

# 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 1997–2016, 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 management.

## KEYWORDS

conflict management, environmental security, fishery resources, governance, illegal fishing, scarcity

## 1 | INTRODUCTION

Climate change and global population growth are projected to have far-reaching effects on systems of food production and natural resource management. A combination of changes in fish stock distributions and increasing demand for fish as food suggests a high potential for increasing conflict over fisheries. Recent investigations into fisheries conflict report that it is far from uncommon at both local and international scales, and that its occurrence and potential drivers are increasing (Mendenhall et al., 2020; Spijkers et al., 2019; Glaser et al., 2018; Pinsky, 2018). Fishery conflicts are often entangled with territorial disputes, as was the case for the infamous Cod

Wars (Nemeth et al., 2014; Spijkers et al., 2019). Some fisheries conflicts are marked primarily by diplomatic measures, such as fishing or trade bans, while others are marked by more hostile acts, such as the attack of foreign vessels (Bailey, 1996; Spijkers et al., 2019). Current examples of fishery conflict include the so-called “mackerel war” between Norway, the European Union (EU), Iceland and the Faroe Islands, which erupted in 2007 when the North-east Atlantic mackerel (*Scomber scombrus*, Scombridae) stock shifted its distribution (Spijkers & Boonstra 2017, Gänsbauer et al. 2016). At the end of 2020, the Marine Stewardship Council (MSC) suspended Atlanto-Scandian herring (*Clupea harengus*, Clupeidae) and blue whiting (*Micromesistius poutassou*, Gadidae), fisheries as a consequence of

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the continuing international disagreement over catch quotas and sharing arrangements. Another example is conflict over the rich fishing grounds of the South China Sea, a strategic commodity given that fisheries play a vital role in ensuring food security in the region (Dupont & Baker, 2014). Importantly, fishers may find themselves on the frontlines of international disputes as the surrounding states fail to resolve competing claims over parts of the ocean and its resources (ibid. 2014).

An important endeavour for fishery conflict and governance scholars has been to parse out what might be driving disputes. Inspiration for understanding conflict can be drawn from the literature on natural resources and conflict more generally. Formal analysis of the role of resources in conflict emerged in the 1960s and 1970s (see works by Hardin (1968), 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 freshwater (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). 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 (Dalby, 2014; Le Billon, 2001; Le Billon & Duffy, 2018; Peluso & Watts, 2001). Results from studies of linkages between the environment and conflict have varied widely. 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 has also become common within the literature on fisheries conflict (although some studies flag the indirect role of scarcity and importance of other variables e.g. Mendenhall et al., 2020; Jimenez et al., 2019; Glaser et al., 2018; Dupont & Baker, 2014; Bavinck, 2005). This emphasis on scarcity 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 (Garibaldi, 2012; Pauly & Zeller, 2016). The decline in the availability of fish, the basic premise goes, drove conflict (Penney et al., 2017; Mitchell et al., 2012; Nyman et al., 2013; Stalley, 2003; Zhang, 2012).

In addition to declining catches, another potential instigator of fisheries conflict is climate change (Mendenhall et al. 2020; Pinsky et al., 2018; Pecl et al., 2017). Climate change is leading to increases in sea temperature as well as changes in salinity, ocean currents, pH and oxygen, impacting fish stock dynamics and altering depth and geographical distributions (Free et al. 2019; Cheung, 2018;

1.	INTRODUCTION	834
2.	MATERIALS AND METHODS	836
2.1	Response variable data source: International Fisheries Conflict Database	836
2.2	Details on hypotheses and predictor data sources	836
2.3	Analysis	838
2.3.1	Establishing time periods for analysis	838
2.3.2	Identifying important predictors: a multi-model approach	839
2.3.3	Cross model evaluation	840
3.	RESULTS	840
3.1	Time period 1 (1975–1996)	840
3.2	Time period 2 (1997–2016)	841
4.	DISCUSSION	842
4.1	Findings for time period 1 (1975–1996)	843
4.2	Findings for time period 2 (1997–2016)	844
4.3	Evaluating the evidence for scarcity-induced conflict	845
4.4	Limitations and recommendations	846
5.	CONCLUSION	846
	ACKNOWLEDGEMENTS	847
	DATA AVAILABILITY STATEMENT	847
	REFERENCES	847

Hughes et al., 2017; 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 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 to fisheries of different groups to a resource causes conflict. The concern is that an absolute decline in fish, whether due to overfishing, mismanagement or redistribution in catch caused by climate change may intensify the risk of future conflict. Although Hendrix and Glaser (2011) performed a quantitative study on the consequences of conflict on fish catch (i.e. opposite directionality), the scarcity hypothesis has not yet been rigorously tested on marine fishery conflict data (contrary to freshwater conflict data sets; see Bernauer & Böhmelt, 2014; Dinar et al., 2015; 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 social conditions:

**Hypotheses 1 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. This hypothesis is tested through three aspects of demand for fishery products: increased demand as a result of a growing population (the Malthusian hypothesis), a rising per capita consumer demand for fish as food, or demand for fishery resources as a source of income.

**Hypotheses 2 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.

**Hypotheses 3 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.

**Hypotheses 4 Macroeconomic performance.** As the economic development and macroeconomic performance of a state increase, the number of conflicts over fishery resources a country engages in with another country decreases.

**Hypotheses 5 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 fisheries 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 prior fisheries 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 management.

## 2 | MATERIALS AND METHODS

We evaluated how a set of seven predictors 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 on the basis that they have often been tested for in previous academic work on conflict over other natural resources.

We used the International Fisheries Conflict Database (IFCD) (Spijkers et al., 2019) as our response data set. We first discuss the response data set and structure, then lay out the rationale behind the 5 hypotheses and the chosen predictors, and finally explain 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 the international conflict.

### 2.1 | Response variable data source: International Fisheries 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 Table S1) and were identified through media reports from the LexisNexis Academic database (ibid. 2019). Following Spijkers et al., 2019, an international fishery conflict is a dispute:

- actualized through “conflict events,” which are actions or behaviours ranging from an exchange of statements to severe military involvement and casualties (as defined by the “intensity of observed behaviour” scale, see Table S1).
- occurring between two or more states and/or vessels that fly their flag;
- related to access to a fishery resource or management of a fishery resource;
- potentially occurring in the larger context of a maritime territorial conflict, where the fishery resource contributes to some degree to that territorial conflict;
- spanning over any length of time.

We removed the EU from our analysis as it did not fit the country-level predictor data sets. We also removed Palestine, Western Sahara and the Falkland Islands (Islas Malvinas) from our data set as there were no data available for these regions for any of the predictor variables.

Finally, because we were interested in exploring if national characteristics (related to supply and demand of fish, and additional economic and social conditions) influence the amount of fisheries conflict that a country experiences, we used country-level conflict data as the level of observation, precluding the use of dyad analysis to explore causes of conflict. Though monadic analyses in peace and conflict studies are not uncommon (Sakuwa 2017), and there is academic interest in how domestic or national factors regulate fisheries conflict (Ásgeirsdóttir 2007), it needs to be noted that country dyad data are commonly used (Bernauer & Böhmelt, 2014; Dinar et al., 2015). Where dyadic analyses are able to grasp important relational aspects of conflict, monadic analyses allow us to investigate the importance of single-state attributes of interest (such as if a country experiences growth in demand for fish, will it experience more conflict over fish?).

### 2.2 | 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 Brashares et al., 2014; Choukri & North, 1975; Pomeroy et al., 2016;

**TABLE 1** Hypotheses and linked predictors and their 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 data set 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 exports and taking into account the changes in stocks. Fisheries products encompass both wild-caught fish as well as cultured fish. Measured in tonnes.	FAO, commodity balances
Democracy	Level of democracy	Scale ranging from 0 to 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	Military expenditure includes all current and capital expenditures on the armed forces (SIPRI n.d.). Measured in percentage of GDP.	Quality of Governance database

Note: For a more elaborate description of all the predictor variables, see SI: Data sources.

Seter et al., 2016; 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 Brashares et al., 2014; Choukri & North, 1975; Homer-Dixon, 1991, 1994; Pomeroy et al., 2016; Seter et al., 2016) 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. The inverse of H2 is the resource abundance (or resource curse) hypothesis, which holds that

a higher prevalence of natural resources has negative effects on for example economic development or democratic governance, for example, breeding corruption and conflict (De Soysa, 2002; Frerks et al., 2014; Owusu, 2018).

Though we were primarily interested in testing H1 and H2, we also integrated three alternative socio-economic hypotheses into the analysis. These additional hypotheses are not exhaustive, but represent commonly tested hypotheses in the conflict literature (see for example Bernauer & Böhmelt, 2020; Bremer, 1992; De Soysa, 2002; Hauge & Ellingsen, 1998) for which data were available.

First, we tested the democracy level hypothesis (H3) by looking at the relationship between the level of democracy in a country and conflict (see Bodea et al., 2016; Van Holt et al. 2016; Mcclanahan et al., 2015; Hegre, 2014; Brochmann & Gleditsch, 2012; Brochmann & Hensel, 2009; Boehmer, 2008; Quackenbush & Rudy, 2009; Salehyan, 2008; Wolf et al., 2003; Oneal & Russett, 1997; Fukuyama, 1992). We tested this using the “democracy level” variable (Table 1). The commonly hypothesized relationship is that domestic institutions influence foreign policies, making democracies less likely to initiate conflict. However, because previous studies specifically on maritime conflict have shown that democracies, or powerful autocratic countries, are significantly more likely to

experience conflict than dictatorships, we adopt this hypothesis as well (Daniels & Mitchell, 2017; DeSombre & Barkin, 2011; Mitchell & Prins, 1999).

Second, 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; Bremer, 1992; Brochmann, 2012; Hauge & Ellingsen, 1998; Yoffe et al., 2003) (Table 1). Lower GDP per capita is reportedly one of the most robust predictors of social conflict, and a common hypothesis is that, as the development and macroeconomic performance of a state increases, the number of conflicts over fishery resources a country engages in decreases (Bernauer & Böhmelt, 2020; De Soysa, 2002). However, a previous study specifically on maritime conflict has shown that states with higher levels of economic development are more prone to conflict (Daniels & Mitchell, 2017). Therefore, the hypothesis here is that more developed economies have more extensive fishing operations, and are thus more likely to experience international fisheries conflict (ibid. 2017).

Third, we tested the military expenditure hypothesis (H5) by looking for a relationship between military expenditure and conflict (see Bodea et al., 2016; Bremer, 1992; 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 naval capabilities and more intensive policing would lead to a greater number of international conflicts.

All of the predictors in Table 1 occur in the same year as the dependent variable, international fisheries conflict. However, we also acknowledge that fisheries conflict in the previous year may be an important predictor for conflict in the next year, a variable we call *prior 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 (Cicccone, 2011; Hauge & Ellingsen, 1998; Theisen, 2008). To test this, we use the conflict data set lagged by one year and dropped the first time point (year 1974) from our conflict data set (Hauge & Ellingsen, 1998; Salehyan, 2009).

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 Figures S1–S2) 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 data set), 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).

## 2.3 | Analysis

### 2.3.1 | 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 analyse 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 stocks, with conflicts being characterized largely by low-intensity events of a diplomatic nature (see Table S1) (Spijkers et al., 2019). The nature of the conflict events altered markedly around the turn of the millennium, 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 data set up into two periods allows us to explore how such a change in the global resource base may have influenced incidences of conflict. Moreover, the United Nations Convention on the Law of the Sea (UNCLOS) entered into force in 1996, formally establishing the limits of the EEZ and fundamentally transforming global fisheries governance. The changing nature of international fisheries conflict, the faster rate of increase in conflict over fishery resources in recent years, the altered availability in global supply of fish catch, and deep changes in fisheries governance 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 ran a piecewise regression model (r package: segmented (Muggeo, 2008)) on the number of conflicts between 1974 and 2016. Using the raw conflict data over time, 1997 and 2000 emerged as breakpoints (see Figure S3 and Table S2). After applying a rolling mean of three years over the data, 1997 and 2002 emerged as breakpoints in the data set (see Figure S4 and Table S3). 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 data set at 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 the most conflict, we built two world maps showing the count of conflict for each country in the analysis (r package: ggplot).

### 2.3.2 | 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 (Gegr & 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” (Gegr & 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 fisheries conflict.

#### 1. Boosted regression trees

Our first model, boosted regression trees (BRT), is a non-parametric 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) (Elith et al., 2008; Jouffray et al., 2019). The optimal parameter settings were selected based on explained deviance.

For BRT, we assessed the cross-validated percent deviance explained. The cross-validated percent deviance explained is calculated as  $1 - (\text{cross-validated deviance} / \text{mean total deviance})$  (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 ( $100/\text{number of variables}$ ) 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 non-linear 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 that *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 data set 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, it offers clear understanding of how predictors influence the outcome, and it does not assume independence between data points. 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 data set 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 value was 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 that includes 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.

#### 2.3.3 | 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 were 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.

We used conflict at the previous time point as a predictor in part to account for temporal autocorrelation. We used Auto Correlation Function (ACF) plots to assess whether temporal autocorrelation had been removed from our data set with the inclusion of this variable. Because this is pooled data, we ran separate ACF plots for each country per model, and found that certain countries in two models had residuals from time T-1 that were still correlated with the residuals from time T (Tables S16–S21). We, therefore, ran these two models again, taking out the countries that displayed autocorrelation between T-1 and T. There were no significant differences in model results or resulting inferences between these different treatments of the data (Tables S22–S23).

When assessing multicollinearity through the VIF scores, we found that the GLM model showed VIF scores estimates much greater than 2.5 (see Table S4), but all VIF scores were no greater than 2.2 within the GLMM (see Table S5) and no greater than 2.2 within the BRT (see Table S6). Despite multicollinearity in the GLM, the consistency of results among all the models suggests that our conclusions are sound. We analysed 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 analysed the performance of our models by comparing model predictions with our actual conflict data, to confirm a monotonic relationship between actual and predicted outcomes in our models.

## 3 | RESULTS

### 3.1 | Time period 1 (1975–1996)

During the first 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, prior 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.

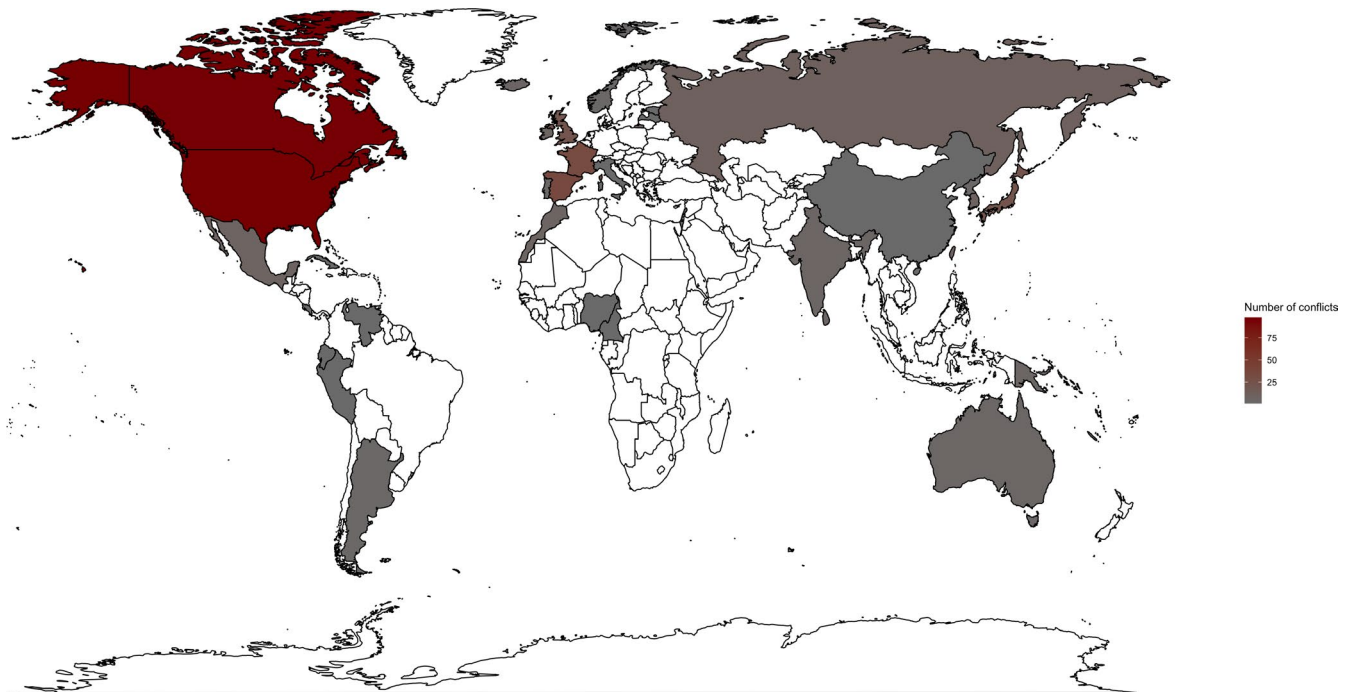
From the PDP, we can see that a country has an increasingly higher probability of experiencing conflict as the amount of conflicts it engaged in during the previous year increases (Figure 2). The same relationship holds for GDP per capita (Figure 2).

### 3.2 | 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 emerged as an influential predictor across the three models (see Table 3). Prior conflict was 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 excluding it 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.



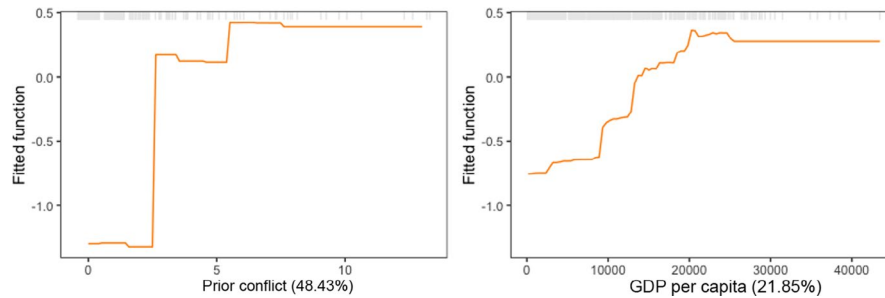
**FIGURE 1** Map of countries experiencing conflict over fishery resources for time period 1 (1975–1996). Figure appears in colour in the online version only [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

**TABLE 2** Model comparison for time 1 (1975–1996)

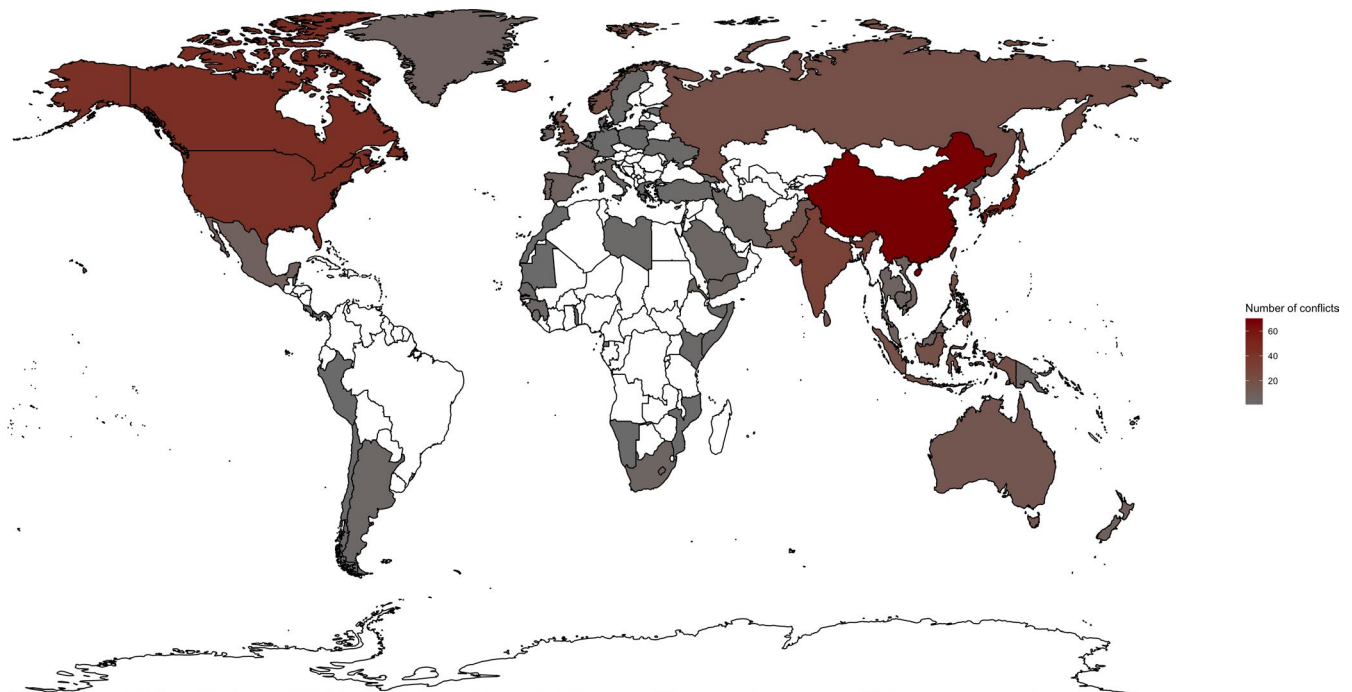
Predictor	BRT	ZINB GLM		
		Count model	Zero-inflation	GLMM
	Relative influence	Coefficient (Standard error)	Coefficient (Standard error)	Coefficient (Standard error)
<b>Prior conflict</b>	<b>48.430055</b>	<b>1.53617 (0.47588)</b>	<b>-4.13908 (1.66194)</b>	<b>1.5205 (0.6758)</b>
<b>GDP per capita</b>	<b>21.850888</b>	-0.20168 (0.79031)	<b>-6.22271 (1.69162)</b>	<b>3.0714 (0.8773)</b>
Domestic supply	9.167361	1.20459 (0.92643)	<b>-3.22221 (1.46331)</b>	2.4764 (1.3486)
Population growth	7.692897	-0.42474 (1.82226)	2.22541 (2.00704)	-2.6453 (1.7593)
Protein from fish	5.454625	-1.86071 (1.35763)	2.83389 (1.93507)	-2.4212 (1.7904)
Democracy level	3.960203	1.18338 (0.77723)	1.40043 (0.94796)	0.2996 (0.7024)
Military expenditure	3.443970	-1.19697 (3.42074)	1.71233 (3.06762)	-2.6367 (2.3191)

Note: 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 S7–S9 for raw output from all three models.





**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 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. Figure appears in colour in the online version only [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**FIGURE 3** Map of countries experiencing conflict over fishery resources for time period 2 (1997–2016). Figure appears in colour in the online version only [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

The three models without fisheries employment as predictor found convergence on the importance of three predictors: prior conflict, domestic supply quantity, and amount of protein consumed from fish (see Table 4).

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 beyond about four past conflict events (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.

## 4 | DISCUSSION

A deeper understanding of international fisheries conflict is critical to conflict anticipation and management. However, we did not find a single hypothesis that could fully explain increases in international fishery conflict. Here we link our results to broader understandings of fisheries conflict and governance.

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 one of the tested hypotheses. Only one predictor, prior conflict, remained significant across both time periods. Particularly during time period 1, prior conflict was a strong predictor. During this time, many of the fisheries conflicts were prolonged, low-intensity

**TABLE 3** Model comparison for time 2 (1975–1996), the three models with fisheries employment as predictor

Predictor	ZINB GLM			GLMM
	BRT	Count model	Zero-inflation	
	Relative influence	Coefficient (Standard error)	Coefficient (Standard error)	Coefficient (Standard error)
Prior conflict	<b>31.122203</b>	<b>4.9257 (1.3211)</b>	42.969 (31.626)	1.8789 (1.2283)
Domestic supply	<b>28.485425</b>	3.5428 (1.9415)	2.402 (10.464)	1.2808 (1.1220)
<b>Protein from fish</b>	<b>14.416985</b>	<b>2.6083 (0.6561)</b>	20.893 (14.936)	<b>3.2177 (0.9302)</b>
Population growth	4.631676	<b>7.4385 (3.5087)</b>	−455.880 (−455.880)	<b>8.4098 (4.1423)</b>
GDP per capita	8.245806	0.4451 (0.5517)	3.259 (16.268)	0.8056 (0.7576)
Democracy level	3.149263	−0.8000 (0.5763)	54.044 (35.815)	−1.4527 (0.8401)
Military expenditure	3.877867	<b>12.9729 (5.5463)</b>	824.609 (522.340)	4.1042 (8.3194)
Fisheries employment	6.070774	0.8768 (0.6174)	78.641 (50.861)	0.9417 (0.8313)

Note: 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 S10–S12 for raw output from all three models.

**TABLE 4** Model comparison for time 2 (1975–1996), the three models without fisheries employment as predictor

Predictor	ZINB GLM			GLMM
	BRT	Count model	Zero-inflation	
	Relative influence	Coefficient (Standard error)	Coefficient (Standard error)	Coefficient (Standard error)
Prior conflict	<b>30.766761</b>	<b>5.08320 (0.98114)</b>	−45.3797 (21.7630)	<b>4.98655 (1.06101)</b>
Domestic supply	<b>28.598450</b>	<b>3.95801 (1.01323)</b>	−71.5552 (25.4029)	<b>3.79510 (1.32148)</b>
<b>Protein from fish</b>	<b>16.238776</b>	<b>1.19910 (0.53838)</b>	1.4120 (1.6591)	<b>2.17422 (0.85789)</b>
Population growth	7.393651	−0.34175 (1.82244)	−1.9172 (3.2316)	−0.9966 (1.9691)
GDP per capita	9.217082	0.16370 (0.51997)	−1.7705 (1.6184)	0.71646 (0.67789)
Democracy level	3.780293	0.02571 (0.36412)	0.6737 (1.0032)	−0.27826 (0.50339)
Military expenditure	4.004987	4.38959 (2.97046)	8.6029 (5.2797)	−2.89693 (3.46971)

Note: 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 S13–S15 for raw output from all three models.

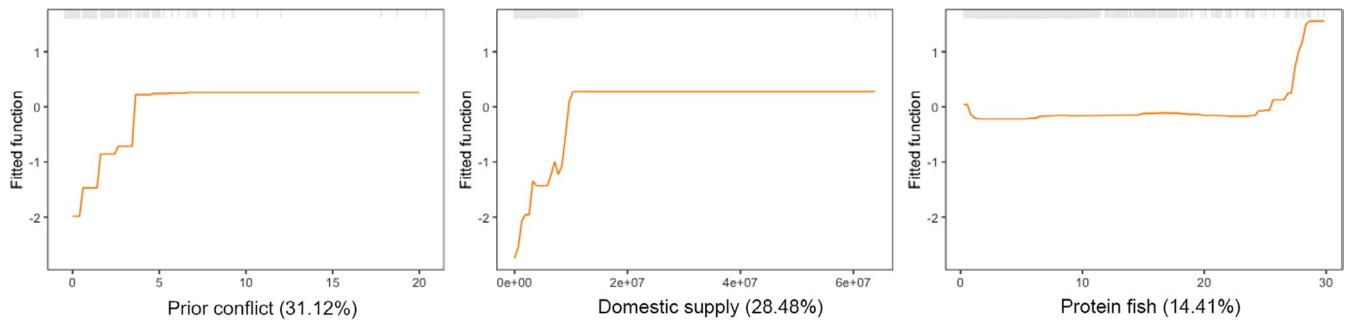
events between the same set of countries (Spijkers et al., 2019). For time period 2, experiencing conflict in the previous year remained an important predictor for conflict in a given year, but the predictor had less predictive power than for time period 1 in the BRT model. This is likely due to international fisheries conflicts not lasting as long during time period 2, but being more intense (Spijkers et al., 2019).

Aside from prior 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, prior 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 the supply of fishery resources were 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.

#### 4.1 | 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 (Anticamera et al., 2011; Pauly & Zeller, 2016; Worm & Branch, 2012). 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



**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. Figure appears in colour in the online version only [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

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
Prior conflict	High	Positive	Moderate	Positive

**TABLE 5** Summary of the findings for time period 1 and time period 2

Note: The findings for time period 1 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.

expressions or hostile diplomatic acts) (Spijkers et al., 2019). Examples include the Pacific salmon (*Genus Oncorhynchus*, Salmonidae) dispute between Canada and the USA or the Cod (*Gadus morhua*, Gadidae) wars between France and Canada (Spijkers et al., 2019).

We found that GDP per capita was a significant predictor for fisheries conflict in time period 1 (see Table 5). Studies linking natural resources such as freshwater to conflict find that decreasing levels of GDP per capita (a general indicator of the development and macroeconomic performance of a country) are significant predictors of conflict (Bernauer & Böhmelt, 2020; Hauge & Ellingsen, 1998; Yoffe et al., 2003). However, focussing on maritime conflict, Daniels and Mitchell (2017) reported 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 (*Reinhardtius hippoglossoides*, Pleuronectidae) 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.

#### 4.2 | Findings for time period 2 (1997–2016)

We found strong support for the demand hypothesis from time period 2, 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), but because the relationship between fish supply and conflict is 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 (Mallory, 2013; Pauly et al., 2014). During period 2, 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 (McClanahan et al., 2015; Pauly & Zeller, 2016; 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 an instructive example of stock depletion and overfishing, 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. 2017, Anticamara et al., 2011). While both of these strategies have allowed China to keep 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 4,000 vessels and is supported by a number of government 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 20 g/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).

#### 4.3 | 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, and seemingly in support of the resource abundance hypothesis that links increased availability of resources to conflict. 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 and thus negating the resource abundance hypothesis. 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 (Agnew et al., 2009; Blomeyer et al., 2012; FAO, 2018; Li & Amer, 2015). Nonetheless, largely due to the increased availability of cultured fish, global supply of fish continues to increase. Could this increase in supply of cultured fish fulfil demand and buffer against conflicts over wild-caught, marine fish? This is a complex issue to be considered more rigorously by fisheries conflict scholars. Here, 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 (only 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 important inputs into aquaculture systems. Therefore, though the total supply of fish is increasing, the decline in availability of marine, wild-caught fish in combination with growing demand is still capable of spurring conflict. These dynamics indicate that the relationship between availability of fishery resources and conflict is even less straightforward than generally thought. Indeed, variables such as the value of, or cultural preferences for, particular species continue to play a more important role in the occurrence of conflict and could be just as important as overall resource availability (Crona et al., 2020; Gallo-Cajiao et al., 2020).

#### 4.4 | Limitations and recommendations

There are a few important limitations to our study. First, the IFCD itself has limitations, as it likely under-reports conflicts in countries with primarily non-English speaking news media, such as parts of South America and Africa (Spijkers et al., 2019). It also 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 (Brochmann, 2012; Mitchell & Zawahri, 2014; Yoffe et al., 2004). This could also clarify whether there are shared predictors between conflict and cooperation. Second, because we were interested in how country-level characteristics influence conflict, we executed a monadic analysis. However, this analysis does not address potential relational aspects of fisheries conflict, for which dyadic analyses would be necessary. Third, 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). Fourth, 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. Fifth, 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; Hauge & Ellingsen, 1998; Hegre, 2014). 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 data set 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 freshwater 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 data set is available. Third, fleet size and fishing effort (or naval capabilities, see data set by Crisher & Souva, 2014) 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 (such as available technologies), 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 data sets, will greatly improve our understanding of conflict drivers across time, scales and geography. Third, looking at the characteristics of fishery resources themselves and how they influence conflict is an unexplored avenue. Characteristics such as the fish's value, its legal status, 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, particularly as potential mediators of conflict intensity.

## 5 | 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. Although 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 DWF 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.

#### ACKNOWLEDGEMENTS

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#### DATA AVAILABILITY STATEMENT

Conflict data from the IFCD are available through the Tropical Data Hub (James Cook University). Digital Object Identifier (DOI): <https://doi.org/10.25903/5f22492a64642>.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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