actually want to eat has become much more expensive. Forgive me for my flippancy but In Iceland we have a saying; 'If you can't take the heat, don't swim in a volcanic lake.'

GB: This is a blatant violation of our rights as a fishing nation!

NNA: These fish are in our waters and have been for many years now. Even the North East Atlantic Fisheries Committee admitted it was utterly powerless once fish began swimming all over the North. Essentially, the United Nations Fish Stocks Agreement is no longer applicable. It is archaic, not suited to such a volatile ocean. Besides, we ourselves are struggling to exploit the fisheries resources in our waters. We are sparring with the Russians and the Norwegians. We had to spend a good chunk of our annual GDP to weaponize our fishing fleet, to act as a deterrent and now with our surveillance drones and EMP torpedoes, we can finally secure our stock.

GB: (Outraged) This is not a matter of our honor and some misguided quest to reclaim ancient lost glory, it is a matter of rights. We do not need the European Union or anyone else for that matter to protect what is rightfully ours. Historical catches are a key factor in determining fishing quotas, and we have always caught mackerel and herring. The United Nations Fish Stocks Agreement clearly states that historical rights matter and that even if the fish shifts its distribution, our right to harvest our fairly allocated and agreed quotas remains in effect. This is a blatant violation of our rights under international law.

NNA: We just explained, the fish stocks agreement is functionally void now. You think historical catches, zonal attachment or any other one of those ridiculous metrics we used to adhere to still make sense in this changed environment? The world has changed.
There are no Coastal State agreements anymore, we have even halted our scientific collaborations. Maybe you would have a leg to stand on if you were part of the European fishing fleet still. Perhaps you should have considered a suite of alternative options for supporting your economy before you decided to abruptly exit. Perhaps, a more effective strategy would be to wait until anchovy moves even further north. Besides, if there was mackerel or herring left in your waters, you would not be pleading us to give you access to take a share of ours.

GB: There is most assuredly a significant stock of mackerel remaining, despite your rampant overfishing, despite your unwillingness to negotiate a fair and just total catch! Our scientists recently revised their stock assessment after some early errors and estimated a substantial abundance, for many years to come. Please admit that you are unwilling to negotiate a fair and equitable sharing and access agreement because you are focused on taking advantage of the ecological windfall resulting from climatic shifts. We know that a large part of the stock might have moved north, but our scientists tell us the stock is healthy. There should be enough for us to craft a sharing agreement for the benefit of all parties. This will require, of course, *sustainable* management from the NNA group, and not this reckless jeapordization of the stocks!

NNA: Egg surveys, trawl surveys, none of the established scientific stock assessment methodologies turned out to be very reliable anymore, which is exactly why we exited the scientific collaborations. You are quite correct that years ago, we thought the stock was very abundant and breeding fast, so we fished hard. The Norwegians, the Europeans, even the Russians. We together learned something to our detriment, it turns out that a chaotic free-for-all is not the best way to manage unpredictable fish stocks… And you need to acknowledge your own wrongdoings in this. We, Iceland and Greenland, we did everything we could to support responsible, precautionary management. We tried for years to get a fair management plan! You were unwilling to cooperate at the time so, yes, we were catching hundreds of thousands of tons. Now… now a few tons at best. And I am sorry to say, those tons are all in our Exclusive Economic Zone, the stock shift is real.

GB: Are you calling our scientists liars, our research invalid? New Nordic Alliance, this is absolutely a despicable way of negotiating! If we do not come to a reasonable agreement here, we will be left with not option but to take this to the courts.

NNA: We ask you again to please acknowledge your own role in this dispute. You should not have promised your fishing industry a return to the glory days. Projections many years ago showed stocks leaving your waters and moving north. Maybe you should have taken climate change a bit more seriously when you had the chance. Look, it's tough, even on us. We are lucky we have our geothermal energy surplus and our digital services, otherwise we could be worse off than you.

GB: We will not leave it at this! We will take you to court!

NNA: Under which jurisdiction precisely do you propose to take this case?

GB: We are a legitimate Coastal State now. You must consider-

NNA: We will hear from you (disconnect tone)

2. **Remodeled Empire - East China Sea**

We are reading excerpts from a transcript of the meeting held at the UN headquarters in New York to address the East China Sea crisis. The objective of this meeting is to discuss ways forward and mobilize action in the international community through the United Nations in response to the escalating crisis spreading across the Pacific region. This crisis is the result of a series of flashpoints that have ratcheted up in the region, year by year, little by little. The excerpts provide a snapshot of the debate held between Security Council members, chaired by the Prime Minister of France. They feature the Prime Minister of Japan (via Videolink), the Foreign Minister of South Korea, the United States Secretary of State, the acting Chair of the Association of Southeast Asian Nations (ASEAN), the President of the European Council, the President of the Global Partnership for the Prevention of Armed Conflict (GPPAC), and the Permanent Representative to the UN of the People's Republic of China.

EXCERPT 1
Wednesday, 11:21 AM

President of GPPAC: *Sehr geehrte Vorsitzende, vielen Dank für Ihre Einladung …*

Interpreter: Madam chair, thank you for convening this Arria meeting on the China Sea crisis. Excellencies, ladies and gentlemen, thank you all for joining us here today to participate in this crisis meeting. As President, I am speaking on behalf of the GPPAC Foundation, an international organization dedicated to advancing peace in the world and preventing conflict. Today, I have failed in that duty following China's decision to veto the Security council resolution to de-escalate the crisis in the region… We must rally together and by means of diplomacy prevent further escalation. Ensuring we can resolve the disputes will require Council members to take concrete action and display considerable political will in the face of a complex and rapidly evolving situation.

We can confirm that the start of this crisis, almost a month ago, was likely accidental. Video footage from U.S. low-flying surveillance drones show a Chinese nuclear-powered missile submarine, *Jin Class*, becoming entangled in the fishing nets of a Japanese trawler southwest of Uotsuri Island in the Senkaku Island chain. All crew lost their lives as the boat was dragged under. While no one was aware then of what had happened exactly, it is important to indicate that this collision was likely accidental.

Permanent representative from the PRC: Nǚshìmen xiānshēngmen…
Interpreter: Ladies and gentlemen, we appreciate the attention that is being paid to the unfortunate accident. To clarify, what is of course an unintentional omission from the visitor to the Security Council President of GPPAC, we vetoed a resolution seeking further multilateral talks for de-escalation – we remain open to bilateral negotiations. Further, we express our concerns that certain rogue actors appear to consider the event something more than an unfortunate accident…

Prime Minister of Japan (via Videolink): Kore wa guuzen dewanai…
Interpreter: (struggling to catch up) With all due respect, we do not believe this was accidental. China has crafted a way to push forward their coordinated, long-planned operation to mobilize hundreds of fishing boats and a large naval force to advance on the Senkaku islands and East China Sea. Likely the Paracel and Spratly islands in the South are next. They *wanted* us to retaliate, to give them an excuse to execute their strategy. Chinese fishing boats have had their fishing gear in the water, but for years now their nets and lines have been empty of fish in their own Exclusive Economic Zone. We have amassed enough evidence to show that their coastal and inland fisheries resources have been severely overfished and are in decline. Their fishing effort simply was, and is not, sustainable, nor is their rapidly growing domestic seafood consumption which now accounts for almost half of global consumption. So they come into our rich fishing grounds, into many other neighboring zones in fact, with an increasing number of boats, and illegally target our fish. It only has gotten worse throughout the last month.

Permanent representative from the PRC: Yǐ wǒmen de qiànyì…

Interpreter: With our apologies, but prior to being interrupted, we were expressing our regrets. We agree with the Japanese representative that the fisheries around China are depleted, owing in no small part to the voracious appetites of our neighbors Japan and Korea, as well as foreign interlopers. To ignore the history of aggression from foreign powers near and far would of course be quite foolish. However, many of these concerns are moot. We fish in our territory – the Diaoyu, Nansha, and Xisha islands – all of which China has actively developed for many decades. Do we question whether Japan can fish near Honshu or Okinawa? Of course not. Would we expect Indonesia to defend Java and Sumatra? Absolutely. China's actions must be viewed in the same light as this regarding its territorial sovereignty.

Prime Minister of Japan (via Videolink): Genzai no jōkyō ni dōi shinai…
Interpreter: This duplicity is no surprise to us. We have felt for years how Chinese vessels aggressively pressed into our territories for our seafood, barely held accountable by their government. Their government welcomed it. Fishing vessels entering disputed zones only strengthened China's maritime presence. China sees these fishing disputes through their nationalist lens, to pursue their own agenda for more resources, more territory! If they truly had not wanted this conflict at sea, they would have steered their fisheries policy away from boosting fisheries production long ago, avoiding what have now been years of fishing clashes at sea to escalate like this. Their attempts at dis-incentivizing their fishermen from expanding operations have been fruitless. A vessel buy-back program to reduce fishing pressure, but at the same time *still* not really lowering fuel subsidies? They never even monitored the actual performance of their policies and programs: vessel tonnage kept increasing, Chinese fishing effort is now at an all-time high. Besides, they also have their eye on prominent shipping routes and natural gas and oil reserves that surround our islands. To try and lay official claim to our marine resources they began extensive territorial remodeling, bringing into being dozens of square kilometres of new land. They do not seem to care about working within the bounds of international law as much now, *ignoring* the UNCLOS prohibition on the use of force.

Permanent representative from the PRC: Nǚshìmen xiānshēngmen…
Interpreter: Strange that you speak as though we are not here. And stranger yet to speak of ignoring international law when Japan has flouted the International Whaling Commission decisions for nearly a century. And let us not forget the devastation Japan visited upon the most valuable commercial fishery in the Pacific, relegating the Pacific Bluefin Tuna to a functionally extinct status. It seems that the cat weeps for the dead mouse – but we are not fooled by this false pretense of concern.

Prime Minister of Japan (via Videolink): (In an authoritative tone) This academic reflection of historic perceptions is devoid of meaning in light of present events. This incident was deliberate – China delivered a targeted threat. So yes, we sent in our Maritime Patrol Aircraft Kawasaki P-1 to track the Chinese submarine after it sunk our trawler. Our data clearly shows that the submarine was headed further into our territory. It was only once this data was available to us that we sent in our Shikishima vessel and its two helicopters. They were quickly met by two Chinese naval destroyers, sent from their nearby military station. We were left with no choice but to engage. Our vessel fired a warning shot over the bow of the Chinese destroyer, but the destroyer did not stop. It fired back, holing the coastguard cutter below the waterline and sinking our vessel and our men… Ladies and gentlemen, with all due respect, these are clear intimidation tactics threatening Japanese sovereignty.

Excerpt 2
Wednesday, 19:48 PM

US Secretary of State: Thank you, Chair. Well. I think this is a good time to clearly state our involvement: we do not take a position on ultimate sovereignty of the islands. But they *are* covered by the U.S.-Japan Security Treaty. With South Korea's decision to not come to Japan's aid and defense, we -

Foreign Minister of South Korea: *Ulineun tongbodoeji anh-assda...*
Interpreter: No intelligence has been shared with us. May I remind you of Japan's actions undertaken against our country, starting decades ago? How can they expect us to come to their aid when they forced us to break the General Security of Military Information Agreement already in 2016? Not only that, this was followed by aggressive and unsafe behavior at sea, provoking and threatening us near the Yellow Sea. Not to mention their inability to apologize for their dogmatic behavior and occupation decades ago during -

Chair: Please, Foreign Minister! Let us remain focused on the current situation here. United States Secretary of State, you have the floor.

US Secretary of State: Thank you, Chair. This is not a critique of South Korea. We are well aware of the long-standing tensions in the region, which structure foreign security policy. However, the last two weeks were chaos. The aggressive seizure of numerous Japanese fishing vessels; last week the sinking of a Japanese Defence forces vessel and three Chinese coastal patrol boats; the sinking of multiple fishing vessels on both sides; the illegal detention of Japanese, Vietnamese and Chinese citizens; the destruction of an offshore oil installation that was a U.S.-Japanese joint venture and which is now spilling oil into the Pacific Ocean… Our U.S. Pacific Fleet Carrier Battle Group is still in a stand-off with a large Chinese naval contingent as we speak. Fortunately, as of yet, no shots have been fired (*pauses*).

We are looking at more than 200 deaths in the region, primarily Japanese Coast Guard and Self Defense forces. China was clear in its message to us all this morning: it vetoed a Security Council Resolution calling for rapid de-escalation, refusing to engage in multilateral talks. China seems to view this situation as an infringement of their sovereignty and will stand down only once they feel the issue has been adequately addressed through bilateral talks with individual countries in the region. With this in mind, the United States is reassessing its will and responsibility to engage in this conflict.

Permanent representative from the PRC: Wǒmen gǎnxiè měiguó…
Interpreter: We thank the US representative for their recognition of Chinese sovereignty in these matters. Further, we appreciate the US re-emphasis on bilateral talks. Multi-lateral negotiations are so often derailed by tedious posturing – by tiresome bickering. Indeed we need look no further than the peacocks parading before us today.

(Angry mumbling coming from the Japanese VideoLink)

Excerpt 3
Thursday, 03:19 AM

President of the European Council: A short statement only, thank you Chair. We, as the EC, do not take any position on the sovereignty of the territories. However, we wish to stress the importance of multilateralism and of the rule of law. We urge the parties involved to cease any use of force and to not threaten Beijing any further. We must de-escalate this crisis using all non-violent policy means at our disposal. Moving out of the region temporarily will facilitate the reverting to a status-quo, and then the parties can seek external assistance in the form of mediation or arbitration, in a transparent manner.

Acting Chair of ASEAN: *Kami menolak cadangan yang disyorkan oleh kesatuan Eropah …*
Interpreter: ASEAN rejects the path laid out by the EU. Let me first thank the United States for being the first responder and attempting to contain the aggression as quickly as they did. We failed to get intra-bloc consensus within ASEAN, so we are only now ready to move forward with a few… proactive ASEAN states. So, ASEAN has invoked 'ASEAN minus X' from Article 21 of our Charter in this crisis. Taiwan, Singapore and Thailand have decided to remain neutral in this political crisis (*nervous shuffling of papers*). In any case… For many years now we have tried to peacefully deal with our own fishing clashes, watching as Chinese vessels moved in, looking to fill their boats with giant clams, sea turtles, fish that is ours, simply because their waters are polluted and nearly empty. Close to 80 percent of their fish stocks are overexploited or collapsed, they barely have feed-grade fish left to catch. We acknowledge some of the efforts China has made in reducing exploitative and illegal behavior, but agree with Japan that the measures undertaken so far are weak and only occasionally enforced. A closer look at the satellite imagery around, say, Subi and Mischief Reef shows how Chinese navy-trained fishing militia vessels have simply invaded the South China Sea. This persistent militia presence and their aggressive tactics are clear threats to our sovereignty.

Permanent representative from the PRC: Zhōngguó chéngrèn ASEAN de kànfǎ…
Interpreter: We acknowledge ASEAN's perception of this issue, yet we do not recognize this criticism as legitimate. Too often in this group, the collective memory of past actions is conveniently brief, especially on the part of Western nations and their rapacious ambition. China represents the largest population in East Asia, and as such we will do whatever we deem necessary to feed our people. Moreover, we are the world's most powerful economy, producing and consuming more than any other nation. We welcome other nations to our table, and we welcome friendships that acknowledge the benefits of harmonious cooperation with Chinese interests. However, we categorically reject the demand to compromise our sovereignty in any of these matters. Calls to do so will be ignored.

Acting Chair of ASEAN: *Kami menolak cadangan yang disyorkan oleh kesatuan Eropah …*
Interpreter: Regretfully this reaction is entirely predictable. History has shown that the tools we use - soft power and international law - are simply not successful in these sorts of disputes. ASEAN has tried too many times. You may recall that we came close to ratifying a Code of Conduct for the South China Sea with China, but Beijing always challenged its binding status and continued to initiate attempts at bilateral talks, undermining the progress we had made as a unified group of nations. With this rapid escalation in the East, the Code will be neglected completely. Moreover, from investigations of a whale carcass stranded at Ha Tinh beach, we have intelligence that the Chinese Type 815 spy ship is possibly connected to a network of chipped marine mammals used by the Chinese government as undetectable underwater surveillance of the South China Sea. This is a blatant violation of our maritime security cooperation agreement. So, with all due respect, with China now having vetoed a peaceful resolution, we have exhausted all diplomatic means to address the crisis and military force is the only way to address the current situation. ASEAN minus X have decided to proactively protect our resources, our territories. Malaysia and Indonesia are preparing a concerted, collective approach to combat Chinese aggression. Their Navies are preparing to assist Japanese and US forces by all means necessary as we speak.

Silence falls over the meeting

3. Oceanic Decolonization - West Africa

We are listening to an episode of Ubuntu Talks, a pan-African political affairs podcast hosted by Coura Bangura. Today, Coura will be speaking with Beyan Boakai, a previous master fisherman for Liberia and now representative for the West African Fishing Fleet, about his fight to reclaim the fish and fisheries infrastructure of West Africa.

Welcome to Ubuntu Talks, this is Coura Bangura. Today I am speaking with Beyan Boakai, the representative of Liberia for the West African Fishing Fleet, a coordinated fleet operating in our common EEZ, now celebrated across West Africa for his leadership in the fight and struggle to reclaim our fisheries and oceans. Welcome, Mr. Boakai.

Beyan: Please, please call me Beyan.

Coura: Beyan! Terrific to have you in the studio today. What a journey the past few years have been for you, and now here back in the studio with your battle seemingly won. How are you? How does it feel?

Beyan: Honestly… It still feels unfinished. I am happy, ecstatic, about our ability, together with our friends in Mauritania, to reclaim Nouakchott last week, but I know the war is not won. There is still a lot of infrastructure that needs to be reviewed, also within the offshore oil and gas fields many of which are at least partially foreign-owned due to loans the government could not pay off.

Coura: I see, I see. It seems a much longer process than many of us would have fathomed when this conflict first became apparent… I remember during your last visit to our studio a few years ago now how relieved I was after there was finally a halt to the warfare at sea and a return to some sense of normalcy, but you were quick to tell me the battle was not over then either. Did I get that correct?

Beyan: That's right. Once we had reclaimed our oceans, pushing foreign trawlers out of our inshore exlusion zones and expanding those, it dawned on us that the revenues from our resources will continue to go to others, far away, if we do not reclaim our infrastructure. Our ports, processing factories. This realization, then, started off the process of what my wife called *fisheries lawfare*, and this is definitely an ongoing battle. But we are feeling very positive after our friends in Mauritania won back Nouakchott.

Coura: If you will, let's start from the beginning, before the conflict erupted. Back then, of course, foreign vessels fishing in our waters was described by many as a win-win situation. A situation where both West African countries and distant foreign water fishing nations would benefit. What did we not understand at that time?

Beyan: Well of course this was described as a win-win situation by our government, and governments in many neighboring West African countries at that, including Mauritania. Generating desperately needed public revenue, delivering skills and technology for access to our rich waters. All of this back then, seemed like a dream to many of us who were struggling to keep our heads afloat, quite literally.

Coura: But, even at the time many people, including the international community, could sense problems ahead.

Beyan: Yes. But our own governments were too busy enriching themselves off the deal. There was significant money in the licensing fees, export fees, which basically all went straight into our government's personal pet projects and rumor has it, offshore accounts. I mean, the China Africa Fisheries Union was an entirely Chinese-run organization even back then, chaired by local chapters of transnational, state-owned fishing companies. There was no real engagement with our local fisherpeople, the deal was done above our heads really. Many nations profited unfairly from our marine resources. Spain, Russia, China, South Korea… All were able to loot our oceans and feed their farmed fish off of our backs for many years. We lost billions of dollars each year. They did not only exploit our fisheries, but also our people… The horrendous conditions in which our people had to work aboard these foreign vessels, all for cheap fish… And the number of foreign boats just kept increasing. Until, of course, our movement to decolonize our oceans started.

Coura: Right. Why do you think it took so long for West Africa to band together against this almost hostile, neo-colonial take-over of our oceans?

Beyan: Well at the time there were other, bigger issues, right? Renewed political conflict, economic instability, the Ebola riots. The African Union was instrumental in ending such violence, brokering the necessary peace throughout ECOWAS - which was truly a turning point. If the Union had not expanded and confederated, as well as granting greater power to ECOWAS, we would never have been able to band together through unions, an important connector from the onset being CAOPA. It really helped that a new generation took over the leadership of the AU and had a genuine, grounded vision for regional unity. It laid the foundation necessary for small unions, CAOPA and other partners to rise up. Remember, this has not only been a fight to reclaim our fish and infrastructure; but also to develop beyond our national capacities to create a modernized fleet across the region and expand into deep-sea aquaculture.

Coura: Right. But first, let's go over your recollection of this revolutionary conflict once again for our new listeners. What do you remember most of that turning point, the period when this volatile conflict erupted with the Chinese, South Korean and Spanish boats in particular?

Beyan: Well. I was leading the fisherpeople on my Yongoro 6 at the time. We all had had enough for a long time already. For years we could not gain access to our own fishing grounds, occupied by enormous, hulking mothership trawlers and their fleets of buzzing smaller boats posing as small-scale fishers. We were forced to buy back fish landed by international vessels at 5 times the price. Out of frustration the rebel movement grew, with some fisherpeople setting up headquarters on a rusty, decommissioned oil rig. We had already teamed up with the vigilante Sea Wolves to make a stand and push away these vessels from our coasts, but many of us were losing patience. It was honestly feeling like a losing battle because we knew our rebellion would never make a difference as long as these access agreements existed, as long as foreign investments dominated our infrastructure and our resources. Ports, processing factories, fish markets… So many of it was foreign owned, often because our governments were not able to pay of the loans they had signed. Foreign investors knew this, they lied to us, they took advantage. At sea and on shore, we were treated as the outlaws by our own governments! We were forced to confront our own Coast Guard as they turned against us, paid off by our politicians and foreign investors.

Coura: And then the first shots were fired…

Beyan: Yes. Despite the months' long tensions in the area, and on-and-off clashes between vessels, I had honestly not felt it coming. It is still difficult to talk about, also because what actually happened remains controversial and we are still dealing with the repercussions in court. But it had started earlier that week with a stabbing leading to the death of a local woman, Mariama Sesay, a much-loved fishtrader, over the prices charged by the colonizers for our own fish. Those had skyrocketed not least because of overexploitation, but also because of greed. There was such a desperate hunger for high-quality protein globally, everything good was exported and the scraps offered to us at exorbitant prices. It was the stabbing of Mariama that led a group of fisherpeople to retaliate at sea. This is when shots were fired late at night. No one knows exactly how it all started… There is evidence that it was the Coast Guard that shot first, at our own vessels, protecting foreign interests at the direction of the fisheries ministry… I was immediately informed through radio, and set course to the area right away. I was stopped by the Coast Guard, detained. Beaten. Tortured. (a deep note of sadness in his voice) In just 24 hours we had lost 21 fisherpeople. One confirmed Spanish death. Those numbers tell the real story, I think.

Coura: More lives were lost over the course of those three weeks, while you were detained.

Beyan: It was excruciating. I was not kept informed, was not allowed to attend the funerals of those in our community. They had no grounds to keep me detained, it was chaos.

Coura: Things quieted down after those three weeks of on-and-off violence. What happened?

Beyan: I was released, eventually. I came back to thousands of messages, phone calls, of disgruntled, angry, scared fishermen from all across West Africa. I felt it: this was our time. But we had to avoid violence, we had to be smart. Use the tools of the colonizers against them. Not in the least because we knew we did not have the means to win this war on the water. We quietly, but powerfully, revolted, engaging with partners mainly through CAOPA as a platform . Many CAOPA members stopped engaging with international vessels, traders, processing facilities. Foreign products were boycotted. It had a ripple effect across the world: The ICIJ, ProPublica, and CENOZO investigative media alliance had campaigned across the west to raise awareness, raise the alarm. The news spread like wildfire and became known as our ocean decolonization fight.

Coura: Under this mounting pressure, things started to change for the better.

Beyan: It took a long time. After months, we finally had some politicians fighting for us, partially thanks to help from an increasingly stronger African Union which put pressure on individual governments, but mainly thanks to our strong fisherpeople. The Coast Guard was called back and told to show restraint, and more naval vessels were made available to enforce our West African Exclusive Economic Zones, in part supported by the U.S. Africa Command's Security Cooperation program. Slowly but surely, most of the foreign vessels retreated under the mounting pressure. But, they still basically owned our facilities and, when criticized, said they were acting under the law.

Coura: That's right! After the infamous violent clashes at sea, you came to our studio the first time together with your Sea Wolves partner, explaining the physical fight might be over, but that indeed we were far from claiming back our ocean resources.

Beyan: My wife was the first to make me aware. She is the brains behind that second phase of our ocean decolonization strategy. We had to kill the unfair access agreements, reclaim ownership over our fishing ports and fish processing factories. And we also want to stress that we are *not* against all foreign investments or partnerships! But it needed to be to the benefit of West Africa as well. The community, the fisherpeople, needed to be consulted and benefited. Fighting for transparency within fisheries access agreements between governments as well as big foreign companies and our governments was the first step. Many of them had only been established due to the shortsightedness, or sometimes outright corruption amongst our politicians. We advocated for the renegotiation of those access agreements and only establish new ones if both parties were on equal footing. My wife led this with success: Liberia is now in the process of establishing an international investment treaty with foreign interests, informed by local communities through consultation rounds. Transparency obligations and mandatory reporting will be included. We are even striving to make the reporting of beneficial ownership obligatory so no foreign-owned companies can front as a West-African enterprise. (pauses)

My wife… She was fearless despite all the threats we were getting. You know, we had to work underground, off the grid, for months because of the possibility of retaliation against our family.

Coura: But now, months after this lawfare process as you call it had started, you have won some battles and with the recent reclaiming of Nouakchott, you feel optimistic?

Beyan: Yes. Now our politicians are finally treating the fisheries industry as what it should have been all along: the lifeblood of West Africa, an engine for our future prosperity. It is this political support that makes me optimistic. We can finally invest in our future. Within the African Union we have created a shared quota system, allowing for greater flexibility and efficiency, and we increasingly reinvest profits from our fishing industry in aquaponics and community deep-sea aquaculture, creating more jobs. These facilities in the open ocean are really our future. Gaining our fishing grounds and ports back was an important step to free ourselves from exploitation, but we now know that aquaculture is an important part in securing nutritious food for generations to come.

Coura: Amazing. Thank you Beyan, for your inspirational work, and continued fight in reclaiming our ocean resources and beyond. An honor to have you back on Ubunte Talks.

4. Polar Renaissance – Arctic

This is a speech by Sardana Nikolaev, CEO of Sakha Fishing and chair of the indigenous-business partner organization 'Polar Renaissance', held during the fifth anniversary of the Arctic reconciliatory meeting. All Arctic Heads of State are present for this meeting at the Arctic Council – from the United States of America, the Russian Federation, the Kingdom of Denmark, Canada, Iceland, the Republic of Finland, The Kingdom of Sweden, and the Kingdom of Norway - to further strengthen Arctic cooperation.

Sardana: Today I am here to celebrate with you all. A celebration of our renewed international Arctic cooperation. No so long ago, we were on the brink of conflict, so standing here in front of the Arctic Council, with all Heads of State present, feels like a true victory. I am speaking today not only on behalf of my fishing company, Sakha Fishing, but also on behalf of '*Polar Renaissance'*, a pan-Arctic initiative by indigenous business leaders that is passionate about the Arctic, its people and its future. I want to start by reminding us all why our, though still fragile, Arctic unity is such an achievement.

When I was young and not yet the business owner I am today, Russia was still ruled by Putin, and had long ignored *(pauses)…* Well, with apologies to my Russian colleagues in the room, basically welcomed some of the consequences of climate change and ocean warming. The disappearance of the sea ice in the Arctic in particular was embraced by our politicians. It was much more rapid than any of us expected, of course. My Yakut ancestors, humble fisherpeople surviving mainly on whitefish catches, were initially wary of the changes that came so rapidly. We started experiencing near ice-free summers much more quickly than any models had suggested... (sighs). Despite this, few Russian politicians took seriously the disastrous consequences of these changes. The Yakut people were some of the few, together with some lone scientists, that witnessed first-hand some of the pervasive changes Siberia at large was undergoing: thinning sea ice, flooding, thawing permafrost, changing migration patterns of land and sea animals. Their concerns were dismissed. Our government and many Russian businesses, from fishing to mining to energy companies, instead saw a new gold rush. They thought that, at worst, some of the adverse effects of climate change such as the wildfires we already saw intensifying, could surely be managed. The promise of the Northern Sea Route, the trans-Arctic shipping routes, all the resources that would become available… The chance to build a "new palace"… it was all too good to pass up. Our government took advantage, started subsidizing new technologies and ocean businesses with the help of other interested nations from the East, and pushed into the Arctic, both economically and militarily. Planning for new seaport facilities, reconditioning abandoned Soviet military bases, mining operations, oil and gas pipelines and, of course, fishing ports and processing facilities. One funny story, at least in hindsight, was the hysterics and extreme absurdity as a Canadian Coastguard contingent and a Russian navy strike force led by a weapnized icebreaker, squeezed past each other while navigating the narrow and still treacherous Northwest Passage. During this time, the cooperation achieved by the Arctic Council had already started to erode.

Parts of Siberia, and indeed many historically remote areas inhabited by indigenous people all over the Arctic, saw businesses rush in. Older generations of fisherpeople in Yakutia were weary, but, similar to many Inuit and Yupik people in the American, Canadian and Greenlandic Arctic, we had been grappling with the loss of traditional livelihoods and high rates of unemployment for decades. Community elders witnessed more and more young Yakut people being drawn in by the economic boom. Young Yakuts hoped it could provide some stability in an environment where the weather became less predictable, where sea ice was unstable and traditional fishing and hunting much harder to maintain. They were promised a 'New Era of Prosperity´ by the government. It drove them to leave behind family businesses and start working for large fishing companies, in new fish processing facilities, or other maritime industries; back then none of them led by indigenous people. I became one of those young Yakuts searching for an opportunity.

To my community and I, it seemed great for a few years, mainly because we were not aware of the ongoing political tensions or environmental destruction. We know now that any journalist or whistleblower coming out against the government was quickly silenced. Yet all industries were grappling with the consequences of tensions in the changing Arctic soon enough. The oil and gas industries were first. As the retreating sea ice revealed more and more untapped fossil-fuel resources all over the Arctic, political and eventually military tensions between Russia and Norway over competing interests in the Barents Sea soon made the sector unstable. Russia had made clear, by running aggressive military exercises that it would not share the oil resources found in the north Barents Sea, though Norway initially claimed part of it. Under pressure from its domestic politics that were distinctly anti-fossil fuel, Norway eventually backed down, and Russia thought itself unchallenged to claim these resources…

Also within the fishing industry, this is when I first started in the sector, executives seemed initially excited about changes to the Arctic ecosystem: the continuous increase of boreal fish predators such as cod was welcomed as a gift. But after the regulations on Arctic fishing were officially abandoned in 2034 and the fiction of exploratory fishing was exposed for what it was, everyone suddenly had fishing vessels in the Arctic, and illegal fishing was rampant. The influx of new species continued, but so did the influx of commercial fishing vessels, from all Arctic states. Without any legal framework, there was not much any country could do. An exponential increase in competition for Arctic fish created tensions in the area between fishing fleets. This is when I first became aware of just how politicized and dangerous the business I was in was becoming without a rulebook to guide us. . The danger became particularly tangible when Russia assigned next generation naval vessels to accompany our boats to scare off competitors, occasionally ramming boats. Sometimes Chinese vessels were employed to accompany our fishing boats, keen to protect the investments Beijing had made in the Russian fisheries business as part of their Polar Silk Road plan. It all culminated in a near month-long stand-off just outside the Norwegian Exclusive Economic Zone, where Norway had detained four vessels that, allegedly, had made incursions into the Norwegian zone. Three of the vessels were Russian-flagged, one Chinese. Russia and Norway came close to military conflict at that time...

(pauses)

‘POP’! Then the carbon bubble burst. Oil and gas prices collapsed to precipitous lows almost overnight. This happened much, much faster than economists were projecting. The European central bank, followed by a large number of pension funds and other institutional investors, rapidly divested from all fossil fuel assets in an unstoppable cascade. Insurance companies stopped offering coverage for oil and gas exploration, and simultaneously two international oil companies announced plans to completely transition to renewables. The era of fossil fuels was over… Again, apologies to my Russian colleagues, but we all knew that the Russian economy was vulnerable, that it was a petro-state which had been a haven for crony capitalism… Russia had not invested in developing new industries or new institutions, but had focused solely on military expenditure. I have to say, the fact that I can stand here and speak these words without fear of being poisoned (glances nervously at the Russian diplomats in the room) is a testament to the fundamental changes that have been going on ever since in Russian society. In any case, investment in Russian companies by the Arctic states was completely brought to a halt. And so, Russia, unlike ever before, started struggling with skyrocketing national debt. Due to Russia's extreme increase in military spending, in anticipation of securing revenues from unexploited Arctic resources, it had quickly ran through its accumulated reserves, and then steadily racked up national debt which got close to 80% of its GDP.

My sector, the fishing sector, was also hit hard by these developments. The Russian government could no longer afford to subsidise the large and overextended Russian fishing fleet and without state support it fragmented and splintered. To make things worse, China came in to repossess the assets it had invested in. Unemployment, soaring inflation and loss of confidence in the banking system put huge pressure on the government, which struggled to manage the situation. As we know, the Russian Federation was finally backed into a corner and sought rescue from the newly green-tinged International Monetary Fund, granted of course only under stringent conditions. Russia was not only forced into beginning a process of fundamental economic transformation, but also to stop and even reverse its military build-up in the Arctic. Now, that weaponized icebreaker which I spoke about is part of the same outdoor museum in Murmansk as the Lenin, the soviet nuclear powered icebreaker, that was launched during another period of extreme hubris, in 1957.

At just about this time, I had worked my way up to become CEO of Sakha Fishing, and struggled to steer my company through the mounting financial pressure and increasing illegal fishing as still more vessels moved into the Arctic. In all this turmoil, the Indigenous Peoples Secretariat had remained united, hosting annual meetings to voice indigenous peoples' rights in the Arctic. I attended because I had hoped that with the Russian economic meltdown, the chaos in the fishing industry and the new reality of climate change, new Yakut business opportunities would be part of those discussions. Amazingly, already in that first, long meeting, we discussed a pan-Arctic indigenous-business alliance '*Polar Renaissance*', which would be supported by the Secretariat as part of a larger reconciliation process. With Polar Renaissance and the Secretariat, we negotiated for Norway, Canada and Sweden to create a joint Arctic trust fund supporting indigenous-led transformation initiatives in the entire Arctic, including business, as part of a climate reparations agreement. This transformed the living conditions and future prospects not only for many Russian indigenous people, but indigenous communities all over the Arctic. It ultimately set off the ongoing institutional transformation we see today.

Now we are celebrating the fifth anniversary of our first Arctic Reconciliation meeting. At that meeting, we recognized our common history, highlighted current achievements and created a vision for the next 50 years based on our shared humanity and our desire to secure and nourish our collective wellbeing. We are working towards the ratification of the Arctic Treaty that Russia is now also part of. As part of the Arctic treaty negotiations, we hope to not only set up a body to manage our fisheries, overseeing all the high seas of the Arctic Ocean, but make sustainability performance and corporate social performance with respect to indigenous communities an obligation for ALL enterprises operating in the Arctic. Collectivily, we are building towards a better future together, but in recognition of our 150 year vision, we also need to recognize the new challenges that continue to emerge. For my own industry, mercury, trapped for thousands of years in permafrost, is a serious threat, slowly seeping into our Arctic foodwebs. The Arctic has changed and will continue to change. But, with a united Arctic, we stand a chance. Thank you all for listening.

SI: Alternative pathways

1. **Scramble for the Atlantic - North-East Atlantic**

- Great Britain's economy crashes following Brexit, prompting its citizens to overwhelmingly vote to rejoin the EU. After several years, the EU allows them to rejoin as a member state and the UK then collaborates with the other EU states as well as Iceland and Norway to modernize the management of the stocks in the North-East Atlantic, making their strategies resilient to climatic changes.
- Brexit proves to be a success for Great Britain, and it manages to negotiate with other Coastal States for extra stock quotas based on the principle of zonal attachment. Strict controls on fishing by foreign vessels are implemented in its EEZ, best practices in fisheries management are adopted and considerable investments made in technological advancements (e.g. sophisticated ecosystem models that optimize harvest strategies). These measures result in a more sustainable fishery, without conflict with neighboring states.
- Great Britain fails to negotiate extra stock quotas after Brexit, and due to the loss of the EU as its main export market, the profitability of its fisheries greatly declines. As a result, Great Britain turns to various warm water species that have become more abundant due to climate change. These stocks become part of lucrative catch-and-release recreational fisheries. Inshore fishing grounds are largely protected as nursery grounds for those species, to increase biodiversity, to act as natural carbon stores and to protect coasts. Only a few large commercial offshore fishing vessels remain, mainly targeting pelagic species. Other Coastal States start to look at this new approach with increasing interest

2. **Remodeled Empire - East China Sea**

China takes renewed control over its fisheries sector, reducing the amount of overfishing and fishing vessel incursions from Chinese actors. China's marine sector would shrink due to reduced landings, effectively following in the footsteps of Japan, South Korea and Taiwan. This paradigm shift in the country's food security strategy (this is: letting go of the idea of self-sufficiency in fish supplies) would occur through several policy changes. China effectively executes on its plans to cull down its fishing fleet and total catches over the next years, partially through setting and enacting tougher penalties on illegal fishing, the poaching of endangered species and marine pollution. The labor force within wild-capture fisheries would continue to shrink, and China would heavily invest money in tackling issues associated with aquaculture, boosting the sector.

3. Oceanic Decolonization - West Africa

- West African governments try to squeeze as much revenue out of already overexploited fisheries as possible. Rural fishery communities feel the pressure and continue to struggle. Urbanization pulls young people from the communities to cities, where more profits can be made. Fishing activity slowly declines and the system grinds on at a bio equilibrium. Fisheries dwindle, becoming less attractive even to foreign fleets as they are no longer profitable.
- China shifts its food security strategy and offers West African governments to stop harvesting fish in the area with their own vessels in exchange for exclusive sourcing agreements to feed their growing population. China would focus on processing and exporting fish harvested from West Africa and pull out its trawlers from the region. This, however, negatively influences local food security as it drives up fish prices in West African markets.

4. Polar Renaissance – Arctic

- Tensions between the States become even more strained due to two issues. First, growing ship traffic along the Northern Sea Route causes force-on-force situations along the straits. Russia and Canada are on one side of the issue, and the USA and the EU on the other side. The latter group views the straits as “common heritage of mankind”, while the former group wants to maintain their exclusive national jurisdiction over these sea lanes. The straits issue becomes another source of interstate conflict in the region. Second, the Norwegian archipelago of Svalbard (where a large part of the population is Russian), its surrounding continental shelf and Fisheries Protection Zone becomes a source for Norway-Russia conflict.
- A major oil spill north of Siberia occurs either due to a tanker collision, a blowout on an offshore installation or a rupture in a pipeline. Given the vulnerability of the Arctic marine environment, this effectively puts an end to commercial fishing in large parts of the region.

SI Methods: Workshop

The expert workshop (titled *Governing Resource Conflict in the Anthropocene*) took place in Santa Barbara, California at the NCEAS facilities from the 22nd to 25th of November, 2018. The workshop consisted of 11 research scientists with expertise in environmental politics and governance, climate-conflict studies, ecology, human geography, fisheries and international law (Table 1). The organizers and facilitators (Jessica Spijkers and Tiffany Morrison) oversaw the selection of participants to ensure disciplinary breadth and gender balance (6 females, 4 males).

The topic of study was initially outlined to the experts in background material sent to them before the workshop. The material included specific questions to prime the experts such as:
• What are the anticipated drivers (e.g. scarcity, climate change, population pressures) of future resource conflicts?
• In which socioeconomic and environmental contexts can we expect anticipated conflict to spark wider social and political disruption?
• Can we reasonably expect more conflict over natural resources in the future (taking into account multiple temporal and spatial scales), or could current conflicts be catalysts for peacebuilding?
• Are there governance interventions or mechanisms to anticipate, prevent, or indeed harness conflict and its impacts?

The exercises described below were interspersed with four presentations by different participants to stimulate thoughts, creativity and communication. Topics include: policy conflict and natural resources and conflict; climate change and conflict; conflict, food, fisheries and climate; and conflict and development.

Table 1: Fields of expertise of workshop participants

Expertise (Background as well as current role) relevant to the topic	Number of participants
Climate-security/conflict	4
Development studies	5
Environmental governance	6
Fisheries science	4
International law	2
Climate-ocean interactions	2
Human geography	1
Sustainability science	4

The workshop comprised 4 exercises designed to extract the data used in this paper, all of which was stored immediately on a shared drive:

1. **Exercise 1: defining conflict (1hr)**
   Output data: A shared understanding of the types of fisheries conflicts that exist.
   Exercise: Participants worked in groups (3 groups of 3-4 people, selected at random) to address the following questions, by writing responses on cards and then discussing the answers in small groups (30min): What type of conflict has been part of/the main focus of your research? What other types of conflict related to natural resources do you think exist or could commence in the

future or have you come across in other works? Each group then explained their data, the wider group discussed and we put answers on a poster. We filled in the type of resource, scale of conflict, and potential geographical location. The poster was discussed in the wider group in order to come to a shared definition of conflict.

2. **Exercise 2: Identification of the current drivers of fisheries conflict (1hr)**
   Output data: A list of the drivers (social, economic, political and environmental) of fisheries conflict as defined in exercise 1.
   Exercise: Participants formed 3 groups and wrote 2-3 key driving forces (this amount was chosen to avoid cognitive overload (Miller 1994, Gross 2012)) for conflict (the specific kinds of conflict resultant from exercise 1) on cards. Historical and current trends for each driver were also discussed in the groups (e.g. has the driver been slowing down or speeding up, with participants choosing their own time perspectives).
   Each group did 3 rounds (all three were the same format), and together clustered the drivers in themes as they saw fit (social, economic, political, environmental). Afterwards, in a plenary session, we combined the driving forces on a whiteboard. One group at a time, all drivers that came out of the previous exercise was shared with the group and added to the wall (by participant). They gave a brief explanation of why they think this driver is relevant. The facilitator asked what overarching category (social, political, environmental or economic) this driver belonged to, what effect the driver has on the type of conflict and if the driver has historically been slowing down or speeding up. At the end, we discussed in group whether any drivers needed to be added.

3. **Exercise 3: Identification of how drivers of conflict are expected to change into the future (1hr)**
   Output data: Explorative combinations of conflict drivers and their possible outcomes.
   Exercise: To explore the space of future uncertainty, participants were asked to think of new combinations of drivers that possibly lead to potentially new sources of conflict. The participants worked in random groups of 2 where every pair picked at random two (or three, to make sure we used all cards) driver cards from the previous exercise. The couples then had a free-form 12-minute brainstorm session on how that combination of drivers could lead to already identified as well as new types of conflict in the future. They then share all their identified combinations in plenary to discuss how they would function. We performed three rounds of this. Then divided in three new groups, participants discussed each set of driver combinations we identified earlier to identify where (geographically) they would foresee these changes happening, and at what scale. This was then discussed in plenary group by

group. All discussed combinations of drivers were recorded and later used to explore possible future interactions amongst drivers within the four narratives.

4. **Exercise 4: Identification of governance options appropriate and effective for managing the identified current and future types of conflicts and/or their drivers (2hrs).**
   Output data: List of governance structures, practices and interventions that could either help prevent or de-escalate fisheries conflict.
   Exercise: Participants, individually, took 10 minutes to think about questions below:
   • What kind of governance structures are these (ones that already exist, but otherwise not defined)?
   • On what scale do they exist and are they place/resource specific?
   • How do they address/cope with the current and future conflict types and their changing drivers? Are they successful?
   They reported back in plenary where it was discussed in free-form. Later two smaller groups of participants discussed currently non-existing governance structures that could be developed in the future for conflict mitigation. The groups reported back in plenary where it was discussed in free-form.

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Supplemental Information (Tables)

SI Table 1: Political drivers and conditions that have triggered fisheries conflict and fishery conflict case studies for reference. Also see SI: References for supplementary information.

Underlying drivers	References	**Immediate conditions**	References
Geopolitics (Changing power dynamics/international context)	Conflict over mackerel (Spijkers & Boonstra 2017, Gänsbauer et al. 2016) Fishery conflicts in the Yellow Sea (Kim 2012) Disputes over South Korean Saury, Japan versus South Korea versus Russia (Valencia & Lee 2002) Tuna disputes between Japan & Taiwan (Chen 2011)	Poor rule enforcement/ patrolling	Local fishery conflicts in Senegal (Dubois & Zografos 2012) Fishery conflicts in the Yellow Sea (Kim 2012) Fishery conflicts between Belize, Guatemala and Honduras (Perez 2009) Conflicts between Vietnamese boats and Pacific Island States (Song et al. 2019) Local fishery conflicts in Bangladesh & Ghana (Bennett et al. 2001)
		Absence of comprehensive and inclusive management practices	Local fishery conflicts in Ghana (Owusu 2018)

			Local fishery conflicts in South Africa (Visser 2015) Local fishery conflicts in Southeast Asia (Pomeroy et al. 2007) Local fishery conflicts in Bangladesh & Turks and Caicos Islands (Bennett et al. 2001)
Low quality of governance (e.g. high levels of corruption, crime)	Local fishery conflicts in Ghana (Owusu 2018) Local fishery conflicts in Southeast Asia (Pomeroy et al. 2007) Local fisheries conflicts in Indonesia (Muawanah et al. 2012)	Change in international/national/local regulations/rules (in relation to access to fishery space, fishery resources, or participation rights)	Fishery conflicts between Belize, Guatemala and Honduras (Perez 2009) Conflicts between Vietnamese boats and Pacific Island States (Song et al. 2019) Local fishery conflicts in Bangladesh & Turks and Caicos Islands (Bennett et al. 2001) Conflicts along Coromandel Coast of India (Bavinck 2005) Conflict over flying fish (Blake & Campbell 2006) Fishery conflicts in the Yellow Sea (Kim 2012) Turbot war, Spain versus Canada (Silk 2001)

		Territorial issues (e.g. maritime boundary delimitations, disputed islands)	Conflict over flying fish (Blake & Campbell 2006) Fishery conflicts in the Yellow Sea (Kim 2012) Fishery conflicts between Belize, Guatemala and Honduras (Perez 2009) Disputes over South Korean Saury, Japan versus South Korea versus Russia (Valencia & Lee 2002) Lobster conflict, US versus Canada (Cook 2005)

SI Table 2: Social drivers and conditions that have triggered fisheries conflict and fishery conflict case studies for reference. Also see SI: References for supplementary information.

Underlying drivers	References	**Immediate conditions**	References
Human migration/ displacement	Local fishery conflicts in Kenya (Okemwa et al. 2017) Local fisheries conflicts in Indonesia (Muawanah et al. 2012)	Unequal distribution of benefits (real or perceived)	*All cases of fisheries conflict ultimately exhibit this*
Population growth	Fishery conflicts in the Yellow Sea (Kim 2012)	Ethnic tensions	Local fishery conflicts in South Africa (Visser 2015)

Insufficient ecosystem knowledge	Conflict over mackerel (Spijkers & Boonstra 2017) Conflict over flying fish (Blake & Campbell 2006) Fishery conflicts between Belize, Guatemala and Honduras (Perez 2009) Pacific Salmon conflict (Miller 2000)		Local fishery conflicts in Bangladesh & Turks and Caicos Islands (Bennett et al. 2001) Tuna disputes between Japan & Taiwan (Chen 2011)

SI Table 3: Economic drivers and conditions that have triggered fisheries conflict, and fishery conflict case studies for reference. Also see SI: References for supplementary information.

Underlying drivers	References	**Immediate conditions**	References

<table>
<tr><td rowspan="2">Extractive activities (e.g. oil, gas)</td><td rowspan="2">Local fishery conflicts in Ghana (Owusu 2018)</td><td>Fishing effort</td><td>Conflict over flying fish (Blake & Campbell 2006)

Fishery conflicts in the Yellow Sea (Kim 2012)

Local fishery conflicts in Kenya (Okemwa et al. 2017)

Conflicts between Vietnamese boats and Pacific Island States (Song et al. 2019)

Local fishery conflicts in Ghana (Bennett et al. 2001)

Disputes over South Korean Saury, Japan versus South Korea versus Russia (Valencia & Lee 2002)

Lobster conflict, US versus Canada (Cook 2005)</td></tr>
<tr><td rowspan="4">Unequal levels of technology available</td><td rowspan="4">Local fishery conflicts in Senegal (Dubois & Zografos 2012)

Local fishery conflicts in South Africa (Visser 2015)

Local fishery conflicts in Kenya (Okemwa et al. 2017)

Local fishery conflicts in Ghana (Bennett et al. 2001)

Conflicts along Coromandel Coast of India (Bavinck 2005)

Conflict over flying fish (Blake & Campbell 2006)

Local fisheries conflicts in Indonesia (Muawanah et al. 2012)

Ghana versus Chinese DFW conflicts (Penney et al. 2017)</td></tr>
<tr><td>Globalization (increased connectivity, trade)</td><td>Local fishery conflicts in Ghana (Owusu 2018)

Tuna disputes between Japan & Taiwan (Chen 2011)</td></tr>
<tr><td>Growing demand for seafood</td><td>Fishery conflicts in the Yellow Sea (Kim 2012)

Conflicts between Vietnamese boats and Pacific Island States (Song et al. 2019)

Tuna disputes between Japan & Taiwan (Chen 2011)</td></tr>
<tr><td>Labor shifts from decreasing agriculture to fisheries</td><td>Local fishery conflicts in South Africa (Visser 2015)</td></tr>
</table>

SI Table 4: Environmental drivers and conditions that have triggered fisheries conflict, and fishery conflict case studies for reference. Also see SI: References for supplementary information.

Underlying drivers	References	**Immediate conditions**	References
Climate change	Conflict over mackerel (Spijkers & Boonstra 2017, Gänsbauer et al. 2016) Local fishery conflicts in Senegal (Dubois & Zografos 2012)	Stock migration/ redistribution	Conflict over mackerel (Spijkers & Boonstra 2017, Gänsbauer et al. 2016) Local fishery conflicts in Senegal (Dubois & Zografos 2012) Local fishery conflicts in Kenya (Okemwa et al. 2017) Pacific Salmon conflict (Miller 2000)
Pollution	Fishery conflicts in the Yellow Sea (Kim 2012)	Declining stock status (abundance/health of stock)	Conflict over flying fish (Blake & Campbell 2006) Fishery conflicts in the Yellow Sea (Kim 2012) Conflicts between Vietnamese boats and Pacific Island States (Song et al. 2019) Pacific Salmon conflict (Miller 2000) Turbot war, Spain versus Canada (Silk 2001) Fishery conflicts between Belize, Guatemala and Honduras (Perez 2009) Local fisheries conflicts in Indonesia (Muawanah et al. 2012) Ghana versus Chinese DFW conflicts (Penney et al. 2017)
Erosion	Local fishery conflicts Ghana (Bennett et al. 2001)		

SI Table 5: Status and trends (based on events of the past 5 years) of the political drivers and conditions of conflict in all four case studies. NEA = North East Atlantic, ECS = East China Sea; CoWA = Coast of West Africa; A = Arctic. Also see SI: References for supplementary information.

Driver/condition	**NEA** [EU & Great Britain, Iceland, Norway]	**ECS** [China, Japan]	**CoWA** [West-African countries]	**Arctic** [Arctic Council States]	References
Geopolitics	**Status:** Democratic **Trend:** Increased nationalism, has already causes fisheries issues (Brexit)	**Status:** China authoritarian, Japan democratic **Trend:** Increased nationalism, has already caused fisheries issues (e.g. burgeoning trade war between USA and China, fisheries exempted from levies; in greater East Asia area: South Korea vs Japan flaring up)	**Status:** Mostly democratic **Trend:** Increased regionalism (e.g. Agenda 2063). African Union is helping to lessen conflicts among states and establish greater regional cohesion.	**Status:** Democratic, except for Russia which is a totalitarianism under Vladimir Putin **Trend:** Increased nationalistic tendencies in certain countries (e.g. Russia, USA). Somewhat troubled, complicated relations between certain states (e.g. USA – European Arctic states; Russia - European Arctic states)	World Economic Forum (2018) The African Union Commission (2019) Bieber (2018) Junior & Luciano (2018) Panda (2019) Valencia (2019) Brzozowski (2019)
Low quality of governance	**Status:** Overall high press freedom, low corruption. However, European democratic institutions increasingly exposed to corruption **Trend:** Stagnant	**Status:** Low press freedom & high corruption in China, average/high press freedom Japan, average/low corruption Japan **Trend:** Decline in press freedom, increase in corruption in all	**Status:** Low press freedom and high corruption **Trend:** Both press freedom and corruption slowly improving on average but regional diversity	**Status:** Overall high press freedom, low corruption amongst Arctic countries. Exception is Russia with high corruption and low press freedom. **Trend:** Corruption stagnant/getting worse in areas, press freedom mostly stagnant	Reporters Without Borders (2018) Transparency International (2018) Fitzgibbon (2019)

Poor rule enforcement/ patrolling	**Status:** High level of patrolling, strong rule enforcement **Trend:** Increased patrolling (e.g. EU plan for strengthened 'European Border and Coast Guard'), continued strong rule enforcement	**Status:** High level of patrolling by both states, weak rule enforcement by China (weak rule of law), other strong **Trend:** Increased Coast Guard patrol by Japan, China. Weakening rule of law in China, stagnant in Japan. Also continued patrolling by USA.	**Status:** Low level of patrolling (few resources). Overall weak rule enforcement (weak rule of law) **Trend:** Overall increased patrolling and enforcement, but dependent on country rule of law is improving/worsening	**Status:** Relatively little patrolling in Arctic, overall high rule enforcement by Arctic states **Trend:** Increased patrolling by for example Norway or Russia. Continued strong rule enforcement by Arctic states	Axe (2019) Morgan & Chan (2018) Morris (2017) Insinna (2018) European Parliament (2019) Croitoru et al. (2019)
Absence of comprehensive and inclusive management practices	*Highly locally variable*	*Highly locally variable*	*Highly locally variable*	*Highly locally variable*	
Change in international/national/local regulations/rules	**Status:** Local/national unable to determine. International: historically high uptake of international regulation by all nation states **Trend:** Local/national unable to determine. International: EU pushing for more fisheries regulation. Changes coming due to Brexit (renegotiating quotas).	**Status:** Local/national unable to determine. International: China, USA current reluctance to accept international regulation **Trend:** Local/national unable to determine. International: China continued reluctance to follow international rule of law (ignoring international tribunal in	**Status:** Local/national unable to determine. International: historically low uptake of fishery regulations **Trend:** Local/national unable to determine. International: improvement in implementation of fishery regulations (in part due to EU yellow carding for Liberia, Sierra Leone, Ghana, Guinea, Togo).	**Status:** Local/national unable to determine. International: regulations increasing in Arctic (e.g. agreement to not fish until 2033) and historically high uptake of fishery regulations by all states **Trend:** Local/national unable to determine. International: regulations surrounding	Ogundeji (2019) Popescu & Chahri (2017) Harvey (2018) Arctic Council (2019)

		Philippines vs China)		Arctic fisheries set to further increase.	
Territorial issues	**Status:** No unresolved issues in the North Atlantic **Trend:** No issues foreseen	**Status:** Many unresolved issues between China & other states; specifically between China & Japan: Senkaku Islands **Trend:** Increased presence of vessels has heightened concerns (no sign of resolution)	**Status:** No unresolved maritime issues between West African countries **Trend:** There have been issues solved (e.g. Ivory Coast versus Ghana) recently	**Status:** Many competing claims for continental shelf in Arctic (Canada, Denmark, Norway and Russia) **Trend:** More claims to likely come	South China Morning Post (2019) Macdonald (2015)

SI Table 6: Status and trends (based on events of the past 5 years) of the social drivers and conditions of conflict in all four case studies. NEA = North East Atlantic, ECS = East China Sea; CoWA = Coast of West Africa; A = Arctic. Also see SI: References for supplementary information.

Driver/condition	**NEA** [EU & Great Britain, Iceland, Norway]	**ECS** [China, Japan]	**CoWA** [West-African countries]	**Arctic** [Arctic Council States]	**References**
Migration	**Status:** Current high levels of migration to European countries, variable amongst countries. High mobility within. **Trend:** Set to continue	**Status:** China, Japan increasingly destination country for international migrants. Internal migration declining. **Trend:** Set to continue. Depending on climate scenario, drought in the	**Status:** High rate of emigration (e.g. Nigeria). High rate of internal migration **Trend:** Emigration rate set to increase. Climate impacts	**Status:** All countries except Russia: high levels of migration. Russia: more emigration. **Trend:** Set to continue	Perry & Sumaila (2007) ESPAS (2015) IOM (2019) Statistics Bureau of Japan (2018) Gandhi (2018)

		inland regions may cause more human migration to the coastal regions.	(drought) in inland may cause more migration to the coast.		Kirwin & Andersson (2018) Timofeychev (2019)
Population growth	**Status:** Slow growth. **Trend:** Continued overall slow growth, then decrease. Globally, population set to reach over 9 billion people in 2050.	**Status:** Slow population growth (China) and population decline (Japan). **Trend:** Set to continue. Globally, population set to reach over 9 billion people in 2050.	**Status:** Rapid growth. **Trend:** Continued rapid growth (2.3 percent annually). Globally, population set to reach over 9 billion people in 2050.	**Status:** Slow growth for all except Russia (slow population decline). **Trend:** Set to continue. Globally, population set to reach over 9 billion people in 2050.	ESPAS (2015) United Nations (2019)
Insufficient ecosystem knowledge	**Status:** Good availability of scientific knowledge on NEA fisheries (e.g. through ICES). **Trend:** Expected continued good quality. However, rapid changes occurring due to climate change which the scientific community has struggled to keep up with in certain cases (e.g. NEA mackerel), which could become worse.	**Status:** In China, not a lot of data sharing or science-based policy recommendations. **Trend:** Improving (e.g. China developing big data projects to better understand pollution, IUU).	**Status:** Limited knowledge on many fisheries, which leads to uncertainty in stock assessments, & scientific advice. **Trend:** Improving (e.g. joint activity between RFMOs to increase knowledge; West Africa Regional Fisheries Program funded by World Bank).	**Status:** Gaps in scientific knowledge on fisheries (particularly middle-trophic). **Trend:** Efforts to build scientific knowledge on fisheries underway.	CITES (2016) Godfrey (2019) Van Pelt et al. (2017) Cao et al. (2017) Spijkers & Boonstra (2017).
Ethnic tensions	**Status:** No apparent ethnic conflict within or between states. Not an ethnically diverse area.	**Status:** Ethnic tensions within China, Japan. Amongst countries within broader East	**Status:** Ethnically diverse area with many historical	**Status:** Some ethnic tension within certain Arctic states (Russia, USA).	Annan (2014) Adekola (2018) Buruma (2019)

	Trend: No apparent growing ethnic conflict within or between states.	Asia area, lingering tensions specifically between Japan and South Korea (Japanese war & imperialism). **Trend:** Ethnic tensions between Japan and South Korea worsening. Within China and Japan, lingering ethnic tensions towards specific subpopulations.	tensions. Current ethnic tensions within countries locally variable. Example: current ethnic conflict within Nigeria. Between countries no current ethnic conflicts. **Trend:** Violent conflicts fueled by ethnic tensions between countries in decline. However, some recurring intra-state ethnic tensions	No apparent ethnic tensions between Arctic countries. **Trend:** No apparent growing ethnic conflict within or between states.	

SI Table 7: Status and trends (based on events of the past 5 years) of the economic drivers and conditions of conflict in all four case studies. NEA = North East Atlantic, ECS = East China Sea; CoWA = Coast of West Africa; A = Arctic. Also see SI: References for supplementary information.

Driver/condition	NEA [EU & Great Britain, Iceland, Norway]	ECS [China, Japan]	CoWA [West-African countries]	Arctic [Arctic Council States]	References
Unequal technological developments	**Status:** Fairly high technological development. Norway, Iceland and certain EU countries in particular invest heavily in fisheries R&D. **Trend:** Set to continue	**Status:** For non-artisanal fleet (especially Distant Water Fishing Fleet), fairly high technological development. Japan in particular invests heavily in R&D for fisheries (China	**Status:** Fairly low technological development of fleets (mostly artisanal fishing by local people, industrial fishing dominated by foreign companies with more	**Status:** Fairly high technological development & investment amongst all Arctic countries for fisheries. **Trend:** Set to continue	Chang & Lee (2018)

		very much in aquaculture). **Trend:** Set to continue	technologically developed vessels). Improving through international aid (e.g. UNIDO) and increased state subsidies. **Trend:** Set to continue		
Increase in extractive activities (e.g. oil, gas)	**Status:** In certain areas such as Greater North Sea there is oil and gas exploration. **Trend:** No change foreseen	**Status:** China recently initiated new oil and gas drilling projects in East China Sea **Trend:** Likely more oil and gas resources in East China Sea, which could be explored, dependent on oil prices. China seems set on building more oil and gas exploration platforms in the area	**Status:** Offshore oil and gas have been growing significantly and at a rapid pace in recent years. Pollution, restricted fishing zones are issues (e.g. Ghana). **Trend:** Continued offshore oil and gas exploration & production.	**Status:** Almost a quarter of the world's untapped fossil-fuel resources are in the Arctic which, as ice retreats, could be exploited. Many Arctic governments such as Russia (and non-Arctic such as China), are planning to tap into the wealth (e.g. Norway opened up part of Arctic Barents Sea for oil and gas licensing). **Trend:** Likely the race for Arctic riches will continue and intensify	Dillow (2018) Oirere (2019) Offshore Technology (2018)
Globalization	**Status:** Generally, due to globalization, more fish is exported to international markets than ever before. Geographically	**Status:** Generally, due to globalization, more fish is exported to international markets than ever before.	**Status:** Generally, due to globalization, more fish is exported to international markets than ever before.	**Status:** Generally, due to globalization, more fish is exported to international markets than ever before.	Cao et al. (2017) Crona et al. (2015) FAO (2018)

	dispersed fish stocks are now connected via distant markets and depletion is increasing. In particular Norway is second largest fish exporter, has an extensive salmonid aquaculture sector and large fishing fleet targeting cod, herring, mackerel and other whitefish and small pelagic species. EU is the largest single marker for fish and fish products. **Trend:** Increased growth in Norwegian exports, increased imports of fish to EU	Geographically dispersed fish stocks are now connected via distant markets and depletion is increasing. China is the largest exporter of fish and fish products. Japan and China both import significant amounts of fish. **Trend**: China's rate of export growth is decreasing.	Geographically dispersed fish stocks are now connected via distant markets and depletion is increasing. Africa in general is a net importer in volume terms but a net exporter in terms of value, due to higher unit value of exports, which are destined primarily for developed country markets, particularly Europe. **Trend:** Declining rates of import of fish into Africa due to reduced economic growth in Africa.	Geographically dispersed fish stocks are now connected via distant markets and depletion is increasing. In particular Norway is second largest fish exporter. US second largest importer. Russia provides most of traditional groundfish species are primarily. **Trend:** Set to continue	
Demand for seafood	**Status:** Globally, demand for seafood increasing (due to population growth, increased consumption). Increasingly we are eating aquacultured fish. Demand for seafood with in Europe specifically is also increasing. **Trend:** Demand for and consumption of seafood likely to keep slightly increasing in Europe.	**Status:** Globally, demand for seafood increasing (due to population growth, increased consumption). Increasingly we are eating aquacultured fish. Both China and Japan high consumption of fish. China's demand growing, Japan's declining.	**Status:** Globally, demand for seafood increasing (due to population growth, increased consumption). Increasingly we are eating aquacultured fish. Demand for and total consumption of seafood keeps growing in West Africa.	**Status:** Globally, demand for seafood increasing (due to population growth, increased consumption). Increasingly we are eating aquacultured fish. Increased demand and consumption of fish for the Arctic states.	FAO (2018) EUMOFA (2018) Kamoey (2015)

		Trend: China demand and consumption likely to keep growing (shifting to more expensive types of seafood). Japan's slight decline in demand and consumption likely to continue.	**Trend:** Demand for and total consumption of seafood will likely keep growing in West Africa. However, in Africa overall, per capita fish consumption is expected to decrease by 0.2 percent per year (as demand cannot outpace population growth).	**Trend:** Demand for and total consumption of seafood will likely keep slightly growing for the Arctic states.	
Labor shifts from decreasing agriculture to fisheries	**Status:** Europe has less than 1 percent of the global population engaged fisheries sector, and the number is decreasing. No such labor shift ongoing. **Trend:** No such labor shift expected.	**Status:** Asia in general has an increasing number of people engaged in capture fishing. Unclear if it is a labor shift from other agricultural sectors. **Trend:** Likely to continue	**Status:** Africa in general has an increasing number of people engaged in capture fishing. Unclear if it is a labor shift from other agricultural sectors. **Trend:** Likely to continue	**Status:** None of the Arctic states seemingly experiencing a shift from the agricultural sector to the fisheries sector (Russia even reports a shortage of fisherpeople and Greenland has seen Chinese fisheries workers enter their businesses). **Trend:** No such labor shift expected.	FAO (2018)
Increased fishing effort	**Status:** European states in general fairly high industrial fishing effort (greater engine power, not that	**Status:** China and Japan very high industrial fishing effort (especially stand out against other nations with respect to	**Status:** Fishing effort increased particularly for the artisanal sector in the last decades. Low fishing effort for	**Status:** Russia, USA and Canada relatively high industrial fishing effort among Arctic states. **Trend:** North	McCauley et al. (2018) Belhabib et al. (2018)

	many vessels), particularly Spain. **Trend:** European fishing effort has increased very little up to 2010.	distant-water fishing and fishing on the high-seas). Japan has been scrapping their amount of boats. **Trend:** Asia had relatively high rates of increased fishing effort compared to other continents up until 2010.	the industrial fleet. **Trend:** African fishing effort has increased very little up to 2010.	American and European fishing effort increased very slightly up until 2010.	Sala et al. (2018) Anticamera et al. (2011)

SI Table 8: Status and trends (based on events of the past 5 years) of the environmental drivers and conditions of conflict in all four case studies. NEA = North East Atlantic, ECS = East China Sea; CoWA = Coast of West Africa; A = Arctic. Also see SI: References for supplementary information.

Driver/condition					References
	NEA [EU & Great Britain, Iceland, Norway]	**ECS** [China, Japan]	**CoWA** [West-African countries]	**Arctic** [Arctic Council States]	
Climate change	**Status:** Globally, human-induced warming reached approximate 1°C above pre-industrial levels in 2017. Northern Hemisphere mid-latitude in particular is experiencing regional warming more than double the global average. Despite high exposure to climate change impacts, nations less vulnerable due to higher adaptive capacity and lower sensitivity.	**Status:** Globally, human-induced warming reached approximate 1°C above pre-industrial levels in 2017. China in particular vulnerable due to high sensitivity of the region (fish important for food and income security). **Trend:** Keeping to climate target of 1.5C warming hampered by political inertia/denial (Brazil, USA, Australia etc.)	**Status:** Globally, human-induced warming reached approximate 1°C above pre-industrial levels in 2017. The region is highly vulnerable due to high sensitivity and low adaptive capacity (fish important for food and income security). **Trend:** Keeping to climate target	**Status:** Globally, human-induced warming reached approximate 1°C above pre-industrial levels in 2017. Northern Hemisphere mid-latitude in particular is experiencing regional warming more than double the global average. Despite high exposure to climate change impacts, nations less	Allen et al. (2018) Blasiak et al. (2017) Sauer (2018) Yletinen (2019) Foy (2019)

	Trend: Keeping to climate target of 1.5C warming hampered by political inertia/denial (Brazil, USA, Australia etc.)		of 1.5C warming hampered by political inertia/denial (Brazil, USA, Australia etc.)	vulnerable due to higher adaptive capacity and lower sensitivity. **Trend:** Keeping to climate target of 1.5C warming hampered by political inertia/denial (Brazil, USA, Australia etc.)	
Pollution	**Status:** Contaminant concentrations are generally below levels likely to harm marine species in the OSPAR areas, though they have not yet reduced to background levels. Marine litter is an issue. **Trend:** OSPAR countries have made significant efforts to reduce discharges, emissions, and losses of contaminants to both air and water. The effect of these efforts is clearly visible in reduced inputs to the Greater North Sea.	**Status:** Particularly coastal waters adjacent to ECS have been affected by land-based pollution. Other threats as well (oil spills and mariculture pollution). Bohai Sea poses the highest ecological risks for crustacean, fish and molluscs. Marine litter is an issue. **Trend:** Damaging events still occur (condensate oil spill in 2018), however Chinese policy objectives include amelioration of coastal pollution.	**Status:** Poor collection of municipal waste on West African coastal areas is a major challenge. Marine litter is an issue. **Trend:** West African states have adopted a protocol in 2019 to combat pollution from land-based activities.	**Status:** High levels of pollutants such as mercury and persistent organic pollutants. Significant levels of mercury contained in permafrost (some species already affected). Marine litter is a growing issue (e.g. plastics). **Trend:** More research is underway to better understand the gravity of the issues.	Varotsos & Krapivin (2018) Chang et al. (2012) Wang et al. (2018) Cao et al. (2017) Schuster et al. (2018) Croitoru et al. (2019) Barst et al. (2019) IDDRI (2019) OSPAR (2017) AMAP (2018)
Unexpected stock migration/ redistribution	**Status:** Abrupt changes in distribution already occurred.	**Status:** No reports found on sudden stock redistribution	**Status:** Some reports found on sudden stock and	**Status:** Large boreal fish predators such as cod (Gadus	Lam et al. (2012)

	Northeast Atlantic mackerel redistributed ca 2007 due to changing sea temperatures. **Trend:** EEZs in northeast Atlantic projected to receive influx of new transboundary species depending on level of warming.	aside from expected migrations due to naturally fluctuating migration patterns **Trend:** Moderate to high influx of new transboundary species projected to enter in the region's EEZ depending on the level of warming.	extensive redistribution such as West Africa's sardinella **Trend:** Moderate influx of new transboundary species projected to enter in the region's EEZs depending on the level of warming.	morhua) have been increasingly shifting into the Arctic seas **Trend:** Warming in Arctic Ocean opens up new habitats for marine species. Increase in habitat suitability and productivity will allow a high influx of new species. Due to additional human activity in the Arctic, even more temperate species will get introduced in the area (invasion risk).	Lam et al. (2016) Bruge et al. (2016) Cheung & Reygondeau (2016) Frainer et al. (2017) Pinsky et al. (2018) Chan et al. (2019) Green (2018)
Declining stock status (abundance/health of stock)	**Status:** Some stocks recovered, some overfished. Currently 73 percent of stocks within biologically sustainable levels. **Trend:** Likely higher future fish catch due to climate change Dependent on climate scenario.	**Status:** Difficult to assess due to reporting issues (China). However, the northwest Pacific is the most productive fishing area. **Trend:** The catches in the East China Sea are seemingly stable and even increasing. This could suggests an improving stock status but more	**Status:** Many stocks in region overexploited (destructive gear, high foreign and domestic fishing pressure). **Trend:** Currently continued decline of catches. In future potential severe	**Status:** Very limited catch (some by Russia and Canada) **Trend:** Likely higher future fish catch due to climate change (new fisheries opening up). Dependent on climate scenario. However, no catches from the Central	Cheung et al. (2010) Lam et al. (2012) Lam et al. (2016) Cheung & Reygondeau (2016) FAO (2018) Mallory (2016)

		likely an expansion in fishing intensity. Future possible decrease in maximum catch potential in the region due to climate change. Dependent on climate scenario.	decrease in maximum catch due to climate change. Dependent on climate scenario.	Arctic Ocean should be expected in the coming years, as in 2017 the Arctic states agreed on a fishing ban for the next 16 years	Zhang et al. (2019) Neslen (2019) Bale (2016)
Erosion (coastal)	**Status:** Receding coast lines an issue in Great Britain and Iceland **Trend:** Increasingly a problem	**Status:** General gradual erosion of coast line **Trend:** Set to increase	**Status:** Many coastal areas (e.g. in Senegal & Benin) intensive human inhabitation had led to erosion of coastal areas. **Trend:** Continued retreat of coasts in West Africa.	**Status:** Arctic coastlines are experiencing high rates of erosion. **Trend:** Increasing due to declining permafrost increasing storms.	Kupilik et al (2019) Ndour et al. (2018)

SI: Additional sources for narratives

1. *North East Atlantic scenario sources*

Usage	Sources
Brexit and fisheries	Undercurrentnews, 2019. UK expert warns violence at sea could be reality of no-deal Brexit. Lichfield, J., 2019. A “Brexit bonanza” for UK fishing? That’s a fishy tale with an unhappy ending. Guard. No-Deal Threat to UK distant water fishing, 2019. Fiskerforum.

2. *West Africa scenario sources*

Usage	Sources
Chinese actions related to ocean infrastructure in developing countries	Abi-Habib, M., 2018. How China Got Sri Lanka to Cough Up a Port. New York Times. Chimbelu, C., 2019. Making Chinese investment in African ports work despite risks. Dtsch. Welle.
Foreign-owned trawlers operating in West Africa	Samari, M., 2019. Investigation ties foreign-owned trawlers to illegal fishing in Ghana. Chinadialogue Ocean. Samari, M., 2019. How Ghana's weak penalties are letting trawlers off the hook. Chinadialogue Ocean.
Oceanic operations along the coast of West Africa & their impacts	Environmental Justice Atlas [WWW Document], 2019. URL https://ejatlas.org Fitzgibbon, W., 2019. Probed, Sacked and Ignored: How countries reacted to West Africa leaks.

3. *East China Sea scenario sources*

Usage	Sources
Arria formula meeting	UN Security Council Working Methods, 2019. Secur. Counc. Rep.
Events and country behaviors in South China Sea	Sutton, H.I., 2019. Chinese Nuclear Submarine May Have Been Involved In Incident In South China Sea. Forbes. Venzon, C., 2016. Fishing fuels conflict in the South China Sea. Nikkei Asian Rev. Poling, G.B., 2019. Illuminating the South China Sea's Dark Fishing Fleets. Council on Foreign Relations, 2019. China's Maritime Disputes. Fridtjof Nansen Institute, 2017. Fish, not oil, at the heart of the South China Sea conflict. Greer, A., 2016. The South China Sea Is Really a Fishery Dispute. Dipl.

	Yee, T.H., 2019. South China Sea talks between Asean, China reach milestone. The Straits Times. Quang, N.M., 2019. Saving the China-ASEAN South China Sea Code of Conduct. Dipl. South China Sea: Fishing on the front line of Beijing's ambition, 2019. Financial Times. Macikenaite, V., n.d. The Implications of China's Fisheries Industry Regulation and Development for the South China Sea Dispute.
Events and country behaviors in the East China Sea	Kyodo, J., 2019. China instructs its fishermen to stay away from Senkaku Islands. The Japan Times. Johnson, J., 2019. U.S. sends B-52s for missions over disputed South and East China seas and around Japan. Japantimes. Cooper, Z., 2018. Flashpoint East China Sea: Potential Shocks. Geopolitical Futures, 2016. China Goes Fishing in the East China Sea. Gao, C., 2019. Inside the Navy's Plans to Fight China's Submarines. Natl. Interes.
EU interests in the East and South China Sea	European Union External Action, 2019. Statement by the Spokesperson on recent developments in the South China Sea. Gerstl, A., 2018. The EU's interest and policy towards East Asia maritime security. Marit. Issues.

4. *Arctic scenario sources*

Usage	Sources
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