Income Opportunities and Sea Piracy in Indonesia*

Evidence from Satellite Data

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First Version: June, 2013
Current Version: October, 2014

Abstract

This study investigates the determinants and responses to sea piracy. First, the effect of income opportunities among fishermen on piracy is estimated by exploiting a new source of exogenous variation, based on insights from marine biology. Using satellite data to construct a monthly measure of local fishing conditions it is found that better income opportunities reduce piracy. Second, to address the typical policy response to piracy, the effect of a large military operation is estimated. Results show that the operation significantly reduced the amount of piracy. However, the success of the operation depended on local income opportunities for fishermen.

Keywords: Sea Piracy, Indonesia, Crime, Income Opportunities and Deterrence
JEL: K42, D74, O13, J30

*I thank Niklas Bengtsson, Johannes Buggle, Frederico Finan, Solomon Hsiang, Mikael Lindahl, Edward Miguel, Fredrik Sävje, and seminar participants at UC Berkeley Development Lunch, Pacific Conference for Development Economics (UCLA) and EEA/ESEM (Toulouse School of Economics). I am also grateful for helpful discussions with Eko Susilo at the Institute for Marine Research and Observation in Indonesia and with Stefanie Intan Christienova at Statistics Indonesia.

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1 Introduction

Since the beginning of the 21^{st} century, the ancient phenomenon of sea piracy has seen a revival in many developing countries (Elleman et al., 2010). This has contributed both to substantial human suffering as well as considerable economic costs. Estimates suggest that the costs to the international economy could range between 7 and 12 billion U.S. dollars per year and that the welfare losses are considerable (Bowden, 2010; Besley et al., 2014).[1]

One of the prominent factors mentioned when trying to explain this rise in criminal activity at sea has been the poor living conditions among fishermen, which has been put forward in contemporary as well as historical work on the determinants of sea piracy. For example, maritime historian Henry Ormerod mention that fishermen in the Ancient Mediterranean turned to piracy when fish catches were too low, taking advantage of their boats, seafaring skills and navigational knowledge (Ormerod, 1924). Other studies emphasize that "piracy was typically a seasonal job" - that fishermen turned to to supplement their incomes from lawful activities (Elleman et al., 2010). In addition, recent interviews with contemporary pirates in Indonesia bear witness about recruitment from unemployed fishermen and sailors (Frecon, 2006). These accounts are not surprising given that the skills and capital required for piracy are similar to those required for fishing.[2] This paper investigates these claims by studying the impact of local income opportunities among fishermen in Indonesia, recently reported as the most piracy prone country in the world, on pirate activity (Kemp, 2013).

Several empirical challenges exist in estimating the impact of income opportunities on sea piracy. Most prominent is probably the risk of reversed causality since an increased likelihood of being attacked by pirates may prevent fishermen from going to sea.[3] Other challenges include factors affecting both the income of fishermen and the amount of piracy, such as

[1]Besley et al. (2014) find that the generation of 120 million U.S. dollars of revenue for Somali pirates led to a welfare loss between 0.9 and 3.3 billion U.S. dollars.

[2]As highlighted by Elleman et al. (2010) a large number of pirates use small fishing skiffs when operating.

[3]In fact, this channel was highlighted by Lim Kit Siang, a member of the Malaysian parliament, who claimed that "fishermen ... dare not go out to sea because of the lawlessness in the Straits of Malacca [in Indonesia]" (Siang, 2004).

the general economic or policy environment. To deal with these issues, this study introduces a new source of exogenous variation in local income opportunities for fishermen. This measure is based on the reasoning that a fisherman's legal income opportunities are largely determined by changes in the amount of fish available in nearby waters. The measure relies on a marine biological literature which has shown that the amount of fish in a specific location can be estimated with satellite data on oceanographic conditions in that area. These conditions are in turn determined by complex environmental interactions of sunlight, temperature and nutrients in the water. Hence, given a set of time and location fixed effects, this measure is arguably an exogenous determinant of the income opportunities for fishermen. By combining this measure of fishing conditions with the timing and location of piracy attacks in the Indonesian exclusive economic zone, the effect of income opportunities on piracy is estimated.

The main results show that good fishing conditions reduces the mean number of piracy attacks by about 50% and the probability of an attack occurring at all by 37 %. Several steps are taken to ensure that these effects are in fact driven by changes in local income opportunities among fishermen. In a first step the findings in the marine biological literature are reconfirmed, providing evidence that the measure of fishing conditions captures the local availability of fish. Second, the results are shown to be unaffected by other factors that may correlate with both fishing conditions and the possibility to conduct piracy, such as local weather conditions. Third, an improvement of fishing conditions is shown to increase the income of fishermen in Indonesia and induce them to select away from other income generating activities. Heterogeneity analysis provides additional support for the proposed mechanism by showing that effects are about 80% larger in areas that experienced slow growth during the sample period. This suggests that the availability of other income sources makes piracy less sensitive to fluctuations in fishing conditions. Further heterogeneity analysis shows that effects tend to be larger in areas with high average levels of shipping traffic, indicating that the supply of vessels to attack is an important factor when determining the response to worsening income opportunities.

In an additional analysis, the consequences of the typical policy response to piracy are investigated. This part of the paper focuses on an intensive military operation that increased the risk for pirates of getting caught. It is shown that the number of piracy attacks were reduced both during and the years after the operation and that the effect of the operation decreased with time. In the short run, the operation reduced the number of attacks by about the mean in the control group. A heterogeneity analysis shows that the operation had a direct effect on the number of attacks in piracy prone areas with poor fishing conditions and a strong persistent effect in areas with better fishing conditions. Results show that the longer term effects of the operation are bigger when the income opportunities of fishermen are better, suggesting that it enables them to select away from piracy.

This study contributes to several literatures. Broadly, it relates to the literature investigating the determinants of conflict, especially the part of this literature that focus on the role of economic conditions (Collier and Hoeffler, 1998; Miguel et al., 2004; Blattman and Miguel, 2010) as well as climatic factors (see Hsiang et al., 2013, for a recent review). Both of these fields have extensively relied on cross country analysis (Blattman and Miguel, 2010; Hsiang et al., 2013) and this study hence provides novel micro evidence focusing on a growing violent activity with severe economic and welfare costs.[4]

In addition, this study contributes to the extensive literature investigating the effect of legal labor market opportunities and deterrence on crime. Following the seminal theoretical framework proposed by Becker (1968), there has been an extensive amount of empirical work investigating these two issues (see, e.g., Mustard (2010) for a review focusing on labor markets and Chalfin et al. (2014) for a review focusing on deterrence).[5] The results in this paper are in line with the predictions proposed by Becker (1968); that the crime level is affected both by changes in the opportunity costs of conducting crime and by the probability of apprehension. In testing these predictions, this study adds to the literature by exploiting a context in which the offenders (pirates) and victims (mainly international cargo ships) are drawn from two different populations and thus enables the iden-

[4] A recent exception in the conflict literature is Dube and Vargas (2013) who use price shocks to study civil conflict in Colombia.

[5] Iyer and Topalova (2014) also focus on income opportunities and crime in a developing country setting, but use rainfall and trade shocks to identify a positive effect of poverty on crime in India.

tification of the pure effect of changes in income opportunities for offenders on crime, without having to deal with the potentially confounding effect of income opportunities on the availability of resources to steal. It also provides novel evidence on the interaction effect of deterrence and available income opportunities as discussed above.

Thematically this paper most closely relate to a recent empirical literature on the determinants of piracy. Previous studies in this area have taken a cross-country approach and typically focused on the role of state capacity in determining piracy, but a few recent papers also partly address the issue of income opportunities empirically (see Cariou and Wolff, 2011; Jablonski and Oliver, 2012; Daxecker and Prins, 2012; Ludwig and Flückiger, 2014).[6] These studies tend to find a negative correlation between different income measures and the number of piracy attacks. The negative correlation also holds when focusing on the aggregate fishery production in a country, suggesting that income opportunities among fishermen might have an important causal impact on the number of piracy attacks. This study contributes to the literature by exploiting an as-if random assignment in fishing conditions to enable a credible identification of the causal effect.

The paper is organized as follows. The next section provides an overview of sea piracy as well as the fishing industry in Indonesia. Section 3 presents the main data sources used and explains how the different samples are constructed. Section 4 describes the empirical strategy in detail and the construction of the measure of fishing conditions. This is followed by a test of the validity of this measure by investigating how the price of fish as well as the income and working hours of fishermen are affected by changes in fishing conditions. Section 6 reports the main results on piracy attacks

[6]Most closely related to this paper is the simultaneous, but independent, paper by Ludwig and Flückiger (2014). They find a positive correlation between a country's yearly level of phytoplankton and fish catches; and a negative correlation between phytoplankton and piracy for a subsection of the years included in this study. In contrast to Ludwig and Flückiger (2014), this paper uses a more refined source of exogenous variation by exploiting a two dimensional measure of fishing conditions based on previous marine biological studies in Indonesia. The micro approach in this study also enables the use of local labor market data for fishermen as well as seasonal and within country geographical variation resulting in a more than 60 times larger sample size. In addition, the focus of this paper is broader by looking not only at changes in income opportunities but how these effects vary with other determinants of piracy as well as the role played by anti-piracy operations.

as well as the heterogeneity of these results. The following section investigates the impact of the 2005 anti-piracy operation. Section 8 addresses the robustness of the results, and section 9 offers a summarizing discussion and concluding remarks.

2 Background

2.1 Piracy in Indonesia

During the last 15 years the waters around the Indonesian archipelago have been ranked among the most pirate-prone in the world (Chalk, 2008). The number of attacks have varied substantially over this period, from above a hundred attacks a year in 2000-2004 to a record low number of less than 50 in 2009 (ICC International Maritime Bureau, 2013; Elleman et al., 2010). However, since 2009 the number of attacks has been on the rise again and Indonesia is taking over as the most pirate prone country in the world (Kemp, 2013). According to the International Maritime Bureau (IMB), Indonesia accounted for more than a quarter of all global piracy incidents in 2012 with a total of 81 attacks. In these attacks, 73 vessels were boarded and 47 crew members were taken as hostage (ICC International Maritime Bureau, 2013).

Piracy attacks in Indonesia are often carried out using simple technology such as skiffs, knives and small arms. The typical attack is carried out by a group of 5-10 pirates targeting an international cargo or bunker ship and involves stealing the personal belongings of the crew members and/or the vessel's safe (Elleman et al., 2010). However, more violent attacks in which the crew gets kidnapped or the ship gets hijacked does also exist. On some occasions attacks are also carried out towards smaller vessels such as fishing boats or yachts. There are substantial revenues to be made from piracy. Raymond (2010), e.g., documents that an attack in Indonesia typically results in rewards between 10,000 - 20,000 U.S. dollars. This implies an individual return from an attack that corresponds to about 7 to 30 times the average monthly income for fishermen.[7]

[7]This calculation is based on the average monthly income of fishermen in 2011 of 1,176,675 rupiah per month (BPS, 2012), which correspond to approximately 134 U.S.

Despite the large number of piracy attacks in the Indonesian waters, there have been few interventions aimed at reducing piracy and the authorities have been criticized for their inaction. Lack of funding has prevented the Indonesian government from supplying enough patrol ships and the government has been resistant to join international agreements on anti-piracy in the region, partly due to disputes with Malaysia on their territorial waters (Raymond, 2010; Hays, 2012). Indonesia has also rejected offers from other countries to patrol their Exclusive Economic Zone (Hays, 2012). During the 2000's some progress has, however, been made and in July 2005 Indonesia initiated Operation Octopus to combat piracy in the Malacca and Singapore Strait. The operation involved patrolling of navy ships, helicopters, aircraft as well as troops on land and it has been put forward as an explanation to why the number of piracy attacks decreased in the end of 2005 in the Malacca Strait (Storey, 2008). The effect of this operation is investigated in section 7 below.

2.2 Fishing Industry

Indonesia is the third largest fishing nation by quantity produced and a major exporter of fish (FAO, 2013, 2011). The fishing industry is also a vital part of the Indonesian economy, accounting for 21 percent of Indonesia's agricultural economy, 3 percent of national GDP and providing over six million people with direct employment (FAO, 2013).[8] Marine fishery captures correspond to the majority of fishery production in Indonesia and in 2009 marine captures amounted to 4.8 million ton fish. About half of the captured fish, and by far the largest group, are the so called small pelagic fishes. This group includes species such as sardine and mackerel (Asia-Pacific Economic Cooperation, 2013).

Marine fishing is carried out by traditional as well as commercial fisheries. Traditional fishing is conducted in small vessels in trips lasting one to two days close to the shore line, mostly for subsistence by fishers and their families. Commercial fishing on the other hand is carried out further from the shore line (4 nautical miles and beyond), but is also usually

dollars per month.

[8]These numbers are probably lower bounds since they exclude illegal fishing, which is estimated to be substantial in Indonesia.

conducted from small boats. Often coastal fishing is conducted within 20 nautical miles from a port (Mathews et al., 1995). All in all, estimates indicate that as much as 90 percent of all fish production is carried out by small scale operators using simple technologies (Verité, 2012). This makes fishing sensitive to changes in weather and environmental conditions.

Fish catches are largely determined by the different fishing seasons in Indonesia, which are in turn influenced by the two monsoons present in the area; the western and south-eastern monsoon. The primary boat fishing season is during the south-eastern monsoon, which occurs from June to September. Pelagic fishes are typically abundant during this part of the year (Hendiarti and Aldrian, 2005). From December through March the western monsoon occurs. During this period winds are typically stronger and rains heavier. This makes boat fishing more difficult and fishing is therefore often carried out closer to the shore. Although these patterns are evident all over Indonesia, the monsoonal system affects the coastal processes in each region differently (Hendiarti and Aldrian, 2005).

Several studies document high variability in the income of fishermen in Indonesia (see, e.g., Sugiyanto et al., 2012; Verité, 2012). In a recent study of the income of poor households in Yogyakarta by Sugiyanto et al. (2012) it was, e.g., noted that:

> "The largest fluctuation [among all surveyed occupations] occurred in the income and consumption of the fishermen. Due to the seasonal nature of their profession, they achieved the highest maximum income and the lowest minimum income. If the season was good and there was a large catch, fishermen would take in especially large incomes, but usually this season only lasts about three months. For the rest of the year the southern coastal fishermen tend to be unemployed because they are unable to go fishing due to the seasonal weather changes that limit the possibility of catching a profitable number of fish."

There is also evidence that the income of fishermen depends on how successful fishing trips are and that fishermen may not receive any payment if catches are not sufficient to cover expenses (Verité, 2012). Environmental and weather conditions affect fishermen's income, not only by determining the amount of fish in the water and hence how successful fishing trips are, but also by influencing the number of trips that can be carried out in a given month. During periods of extreme weather, fishermen may be forced to stay on shore, which, e.g., happened during the 2011 western monsoon in Indonesia (Ministry of Marine Affairs and Fisheries, 2012). These facts, combined with low income levels, puts many fishermen in an economically vulnerable situation (Fauzi, 2005).

3 Main Data

This section presents the data sources used for constructing the four samples employed in the analysis. Each sample is constructed for a given geographical unit, which reflect the level at which the outcome data is available. These samples represent (a) 16 coastal fish markets, (b) 250 coastal districts, (c) 197 cells covering the whole Exclusive Economic Zone (EEZ) of Indonesia and (d) 325 fishing ports.[9] Figure 1 shows the geographical distribution of these samples and Table 1 provides summary statistics for the data presented below.

For each of these four samples satellite data on the chlorophyll-a concentration and sea surface temperature of the water is used to construct a measure of fishing conditions, following the approach outlined in Section 4.1. This is done for the whole cell for sample (c) and for a 20 nautical mile zone surrounding the specific location/border for samples (a), (b) and (d), following the common zone of operation discussed above. The data is derived from the NASA Modis Aqua satellite and is available for every month from July 2002 to June 2013 at a 0.05 degree spatial resolution (Acker and Leptoukh, 2007). To construct control variables additional environmental satellite data on monthly accumulated rainfall (0.25 degree spatial resolution) and average monthly wind speed (2.5 degree spatial resolution) is also

[9]The samples have been constructed based on the following criteria. Sample (a) includes all markets that fulfil the requirements discussed below in this section. Sample (b) includes all coastal districts in the 2000 census for which labor market data is available as discussed below. Sample (c) includes all ports with information available about their location on the website of the Ministry of Maritime Affairs and Fisheries of Indonesia at the time of data collection. Sample (d) is the result of splitting the EEZ of Indonesia into equal sized 2×2 degree cells.

collected for the same time period. The sources of the additional data are the Tropical Rainfall Measuring Mission and the National Center for Environmental Prediction, respectively. These datasets are chosen since they provide the longest possible time series on these variables for Indonesia.

Sample (a) is constructed to investigate the impact on the local price of fish. Data on the average monthly price of fish for January 2008 to April 2012 is collected for each market from the monthly reports produced by the Indonesian Directorate General of Processing and Marketing of Fishery. These include the local price for a number of fish species in different local markets (Direktorat Jenderal Pemasaran dan Pengolahan Hasil Perikanan, 2012). Species that occur at least 5 times during the sample period and markets that have data for at least 10 time periods are included.[10] From Table 1 it can be seen that the average monthly price of fish is 22,544 rupiah per kilo, which corresponds to approximately 2.4 U.S. dollars per kilo. The price varies considerably both between markets and within markets over time.

Sample (b) is constructed to investigate the impact on labor market outcomes. This sample uses data from 7 survey rounds of the Indonesian labor market survey (SAKERNAS), carried out each February and August from 2007 to 2010. These rounds are chosen since they include detailed industry and occupation information, which enables the identification of marine coastal fishermen. Additional information in the survey on the district location of jobs makes it possible to match each coastal fisherman surveyed in a particular month to the fishing conditions in the coastal area of that district the same month. During this time period a total of 9,962 such fishermen responded to the survey and they are in turn used to calculate district averages. For these fishermen the share of total working hours dedicated to fishing the previous week is constructed as well as the number of hours dedicated to other jobs. In Table 1 it can be seen that fishermen tend to spend as much as 97 % of their working hours fishing, working on average 41 hours per week. Information on the income the previous month is available for those fishermen that are self-employed, which constitute about 66% of the previous sample. Using the response from these individ-

[10]Species that are used in fish farming are excluded from the analysis as well as markets that are not located in coastal fishing communities.

uals the average income as well as the income per day worked is calculated. Self-employed fishermen earn on average 771,101 rupiah per month and 41,863 rupiah per day worked.

Samples (c) and (d) are constructed to investigate the impact on sea piracy. This data is from the National Geospatial-Intelligence Agency (NGA), who provides geocoded data on piracy attacks including the type of attack, aggressor, victim, date of occurrence, as well as a short description of the event. The dataset covers attacks that occurred from 1978 until today. The NGA combines data from several agencies that monitor and report on piracy incidents (such as the International Maritime Bureau (IMB) and the UK Maritime Trade Operation) and it is thus likely to be the best source available to find reliable data on piracy attacks. However, since much of this data rely on self-reporting by ships some attacks are likely to go by without being recorded. Hence, the data used in this study is still likely to underestimate the true number of attacks. The IMB, e.g., believes that its reports only capture about half of all attacks that occur (Bowden, 2010).

The NGA data is used to determine the location of attacks as well as the number of attacks per cell in sample (c) and the number of attacks for a 40 nautical mile zone surrounding the fishing ports in sample (d). Pirate attacks are broadly defined in this study and include both attacks that have been carried out, attempted attacks that could be avoided as well as suspicious approaches. Further, in the aggregate number of attacks both ships that were on route and anchored when the attack was carried out are included. During the period of interest in this study a total of 1,062 attacks were carried out in the EEZ of Indonesia, of which most have been attacks on merchant or international cargo ships. Compared to other countries' EEZ the number of attacks in Indonesia is substantial, as can be seen in Figure 2. There is also considerable seasonal and geographical variation in the number of attacks, illustrated in figures 2 and 5. Most attacks have taken place in the Malacca strait, which is a vital shipping lane for vessels travelling from Europe and the Middle East to East Asia. From high levels in the beginning of the decade, the total number of attacks decreased substantially in the second half, only to increase again during the beginning of the first decade.

4 Empirical Strategy

This section discusses the issues involved in estimating the causal effect of income opportunities on piracy and presents the proposed solution in this paper. The first part of the section provides details about the construction of the measure of fishing conditions and the second part describes the baseline empirical specification.

4.1 Fishing Conditions

Estimating the impact of income opportunities for fishermen on the number of piracy attacks in Indonesia involves a number of empirical challenges. This is because there are many reasons for why there may be a correlation between these two variables. Most notable is probably the risk of reversed causality, since a high number of attacks may prevent fishermen from going to sea. Other factors affecting both the income of fishermen and the amount of piracy involve the general economic and policy environment.

In order to identify the effect of interest and overcome these challenges, this study exploits oceanographic data to construct a measure of fishing conditions and thereby a proxy for the income opportunities of fishermen. This measure is determined by complex environmental interactions that, given a few conditions discussed below, are likely to be exogenous to piracy. The construction of the measure is based on a marine biological literature, which have found that satellite data can be used to estimate the abundance, migration patterns, distribution, and growth of fish in a given area (see, e.g., Semedi and Hadiyanto, 2013; Semedi and Dimyati, 2009; Nurdin, S; Lihan, T; Mustapha, 2012; Hendiarti and Aldrian, 2005).[11] This is possible since the base of the ocean food web, phytoplankton, uses chlorophyll-a for the photosynthesis, which affects the colours of the ocean and therefore can be observed by satellites (see Figure 3). In combination with satellite data on the sea surface temperature of the ocean, which is informative of how suitable conditions are for different species, the abundance of fish can be estimated. This paper will rely on the findings of Semedi and Hadiyanto

[11]These studies typically collect daily data from vessels on fish captures and then correlate this with in situ as well as satellite data on different characteristics of the waters, such as the sea surface temperature, chlorophyll-a concentration and salinity.

(2013), who study the relationship between the catch per unit of effort of small pelagic fishes and oceanographic conditions in the Makassar Strait in Indonesia between 2007 and 2011. They find that all captures were made in waters with a chlorophyll-a concentration of 0.3 mg/m^3 to 2.8 mg/m^3 and a sea surface temperature (SST) between 26 °C to 30 °C. Based on this finding the following equation is used to construct the measure of fishing conditions for a particular month (t) and area (a):

$$f_{at} = \frac{\sum_{i=1}^{n_a} \mathbb{1}[26 \leq SST_{iat} \leq 30 \wedge \ 0.3 \leq chlorophyll_{iat} \leq 2.8]}{n_a}, \tag{1}$$

where $\mathbb{1}[.]$ is an indicator function. This function takes on the value 1 when the observational point i in area a and month t satisfies the requirements established in Semedi and Hadiyanto (2013), i.e. when fishing conditions are good, and zero otherwise. In order to make the measure comparable between units, the sum of all good points in area a is divided by the total number of observational points (n_a) in that particular location (see panel (c) of Figure 3 for an illustration of this).[12] This produces a ratio between 0-1 for each geographical and time unit, which has the intuitive interpretation that it estimates the share of good fishing spots in a particular area at a given point in time.[13] The benefit of this measure is that it is determined by processes exogenous to piracy. Growth of phytoplankton, e.g., depends on the availability of sunlight, temperature and the nutrients in the water. These are in turn determined by environmental processes such as upwellings, during which ocean currents bring cold and nutrient rich water from the bottom of the ocean to the surface (NASA Earth Observatory, 2002).

The temporal and geographical variation of this measure of fishing con-

[12]The number of observational points for each area (n_a) is determined by the spatial resolution of the satellite data, the size of the unit as well as the share of an area that is covered by water.

[13]Since this measure is based on a study in a particular area in Indonesia and is focusing on small pelagic fishes, the external validity of this measure might be a concern. In order to investigate this, it has therefore been compared to a measure of "good fishing spots" derived by experts at the Institute for Marine Research and Observation in Indonesia (see Figure 6). These measures are positively correlated, also after conditioning on time and cell fixed effects.

ditions as well as the other main variable of interest, piracy attacks, is illustrated in figures 4 and 5. Both figures illustrate a clear and strong relationship between fishing conditions and piracy, namely that when fishing conditions are poor the number of piracy attacks in a given location tends to be high. The next sub-section outlines the strategy used to exploit this variation and determine whether this relationship can be given a causal interpretation.

4.2 Baseline Specification

Even though the above measure is determined by factors that are out of control of the fishermen, it is not randomly assigned. This is because certain areas or time periods may simply have better fishing conditions on average, which indeed the above discussion implies, as well as characteristics that make them more or less prone to piracy attacks. A location close to the shore may, for example, experience oceanographic processes that produce better fishing conditions at the same time as this location is easier to access for pirates, making piracy attacks more common. Time specific factors could also be important, e.g., if anti-piracy policies are introduced in times when piracy is high due to poor fishing conditions. Hence, in order to exploit the as good as random variation in the fishing conditions variable the following fixed effect model is the preferred specification:

$$p_{at} = \beta f_{at} + \delta_a + \gamma_t + X'_{at}\lambda + \epsilon_{at}, \tag{2}$$

where p_{at} is a measure of piracy attacks or the distance to an attack in/from area a at time t (a particular month in a particular year), δ_a correspond to location fixed effects, γ_t to time fixed effects for each month-year combination and X_{at} is a vector of environmental control variables. Controls are included to deal with a potential threat to identification, namely that there are other factors that correlate with both fishing conditions and piracy. These are factors such as extreme weather conditions that may affect both the fishing conditions in the water as well as the possibilities to conduct piracy. It has, e.g., been mentioned in the previous literature that high wind speeds may prevent pirates from navigating their small skiffs (see e.g. Besley et al., 2014) at the same time as winds could affect oceanographic processes that influence fishing conditions. The fishing conditions variable, f_{at}, is entered into the specification in a number of different ways in order to take the potential non-linearity of this relationship into account. However, the preferred specification is a dummy variable coded as 1 if fishing conditions are above the median, i.e. when fishing conditions are good, and 0 otherwise. This definition has been chosen to facilitate the interpretation of the coefficient and to avoid making strict assumptions on the structure of the relationship between fishing conditions and piracy. Under the assumption of strict exogeneity conditioned on the fixed effects, β would identify the true causal impact of fishing conditions on piracy. Standard errors are typically clustered at the area level to take into account serial correlation of the errors over time. However, standard errors following Conley (2008) and Hsiang (2010) that are in addition adjusted for spatial correlations are also reported when warranted.

5 Availability of Fish and Income Opportunities

This section addresses the link between the measure for fishing conditions and the income opportunities of fishermen. As discussed above, previous qualitative evidence suggests that the amount of fish caught is an important determinant of income. To validate this claim, this section implements two different empirical strategies. First, the availability of fish is investigated by studying the local price of fish in coastal markets in Indonesia.[14] Second, the labor market outcomes of marine fishermen in coastal districts are studied using data from the Indonesian Labor Market Survey (SAKERNAS). Panels (a) and (b) of Figure 1 illustrate the geographical spread of these two samples.

Table 2 shows the results from regressions of the average monthly price of fish on local fishing conditions following a similar set-up as specification (2) above. The average price is used in these regressions to capture

[14] Investigating the quantity of fish caught would have been preferred over the price of fish for the reasons discussed below in this section. However, a credible analysis of the quantity of fish is not possible since reliable disaggregated data on fish captures is not available.

the total abundance of fish in a particular location. This is done since the composition of the species in the catch may vary between seasons as well as markets. Results are reported both for a dummy variable indicating above median fishing conditions and the continuous measure of fishing conditions. Both of these show that an improvement of fishing conditions significantly reduces the price of fish. A shift from below median fishing conditions to above, i.e., from relatively poor to good conditions, corresponds to a reduction of about 6% of the mean price of fish. The results are robust to including both market and time fixed effects for each month each year. Given the small number of clusters, p-values have also been calculated using the wild cluster bootstrap procedure suggested by Cameron et al. (2008). All results are still statistically significant at conventional levels when using this approach. This analysis provides further support for the findings in the marine biological literature, namely that changes in oceanographically determined fishing conditions do affect the amount of fish available. These results should, however, be interpreted with caution for several reasons. First, some of the fish sold in these markets have likely been caught in other areas where fishing conditions may be different. These estimates are therefore likely to capture only part of the effect of changes in fishing conditions on the price of fish. Second, since the structure of demand for fish is unknown it is hard to infer from these estimates exactly how the quantity of fish is affected. With these caveats in mind, it is still reassuring that this analysis provides robust significant results in the expected direction.

The effect of fishing conditions on different labor market outcomes for fishermen is presented in Table 3. Panel A uses the above median measure of fishing conditions, whereas panel B uses the continuous measure. All regressions include 31 province and 4 year fixed effects. The level of the fixed effects has been chosen to accommodate the fact that sampling from districts varies over time, which makes comparisons within districts over time noisy. Column (1) shows that the share of total working hours that are dedicated to fishing increases when fishing conditions improves. A shift from below to above median fishing conditions increases the share of hours spent on fishing by 1.6 percentage points. This small relative effect, however, corresponds to a large decrease in the number of hours dedicated to other types of work as shown in column (2). Good fishing conditions reduce the number of work hours that are not dedicated to fishing by 56% of the mean. Column (3) reports the effect of fishing conditions on the income per day worked the previous month for self-employed fishermen and shows that the income of this group increases by more than 10 % when fishing conditions are good. Results for the continuous variable are similar but tend to be larger, especially in the income regression. To sum up, these results suggest that the measure of fishing conditions defined in this study has clear labor market consequences for fishermen. Better fishing conditions increase the share of work time spent on fishing and the income from fishing per day worked, but reduces the amount of time spent on other income generating activities. Hence, results are consistent with fishermen supplementing their income from fishing with incomes from other activities when fishing conditions are poor.

6 Main Results

This section reports the main results from estimating equation (2) and is divided into two parts. The first part carries out the analysis for two different samples. First, the effects are estimated for the whole EEZ of Indonesia using 197 cells of the size 2 degrees latitude by 2 degrees longitude (approximately 200 km by 200 km) to get at the overall impact of changes in fishing conditions on piracy.[15] Second, to investigate how local these effects are, and how they vary by conditions on land, results are also reported for the 325 major fishing ports in Indonesia. The second part of this section investigates the heterogeneity of the results in both of these samples.

6.1 Impact on Piracy Attacks

Tables 4 and 5 show the results from the cell sample. The number of attacks is used as outcome in Table 4, whereas the outcome has been recoded as a dummy variable in Table 5. This has been done to capture the extensive margin effect of whether an attack occurred or not. In both tables, column (1) shows a positive unadjusted correlation between piracy attacks

[15]The choice of the cell size is further discussed in the robustness analysis in section 8.

and fishing conditions. This is not surprising since areas with on average better fishing conditions are likely to have a greater number of fishermen and thus a larger pool of potential pirates (see Figure 5). However, controlling for time invariant factors by introducing cell fixed effects in columns (2) to (4) produces a robust and highly statistically significant negative estimate of the impact of fishing conditions on piracy. The estimate is robust to adjusting standard errors for spatial correlations as well as including time fixed effects and weather controls. This provides support for the effect being driven by changes in income opportunities determined by fishing conditions and not any other confounding factors. The preferred specification, presented in column (4), shows that good fishing conditions reduces the mean number of attacks by about 50% and the baseline probability of an attack occurring at all by 37%. However, a potential concern with these results is that time fixed effects may differ between cells due to differences in seasonality. To deal with this, column (5) introduces 2,363 month by cell fixed effects. This substantially reduces the within variation to ten observations per group and is therefore less precise compared to the preferred specification. Nevertheless, this still produces results of comparable magnitude. The estimate for the number of attacks is still significant at the 5% level, but the extensive margin coefficient is no longer statistically significant.

To determine whether these results also hold at the more local level, Table 6 reports the results for fishing ports. For each of these ports the fishing conditions have been calculated for a 20 nautical miles zone surrounding the port, following the approach in the price analysis above. Two different outcomes are then investigated in the table. The first outcome is the number of attacks carried out within 40 nautical miles from the port, shown in columns (1) and (2), and the second outcome is the the size of the attack free zone surrounding the port, columns (3) and (4). The latter outcome is defined as the distance from the port to the closest attack occurring in the Indonesian EEZ in that particular month conditional on an attack occurring. Uneven columns include 325 port fixed effects and 132 time fixed effects for each month-year combination, whereas even columns include 3,876 month by port fixed effects. The first set of results are in line with the findings in the previous section and show that good fishing conditions decrease the number of attacks carried out in the vicinity of the port by about 30%. The second set of results show that improved fishing conditions increases the attack free radius around the port by 0.14-0.30 degrees (approximately 14-30 km) corresponding to a 2-5% increase compared to the mean radius, implying that attacks that do occur are carried out by other fishermen in ports further away.[16] These effects are highly statistically significant when clustering standard errors at the port, but less precisely estimated when taking spatial correlation into account. The latter is likely a result of the clustering of many fishing ports, which results in partly overlapping fishing zones.

Although intuitive to understand, a shift from below to above median fishing conditions will not capture any potential non-linearity in the relationship between fishing conditions and piracy. To deal with this, Figure 7 plots the response functions from linear regressions as well as second, third and fourth order polynomials using the continuous measure of fishing conditions when estimating equation (2) for both the cell and port samples. In addition to the predicted response, the graphs also show the 95% confidence intervals of these estimates. Results show a statistically significant negative effect of the continuous measure of fishing conditions on piracy. A clear pattern also emerges from this analysis, namely that the effects tend to be larger when fishing conditions are poor. This finding is consistent with fishermen responding more strongly to changes in income opportunities closer to the subsistence margin.

6.2 Heterogeneity

The previous analysis does not take into account other factors that may be important in determining whether entering into piracy is a desirable or feasible option. Guided by the theoretical crime literature, this section addresses how the main effects discussed above vary with; (1) other economic opportunities as well as (2) the amount of resources available for theft. Two additional data sources are required for these two analyses. The first analysis uses data on average visible stable lights at night for 2002 and

[16] An alternative interpretation of this finding is that pirates are simply travelling longer distances to carry out an attack. This explanation would, however, be hard to reconcile with the improved incomes for fishermen.

2012 from the National Oceanic and Atmospheric Administration. In the latter analysis, data from the National Centre for Ecological Analysis and Synthesis (NCEAS) on shipping lanes in the world in 2005 is used.[17] Both of these data sources are illustrated in Figure 8 and the summary statistics of the constructed variables are reported in Table 1.

Theoretically, we would expect factors that affect the opportunity cost of conducting piracy to influence the response of pirate activity to changes in fishing conditions. If other legal income opportunities are available to fishermen, one would expect less of a response in piracy to changes in fishing conditions since fishermen could more easily turn to other income generating activities. To get a proxy for local legal income opportunities this study follows a recent literature in economics that has shown that satellite data on lights at night is a strong predictor for local economic activity (see e.g. Michalopoulos and Papaioannou, 2013; Henderson et al., 2012). To get a measure of how economic opportunities have developed in the areas surrounding the ports used in the analysis above, the average stable lights at night in a 50 km radius around the port is calculated for 2002 and 2012. Thereafter the growth in lights during the sample period is determined for each port. This data is then used to split the sample from the port analysis into high growth and low growth areas (above and below the median growth in the sample). The results from this analysis are presented in Table 7.[18] It is shown that areas where growth was slow or negative during the period are substantially more sensitive to changes in fishing conditions with a point estimate that is 80% larger than in high growth areas. This suggests that other local income sources could mitigate the impact of a fishing condition induced income shock on piracy. It also provides additional support for fishing conditions affecting sea piracy through changes in income opportunities. Growth in lights at night has been chosen as the proxy for local income opportunities since it provides information about whether economic conditions have improved or deteriorated during the sample period. For a given location, this should be more informative about the dynamics of the economy and the availability of al-

[17] See Halpern et al. (2008) for a description of how this data was constructed.

[18] 8 ports did not have any light in 2002 and are therefore dropped from the analysis, since growth rates could not be calculated for these areas. This should not be a major concern, however, since it only corresponds to about 2% of the sample.

ternative income opportunities than a measure of the aggregate size of the economy.[19]

From the traditional crime literature we would also expect that increased returns from crime, in the form of additional resources available for theft, would affect piracy. In this case that would correspond to changes in the number of potential targets, i.e. shipping traffic intensity in the Indonesian EEZ. The NCEAS data on shipping lanes in 2005 is used to determine the average number of ship tracks for each cell used in the above analysis.[20] Cells with lower levels of shipping traffic intensity are then removed gradually from the sample by each quartile of shipping traffic intensity in 2005. The results are presented in Table 8 and show a clear pattern, coefficients are larger for areas with higher shipping traffic. The point estimate for the highest quartile is 81% larger than the average effect for the full sample. This shows that the response to changes in fishing conditions tends to be stronger when there are more targets available. These effects are however not significantly different from each other. A potential concern with this approach is that the measure for shipping intensity is defined in the middle of the sample period. If shipping traffic is responding to increases in piracy, this division of the sample could be problematic. Given that the most piracy prone area of Indonesia, the Strait of Malacca, is the "shortest, cheapest and most convenient sea-link between the Pacific and Indian Oceans" (Gupta, 1974), this is probably not a major concern. Performing the analysis only on the sample after October 2005 produces results with a similar pattern.

[19]In addition, level based measures of income opportunities are likely to introduce bias, since a larger economy around a fishing port reasonably implies that more ships are travelling to that particular location. As shown below, a larger number of potential targets increases the response in piracy to changes in fishing conditions, which could attenuate the effect of alternative income opportunities. This attenuation bias is possibly less of a concern for the growth analysis, since the relationship between growth and shipping traffic is likely weaker.

[20]Since information on the shipping traffic intensity is only available for 2005, this pattern is assumed to be constant for the whole sample period.

7 Evaluating Operation Octopus

As discussed above, Indonesia launched the 3 months long Operation Octopus in July 2005 to fight piracy in the Malacca and Singapore Straits (Storey, 2008). This section aims to evaluate both how effective this operation was in reducing piracy as well as how this affected the response in piracy to changes in fishing conditions. Panel (a) of Figure 9 shows the area where the operation was carried out (Malacca and Singapore Straits, coloured red) as well as the control area used for this analysis (Makassar Strait and Java Sea, coloured grey). The South China Sea, which is neighbouring both the Malacca and Singapore Straits, has been excluded from the analysis since piracy in the area could have been affected by the operation.[21] Panel (b) of Figure 9 shows the number of attacks each month in the two areas. Before the operation was initiated the number of attacks in both areas seems to follow roughly similar trends, but with strong seasonality. However, when the operation started in July 2005 there is a significant decrease in the number of attacks in the Malacca and Singapore Straits. This drop persists for some time, but after a few years the number of attacks seems to revert back to similar levels as in the control area. To investigate this pattern more formally the following difference-in-differences specification is estimated in the port sample:

$$p_{at} = \beta(d_t * o_a) + \delta_a + \gamma_t + X'_{at}\lambda + \epsilon_{at}, \tag{3}$$

where p_{at} are the number of piracy attacks around port a at time t and d_t is a time dummy that switches on from July 2005 onwards. The sample has been limited to ports located in the two areas in Figure 9 and the dummy variable o_a indicate if a particular port is covered by the operation. The variables δ_a and γ_t represent port and time fixed effects and X_{at} is a vector of controls for local wind speed, rainfall and fishing conditions. Under the key assumption of parallel trends in the absence of treatment, β captures the effect of Operation Octopus on the number of piracy attacks. Panel A of Table 9 shows the results from estimating equation (3). The results show a strong immediate reduction in the number of attacks during

[21] Not only are spillovers possible from the neighbouring areas, but the exact geographical coverage of the operation is unknown.

the operation and the two years after it. In other words, the operation seems to have had an effect on piracy also after it was finalized. This could be because of incapacitation effects or deterrence effects due to a higher perceived risk of getting caught. The reduction roughly corresponds to the mean number of attacks in the control group. After two years the point estimate is substantially smaller and no longer statistically significant, suggesting that the effect of the operation disappears over time.[22]

To be able to say something about how the effectiveness of the operation varies by local income opportunities, the heterogeneity of this effect is investigated with regards to fishing conditions. This is done in two different ways. First, the sample is split into ports for which the average fishing conditions prior to July 2005 was above the median and into ports for which average fishing conditions were below the median. Results are reported in panels B and C of Table 9 and show that the operation reduced piracy both in ports with good and poor fishing conditions. However, a clear pattern emerges from this analysis. During the 3 month operation, the reduction in the number of piracy attacks are entirely driven by ports with poor fishing conditions, whereas the reduction during the period after the operation is driven by ports with good fishing conditions. Overall the effects are bigger and more persistent for ports with good fishing conditions prior to July 2005.

This approach is straight forward, but relies on the assumption that the operation did not target ports based on their previous average fishing conditions, which is positively correlated with the number of previous attacks. To avoid making such an assumption, an analysis in which the contemporaneous measure of fishing conditions is instead interacted with $d_t * o_a$ in equation (3) is also carried out. This analysis assumes that the operation did not explicitly target ports with a particular set of future fishing conditions in a particular time period, which is very unlikely. Results are presented in panel D of Table 9 and are strongly consistent with those in panels B and C.

Hence, the operation seems to have had a strong direct effect on the

[22]Estimating this regression for an aggregate sample including all attacks in the two areas, and not just those close to a fishing port, produces very similar results. However, the port sample is preferred since it enables controlling for location fixed effects.

number of attacks when fishing conditions were poor. This is potentially because areas tend to be more prone to piracy during those periods and that the operation therefore was more successful in reducing it. The number of attacks continues to be lower in these areas also after the operation. However, the persistent effect of the operation is much stronger when fishing conditions are good. Suggestively, this is explained by the better income opportunities available in these locations and periods, which enables more fishermen to stay away from piracy during a longer time period.

8 Robustness Checks

This section addresses the sensitivity of the results presented above. The identification assumption as well as the estimation strategy and sample selection is discussed.

The main identification assumption in the analysis is that fishing conditions are as good as randomly assigned conditional on the fixed effects. To investigate this, leads and lags have been included in the most restrictive main specification, i.e. column (5) in Table 4. The point estimates of these and their respective confidence intervals are presented in Figure 10. As can be seen from the figure the point estimate on the main variable of interest is largely unaffected and the estimates of these controls are typically small and insignificant. The only estimate with a similar magnitude and significance is the 12 months lag of the fishing conditions variable. This could potentially be explained by fishermen taking past experiences from the same month the previous year into account when deciding on moving into piracy.

Even if fishing conditions are as good as randomly assigned, there could be other reasons than changes in income opportunities that explain why an improvement of fishing conditions reduces the amount of piracy. The most likely such scenario would probably be extreme weather conditions affecting both oceanographic conditions and the possibilities of engaging in piracy (or other income opportunities). As discussed above, the effects are robust to the inclusion of local controls for rainfall and wind speed. This should mitigate concerns about the effects of interest being driven by other factors than changes in fishing conditions. Another potential concern is that an improvement of fishing conditions increases the number of fishermen at sea, and that this may have a direct effect on piracy attacks. Such a mechanism may work in either, or both, of the two following directions. On the one hand, an increase in the number of fishing boats may increase the number of potential targets for pirates since fishing boats are also sometimes attacked. However, very few fishing boats are attacked in this sample and excluding them from the analysis produces identical results. On the other hand, an increase in the number of fishing boats at sea may provide monitoring and thus make it harder for pirates to carry out attacks. Although this cannot be fully ruled out, there are a number of reasons why this is not likely to be a major concern. From the background section above it is clear that fishing in Indonesia is typically a small scale and simple technology business. This would likely make it difficult for most fishermen to conduct efficient monitoring, since it would take considerable time before fishermen could return to the shore and report to the relevant authorities. The limited resources available for addressing piracy would also tend to limit the possibilities for monitoring even if the fishermen were able to contact the relevant authorities in time. In addition, the analysis of labor market outcomes in Section 5 as well as the heterogeneity analysis in Section 6.2 clearly suggests that results are driven by changes in income opportunities.

To take into account the fact that the outcome variable in some of the analyses above is a count variable, fixed effect poisson and probit methods are also implemented to estimate equation (2). The results from these regressions are presented in Table 10 and are very similar to the OLS results both in terms of size and significance.

Finally, a potential concern might be that results are driven by the choice of the unit of analysis. For both the cell and port analysis, relatively large units have been chosen. There are several reasons for this. First, larger areas reduce the problem caused by potential spillovers between locations. This would occur if fishermen choose to fish in a neighbouring area when fishing conditions deteriorate at home. Hence, choosing smaller units of analysis would risk attenuating the true effect.[23] Second,

[23]Note that it is not clear that smaller units of analysis would produce a more precise measure of fishing conditions, since the exact location of where fishing is conducted is

for the cell analysis, larger units also allows fishing conditions to be connected to piracy attacks carried out further away from where fishing is conducted. This is reasonable since piracy attacks are typically carried out with faster boats. Finally, larger areas facilitates the addition of correctly defined control variables (wind speed and accumulated rainfall) since these have lower spatial resolutions. The fact that the results from the different analyses above are very similar is reassuring. Both the analysis of fishing ports as well as the analysis of cells covering the whole EEZ shows that an improvement of fishing conditions reduces the number of attacks. In addition, the analysis of the size of the attack free zone does not use a predefined area for where attacks could occur and still shows consistent results.

9 Discussion and Concluding Remarks

This study investigates the impact of changes in legal income opportunities on piracy in Indonesia. The empirical strategy exploits exogenous changes in fishing conditions and finds that these affect piracy on both the intensive and the extensive margin. This is true both for an empirical strategy that uses data from cells covering the whole Indonesian EEZ and for one using data from 325 fishing ports. The main result shows that good fishing conditions reduces the number of attacks by 50% of the mean. An analysis of the impact of changes in fishing conditions on both the price of fish as well as the income and working hours of fishermen provide support for the proposed mechanism, namely that the effects are driven by changes in income opportunities. Further heterogeneity analysis shows that effects are substantially smaller in areas where growth was high during the sample period than in areas with slow growth. This provides additional support for the income opportunities explanation.

The finding in this study is an example of how environmental factors can influence criminal activity. Given that these factors are in turn likely to be influenced by shifts in the climate, the study also shines light on the

not known. An alternative approach would be to weight fishing areas by their distance from a particular port, but this is not likely to improve precision either since different types of fishing is carried out at different distances from the shore.

potential detrimental effect of climate change. Previous studies suggest that fishing conditions in Indonesia may be particularly affected, Cheung et al. (2010) e.g. investigates the regional fish catch potential in 2055 and find that the Indonesian EEZ will be hardest hit of all countries studied with a more than 20% decline in 10-year fish catch potential. Even if it is hard to make any extrapolations from the short term analysis in this paper, the findings are consistent with climate change having important implications for piracy.

Further, evaluating the effect of a large anti-piracy operation in Indonesia it is found that it reduced the number of attacks substantially. The effect of the intervention persisted for a few years, but decreased over time. Notably, the operation affected piracy in a particular location differently depending on the fishing conditions in that area. In areas with poor fishing conditions, the operation had a direct effect on the number of attack, whereas it had a stronger persistent effect where fishing conditions were good. Although these results may have alternative explanations they are consistent with fishermen responding to the anti-piracy operation by selecting away from piracy, especially when income opportunities from fishing are good.

The results in this study provide some potential insights for policy, namely that improved income opportunities in periods when fishing conditions are poor, could be a viable strategy to reduce the number of piracy attacks. This may be especially important as a compliment to anti-piracy operations since there is suggestive evidence that such operations have stronger persistent effects when fishing conditions are better.

References

Acker, J. G. and Leptoukh, G. (2007). Online Analysis Enhances Use of NASA Earth Science Data. *Eos, Trans. AGU*, 88(2):14–17.

Asia-Pacific Economic Cooperation (2013). Potential Contribution of Small Pelagic Fish to Food Security within the Asia-Pacific Region. *Report.*

Becker, G. (1968). Crime and punishment: An economic approach. *Journal of Political Economy*, 76(2):169–217.

Besley, T., Fetzer, T., and Mueller, H. (2014). The Welfare Cost of Lawlessness: Evidence from Somali Piracy. *Journal of the European Economics Association, forthcoming.*

Blattman, C. and Miguel, E. (2010). Civil War. *Journal of Economic Literature*, 48(1):3–57.

Bowden, A. (2010). The Economic Costs of Maritime Piracy. *Working Paper.*

BPS (2012). *Statistik Upah (Wage Statistics).*

Cameron, A., Gelbach, J., and Miller, D. (2008). Bootstrap-based improvements for inference with clustered errors. *The Review of Economics and Statistics*, 90(August):414–427.

Cariou, P. and Wolff, F. C. (2011). A longitudinal analysis of piracy in shipping. *Economics Bulletin*, 31(2):1055–1062.

Chalfin, A., Mccrary, J., and Berkeley, U. C. (2014). Criminal Deterrence : A Review of the Literature. *Working Paper.*

Chalk, P. (2008). 'The Maritime Dimension of International Security: terrorism, piracy, and challenges for the United States. *Report.*

Cheung, W. W. L., Lam, V. W. Y., Sarmiento, J. L., Kearney, K., Watson, R., Zeller, D., and Pauly, D. (2010). Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, 16(1):24–35.

Collier, P. and Hoeffler, A. (1998). On economic causes of civil war. *Oxford economic papers*, 50:563–573.

Conley, T. G. (2008). Spatial Econometrics. *The New Palgrave Dictionary of Economics*.

Daxecker, U. and Prins, B. (2012). Insurgents of the Sea: Institutional and Economic Opportunities for Maritime Piracy. *Journal of Conflict Resolution*, 57(6):940–965.

Direktorat Jenderal Pemasaran dan Pengolahan Hasil Perikanan (2012). Warta Pasarikan. *Report*.

Dube, O. and Vargas, J. F. (2013). Commodity Price Shocks and Civil Conflict: Evidence from Colombia. *The Review of Economic Studies*, 80(4):1384–1421.

Elleman, B., Forbes, A., and Rosenberg, D. (2010). *Piracy and maritime crime: Historical and modern case studies*. Naval War College Press, Newport, Rhode Island.

FAO (2011). *FAO Yearbook: Fishery and aquaculture statistics*.

FAO (2013). Indonesia, FAO to strengthen fisheries and aquaculture cooperation.

Fauzi, A. (2005). *Kebijakan Perikanan dan Kelautan*. Jakarta.

Frecon, E. (2006). *Pirates Set The Straits on Fire... Causes and Context of the Pirate Arsons In the Malay Archipelagos Since the Nineties*. Konrad Adenauer Stiftung, Singapore.

Gupta, B. S. (1974). The Malacca Straits and the Indian Ocean : a study of the strategic and legal aspects of a controversial sea-lane. Macmillan Co. of India, Delhi.

Halpern, B. S., Walbridge, S., Selkoe, K. a., Kappel, C. V., Micheli, F., D'Agrosa, C., Bruno, J. F., Casey, K. S., Ebert, C., Fox, H. E., Fujita, R., Heinemann, D., Lenihan, H. S., Madin, E. M. P., Perry, M. T., Selig, E. R., Spalding, M., Steneck, R., and Watson, R. (2008). A global map of human impact on marine ecosystems. *Science (New York, N.Y.)*, 319(5865):948–52.

Hays, J. (2012). Combating Piracy in Asia.

Henderson, J. V., Storeygard, A., and Weil, D. N. (2012). Measuring Economic Growth from Outer Space. *American Economic Review*, 102(2):994–1028.

Hendiarti, N. and Aldrian, E. (2005). Seasonal Variation of Pelagic Fish Catch Around Java. *Oceanography*, 18(4).

Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America. *Proceedings of the National Academy of Sciences of the United States of America*, 107(35):15367–72.

Hsiang, S. M., Burke, M., and Miguel, E. (2013). Quantifying the influence of climate on human conflict. *Science (New York, N.Y.)*, 341(6151):1235367.

ICC International Maritime Bureau (2013). Piracy And Armed Robbery Against Ships: 2012 Annual Report. *Report*.

Iyer, L. and Topalova, P. (2014). Poverty and Crime : Evidence from Rainfall and Trade Shocks in India. *Working Paper*.

Jablonski, R. S. and Oliver, S. (2012). The Political Economy of Plunder: Economic Opportunity and Modern Piracy. *Journal of Conflict Resolution*, 57(4):682–708.

Kemp, T. (2013). Crime at sea: The world's most pirate-infested waters.

Ludwig, M. and Flückiger, M. (2014). Economic Shocks in the Fisheries Sector and Maritime Piracy. *Working Paper*, (56959).

Mathews, C., Monintja, D., and Naamin, N. (1995). Studies of Indonesian tuna fisheries, Part 2: Changes in yellowfin abundance in the Gulf of Tomini and North Sulawesi. *FAO Report*.

Michalopoulos, S. and Papaioannou, E. (2013). Pre-Colonial Ethnic Institutions and Contemporary African Development. *Econometrica*, 81(1):113–152.

Miguel, E., Satyanath, S., and Sergenti, E. (2004). Economic shocks and civil conflict: An instrumental variables approach. *Journal of political Economy*, 112(4).

Ministry of Marine Affairs and Fisheries (2012). Bad weather, Fishermen Economy Worsen.

Mustard, D. B. (2010). How Do Labor Markets Affect Crime ? New Evidence on an Old Puzzle. In *Handbook on the Economics of Crime*, number 4856, pages 342–358.

NASA Earth Observatory (2002). Chlorophyll & Sea Surface Temperature.

Nurdin, S; Lihan, T; Mustapha, A. (2012). Mapping of Potential Fishing Grounds of Rastrelliger kanagurta (Cuvier, 1816) in the Archipelagic Waters of Spermonde Indonesia Using Satellite Images. *Working Paper*, (March 2012).

Ormerod, H. A. (1924). *Piracy in the Ancient World: An Essay in Mediterranean History*. The University Press of Liverpool Ltd.

Raymond, C. Z. (2010). Piracy and Armed Robbery in the Malacca Strait. In *Piracy and maritime crime: Historical and modern case studies*, volume 62.

Semedi, B. and Dimyati, R. D. (2009). Study of Short Mackerel Catch, Sea Surface Temperature, and Chlorophyll-a in the Makassar Strait. *International Journal of Remote Sensing and Earth Sciences*, 6(1):77–84.

Semedi, B. and Hadiyanto, L. (2013). Forecasting the Fishing Ground of Small Pelagic Fishes in Makassar Strait Using Moderate Resolution Image Spectroradiometer Satellite Images. *J. Appl. Environ. Biol. Sci*, 3(2):29–34.

Siang, L. K. (2004). DAP call on government to set up a special squad to end the reign of fear of terror paralyzing Malaysian fishermen as a result of the latest abduction of three Kuala Sipitang fishermen by Indonesian pirates.

Storey, I. (2008). Securing Southeast Asia's Sea Lanes: A Work in Progress. *Asia Policy*, 6(1):95–128.

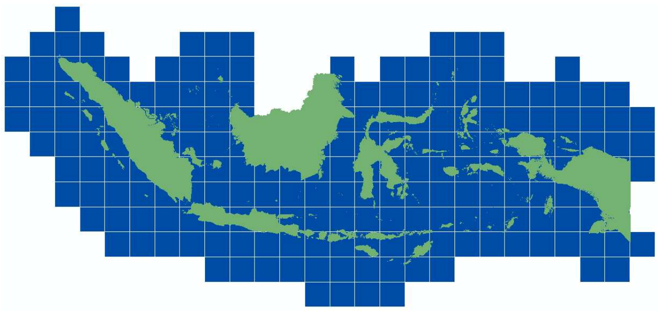
Sugiyanto, C., Kusumastuti, S. Y., and Donna, D. R. (2012). Managing Risks : How do Poor Households Smooth Their Income and Consumption? *Working Paper*.

Verité (2012). Research on Indicators of Forced Labor. *Report*.

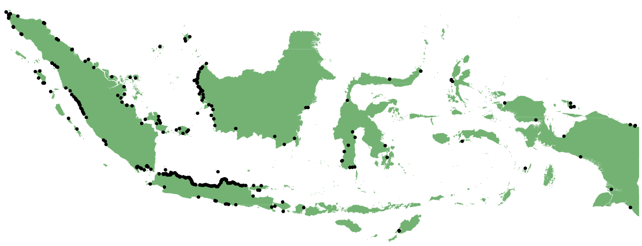
Figure 1: Samples used for analysis

(a) Price sample

(b) Labor market sample



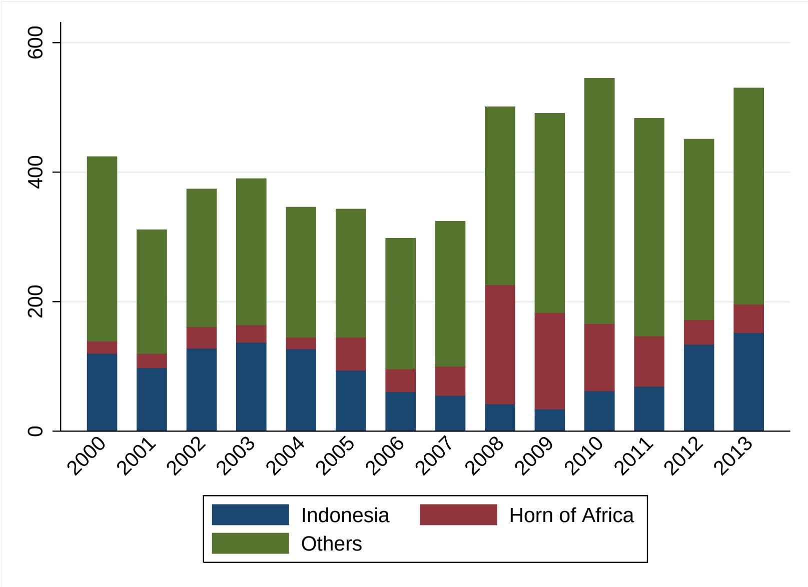
(c) Cell sample



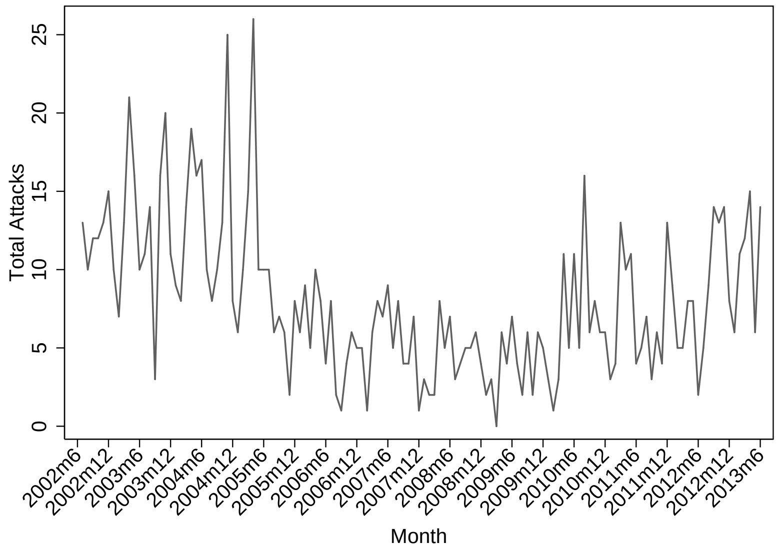
(d) Port sample

Notes: This figure shows the geographical distribution of the four main samples used in the analysis. Panel (a) shows the location of 16 coastal fish markets used in the price analysis. Panel (b) shows the 20 nautical mile fishing zone of the Indonesian districts used in the labor market outcomes analysis. Panel (c) shows the 2×2 degree cells covering the whole EEZ of Indonesia used in the main analysis. Finally, panel (d) shows the location of the 325 fishing ports used in the port sample analysis.

Figure 2: Piracy attacks in Indonesia and the world



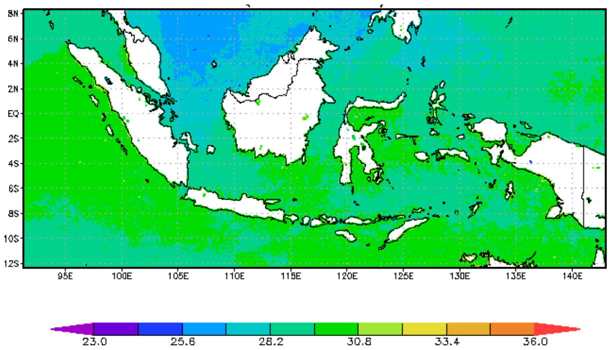
(a) Number of piracy attacks in the world by year



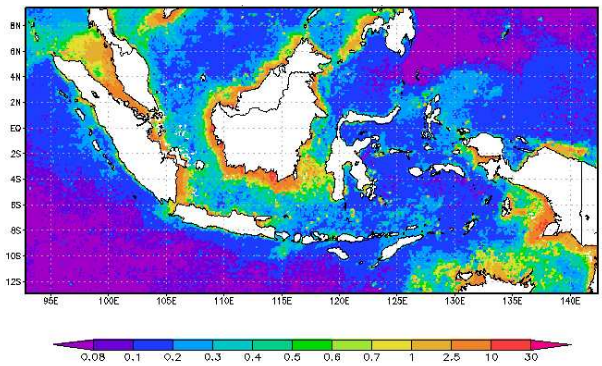
(b) Total attacks in Indonesia by month

Notes: This figure shows the time variation in the number of piracy attacks in Indonesia and the World. The data is from the National Geospatial-Intelligence Agency. Panel (a) shows the total number of attacks in the world by year from 2000 until September 2013. This graph also shows the share of attacks that were carried out in the EEZ of Indonesia as well as in the EEZ of Somalia and Yemen (Horn of Africa). Panel (b) shows the number of attacks by month in the EEZ of Indonesia from July 2002 to June 2013.

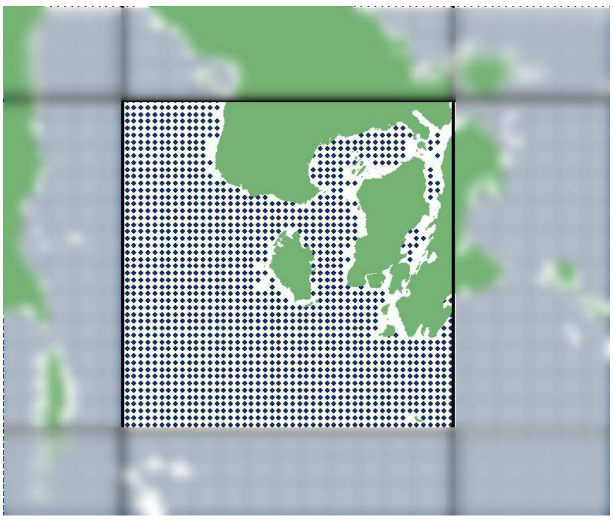
Figure 3: Constructing measure of fishing conditions



(a) Sea surface temperature



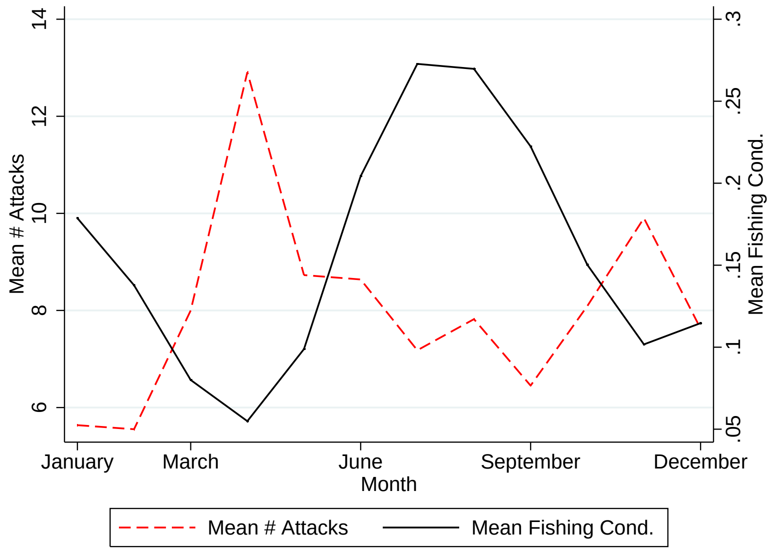
(b) Chlorophyll-a concentration



(c) Observational points within cell

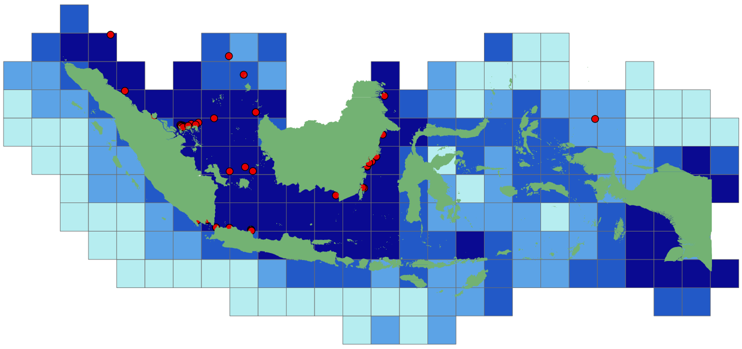
Notes: This figure illustrates the construction of the measure of fishing conditions. The two top panels show the raw data from the NASA Modis satellite for a given month. Panel (c) clarifies how a particular unit of analysis has been constructed by illustrating the observational points within a cell.

Figure 4: Monthly fishing conditions and piracy attacks

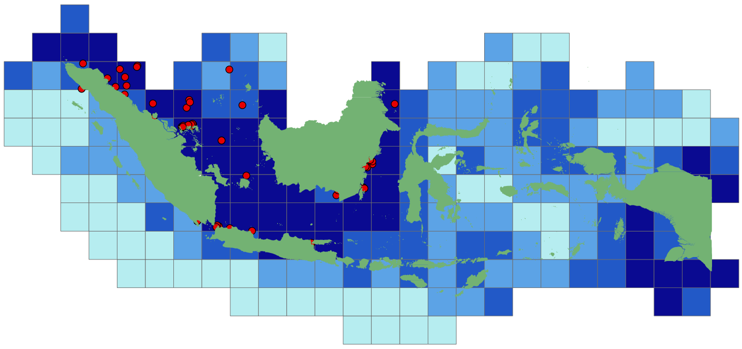


Notes: This graph shows the average fishing conditions for each month over all years during the sample period as well as the average number of attacks that particular month. The graph has been constructed using the cell sample covering the whole EEZ of Indonesia.

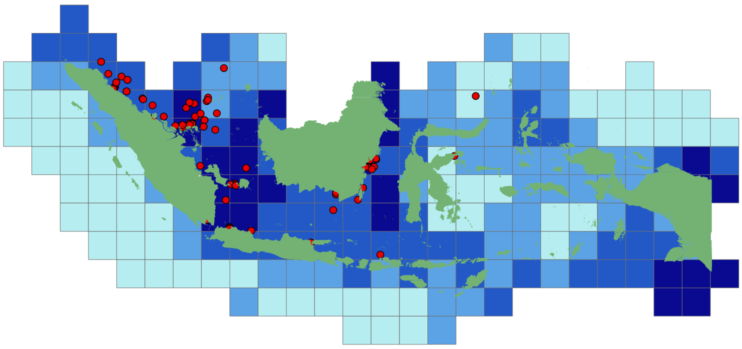
Figure 5: Total piracy attacks and average fishing conditions by month, July 2002-June 2013



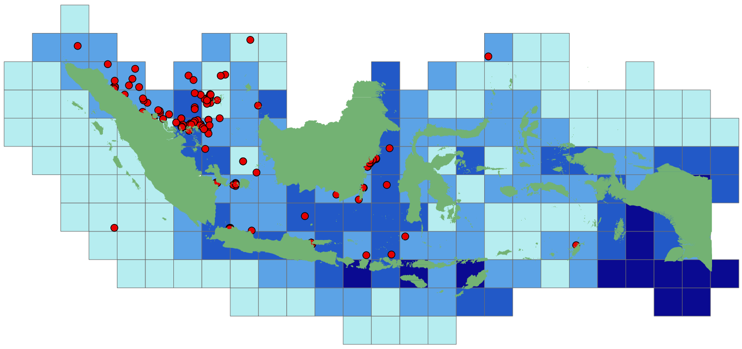
(a) January (62 attacks)



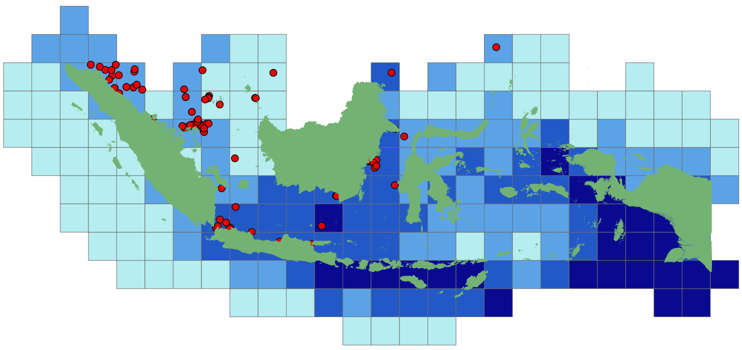
(b) February (61 attacks)



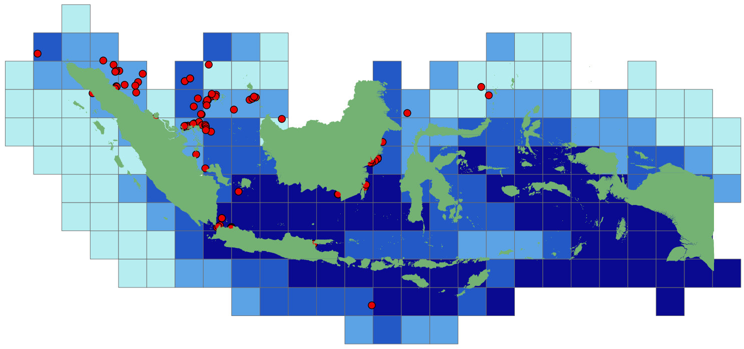
(c) March (88 attacks)



(d) April (142 attacks)

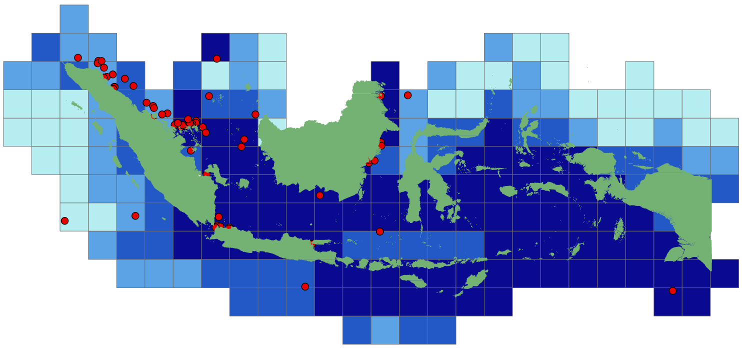


(e) May (96 attacks)

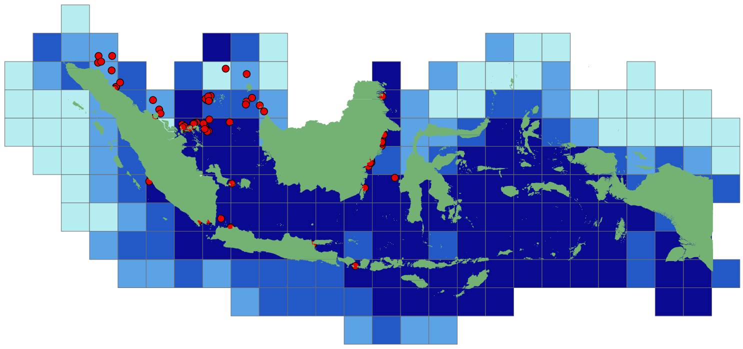


(f) June (95 attacks)

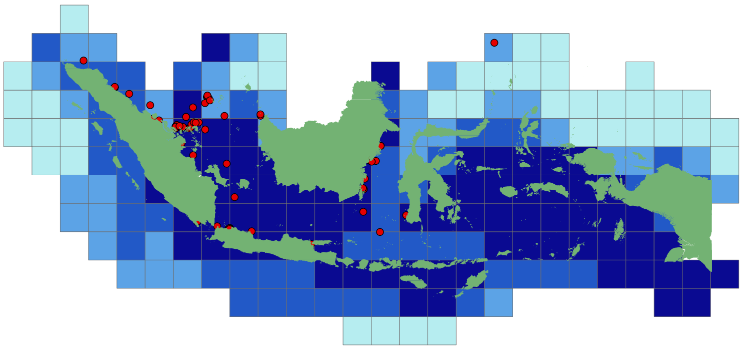
Notes: This figure shows the total number of attacks each month during the sample period and the average fishing conditions during that month in each cell. Good fishing conditions are illustrated by darker colours of the cells.



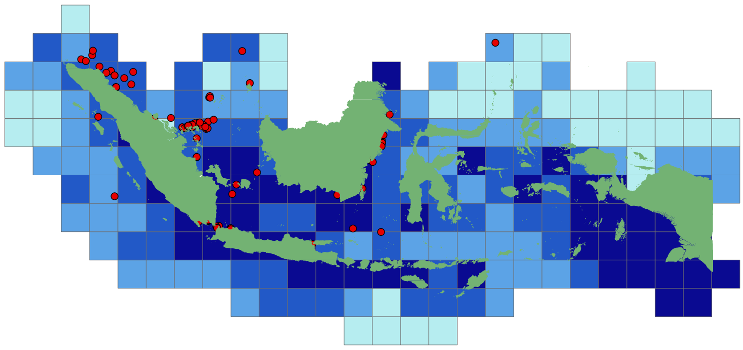
(a) July (79 attacks)



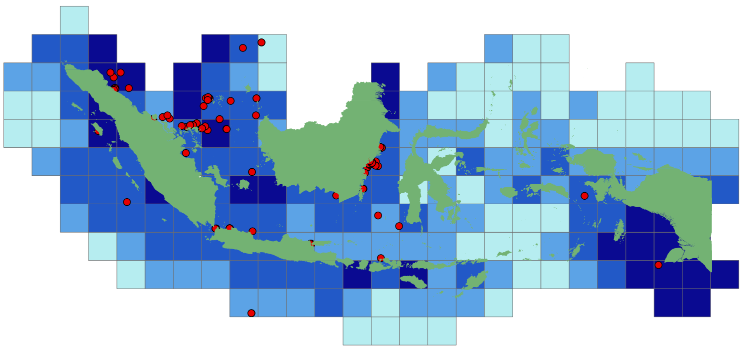
(b) August (86 attacks)



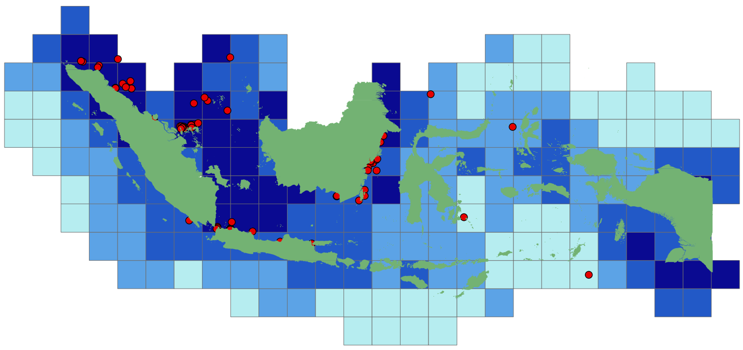
(c) September (71 attacks)



(d) October (89 attacks)

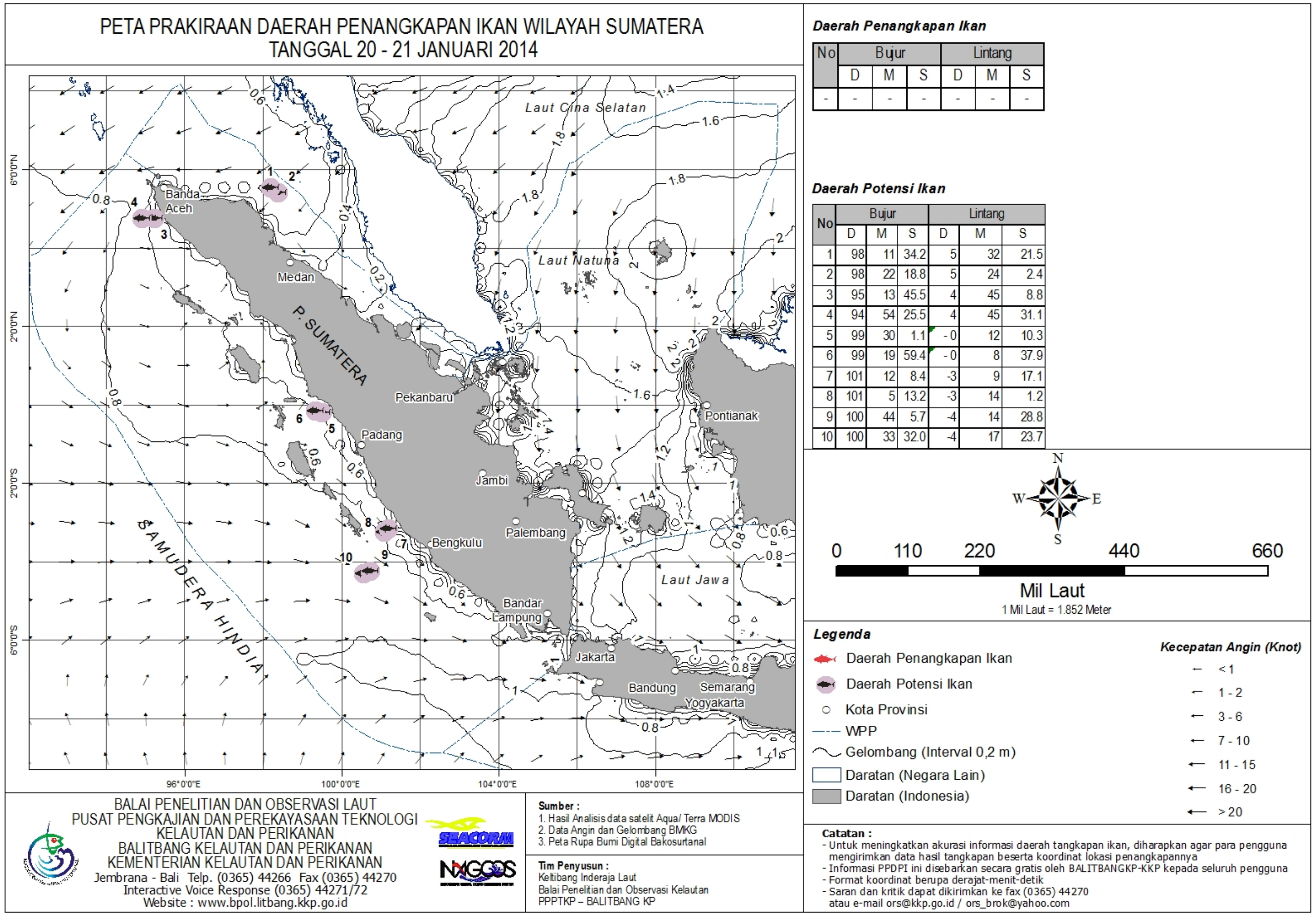


(e) November (109 attacks)



(f) December (84 attacks)

Figure 6: Map showing areas of fish abundance



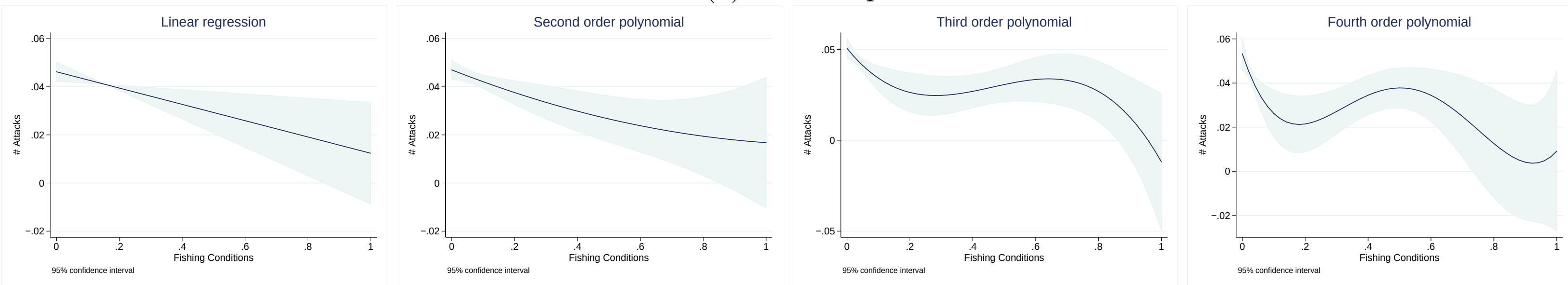
No	Bujur			Lintang		
	D	M	S	D	M	S
-	-	-	-	-	-	-

No	Bujur			Lintang		
	D	M	S	D	M	S
1	98	11	34.2	5	32	21.5
2	98	22	18.8	5	24	2.4
3	95	13	45.5	4	45	8.8
4	94	54	25.5	4	45	31.1
5	99	30	1.1	- 0	12	10.3
6	99	19	59.4	- 0	8	37.9
7	101	12	8.4	-3	9	17.1
8	101	5	13.2	-3	14	1.2
9	100	44	5.7	-4	14	28.8
10	100	33	32.0	-4	17	23.7

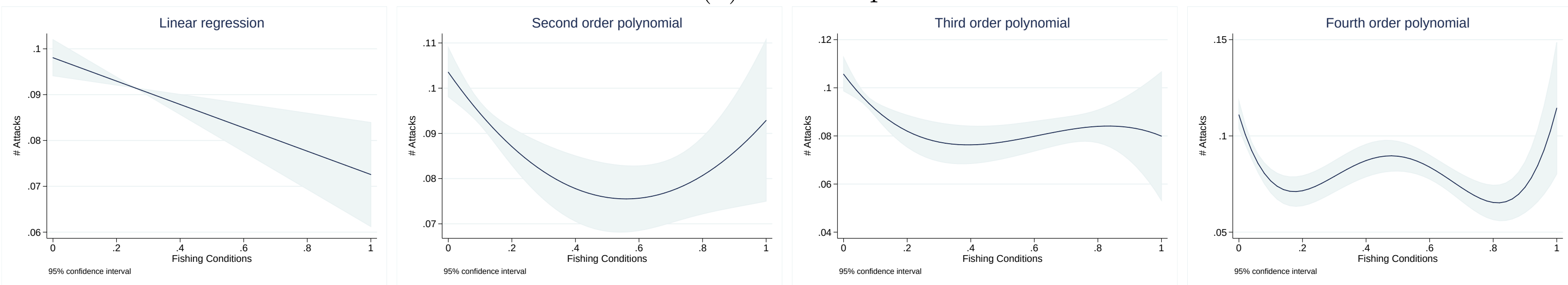
Notes: This figure shows a map of areas of fish abundance in the eastern part of Indonesia produced by experts at the Indonesian Institute for Marine Research and Observation. These estimates have been used to validate the measure of fishing conditions in this paper.

Figure 7: Response functions with continuous measure of fishing conditions

(a) Cell sample

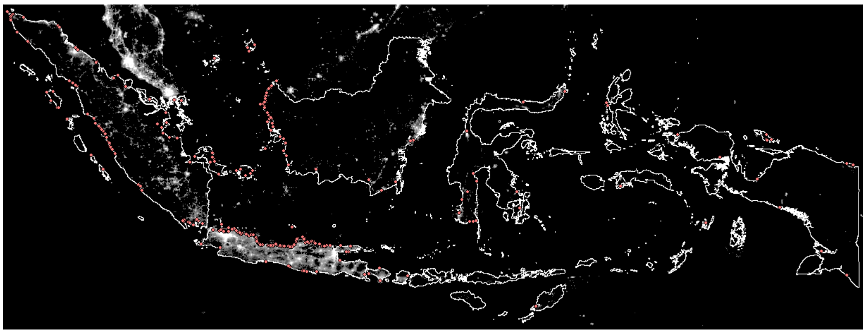


(b) Port sample



Notes: This figure plots the response function of linear and polynomial regressions using the continuous measure of fishing conditions (which ranges between 0 and 1). All regressions control for location fixed effects, time fixed effects for each month-year combination as well as for wind speed and accumulated rainfall. The top four figures in panel (a) are using the cell sample, whereas the bottom four figures run the corresponding regressions for the port sample. The shaded areas illustrate the range of 95% confidence intervals based on standard errors clustered at the geographical unit of analysis. Note that few observations have fishing conditions close to one.

Figure 8: Data used in heterogeneity analysis

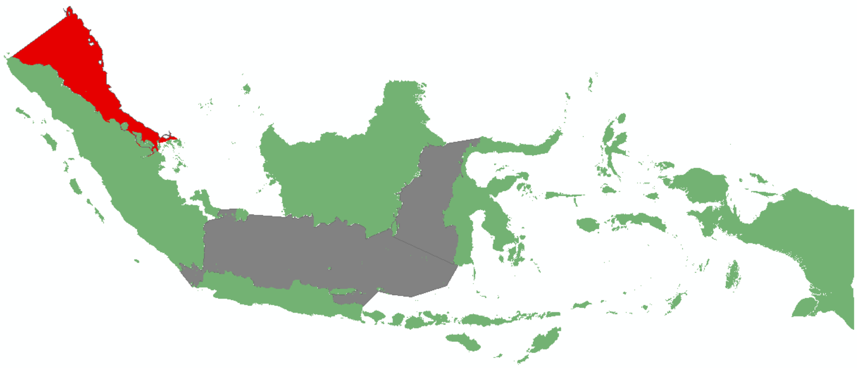


(a) Lights at night in 2002

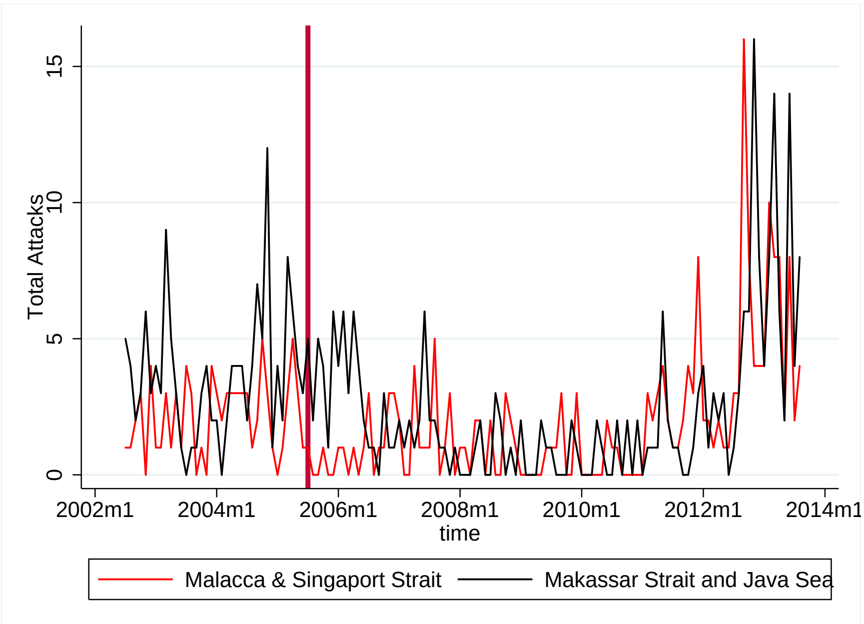
(b) Major shipping lanes in Indonesia in 2005

Notes: This figure illustrates the data used in the heterogeneity analysis in section 6.2. Panel (a) shows the average stable lights at night in Indonesia in 2002 and the location of fishing ports, where the lighter the area the higher were the average lights at night during 2002. Panel (b) shows the average number of shipping tracks in Indonesia in 2005, where darker areas indicate that more ships travelled through that particular location in 2005.

Figure 9: Operation Octopus



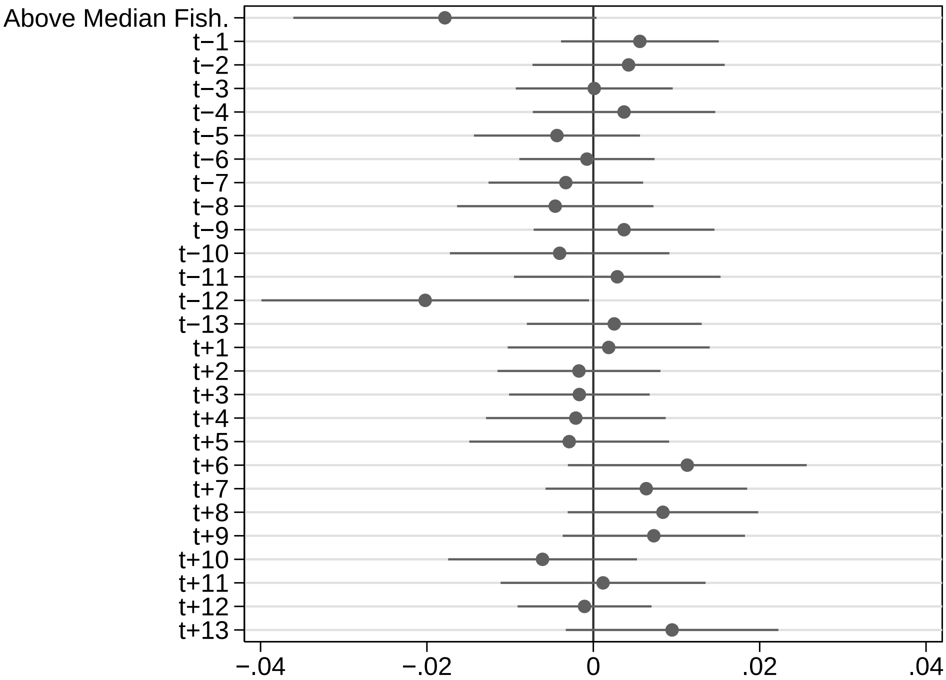
(a) Areas covered by Operation Octopus



(b) Number of attacks before and after Operation Octopus

Notes: This figure shows the variation used for the evaluation of Operation Octopus in section 7. Panel (a) shows the areas affected by the operation (Malacca & Singapore Strait, in red) and those unaffected (Makassar Strait and the Java Sea, in grey). Panel (b) shows the number of attacks before and after Operation Octopus in these two waters, where the vertical line represents the initiation of the operation in July 2005. The operation lasted for 3 months.

Figure 10: Point estimates and confidence intervals of lags and leads



Notes: This figure shows the point estimates and the 95% confidence intervals of the impact of lags and leads of above median fishing conditions on the number of piracy attacks. These coefficients are simultaneously estimated in a single regression corresponding to column 5 in Table 4, i.e., controlling for wind speed and accumulated rainfall as well as month by cell fixed effects. The number of observations are 20,826 and standard errors are clustered on 197 cells.

Table 1: Summary statistics

	MEAN	SD	MIN	MAX	OBS
Price Sample					
Fish Price	22544	8737	5613	62500	422
Fishing Conditions	0.271	0.344	0.000	1.000	422
Above Median Fish.	0.500	0.501	0.000	1.000	422
Chlorophyll-a	2.592	4.433	0.104	39.015	422
SST	29.934	1.504	23.214	33.045	422
Labor Market Sample					
Income per month	771101	466043	0	5000000	896
Days needed for income	20.5	5.6	0	31	896
Income per day worked	41863	29954	0	299762	894
Hours worked in fishing	41.2	15.5	0	98	1053
Share of work hours in fishing	0.97	0.06	0.55	1	1036
Hours worked excl. fishing	1.2	2.8	0	24	1053
Fishing Conditions	0.333	0.332	0.000	1.000	1053
Above Median Fish.	0.500	0.500	0.000	1.000	1053
Chlorophyll-a	1.007	1.289	0.047	10.121	1053
SST	29.271	1.296	24.377	31.868	1053
Cell Sample					
# Attacks	0.041	0.293	0.000	8.000	25948
Attacks (1 or 0)	0.027	0.162	0.000	1.000	25948
Fishing Conditions	0.157	0.261	0.000	1.000	25948
Above Median Fish.	0.500	0.500	0.000	1.000	25948
Chlorophyll-a	0.562	1.036	0.028	14.916	25948
SST	29.539	1.304	24.270	32.628	25948
Wind Speed	3.848	1.965	0.720	13.070	25948
Accumulated Rainfall	200.151	129.010	0.001	892.077	25948
Shipping Traffic	1.607	2.222	0.010	16.026	197
Port Sample					
# Attacks	0.091	0.453	0.000	10.000	40832
Attack Free Zone	6.311	5.661	0.005	43.439	39638
Fishing Conditions	0.257	0.296	0.000	1.000	40832
Above Median Fish.	0.500	0.500	0.000	1.000	40832
Chlorophyll-a	1.798	2.783	0.000	46.333	40832
SST	30.053	1.107	23.047	33.292	40832
Wind Speed	2.595	1.134	0.720	10.210	40832
Accumulated Rainfall	200.623	130.036	0.000	998.171	40832
Average Stable Lights 2002	3.121	3.591	0.000	14.188	325
Average Stable Lights 2012	4.244	4.745	0.000	17.414	325
Growth in Lights (2002-2012)	0.722	1.977	-1.000	23.467	317

Notes: This table reports summary statistics for the four main samples used in the analysis. Columns (1) through (4) reports the mean, standard deviation, minimum and maximum values of the listed variables, whereas column (5) show the number of observations. The construction of these variables are explained in sections 3, 4 & 6.2.

Table 2: Impact of fishing conditions on the average price of fish

	(1)	(2)	(3)
Panel A			
Above Median Fish	-3778.1***	-1436.2**	-1428.7**
	(1094.8)	(619.9)	(528.7)
R^2	0.0469	0.617	0.688
N	422	422	422
P-values Wild Cluster Bootstrap	.002	.039	.0172
Panel B			
Fishing Conditions	-4860.1**	-1917.4**	-1872.6***
	(1695.0)	(665.3)	(599.9)
R^2	0.0367	0.617	0.687
N	422	422	422
P-values Wild Cluster Bootstrap	.0064	.0152	.0176
Market FE	No	Yes	Yes
Time FE	No	No	Yes
Mean Outcome			22,544

Notes: This table reports the effect of fishing conditions in a 20 nautical mile radius surrounding a coastal market on the average price of fish in that market. Panel A uses a dummy variable equal to one if fishing conditions are above the median, whereas panel B uses the continuous measure of fishing conditions. Column (2) introduces fixed effects for each market and column (3) fixed effects for each month and year combination. Regular clustered standard errors on 16 local traditional markets in parenthesis. Given the low number of clusters, p-values using the Wild Clustered Bootstrap procedure suggested by Cameron et al. (2008) are also reported for the variable of interest for each regression.

Table 3: Impact of fishing conditions on labor market outcomes

	(1)	(2)	(3)
Panel A			
Above Median Fish.	0.0159***	-0.675***	4365.8*
	(0.00457)	(0.212)	(2402.9)
R^2	0.0834	0.0789	0.145
N	1036	1053	894
Panel B			
Fishing Conditions	0.0187***	-0.849**	11152.3**
	(0.00677)	(0.328)	(4075.4)
R^2	0.0778	0.0748	0.150
N	1036	1053	894
Mean Outcome	0.97	1.2	41,863

Notes: This table reports the effect of fishing conditions in a 20 nautical mile zone from the coast on the labor market outcomes of coastal marine fishermen. Panel A uses a dummy variable equal to one if fishing conditions are above the median, whereas panel B uses the continuous measure of fishing conditions. Column (1) reports the effect of fishing conditions on the share of total working hours that are dedicated to fishing and column (2) on the number of hours dedicated to work excluding fishing. Column (3) shows the effect of fishing conditions on the income per day the previous month for self employed fishermen. All regressions include fixed effects for 31 province and 4 years. Standard errors clustered at the provincial level are reported in parenthesis.

Table 4: Impact of fishing conditions on the number of attacks

	(1)	(2)	(3)	(4)	(5)
Above Median Fish.	0.023**	-0.024***	-0.022***	-0.021***	-0.016**
	(0.011)	(0.0076)	(0.0069)	(0.0065)	(0.0080)
	[0.0041]	[0.0054]	[0.0053]	[0.0054]	[0.0064]
Wind Speed				-0.0020	-0.0014
				(0.0016)	(0.0017)
Accumulated Rainfall				0.0000055	-0.000013
				(0.000015)	(0.000019)
R^2	0.0016	0.24	0.25	0.25	0.31
N	25948	25948	25948	25948	25948
Cell FE	No	Yes	Yes	Yes	No
Time FE	No	No	Yes	Yes	No
Month by Cell FE	No	No	No	No	Yes
Mean Outcome					0.041

Notes: This table reports the effect of the dummy variable of above median fishing conditions on the number of piracy attacks using the cell sample. Column (2) introduces cell fixed effects and column (3) time fixed effects for each month and year combination. Column (4) introduces monthly controls for both the average wind speed and accumulated rainfall within a cell. Finally, column (5) introduces fixed effects for each month and cell combination. Standard errors clustered on 197 cells in parenthesis and Conley (2008) standard errors adjusted for spatial correlations (assuming a cut-off of 500 km) in brackets.

Table 5: Impact of fishing conditions on whether an attack occured or not

	(1)	(2)	(3)	(4)	(5)
Above Median Fish.	0.017***	-0.011***	-0.011***	-0.0099***	-0.0042
	(0.0063)	(0.0032)	(0.0029)	(0.0029)	(0.0033)
	[0.0024]	[0.0026]	[0.0025]	[0.0026]	[0.0030]
Wind Speed				-0.00074	-0.000034
				(0.00072)	(0.00091)
Accumulated Rainfall				0.0000049	-0.0000095
				(0.000010)	(0.000010)
R^2	0.0028	0.24	0.25	0.25	0.32
N	25948	25948	25948	25948	25948
Cell FE	No	Yes	Yes	Yes	No
Time FE	No	No	Yes	Yes	No
Month by Cell FE	No	No	No	No	Yes
Mean Outcome					0.027

Notes: This table reports the effect of above median fishing conditions on a dummy equal to one if a cell experienced an attack in a particular month. Column (2) introduces cell fixed effects and column (3) time fixed effects for each month and year combination. Column (4) introduces monthly controls for both the average wind speed and accumulated rainfall within a cell. Finally, column (5) introduces fixed effects for each month and cell combination. Standard errors clustered on 197 cells in parenthesis and Conley (2008) standard errors adjusted for spatial correlations (assuming a cut-off of 500 km) in brackets.

Table 6: Impact of fishing conditions near ports

	Number of attacks		Attack free radius in degrees	
	(1)	(2)	(3)	(4)
Above Median Fish.	-0.026***	-0.030***	0.14***	0.30***
	(0.0053)	(0.0081)	(0.037)	(0.087)
	[0.012]	[0.019]	[0.085]	[0.16]
Wind Speed	-0.016***	-0.0087***	0.089***	-0.23***
	(0.0041)	(0.0027)	(0.027)	(0.058)
Accumulated Rainfall	0.000028*	-0.000082***	-0.0011***	0.0025***
	(0.000015)	(0.000023)	(0.00024)	(0.00026)
R^2	0.25	0.26	0.74	0.49
N	40832	40832	39638	39638
Port FE	Yes	No	Yes	No
Time FE	Yes	No	Yes	No
Month by port FE	No	Yes	No	Yes
Mean Outcome	0.09	0.09	6.3	6.3

Notes: This table reports the effect of above median fishing conditions in a 20 nautical mile zone surrounding a fishing port on the number of attacks within 40 nautical miles from the port (first two columns) and the distance to the closest attack (last two columns). Columns (1) and (3) control for port and time fixed effects for each month and year combination, whereas columns (2) and (4) include fixed effects for each month and port combination. Standard errors clustered on 325 ports in parenthesis and Conley (2008) standard errors adjusted for serial and spatial correlation (allowing for temporal serial correlation during the full sample period and that spatial correlation vanishes after 50 km) in brackets.

Table 7: Heterogeneous effects by local growth

	<Median Growth	>Median Growth	Full Sample
	(1)	(2)	(3)
Above Median Fish.	-0.036***	-0.020***	-0.0064
	(0.010)	(0.0060)	(0.0059)
Above Median * Slow Growth			-0.042***
			(0.014)
R^2	0.31	0.12	0.25
N	19465	20331	39796
Mean Outcome	0.15	0.04	0.09

Notes: This table reports the effect of above median fishing conditions on the number of piracy attacks near a port (i.e. corresponding to column (1) in table 6) splitted by the local growth in lights at night in a 50 km area surrounding the port between 2002 and 2012. The first column reports the estimated effect for ports that experienced below median growth and the second column for ports that experienced above median growth. Column (3) estimates the effect for the full sample (excluding the 8 ports for which growth cannot be calculated) interacting the above median fishing conditions variable with a dummy variable equal to one if growth was below the median. All regressions control for port fixed effects, time fixed effects for each month and year combination as well as for wind speed and accumulated rainfall. Standard errors clustered on 325 ports are reported in parenthesis.

Table 8: Heterogeneous effects by shipping traffic intensity

	Full Sample	>25th %ile	>50th %ile	>75th %ile
	(1)	(2)	(3)	(4)
Above Median Fish.	-0.021***	-0.024***	-0.026***	-0.038**
	(0.0065)	(0.0086)	(0.0096)	(0.017)
R^2	0.25	0.26	0.27	0.18
N	25948	19401	12934	6600
Mean Outcome	0.041	0.044	0.058	0.060

Notes: This table reports the effect of above median fishing conditions on the number of piracy attacks within a cell (i.e. corresponding to column (4) in table 4) splitted by the shipping traffic intensity in a cell in 2005. Column (1) reports the effect for the full sample, whereas the following columns gradually remove the cells with the lowest quartile of shipping traffic intensity. All regressions control for cell fixed effects, time fixed effects for each month and year combination as well as wind speed and accumulated rainfall. Standard errors clustered on 325 ports are reported in parenthesis.

Table 9: Direct effect of Operation Octopus and heterogeneous effects by fishing conditions

	Outcome: Number of attacks			
Sample included after July 2005:	3 months	1 year	2 years	3 years
A: Direct effect of Operation Octopus				
Post July 2005 * Patrolled Port	-0.22***	-0.20***	-0.14***	-0.078
	(0.082)	(0.063)	(0.044)	(0.050)
R^2	0.39	0.40	0.34	0.31
N	6373	7926	9894	11526
Mean of Outcome in Control	0.202	0.205	0.205	0.182
B: Effects for ports with good fishing conditions prior to July 2005				
Post July 2005 * Patrolled Port	0.00022	-0.60**	-0.51**	-0.46**
	(0.47)	(0.23)	(0.19)	(0.20)
R^2	0.42	0.44	0.36	0.34
N	3167	3933	4906	5703
C: Effects for ports with poor fishing conditions prior to July 2005				
Post July 2005 * Patrolled Port	-0.27***	-0.15***	-0.062***	0.0033
	(0.059)	(0.050)	(0.023)	(0.031)
R^2	0.36	0.37	0.35	0.31
N	3206	3993	4988	5823
D: Heterogeneous effects by fishing conditions				
Above Median Fish.	-0.016	-0.041*	-0.027	-0.022
	(0.028)	(0.022)	(0.019)	(0.017)
Above Median * Post * Patrol	-0.30	-0.33***	-0.15**	-0.10*
	(0.25)	(0.096)	(0.058)	(0.055)
Post July 2005 * Patrolled Port	-0.20**	-0.094*	-0.086***	-0.034
	(0.082)	(0.053)	(0.029)	(0.033)
R^2	0.39	0.40	0.34	0.31
N	6373	7926	9894	11526

Notes: Panel A in this table reports the results from estimating equation (3). The columns present the estimate for the following time periods after the initiation of the operation; three months (i.e. during the operation), one year, two years and three years. Panels B reports the results from estimating equation (3) for ports that had average fishing conditions above the median in the sample prior to July 2005. The results from the corresponding regression for ports with average fishing conditions below the median are reported in panel C. Panel D interacts the post and patrol interaction with the dummy for above median fishing conditions. All regressions include port fixed effects, time fixed effects for each month and year combination as well as controls for wind speed, accumulated rainfall and above median fishing conditions. Standard errors in parenthesis are clustered on ports.

Table 10: Poisson and probit regressions

	# Attacks		Attack (1 or 0)	
	OLS	Poisson	OLS	Probit
Above Median Fish.	-0.021***	-0.30**	-0.0099***	-0.19***
	(0.0065)	(0.12)	(0.0029)	(0.063)
				[-0.0097]
Wind Speed	-0.0020	-0.14**	-0.00074	-0.033
	(0.0016)	(0.066)	(0.00071)	(0.031)
Accumulated Rainfall	0.0000055	-0.00019	0.0000049	-0.00017
	(0.000015)	(0.00047)	(0.000010)	(0.00030)
N	25948	10287	25948	10209

Notes: This table reports the effects of above median fishing conditions on piracy in the cell sample using OLS estimation (the same as in Table 4 & Table 5) as well as poisson and probit. The first two columns report the results on the number of attacks and the last two columns on a dummy variable indicating whether an attack occurred or not. All regressions include cell and time fixed effects for each month and year combination. Standard errors clustered on cells are reported in parenthesis. Outcomes that are constant within cells are dropped from the poisson and probit regressions, explaining the lower number of observations in these regressions. The marginal effect at the mean for the probit regression is reported in brackets.