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Civil conflict and world fisheries, 1952–2004

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Abstract

While the negative economic consequences of civil conflict are well known, does civil conflict have sector-specific effects that threaten food and economic security? This article surveys the effects of civil conflict on reported marine and inland fish catch, focusing on the effects of conflict through redeployment of labor, population displacement, counter-insurgency strategy and tactics, and third-party encroachment into territorial waters. Analysis of 123 countries from 1952 to 2004 demonstrates a strong, statistically robust and negative relationship between civil conflict and fisheries, with civil wars (1000+ battle deaths) depressing catch by over 16% relative to prewar levels. The magnitude of this effect is large: the cumulative contraction in total fish catch associated with civil war onset is roughly 13 times larger than the estimated effect of an extraordinarily strong El Niño, the ocean-atmosphere phenomenon associated with global declines in fisheries. Robust evidence of a Phoenix effect is lacking: post-conflict fisheries do not quickly bounce back to prewar catch levels due to more rapid growth. Analysis of conflict episodes indicates that conflict intensity, measured by battle deaths, negatively affects fish catch, while population displacement and conflict proximity to the coast do not. While these findings contribute to the growing literature on the economic effects of civil conflict, they also are important for regional fisheries management organizations, which must increasingly pay attention to sociopolitical factors that dramatically affect the utilization of aquatic resources.

Keywords

civil conflict, economic effects, fisheries, Phoenix effect

Introduction

The negative economic effects of conflict have been well documented, leading the World Bank to label it 'development in reverse' (Collier et al., 2003). However, most contributions to this literature focus on aggregate measures of output. Might civil conflict have industry-specific effects with more explicit implications for livelihood and food security?

We view this question through the lens of fisheries. The world's fisheries are natural resources of significant value, comprising more than 15% of annual per capita protein intake for more than 2.9 billion people worldwide (FAO, 2009: 60). Fisheries are the direct source of income for 43.5 million people, over 90% of whom live in developing countries (FAO, 2009: 23). Studies of coastal economies in Africa and Asia indicate that these employment estimates underreport, if anything, the extent of reliance on fisheries for food and income (see Béné & Friend, 2009). Global fisheries are a key component of food and income security in regions of the world where civil conflict has been most prevalent during the past half-century.

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This article explores a heretofore unexamined economic effect of civil conflict: its negative impact on fisheries. While most (92.7%) of world fish capture takes place in marine waters, and most civil conflicts are not maritime affairs, the following examples suggest that the impacts of conflict on fisheries can be substantial:

- Following the start of the war between the Liberation Tigers of Tamil Eelam (LTTE) and the Sri Lankan government in 1983, that country's total fish catch fell by 27%. It would be a decade before Sri Lanka, a country whose population grew by 2.2 million in the interim, would again attain its 1983 catch.[1]
- Three years after the start of the Lebanese civil war (1975–90), Lebanon's fish catch was just half of what it had been on the eve of the conflict.
- After decades of stagnation, Liberia's fish catch had grown to over 15,000 metric tons (mt) per year by the late 1980s. Following that country's invasion by Charles Taylor's National Patriotic Front of Liberia (NPFL) in 1989, Liberian fish catch plummeted by 82%. After the cessation of hostilities in 1996, Liberia's marine fish catch began climbing once again, reaching 14,861 mt in 1999, before Guinea-backed guerrillas rebelled against Taylor's National Patriotic Party government. The following year, Liberia's marine fish catch fell by 31%.

These three cases are emblematic of a larger phenomenon we demonstrate here: civil war has a strong, negative effect on total fish catch. In these examples, all of which were characterized by maritime fighting, blockades of ports, or fighting in coastal areas, this significant downturn is understandable. Less obvious is why the outbreak of hostilities would have such an impact on fish catch in other conflicts.

Our theoretical argument hinges on four mechanisms linking conflict to depressed fish catch: population displacement, labor redeployment, economic counterinsurgency, and third-party encroachment. The first three mechanisms apply to both inland (freshwater) and marine fisheries, while the fourth primarily affects marine catch. We estimate the impact of civil conflict onset, incidence, and termination on reported total (inland + marine), inland, and marine fish catch. Using data from 1952–2004 on 123 countries, we demonstrate a strong, negative, and statistically robust relationship between civil war onset (conflicts with more than 1,000 battle deaths) and fish catch. Civil war leads to mean declines of more than 16% of total catch, an effect that is confined to the first two years of conflict. The effect of civil war onset on marine catch is 13 times larger than that of a significant El Niño event, the coupled ocean-atmosphere phenomenon associated with global declines in fisheries (Watson & Pauly, 2001). We do not find robust evidence of a 'Phoenix effect': in the main, fishery output losses during conflict are not offset by rapid recoveries in the post-conflict period. On average, a post-conflict country requires almost nine years of growth to recover prewar catch levels.

The remainder of the article proceeds as follows. We first summarize the literature on the economic effects of civil conflict, as well as the literature linking conflict and fisheries. Next, we introduce our theoretical argument linking civil conflict to depressed fish catch and identify several mediating factors that would further diminish catch during conflict episodes, and present our hypotheses. We proceed to describe the data, present our estimation strategy and the regression estimates, and identify the most salient findings. Finally, we conclude with a discussion of the significance of this project in terms of food security and the role of the international community and fisheries management organizations.

Literature review

There is broad consensus that low levels of economic development and low rates of economic growth are both a cause and a consequence of civil conflict (Collier, 1999; Murdoch & Sandler, 2002; Collier et al., 2003; Fearon & Laitin, 2003; Collier & Hoeffler, 2004; Miguel, Satyanath & Sergenti, 2004; Cerra & Saxena, 2008). Conflict is more prevalent in poorer countries. Conflict itself destroys physical and human capital, and crowds out productive investment, both within the conflict-afflicted country and in its neighbors. Cerra & Saxena (2008) estimate the immediate cost of a civil war at 6% of GDP – significantly larger than previous estimates (2.2% by Collier, 1999). The negative effect of civil conflict has also been found in specific industries, such as tourism (Neumayer, 2004) and finance (Schneider & Troeger, 2006).

Several studies (Organski & Kugler, 1977; Olson, 1982; Murshed, 2002; Koubi, 2005; Bellows & Miguel, 2009) suggest that while conflict is destructive in the short term, its long-term impact on development may be small due to rapid post-conflict growth rates. While

[1] In 1990, a tentative ceasefire between the Sri Lankan government and the LTTE broke down, leading to some of the most brutal fighting of the entire conflict, including the Sri Lankan government's campaign to retake the Tamil stronghold of Jaffna. In that year, catch again fell by 22%.

early contributions focused on interstate war, this 'Phoenix effect' or 'Phoenix factor' has been demonstrated in intrastate war by Koubi (2005): both civil conflict duration and intensity (proxied by battle deaths) have positive effects on post-conflict economic growth rates. It has been found also in Sierra Leone using disaggregated data and alluded to in several other African cases – notably Mozambique and Uganda (Bellows & Miguel, 2009). However, Cerra & Saxena (2008) find no general support for the Phoenix effect in a broader sample of countries. Looking specifically at Africa, they find that rapid recoveries are a product of high aid inflows. Once aid inflows are introduced into the model, post-conflict growth is no longer positive. We offer insight into this debate using new data.

In international relations, competition over fishery exploitation is more often viewed as a cause, rather than a consequence, of conflict. Mitchell & Prins (1999) find that fisheries and marine resources are among the most common reasons militarized interstate disputes (MIDs) occur between democracies. Others see the case for fisheries as a cause of interstate disputes and conflict to be greatly inflated. Gleditsch & Hegre (1997: 288: footnote 7) note that fisheries disputes, which typically involve the threat or use of force by a state actor against a private fishing vessel (e.g. firing warning shots), make up the majority of MIDs between democracies and should be categorized as simple acts of territorial policing.

Fewer analyses have been dedicated to illuminating the effects of conflict on fisheries (see Jacquet et al., 2010). War can decrease exploitation of fisheries by creating war-zone refugia, regions in which civilian activity is limited because of military activity but in which animal and plant populations may thrive (Dudley et al., 2002). During World War I, naval hostilities led to a significant drop in fishing effort in the North Atlantic; once the war ended in 1918, fishers reported higher catch rates and larger fish (Jennings, Kaiser & Reynolds, 2001). However, the potential for civil conflict to affect marine fishing via this direct mechanism is limited. Most civil conflicts do not have significant maritime components, as rebel organizations typically do not field navies. Murphy's (2007) study of maritime insurgency identified only four groups that regularly engaged in maritime attacks: the LTTE, Gerakan Aceh Merdeka (Indonesia), Abu Sayyaf Group (Philippines), and Al-Qaeda (the USS Cole and the MV Limberg attacks, both of which took place in Yemen).

However, the breakdown of state hegemony that attends civil conflict may affect the maritime activities of non-state actors, allowing piracy to flourish, as it has in Somalia, Yemen, Indonesia, the Philippines, Cambodia, and Thailand (Young, 2007). In addition to conventional piracy, illegal, unreported, and unregulated (IUU) fishing – fish piracy – has been blamed partially for the downward trend in marine fish stocks since the 1950s (Le Gallic & Cox, 2006). Thus, civil conflict could lead to lower *reported* fish catch by increasing IUU activity. Precisely because these catches go unreported, data on the extent of IUU fishing are sparse and unreliable, making a direct test of this substitution effect impossible. The expectation, however, is that reported marine fish catch will be negatively associated with IUU fishing, as a larger proportion of the actual fish catch does not appear in official data on marine capture.

The argument and hypotheses

The most significant impacts of civil conflict on fisheries likely operate through the more general phenomenon of crowding out the investment of time and energy in productive enterprises (fishing) and diverting time and energy to either violent or security-seeking activities such as participating in rebellion or seeking refuge across borders. Collier et al. (2003) note that this phenomenon is widespread in countries experiencing conflicts, both at the state and individual (or household) level. The following section identifies four mechanisms by which conflict may affect fish catch: redeployment of labor from fishing to other activities, population displacement, the direct effects of counter-insurgency on the fishing industry, and opportunistic encroachment by third parties. The first three mechanisms apply to both inland and marine fisheries, while the fourth should primarily affect marine catch.

Redeployment of labor

One of the most basic effects of civil conflict on economic activity is to crowd out productive activities with destructive or defensive ones. Fishing employs men almost exclusively, especially in countries where fleets are artisanal and fisher productivity is low, such as in the developing world, where more than 97% of the world's fishers reside (FAO, 2005).[2] In developing countries, those individuals who are most likely to be employed as fishers are also targets of recruitment by both state and

[2] Fisher productivity (catch/number of fishers) is highly correlated with GDP per capita: for example, in 1995, 301,000 Japanese fishers captured 6.7 million mt of fish, while 6 million Indian fishers were needed to capture 5 million mt (FAO, 2005).

insurgent armed forces. The empirical record provides several examples of declines in fishing effort because fishers left the productive economy to participate in fighting. For example, the LTTE recruited heavily from the Tamil fishing communities of Jaffna province, which, along with onion, tobacco, and small manufactures, form the backbone of the Jaffna economy (Siluvaithasan & Stokke, 2006). The recruitment of Somali fishers into the ranks of pirates also has been widespread (Stuhldreher, 2008).

Population displacement

Another mechanism by which conflict may be associated with depressed fish catch is its effect on population displacement: the seeking of security via exit from conflict zones. Violence and the fear of future violence breed incentives to migrate in search of safety, both across borders and within affected countries (Collier et al., 2003; Moore & Shellman, 2004, 2006). The choice to leave is often quite difficult, as staying and risking harm must be balanced against flight to safety, which entails the loss of property, livelihood, and community. Refugees often wind up inhabiting marginal lands with few economic prospects, making them dependent on humanitarian assistance (Gleditsch & Salehyan, 2006). This is especially the case when livelihoods are dependent on location-specific resources, like fish, which require access to coastal or inland waters and local knowledge of fishing grounds.

Case-based evidence suggests that fighting can have large impacts on fisheries via the mechanism of population displacement. Thorpe et al. (2009) identify two different groups of Sierra Leonean fishers who were displaced by the RUF's activities: northern fishers associated with the industrialized fishing fleet, and southern fishers who used traditional, artisanal methods. Northern fishers were able to take advantage of their mobility and the relative political stability in neighboring Guinea to flee the conflict and continue fishing in Guinean waters. However, southern fishers were unable to flee into neighboring Liberia because of that country's conflict. Most of these fishers wound up as internally displaced persons in the capital city of Freetown. In both cases, fishing activities in Sierra Leone were severely curtailed.

Counter-insurgency strategy

Though we reject the notion that civil conflict most directly affects fish catch by making fishing grounds inaccessible, governments may attempt to curtail fishing activities as part of more general counter-insurgency operations. First, counter-insurgency strategy may be aimed at destruction of fishing-related physical and human capital. Because insurgent forces need resources and local political support to prosecute their war aims, governments have incentives to destroy, or limit insurgent access to, economic resource bases and create dissension within the civilian population of the theater of operation. In zones where fishing makes up a large portion of economic activity, keeping fishing boats docked may diminish the resources available to insurgent forces and create economic hardship and food insecurity among the local population. Villagers in the Indian state of Manipur report harassment, destruction of boats, and being used as human shields by the Indian army in its fight against the People's Revolutionary Party of Kangleipak – all of which have curtailed fishing in the state's rivers (Chopra, 2009).

Second, counter-insurgent operations that are not directly aimed at fishers can limit or eliminate access to fishing grounds. Governments often attempt to restrict insurgent access to arms and supplies by blockading port cities in conflict zones. While these blockades are intended to disrupt the flow of arms, they also restrict the ability of fishers to leave port. Such a strategy, implemented by the Israeli government, was responsible for the decline of the Lebanese fishery in the 1970s. A similar situation occurs in present-day Israel and the Occupied Territories. As of 2009, Palestinian fishing boats harbored in Gaza may go no further than two kilometers from the coast; beyond that point, they are subject to boarding, searches, and harassment by Israeli patrols, drastically reducing fishing effort in the territory (Reigeluth, 2009).

Opportunistic encroachment by third parties

Limited resources and the capital requirements of fielding modern navies mean many developing countries have little control over territorial waters, even under ideal conditions. Civil conflict exacerbates this problem by shifting state resources toward fighting insurgents whose activities are almost always confined to the land. Moreover, civil conflict may precipitate state failure: the loss, by the state, of physical control of territory and the monopoly of the legitimate use of force. This loss extends into the oceans as well. After the collapse of the Somali state in 1991, Somalia's waters became a fertile ground for IUU fishing by Asian, European, and Arabian fleets (Le Billon, 2004; Stuhldreher, 2008). Many displaced Somali fishers began to fight back by organizing into armed bands that would levy 'taxes' on the foreign ships, a practice that has metastasized over time into more traditional piracy. State failure in Somalia has imposed a double loss: the loss of fish catch to foreign fleets and the redeployment of fishers into destructive activities. Similar patterns of state failure and IUU fishing occurred in Sierra Leone, Liberia, and Angola, and IUU fishing has been reported in conflict zones in Indonesia and the Philippines as well (Environmental Justice Foundation, 2005).

It is worthwhile to note that IUU fishing likely leads to an increase in fish catch for a given area, even to the point of severe overexploitation by opportunistic third parties with no long-term interest in the health of a given fishery. Because catches of these fish are unreported, however, they do not appear in the ledgers kept by governments – though whether they contribute to the food security or the economy of the country in whose territorial waters the IUU fishing takes place is an open question. From the perspective of the government and the local economy, a decline due to IUU fishing is just as problematic as a decline due to conflict, climatic factors, or unsustainable harvesting – and is observationally equivalent in the reported catch data.

The preceding discussion identified four mechanisms by which civil conflict could suppress fish catch: redeployment of labor, population displacement, direct effects of counter-insurgency practices, and opportunistic encroachment leading to IUU fishing. These four mechanisms all suggest the following hypothesis:

> H_1: Civil conflict will be associated with a decrease in reported fish catch, *ceteris paribus*.

While we expect that civil conflict will affect both inland and marine fish catch, there are several reasons to believe that the proportional effect will be larger on inland fisheries. Marine fishing fleets tend to be comprised of larger boats and their fishing effort takes place further from land, making them less likely to be affected by conflict than inland fisheries. Furthermore, a larger proportion of inland fisheries are likely to be artisanal and employ only a few persons per boat. Therefore, the proportional effect of labor redeployment and population displacement should be larger with inland fisheries. Evidence from the literature on oil and conflict suggests that offshore resources are generally less affected by conflict and provide less incentive for rebellion (Ross, 2006). This suggests a second hypothesis:

> H_2: The proportional effect of civil conflict will be greater on inland fisheries than on marine fisheries.

The literature on post-conflict growth provides conflicting evidence for a Phoenix effect, or rapid post-conflict growth that helps to recover output losses during the conflict. There are several reasons to believe such an effect would be present in reported catches. First, if conflict creates war zone refugia, post-conflict fishers should enjoy greater catches per unit of effort, as there should be greater fish abundance. Second, post-conflict societies often have surpluses of idle labor, much of which may be difficult to re-incorporate into infrastructure-dependent industries, but can comparatively easily transition into work, such as fishing, that does not require large capital investments or developed infrastructure networks. However, the first mechanism – the creation of war zone refugia – might not operate as expected, owing to the presence of IUU fishing, which would suggest that fishing losses during conflict were not offset by stock redevelopment. In any event, we test for the presence of a Phoenix effect in fisheries with a third hypothesis:

> H_3: Growth in reported fish catch will be higher in the post-conflict period than during the conflict or during peacetime, *ceteris paribus*.

We have identified general factors associated with conflict that we expect to depress reported fish catch. However, not all conflicts are equal with respect to their potential to disrupt fishing activities. Conflict intensity, the degree of population displacement, conflict duration, and conflict proximity to coastal areas (in the case of marine catch) may affect fishing. Larger, more intense conflicts, either in terms of battle deaths or numbers of displaced persons generated, should be more disruptive to fish catch than smaller conflicts. Conflict duration may affect fish catch as well, though the expected direction of the effect is theoretically ambiguous. Longer conflicts may be associated with declining catch, as continued conflict compounds the effects of the mechanisms described in the previous section. Alternatively, fish catch may increase with conflict duration, as longer conflicts may signal a more-or-less stable, low-level equilibrium of conflict to which the society and the economy have adapted. Finally, conflict proximity to coastal areas could affect marine fish catch. The Congolese Civil War, while massive in scope, was largely confined to the eastern provinces – far from the country's ports. In contrast, the Liberian and Sierra Leonean wars engulfed coastal fishing communities, entailing massive disruption of fishing activities.

Thus, we elaborate four hypotheses relating attributes of conflicts to reported fish catch. Clearly, these hypotheses can only be tested with a restricted sample of conflict episodes.

> H_4: The number of annual battle deaths associated with a conflict will be negatively associated with reported fish catch, *ceteris paribus*.
> H_5: The degree of population displacement during conflict will be negatively associated with reported fish catch, *ceteris paribus*.
> H_6: Conflict duration will be associated with reported fish catch, *ceteris paribus*.
> H_7: Conflict proximity to the coast will be negatively associated with reported marine fish catch, *ceteris paribus*.

Data

The dependent variable: Fish catch

Fish catch data are from the FAO Fisheries and Aquaculture Statistics Collection Global Production Tables.[3] The FAO catch data are aggregated from relevant national offices of UN-FAO member countries and trade associations. The FAO acknowledges the difficulty of relying on data from countries lacking in bureaucratic capacity. Where officially reported data are missing or considered unreliable, the FAO provides estimates based on FAO expert analysis, informational exchange with regional fisheries management organizations (RFMOs), and comparisons with official trade statistics (FAO, 2010). To the extent that FAO data are biased, the bias is greatest in countries with exceptionally large fisheries, particularly China, which has systematically over-reported catch (Watson & Pauly, 2001).[4] Whatever the inherent limitations and measurement errors in the data, the FAO production tables are the standard resource for fisheries scientists and economists.

We use three operationalizations of reported fish catch: *total catch*, which sums annual inland and marine catch; *inland catch*, which includes fish caught in inland lakes, rivers, and streams; and *marine catch*, which includes fish caught at sea. The data are collected at the national level and expressed in metric tons (mt). These data show a high degree of unit heterogeneity: the mean yearly *total catch* for Japan in the sample is 5.9 million mt, but only 3,370 mt for Nicaragua. Data are available for a broad cross-section, 171 countries, though availability of control variables restricts the analysis to 123 countries from 1952–2004.

In order to address the potential bias that arises from unit heterogeneity, we use the first difference of log(fish catch), henceforth called *total catch growth*, *inland catch growth*, and *marine catch growth*, as our dependent variables. The variable is calculated for country i, at time t, as (log) fish catch_{it} – (log) fish catch_{it-1}. $\Delta\log(\text{fish catch}_{it})$ is approximately the proportional change in fish catch from one year to the next (Woolridge, 2000: 334). This operationalization is desirable because it standardizes the magnitude of change to the size of the fishery and allows for straightforward interpretation of regression coefficients. Despite significant interannual variance, the rate of *total catch growth* at the global level has declined by 0.2% per year since 1950, a finding consistent with Myers & Worm's (2003) and Zeller & Pauly's (2005) calculations regarding indices of fish abundance and total catches. Descriptive statistics for all variables can be found in Appendix A.

Independent variables

We test for the effect of conflict onset, incidence, and termination at two coding thresholds. First, *civil war onset* is a dummy variable with a value of 1 if the country-year contained the onset of an intrastate conflict characterized by at least one year of 1,000+ annual battle deaths, and 0 otherwise. Second, *civil conflict onset* is a dummy variable with a value of 1 if the country-year contained the onset of an intrastate conflict characterized by 25+ annual battle deaths, and 0 otherwise. Because the effect of conflict onset may not appear immediately, we include one- and two-year lags of both measures. All onset data are from Strand's (2006) update and transformation of the UCDP/PRIO Armed Conflict Dataset (Gleditsch et al., 2002).

We test also whether the incidence of conflict affects fish catch apart from the effect of onset of conflict. The theorized mechanisms leading from conflict to depressed fish catch are not isolated to the outbreak of conflict: continued fighting and counter-insurgency efforts can crowd out productive effort, cause population displacement, and otherwise curtail fishing effort in the same ways as the outbreak of conflict. *Civil war incidence* is a dummy variable coded as 1 in all country-years with at least one active civil war, zero otherwise. *Civil conflict incidence* is a dummy variable coded as 1 in all

[3] http://www.fao.org/fishery/statistics/global-production. Accessed 1 August 2010.
[4] Neither removing China nor removing observations in the 99th percentile for total catch size had any impact on the findings reported in this article.

country-years with at least one active conflict, 0 otherwise. As there is nothing in our theory to discriminate between the effects of onset and incidence, we are agnostic as to which might have a larger impact on fish catch.

Finally, in order to test for a potential Phoenix effect, we include *civil war termination* and *civil conflict termination*, dummy variables coded as 1 in all country-years following the end of a civil war or conflict period (using the two-year intermittency threshold), and 0 otherwise. Because the Phoenix effect may not appear immediately, we test contemporaneous, one-year, and two-year lagged measures.

Conflict intensity: Battle deaths and displaced persons

We use the PRIO Battle Deaths Data, Version 3.0, to measure the number of combatants (soldiers and civilians) killed in combat annually (Lacina & Gleditsch, 2005). We use the average of the annual *high* and *low* estimates. Our operationalization of population displacement is *displaced persons*: the combined number of international refugees and internally-displaced persons (IDPs). IDPs are those who are forced to flee their homes because of violence but who remain within the country in a given country-year. The data are from the Center for Systemic Peace's *Forcibly Displaced Populations* dataset, 1964–2006 (Marshall, 2008). Data were converted to proportions of the total population. The values are highly skewed: with respect to displaced persons, the median value for conflict episodes is 0.002, while the maximum is 0.91 (Liberia in 1994). Because of this, we log-transform both variables.

Conflict duration

To test for the effect of *conflict duration*, we use a count variable of the number of years of continuous conflict in a given country, for a given conflict, with intermittency, that is, gaps in violence signaling the end of continuous conflict episodes. Conflict identifier codes from the UCDP/PRIO dataset were used to identify conflicts.

Proximity of conflict to coast

The effects of intrastate conflicts are almost always non-constant over the country's territory: if the conflicts were to take place in the hinterland, we would expect them to have a lessened effect on marine fish catch than if the fighting were to take place near the coast. Buhaug & Gates (2002) collected data on the geographic extent and center point for each intrastate conflict, covering the period 1946–2004. We operationalize proximity as (log) *distance to coast*, which measures the shortest distance (in km) from the coastline to the nearest edge of the conflict.[5]

Control variables

To the list of variables of interest, we add several controls. First, we control for the size of the country's fishery by including the (log) *fish catch*, as larger, more mature fisheries are expected to grow less rapidly (Pauly et al., 2002). Second, we control for other basic economic and demographic factors that may be associated with fish catch: (log) *GDP per capita*, *GDP growth*, and (log) *population*. Data are from Gleditsch (2002) and have been updated through 2004. Previous research indicates that fish catch growth rates are associated negatively with GDP per capita and population, and positively with GDP growth (Jennings, Kaiser & Reynolds, 2001).

We control also for global climate phenomena that may impact worldwide fish catches by including a control for El Niño-Southern Oscillation (ENSO) events. *ENSO events* have been associated with changes in fish catch or abundance in several global and regional analyses (e.g. Barber & Chavez, 1983; Watson & Pauly, 2001). In some cases, such as that of the Peruvian anchoveta, the onset of ENSO coincides with a dramatic decline in fish abundance across the species. In other cases, ENSO events change fish migration patterns, leading to decreases in some regions but increases in others. Our measure is the annual mean of the *Oceanic Niño Index* (ONI), which is the 3-month running mean of ERSST.v3b sea surface temperature anomalies in the Niño 3.4 region (5°N–5°S, 120°–170°W), based on the 1971–2000 base period. Higher values indicate sustained periods of anomalous ocean warming and are expected to be negatively associated with *catch growth*. Data are from NOAA (2010). All control variables are lagged one year to mitigate concerns regarding endogeneity, except for *ONI*, which is clearly exogenous to both conflict and catch growth. We include both the present and lagged *ONI.*

Estimation and results

Full sample

As our theoretical mechanisms are inherently panel-specific in nature, we use fixed-effects regression models with robust standard errors and time trends. Fixed-effects models convert observed values for the

[5] We also use (log) *distance to conflict center*, which measures the shortest distance (in km) from the coastline to the center of the conflict. Results are similar to those reported here.

dependent and independent variables into deviations from their mean values within each unit, that is, country. In doing so, the fixed-effects model eliminates entirely the cross-sectional elements from the data, thus mitigating concerns about heteroskedasticity across units. We use robust standard errors to address potential heteroskedasticity within units (White, 1980). While there is some reluctance to use robust standard errors in fixed-effects models due to their finite sample properties, Monte Carlo simulations suggest that this reluctance is unwarranted (Kézdi, 2004).

Table I reports the estimated impact of conflict onset, incidence, and termination on all three operationalizations of *catch growth*. Odd-numbered models use the higher (1,000+ battle deaths) threshold for war, while even-numbered models use the lower (25+) threshold for conflict. Models 1 and 2 estimate *total catch growth*, 3 and 4 estimate *inland catch growth*, and 5 and 6 estimate *marine catch growth*.[6] As the dependent variables are approximately the proportional rate of change in the various fish catch measures, the coefficients can be interpreted as changes to the baseline growth rate associated with the independent variables.

The results in Table I indicate five main findings. First, reported catch growth is strongly and negatively associated with conflict onset, though the effect is much more robust for larger (1,000+ battle death) conflicts. At the higher coding threshold (Model 1), *civil war onset* is associated with an immediate 8.7% contraction in *total catch* from the previous year and a subsequent 8.4% contraction the year after. Cumulatively, effect of onset in the first two years is –16.4% (F-test of joint significance = 0.023). The magnitude of the effect is substantively large. The cumulative contraction in total fish catch associated with *civil war onset* is roughly 13 times larger than the estimated effect of an extraordinarily strong El Niño year (defined as moving from the mean *Oceanic Niño Index* value (–0.003) to the maximum value (1.29)). Until the recent and widespread acknowledgement of global climate change, El Niño events were perhaps the most well-known and oft-reported climate phenomena, largely due to their potentially disastrous effects for marine fish catch and agricultural productivity (Pfaff, Broad & Glantz, 1999).

At the lower coding threshold (Model 2), the effect of *civil conflict onset* is more limited, associated with a 3.4% decrease in *total catch growth*, significant at the 0.10 level. Lagged *civil conflict onset* is associated with a 4.2% decrease in *total catch* relative to the previous year and is statistically significant at the 0.05 level. The F-test for joint significance, however, is 0.054, indicating that the relationship between *conflict onset* and *total catch growth* at the lower threshold is somewhat weaker.

Second, as hypothesized, the effect of conflict onset is larger for inland fisheries than for marine fisheries. The cumulative effect of a *civil war onset* in the first three years on *inland catch growth* is estimated at –23.8% (F-test of joint significance = 0.004). However, conflict onset at the lower coding threshold is only associated with a 5.7% contraction in *inland catch growth* two years after the outbreak of hostilities. The effect on marine fisheries is more modest: *civil war onset* is associated with a 6% contraction in *marine catch growth* in the first year of conflict, and lagged indicators of onset are not significant. At the lower coding threshold, *conflict onset* is associated with a 4.1% contraction in *marine catch growth* the year after conflict onset.

Third, the effect of civil conflict is restricted to the first three years following onset. Neither *civil war incidence* nor *civil conflict incidence* is significant in any of the models, and the sign on the coefficient is not consistent. Thus, the effect of civil conflict on fisheries is isolated to the year of and one or two years following the outbreak of conflict, depending on the fishery in question.[7] This finding contrasts with the literature on economic growth and conflict, which finds persistent negative growth effects throughout the conflict period (Collier, 1999; Collier et al., 2003).

Fourth, we did not find robust evidence of a Phoenix effect. If a Phoenix effect were present, we would expect that the coefficients on *conflict termination*, either present or lagged, would be positive and significant. None of the coefficients on the present *conflict termination* variable are significant, and the sign is negative in five out of the six models. While two of the coefficients on the lagged indicators are significant (the one-year lag in Model 4 and the two-year lag in Model 5), the directions of the coefficients are opposite: Model 4 estimates a 6% increase in *inland catch growth* the year after conflict

[6] *Marine catch* models exclude outlier observations (approximately 1.2%), which excludes a particularly influential observation (Serbia in 1992), which affected both point estimates and the robust variance estimator. Robust regression, which addresses outlier observations through weighting but does not address heteroskedasticity across units, returns results similar to those reported here.

[7] We ran models with longer lag structures for both conflict onset and termination but only detected effects in the models reported here.

Table I. Fixed effects estimates of fish catch growth, 1952–2004

	Total catch growth		*Inland catch growth*		*Marine catch growth*	
Variables	*(1) 1000 + BD*	*(2) 25 + BD*	*(3) 1000 + BD*	*(4) 25 + BD*	*(5) 1000 + BD*	*(6) 25 + BD*
(log) Catch$_{t-1}$	−0.084***	−0.084***	−0.158***	−0.159***	−0.052***	−0.052***
	(0.009)	(0.009)	(0.020)	(0.020)	(0.008)	(0.008)
Conflict Onset$_t$	−0.087***	−0.034*	−0.131***	−0.029	−0.060**	−0.024
	(0.033)	(0.020)	(0.040)	(0.025)	(0.030)	(0.017)
Conflict Onset$_{t-1}$	−0.084*	−0.042**	−0.055	−0.023	−0.010	−0.041**
	(0.048)	(0.020)	(0.044)	(0.029)	(0.032)	(0.019)
Conflict Onset$_{t-2}$	−0.040	−0.009	−0.107*	−0.057**	0.003	0.005
	(0.034)	(0.019)	(0.060)	(0.023)	(0.035)	(0.021)
Conflict Incidence$_t$	−0.002	0.002	0.025	0.022	−0.013	−0.007
	(0.016)	(0.012)	(0.026)	(0.022)	(0.014)	(0.011)
Conflict Termination$_t$	−0.042	−0.009	−0.005	0.031	−0.017	−0.006
	(0.052)	(0.027)	(0.057)	(0.042)	(0.034)	(0.022)
Conflict Termination$_{t-1}$	−0.030	−0.002	0.068	0.059*	−0.016	−0.013
	(0.029)	(0.018)	(0.046)	(0.033)	(0.023)	(0.016)
Conflict Termination$_{t-2}$	−0.026	−0.013	0.002	−0.014	−0.040**	−0.025
	(0.018)	(0.014)	(0.053)	(0.038)	(0.019)	(0.015)
(log) Real GDP per capita$_{t-1}$	0.006	0.008	0.018	0.021	−0.006	−0.005
	(0.011)	(0.012)	(0.027)	(0.027)	(0.010)	(0.010)
(log) Population$_{t-1}$	0.114***	0.118***	0.245***	0.250***	0.077***	0.077***
	(0.029)	(0.030)	(0.058)	(0.058)	(0.022)	(0.022)
GDP Growth Rate$_{t-1}$	0.001**	0.001**	0.001	0.001	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
Oceanic Nino Index$_t$	−0.010*	−0.010*	0.009	0.010	−0.007	−0.006
	(0.006)	(0.006)	(0.010)	(0.010)	(0.005)	(0.005)
Oceanic Nino Index$_{t-1}$	0.007	0.007	−0.013	−0.012	0.008*	0.008*
	(0.004)	(0.004)	(0.009)	(0.009)	(0.004)	(0.004)
Time Trend	−0.001	−0.001	−0.003**	−0.003**	−0.001*	−0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Constant	1.967*	2.118*	4.774**	4.938**	1.772**	1.780**
	(1.122)	(1.161)	(1.928)	(1.926)	(0.810)	(0.812)
Observations	5,382	5,382	4,225	4,225	5,316	5,316
R-squared	0.061	0.058	0.093	0.092	0.039	0.040
Country Panels	123	123	106	106	123	123

Robust standard errors in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

termination, but Model 5 estimates a 4% contraction in *marine catch growth* two years after war termination. Taken together, these findings do not corroborate the existence of a consistent Phoenix effect for post-conflict fisheries.

The lack of a Phoenix effect suggests that our estimated effect of conflict onset on fish catch is not an artifact of poor or underreported data during conflict periods. Were poor data to blame, we would expect that the end of conflict would be associated with an increase in catch levels. The lack of evidence for a Phoenix effect suggests that either (a) something fundamentally changed about the way reporting of catch to the FAO was conducted, or (b) the change in fish catch was due to decreased fishing effort or more long-term displacement from increased IUU fishing or effort from countries that share stocks. In either case, the livelihoods and food security of the conflict-affected society are likely harmed.

Fifth, the control variables behave by and large as expected. Total (log) *marine fish catch* is negatively associated with catch growth, indicating that larger fisheries grow more slowly. (Log) *GDP per capita* is not associated with catch growth. This is likely due to the countervailing effects of economic development: higher GDP per capita values are associated with more industrialized fishing sectors that are more likely to fish in over-exploited areas subject to declining overall productivity (Worm et al., 2009). However, these same features make developed fishing fleets highly mobile and able to access far-ocean fisheries. Smaller fisheries are typically less technologically sophisticated and fishing occurs in closer proximity to shore. Consequently, fisheries at lower levels of development are likely to experience greater year-to-year variation in growth rates, as they are less able to pursue migratory stocks into international waters (Alder & Sumaila, 2004). The finding may also be an artifact of the high year-to-year autocorrelation in GDP per capita (r = 0.99). The effects of slowly changing variables are largely captured by the country fixed effects and make it difficult for these variables to attain statistical or substantive significance (Beck, 2001).

GDP growth is positively associated with *total catch growth*, though the estimated effect is relatively small. (Log) *population* is positively associated with catch growth and highly statistically significant; this could be an effect of either increased demand or the increased labor supply that can be applied to fishing effort. *ENSO event* is negatively associated with *total catch growth*, though the effect is only significant at the 0.10 level. A strong El Niño year (defined as moving from the mean annual value (–0.003) to the maximum value (1.29)) is associated with a 1.29% decline in fish catch. While this effect is modest for any individual country, the aggregate effect of El Niño is large, as El Niño is a global phenomenon.

Finally, the models perform poorly in explaining catch growth. The R^2 values for the various models are small, explaining between 19.7% and 30.5% of the observed variance in catch growth across the six models.[8] However, the seemingly poor explanatory power of the model must be assessed in context. Watters & Deriso (2000) note that even among single-species models of well-known and often studied fisheries, such as tuna, R^2 values of 10% to 60% are normal. A global model of fish catch, such as ours, is bound to perform more poorly. The types of data that would be necessary to develop a more powerful explanatory model, specifically data on fishing fleet sizes, sophistication, employment, and fishing effort, are not present in global catch time series.

Restricted sample: Conflict years

We identified four conflict attributes that should affect fish catch during conflict episodes: the number of battle deaths, the level of population displacement, conflict duration, and conflict proximity to coastal areas. We run regressions on restricted samples of conflict-years using random effects and robust standard errors. The random-effects model addresses unit heterogeneity while also using information from the 'between' estimator, which averages observations over a unit and regresses the outcome on the average for the right-hand side variables, to look at differences across units (Plümper, Troeger & Manow, 2005). Owing to differences in temporal coverage and missing data, the samples are restricted to between 425 and 920 country-year observations.

Table II reports results of the restricted sample analysis. Odd-numbered models use the higher (1,000+ battle deaths) threshold, while even-numbered models use the lower (25+) threshold. The two measures of conflict intensity, (log) *battle deaths* and (log) *displaced persons* are relatively highly correlated (r = 0.59), necessitating separate models to estimate their effects. Models 7 and 8 include (log) *battle deaths*, while Models 9 and 10 include (log) *displaced persons*. The first four models estimate *total catch growth*, while Models 11 and 12 estimate *marine catch growth* and include the variable (log) *distance to coast*.

The restricted sample analysis provides some support for the hypothesized relationship between conflict intensity and *total catch growth*. (Log) *battle deaths* is negatively associated with catch growth in Models 1 and 2, though the marginal effect is small: moving from the 50th percentile to the 90th for (log) *battle deaths* is associated with a 2.2% contraction in *total catch* at the higher threshold and 3.1% at the lower threshold. The relationship is stronger at the lower coding threshold, which is likely due to the higher threshold partially capturing the effect of higher casualties. (Log) *displaced persons* is not statistically significant at either threshold, though the sign is in the hypothesized direction.

Conflict duration does not appear to affect *catch growth*. The sign on the coefficient is inconsistent across models and never attains statistical significance. We tested as well for a curvilinear relationship by including the quadratic and third-order transformation of duration, which resulted in no significant effects. Finally, (log) *distance to coast* is not associated with *marine catch growth*. The signs on the coefficients are opposite the hypothesized direction, and the standard errors are over seven times greater than coefficient estimates. Conflict proximity to coastal areas does not drive the association between civil conflict and *marine catch growth*.

[8] The fixed effects themselves explain very little of the variance (R^2 between panels = 0.008).

Table II. Estimates of fish catch growth during conflict episodes, 1952–2004

	Total catch growth		*Total catch growth*		*Marine catch growth*	
Variables	*(7)* *1000 + BD*	*(8)* *25 + BD*	*(9)* *1000 + BD*	*(10)* *25 + BD*	*(11)* *1000 + BD*	*(12)* *25 + BD*
(log) $Catch_{t-1}$	−0.014**	−0.015**	−0.006	−0.007	−0.013**	−0.012**
	(0.006)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)
Conflict $Onset_t$	−0.096***	−0.047**	−0.158***	−0.080**	−0.066	−0.038
	(0.033)	(0.021)	(0.057)	(0.037)	(0.052)	(0.025)
Conflict $Onset_{t-1}$	−0.063	−0.031	−0.085*	−0.022	−0.073	−0.053
	(0.040)	(0.024)	(0.050)	(0.035)	(0.080)	(0.036)
Conflict Onset $_{t-2}$	−0.007	0.003	0.058	0.065*	−0.016	−0.014
	(0.037)	(0.027)	(0.039)	(0.038)	(0.077)	(0.043)
Conflict Duration	−0.0001	−0.0001	0.001	0.001	−0.0001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
(log) Battle Deaths	−0.008*	−0.011**			−0.015	−0.018
	(0.004)	(0.005)			(0.013)	(0.013)
(log) Displaced Persons			−0.006	−0.007		
			(0.005)	(0.005)		
(log) Distance to Coast					−0.001	−0.0001
					(0.007)	(0.007)
(log) Real GDP per $capita_{t-1}$	−0.012	−0.011	−0.020**	−0.021**	−0.020*	−0.020*
	(0.009)	(0.009)	(0.008)	(0.008)	(0.011)	(0.012)
(log) $Population_{t-1}$	0.007	0.004	0.003	0.004	−0.002	−0.006
	(0.010)	(0.010)	(0.008)	(0.009)	(0.016)	(0.016)
GDP Growth $Rate_{t-1}$	0.0001	0.0001	−0.0001	0.0001	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Oceanic Nino $Index_t$	−0.008	−0.005	−0.020	−0.015	−0.022	−0.019
	(0.014)	(0.014)	(0.023)	(0.021)	(0.022)	(0.021)
Oceanic Nino $Index_{t-1}$	−0.005	−0.005	−0.007	−0.011	0.015	0.016
	(0.009)	(0.009)	(0.013)	(0.013)	(0.016)	(0.016)
Time Trend	−0.001**	−0.001*	−0.000	0.0001	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	2.219**	2.056**	0.205	−0.213	2.262	2.047
	(0.972)	(0.968)	(1.590)	(1.711)	(1.715)	(1.678)
R^2	0.031	0.022	0.049	0.042	0.024	0.024
Observations	920	920	495	495	903	903
Country Panels	78	78	46	46	77	77

Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

Discussion and conclusions

Figure 1 shows the average effect of a civil war onset (1,000+ battle deaths) on a fishery compared to a peaceful fishery that experienced no conflict. Assuming mean rates of growth for both (2.12% per year), it is clear that civil war onset is a significant hindrance to the development of a fishery. Not until 8.5 years after conflict onset does the average fishery recover the level of production that existed prior to the conflict. By comparison, the average civil war causes an immediate economic contraction of 6% of GDP, half of which is recovered during the first four post-conflict years (Cerra & Saxena, 2008). The magnitude of the effect on fish catch and the length of its legacy are substantial. Moreover, the gap between the fishery with conflict and the peaceful fishery grows in the near term. By the tenth year following onset, the size of the peaceful fishery is 19.1% larger – 2.7 percentage points larger than the gap in the year following war onset. While the effects of civil conflict on fisheries growth are confined to the first three years of conflict, and the fisheries should converge in size over longer time periods as the peaceful fisheries' growth rate slows due to its larger size, it is clear that civil war imposes both short- and medium-

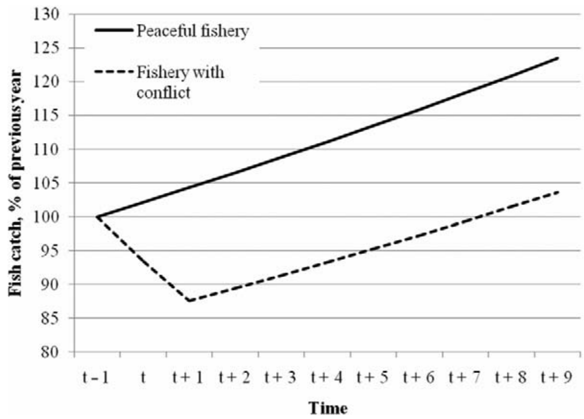

Figure 1. Present effects of conflict and foregone growth of fish catch

term costs. To paraphrase Ghobarah, Huth & Russett (2003), civil wars continue to harm fisheries long after the conflict ends.

The implications for developing countries are particularly dire. Civil conflict is largely a phenomenon of poor countries, as is reliance on fish for dietary protein, which is strongly and negatively correlated with GDP per capita (Kent, 1997). The populations that are most dependent on fish for sustenance are also those at most risk for experiencing civil conflict, which this article has linked empirically to decreased fish catches. Moreover, while the average effect of conflict is considerable, the examples in the introduction demonstrate that the country-specific effect of conflict can be larger. Our findings add to the body of evidence that civil conflict has disastrous consequences for economic development and human security, and we fail to find a silver lining in the form of a Phoenix effect (Collier et al., 2003; Ghobarah, Huth & Russett, 2003).

Three policy recommendations arise from this analysis, pointing to a role for the international community in mitigating the consequences of conflict for fisheries. First, there may be a role for third-party interveners in guaranteeing the integrity of the territorial waters and exclusive economic zones of countries experiencing conflict. There is some precedent for this concept. In 2006, Germany and Denmark sent 11 ships to support the United Nations-brokered ceasefire that ended Israel's month-long war against Hezbollah guerrillas in Lebanon. The arrival of third-party enforcement eased restrictions on Lebanese fishers, who had previously lost access to the Mediterranean because of Israel's blockade. Currently, observers of the conflict in Gaza are calling for a similar role for the United Nations in securing Palestinian access to the seas while addressing Israel's legitimate security concerns. The risks associated with this type of intervention are relatively minor, as patrolling territorial waters to police IUU fishing does not entail the significant costs associated with ground-based intervention or peacekeeping, which requires troops on the ground in conflict zones. Of course, the situation with respect to IUU fishing may be more complex, as many boats involved in IUU fishing fly the flags of the same nations that would be called upon to participate in any third-party monitoring and enforcement.

Second, the recognition that civil conflict imposes a 'tax' on fish catch can be used to inform the policies governing regional fisheries management organizations (RFMOs). RFMOs are intergovernmental organizations that coordinate and control fisheries management in a region. Forty-four such organizations exist, and each is tasked with developing binding, transferable quotas and/or non-binding guidelines governing catch among signatories. These quotas and guidelines can be a function of signatories' previous catches and forecasts generated by fishery stock assessment models. Though the RFMOs that govern relations between developing countries often lack binding quotas, studies of this type, and more in-depth analyses of particular countries, can be used to inform the debate over these agreements and the fisheries they are designed to sustain.

Finally, while our findings contribute to the growing literature on the economic effects of civil conflict, they are also important for bioeconomic models of fish stocks that should eventually include non-physical variables that impact the harvest of aquatic resources. The current trend in fisheries management is toward ecosystem-based approaches, which include physical and biological interactions in predictive models. The need to incorporate social, economic, and political variables is recognized, though efforts in this area are nascent and there is a need to identify relevant non-physical drivers of variability in reported fish catch. This article identifies one such driver that should be incorporated into stock assessment models, for both marine and inland fisheries, especially for countries and regions in which conflict is prevalent.

Replication data

The dataset and do-files for the empirical analysis in this article can be found at http://www.prio.no/jpr/datasets.

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Appendix A. Descriptive statistics

Variable	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
(ln) Population	5382	9.017	1.756	4.957	14.074
(log) Battle Deaths/Population	920	–10.123	2.325	–17.329	–3.838
(log) Displaced Persons/Population	495	–4.273	2.474	–11.991	–0.088
(log) Distance, Conflict Edge to Center	903	1.076	2.145	0	6.938
(log) Inland Catch	4225	8.656	2.431	0	14.222
(log) Inland Catch, First Difference	4225	0.027	0.373	–3.709	5.434
(log) Marine Catch	5316	10.907	2.486	0.693	16.339
(log) Marine Catch, First Difference	5316	0.035	0.203	–0.931	1.068
(log) Real GDP per capita	5382	8.390	1.070	5.139	11.343
(log) Total Catch	5382	11.153	2.358	2.833	16.339
(log) Total Catch, First Difference	5382	0.031	0.227	–3.839	1.792
Civil Conflict Incidence (25 + BD)	5382	0.158	0.365	0	1
Civil Conflict Onset (25 + BD)	5382	0.031	0.174	0	1
Civil Conflict Termination (25 + BD)	5382	0.024	0.154	0	1
Civil War Incidence (1000 + BD)	5382	0.117	0.322	0	1
Civil War Onset (1000 + BD)	5382	0.011	0.103	0	1
Civil War Termination (1000 + BD)	5382	0.011	0.105	0	1
Conflict Duration	920	8.139	8.769	1	48
Oceanic Niño Index	5382	0.031	0.635	–1.242	1.292
Real GDP Growth	5382	2.006	8.139	–68.938	189.741