Marteache et al. Crime Sci (2015) 4:32
DOI 10.1186/s40163-015-0045-2

Crime Science
a SpringerOpen Journal

RESEARCH Open Access

Factors influencing the choice of a safe haven for offloading illegally caught fish: a comparative analysis of developed and developing economies

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Abstract

Using data from 72 countries, this study focuses on factors that affect illegal, unreported, and unregulated (IUU) fishing vessels' choice of country to offload their catch, with a specific emphasis on the differences between developed and developing economies. The concept of *choice-structuring properties* is applied to analyze whether the following factors influence the selection of a country: concealability of vessels and illegally caught fish; convenience of the ports; strength of fisheries monitoring, control, and surveillance measures; effectiveness of country governance; and commitment to wildlife protection regulations. Results indicate that, rather than a country's level of development, situational factors play a key role in what country IUU fishing vessels choose. IUU fishing vessels are more likely to offload illegal catch in countries with better port infrastructure and where concealability is easy to achieve because of high vessel traffic and large amounts of fish imports/exports; and they are less likely to offload their catch in countries with strong governance.

Keywords: IUU fishing, Choice-structuring properties, Developing economies, Situational factors

Background

Developing economies generally suffer from more crime than developed economies (Lafree and Tseloni 2006; Wolf et al. 2014). They are important locations for transnational crimes, such as drug smuggling (Segopolo 1992) and human trafficking (Hatchard 2006; UNODC 2006), as well as a number of other crimes, including financial crimes like money laundering (Duffy 2000), and environmental crimes, such as illegal dumping of hazardous waste (Lipman 1999). Some of the reasons for these higher rates of crime are the breakdown of social cohesion that stems from severe income inequality and poverty (Bourguignon 2000; Wolf et al. 2014), corruption, and the lack of law enforcement capacity (Svensson 2005; Olken and Pander 2011), all of which allow criminal actors to successfully commit crimes with little risk of arrest and prosecution (Hatchard 2006).

Environmental crimes, including wildlife crimes, also occur more frequently in developing economies. Apart from the factors mentioned above, the combination of developing economies' wealth of biodiversity and developed economies' problems with resource depletion (Doughty and Carmichael 2011) often creates a unidirectional flow of illegal wildlife products from developing to developed economies where rich buyers are available (Duffy 2000; Fuller et al. 1987; Lin 2005; Popescu 2013). Adding to this problem, developing economies often delay implementing environmental regulations and controls until their economy is prosperous, facilitating environmental crimes and resulting in lasting damage to their ecosystems (Sachs1984–1985; Hatchard 2006).

Developing economies, which account for 50 % of global fish exports (FAO 2006), are especially affected by illegal, unreported, and unregulated (IUU) fishing. They not only lose about $9 billion dollars to IUU fishing

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annually (Black 2007), but illegal fishing operators also recruit crews in developing economies because they can take advantage of unregulated labor markets and minimal controls on working conditions (EJF 2005). These crews are often subjected to such human rights abuses as financial exploitation and withholding of earnings, imprisonment aboard the vessel without food and water, and physical and verbal abuse (EJF 2010).

Beyond the economic and human rights problems it generates, IUU fishing is also a serious threat for species conservation and global food and job security. About 4.5 billion people worldwide depend on fish for 15–20 % of their daily animal protein intake, and 8 % of the global population, primarily from developing economies, works in the fishing industry (FAO 2010). As of 2008, 85 % of the world's fish stocks were fully exploited, over-exploited, or depleted, with scholars predicting a complete collapse of fish stocks by 2048 at this rate (EFTEC 2008; Worm et al. 2009). Lastly, IUU fishing vessels are also increasingly involved in other illegal activities, including drug and migrant smuggling (UNODC 2011). From an economic and social welfare standpoint, IUU fishing is a serious problem that is likely to continue unless successful solutions are found to curb it. Criminologists can play a key role in understanding the drivers and characteristics of IUU fishing, crafting crime prevention solutions to protect the planet's biodiversity, as well as addressing the ancillary economic and social problems IUU fishing causes.

Co rruption of fisheries' officials and poor surveillance and enforcement of regulations for activities carried out in these countries' exclusive economic zones (EEZs) have been cited among the facilitators of IUU fishing (Standing 2008; Palma 2010). They create an ideal environment for IUU fishing vessels looking to exploit developing economies' plentiful marine resources (Palma 2010). The EEZs of developing economies are the primary origins of illegally obtained fish (HSTF 2006; MRAG 2008). This research focuses on the countries where the illegally caught fish are offloaded, and on the factors that make some destinations more attractive to IUU fishing vessels.

How is IUU fish offloaded?

To engage in IUU fishing, a fishing vessel must: (1) access the waters where the fish are, (2) remove the fish from the water, (3) transport the catch to the destination, and (4) offload the illegally caught fish at the destination's port. Each of these steps must be completed without being detected and detained by the authorities, and obstructing any of these steps will jeopardize the entire fishing trip.

Existing criminological research tends to focus on step (2) of the crime commission process: the opportunities to remove the fish from water (Petrossian 2015; Petrossian and Clarke 2014). The present study, on the contrary, concentrates on the last step (4) of the crime: where the illegally caught fish is offloaded and why this destination is chosen. The only existing study that focused on this step (Petrossian et al. 2015) used the concept of risky facilities to explain what port characteristics facilitated vessel entry and offload of illegal catch. It found that IUU fishing vessels were more likely to visit free ports (ports exempt from certain laws and customs regulations) and ports with higher levels of daily general and fishing vessel traffic, and larger harbor sizes. They were also more likely to visit ports located in countries where illegal fishing, corruption, and less effective catch inspection programs were common.

Theoretical framework

The theoretical framework used in this study is the concept of *choice structuring properties* coined by Cornish and Clarke (1987). These are the characteristics or properties of offenses that "provide a basis for selecting among alternative courses of action and, hence, effectively structure the offender's choice" (p. 935). They make crime attractive to one offender but not another based on his or her goals, character traits, background, and/or expertise, such as the skills and resources needed, or the amount of payoff (Cornish and Clarke 1987). The concept stems from the rational choice perspective (Cornish and Clarke 1986), which states that when offenders plan a crime, they weigh the costs and rewards of committing the crime in a rational manner so as to maximize its rewards and minimize its costs (Felson and Clarke 1998). They are more likely to choose crimes that have a low risk of detection, are easy to commit, and provide what they consider a worthwhile reward.

Two recent criminological studies have used the concept of choice structuring properties to understand the choices made by criminals. Pires (2011) classified choice-structuring properties into (1) *static properties*, used to explain why poaching for the illegal parrot trade is popular in the neo-tropics; and (2) *variance properties*, used to explain why some species of parrots are poached more often than others. Static properties focus on the opportunity structure of the crime, while variance properties are the factors weighed by the offender to make event-related decisions regarding the target, location, and tools, among other factors. Marteache (2012) focused on the variance properties of theft from luggage at airports to determine what airport characteristics made them more likely to experience this type of crime.

The current study

This study builds on previous research by focusing on factors that affect IUU fishing vessels' choice of country to

offload their catch, with a specific emphasis on the difference between developed and developing economies. We compare what group of countries experience more visits from IUU fishing vessels. On one hand, the direction of the illegal wildlife trade in general, and of IUU fishing in particular, leads to the assumption that IUU fishing vessels disproportionately visit developed economies. On the other hand, given the low enforcement capacity of developing economies, the fact that most IUU fishing happens in their EEZs, and the short life-cycle of caught fish, it is also possible that IUU fishing vessels prefer to offload their catch in developing economies. This study also examines what country characteristics facilitate the offloading of IUU fishing vessels' illegal catch. Knowing what specific countries are the primary destinations for offloading illegally caught fish and what factors influence IUU fishing vessels' choice of country can help target law enforcement resources to prevent financial and biodiversity losses, as well as combat ancillary crimes committed by IUU fishing vessels.

It is expected that the choice structuring properties influencing IUU fishers' decision to offload their catch in a particular country will be highly specific and depend heavily on the costs and rewards of committing the crime. This study identifies 5 variance choice structuring properties relevant to where IUU fishing vessels choose to offload their illegal catch. These are: *the concealability of vessels and illegally caught fish; the convenience of the ports; the strength of fisheries monitoring, control, and surveillance measures (fisheries MCS); the effectiveness of country governance; and the country's commitment to wildlife protection regulations.* Accordingly, it is hypothesized that:

1. Countries where it is easy to *conceal* not only vessels at port (among heavy vessel traffic), but also the illegal catch (among the high volume of import and export of goods in general, and fish in particular), offer good opportunities to operate undetected. Therefore, IUU fishing vessels will choose to offload their catch in countries whose ports experience higher traffic of vessels, goods, and fish.
2. The abundance of marine resources, coupled with the quality of port infrastructure, affords the *convenience* of catching highly sought-after species and offloading it through a port with easy transport and access to target markets. Countries with these characteristics will experience a higher volume of visits by IUU fishing vessels.
3. The existence of strong *fisheries MCS* is likely to deter or make it difficult for IUU fishing vessels to offload their catch. Countries where there is little oversight over fisheries-related activities, and where such formal surveillance is weak, thereby allowing high levels of IUU fishing, will be preferred destinations for IUU fishing vessels.
4. Countries with poor *governance* are likely to offer low-cost, low-effort and high-reward criminal opportunities and will, therefore, be prime destinations for IUU fishing vessels to offload their catch. Politically unstable and violent countries are less capable of fighting IUU fishing in their waters and monitoring the legality of offloaded fish. Similarly, the higher a government's effectiveness, and the more adept a country is at controlling corruption within its borders, the better its capacity to prevent these crimes.
5. Lastly, the more *conservation treaties and conventions* to which a country belongs, the more willing and active it is likely to be in protecting its wildlife, and the less likely it is to be visited by IUU fishing vessels. Countries with large numbers of conservation laws are less likely to tolerate IUU fishing in their waters and more likely to fine or arrest IUU fishers who offload their catch in their ports because of their commitment to wildlife protection.

Methods

Dependent variable

Number of visits by IUU fishing vessels by country In 2010, The PEW Charitable Trusts (2010), a non-profit organization that conducts research on marine conservation, among other things, published a report that examined the global movements of vessels that were known to carry out IUU fishing from January 2004 to December 2009.[1] The study recorded a total of 509 different vessel movements in 73 countries (or half of all coastal countries) during the study period[2]. This research uses the total number of visits by IUU fishing vessels to countries' ports of entry. Ports of entry include canals, strait passages, anchorages, marinas, and ports.

Independent variables and their data sources

Concealability is measured by the number of vessels in port, the percent of a country's ports that are within the top 125 ports in the world in total cargo volume, and the value of fish imports and exports.

The number of marine species within the country's waters that are highly commercial internationally and the

[1] The PEW Charitable Trusts used multiple data sources to create the list of IUU fishing vessels and to monitor their movements. According to their report (PEW Charitable Trusts 2010), "the movement data on IUU-listed vessels gathered in this research from across a range of publicly available sources is the most comprehensive compilation of its kind" (p. 8). The report explains the methodology and its limitations in depth.

[2] This research excludes Taiwan from the analyses, as many independent variables were only available for China and IUU fishing vessels only visited Taiwan three times during the study period.

quality of its port infrastructure indicate the *convenience* of offloading the catch at that country's ports.

To measure the level of *fisheries monitoring, control and surveillance,* we used the country's scores on illegal fishing, catch inspection schemes, observer schemes, vessel monitoring schemes, and control of access to stop illegal fishing.

The indicators of the country's *governance* are the level of political stability and the absence of violence and terrorism, the effectiveness of government in general, and the control of corruption.

Finally, the construct *wildlife protection regulation* encompasses the number of environmental protection and conservation treaties and conventions a country belongs to, the percentage of its territorial waters that are marine protected areas, and its environmental sustainability coefficient.

Table 1 lists and describes all the independent variables used in this study and indicates their data sources, which are discussed briefly below.

This research uses a total of eight sources to draw data on the independent variables:

- *University of the Aegean (Greece), Department of Product and Systems Design Engineering* The University of the Aegean, an institution of higher education, offers different interdisciplinary graduate and postgraduate programs. The Department of Product and Systems Design Engineering developed the http://marinetraffic.com website as an academic project, which was designed to monitor real-time data on the daily movements of vessels across the world by using the Automatic-Identification System automated tracking system (University of the Aegean 2015; Marine Traffic 2015).
- *National Geospatial-Intelligence Agency (NGA)* NGA is a US-based intelligence and combat support agency that provides geospatial intelligence to first responders, intelligence professionals, warfighters, and policy makers. It is the primary federal agency that provides geospatial intelligence for the Department of Defense and the US Intelligence Community. The Agency works with a network of over 400 governmental agencies and commercial establishments to provide geospatial information on geographically referenced activities on Earth (NGA 2015).
- *American Association of Port Authorities (AAPA)* The AAPA is a trade organization representing more than 130 public port authorities in the US, Canada, Latin America, and the Caribbean. The organization is comprised of 350 corporate and 200 associate members, and engages in the promotion of issues related to trade, transportation, and environment, as well as port development and operations (AAPA 2015).
- *United Nations, Fisheries and Agriculture Organization (UN FAO)* Established in 1943, the UN FAO is the permanent United Nations organization dealing with the issues of food and agriculture (FAO 2015). Its Fisheries and Aquaculture Department deals with promoting sustainable development and use of fisheries and aquaculture resources (FAO Fisheries and Aquaculture 2015).
- *University of British Columbia, Fisheries Centre (UBC Fisheries Centre)* The UBC Fisheries Centre is the fisheries research arm of the University of British Columbia focused on promoting multidisciplinary studies on marine ecosystems, and promoting collaborations with governments, non-governmental organizations, and maritime communities (UBC, Fisheries Centre 2015). The Centre's http://seaaroundusproject.org project was an initiative, in collaboration with the PEW Charitable Trusts, launched to study the impact of fisheries on the marine ecosystems globally and to offer solutions through providing data and analyses, as well as conducting research on global fisheries (The Sea Around Us 2015).
- *World Economic Forum (WEF)* The WEF is an international institution devoted to promoting political, business, and academic cooperation among countries to improve the state of the world. The Forum works closely with international organizations to identify current and emerging challenges these countries face and to devise solutions (WEF 2015).
- *The World Bank Group (WBG)* The WBG is a family of five international institutions that provide financial assistance to developing economies around the world through low-interest loans, zero- to low-interest credits, and grants. The WBG also engages in research and analysis, and provides policy advice and technical assistance to developing economies (WBG 2015).
- *The United Nations (UN)* Established in 1945, the UN is an intergovernmental organization devoted to promoting peace and security in the world, and building cooperation among member states (of which there are 193) to work together on solving international problems, human rights issues, and international conflicts (UN 2015).

Control variable

Country Development Classification The UN World Economic Development Prospects (WEDP) classifies all countries into three categories: developed economies, economies in transition, and developing economies, based solely on their level of economic development.

Table 1 Independent variables used in the study

Choice structuring properties	Variables	Data sources	Explanation of variables and data sources
Concealability	Number of vessels in port	http://www.marinetraffic.com (University of Aegean (Greece), Department of Product and Systems Design Engineering)	The source provides real-time data on the number of vessels docked at each country's port. This research used data from November 10, 2014[a]
	% of a country's ports within the top 125 ports in the world in total cargo volume	(a) National Geospatial Intelligence Agency World Port Index (2009) (b) American Association of Port Authorities World Port Rankings Report (AAPA 2009)	(a) This source was used to obtain information about the total number of ports in each country (b) This source was used to get information about the top 125 ports by total cargo volume The calculated percentage was recoded into an ordinal measure ('0' = no ports; '1' = 15 % or less of ports; '2' = more than 15 % of ports). A total of 43, 21, and 8 countries fit into these groups, respectively
	Value of fish imports Value of fish exports	United Nations FAOSTAT database (UN FAO 2009)[b]	Data on imports and exports of fish in billion USD were gathered for 2009
Convenience	Number of marine species within the country's waters that are highly commercial internationally	http://seaaroundus.org (University of British Columbia and PEW Charitable Trusts)	Data on highly commercial species were available as of 2009
	Quality of port infrastructure	World Economic Forum Global Competitiveness Report (WEF 2009)	The WEF (2009) report measures countries on their competitiveness on 'infrastructure', among other constructs. The measure 'quality of port infrastructure' is one of the subcategories of 'infrastructure'. Scores for ports range from '1' = extremely underdeveloped; to '7' = well developed and efficient by international standards. These scores were determined by the availability and accessibility of seaport facilities
Fisheries MCS	Illegal fishing score Catch inspection schemes score Observer schemes score	University of British Columbia (UBC) (Pitcher et al. 2006)[c]	Each country was scored on whether vessels were fishing illegally in its fisheries, with '0' = no; '2.5' = occasionally; '5' = often''7.5' = a great deal; and '10' = almost as much, or more than legal vessels. If no information was available, a score of '10' was given to the country.
	Vessel monitoring schemes score Scores on control of access to stop illegal fishing		For each of these fisheries management indicators, countries were scored from 0 to 10, with '0' = no such program is in place and '10' = the program is in place and is almost entirely effective (Pitcher et al. 2006, p. 11)
Governance	Political stability and absence of violence/terrorism Government effectiveness Control of corruption	World Bank Worldwide Governance Indicators (World Bank 2009)	These indicators are complex indices built by the World Bank using "several hundred variables obtained from 31 different sources" (e.g. public opinion surveys, non-profit organization reports, academic research data, and findings from international non-governmental organizations) (Kaufman, et al. 2010, p. 2)

Table 1 continued

Choice structuring properties	Variables	Data sources	Explanation of variables and data sources
Wildlife protection regulation	Number of environmental protection and conservation treaties and conventions a country belongs to	http://seaaroundus.org (University of British Columbia and PEW Charitable Trusts)	These include treaties and conventions related to fisheries, environment, sustainability and other conservation-related issues that a country was a signatory of as of 2009
	Percentage of territorial waters that are marine protected areas	(a) The UN Millennium Development Goals Indicators database http://mdgs.un.org/unsd/mdg/Data.aspx(2010)[d] (b) http://seaaroundus.org (University of British Columbia and PEW Charitable Trusts)	This variable was calculated by dividing the country's 'marine protected areas in square kilometers' (as of 2010[e]) by the country's area of marine territorial waters. The former was extracted from data source (a), the later from data source (b)
	Environmental sustainability coefficient	World Economic Forum Global Competitiveness Report (WEF 2013)	The WEF report (WEF 2013)[f] scores countries from '1' for least sustainable to '7' for most sustainable

[a] This date was selected randomly. It was not necessary to collect data on multiple dates because, according to Petrossian et al. (2015), the correlation between the average number of daily arrivals in port at a given month and daily real-time number of vessels on a randomly selected date in a month are positively correlated, with a correlation coefficient value of $r = 0.92$ and at the $p < 0.01$ significance level

[b] For certain countries, the data were only available for 2007

[c] Researchers from the UBC ranked 54 important fishing nations, responsible for more than 95 % of the World's fish catch on their compliance, with the 1995 UN FAO's Code of Conduct for Responsible Fisheries. Countries were scored on their compliance efforts after UBC researchers examined 2475 reference materials that included international treaties, country synopses from the FAO, national legislation on fisheries, national fisheries agency reports, and published and "grey" literature. Additionally, researchers consulted with fisheries experts for advice on these scores for the majority of the countries (Pitcher et al. 2006)

[d] In September 2000, leaders from more than 180 countries met at the UN and ratified the UN Millennium Declaration (2000) that focused on eight Millennium Development Goals. One of these goals was "ensuring environmental sustainability" by closely tracking progress on several environmental indicators over the next 15 years. One of the indicators was "reducing biodiversity loss" to be achieved by increasing the percent of terrestrial and marine protected areas

[e] These data are only available for 2000, 2010, and 2012

[f] The World Economic Forum added the "environmental sustainability" pillar for the first time in its 2013 report. This measure incorporates several sustainability indicators, such as stringency and enforcement of environmental regulations, fish stocks' overexploitation, number of ratified international environmental treaties, and change in forest cover and forest loss

According to a 2009 UN WEDP Report (UN 2009), 20 of the countries included in this study are considered developed economies, 4 are economies in transition (Albania, Montenegro, Russia and Ukraine), and 48 are developing economies (see "Appendix 1"). For the purposes of this analysis, this variable was dichotomized to reflect two larger groups: 'developed economies' and 'developing economies or economies in transition.'

Analytical approach

Two distinct analyses were performed as part of this research. First, a *T* test analysis was conducted to compare developed and developing economies on the number of visits by IUU fishing vessels made to their ports and on all independent variables. All five hypotheses presented in this research were tested by using a negative binomial regression analysis to determine what variables influenced the number of visits a country received by IUU fishing vessels.

Results

Developing economies experience a higher degree of IUU fishing in their waters. Developed economies score significantly higher for all variables measuring concealability and convenience of offloading illegal catch in their ports. Their governance scores, the level of monitoring of fisheries, and the extent of protection of wildlife are also significantly higher. Contrary to what was anticipated, developed and developing economies did not differ significantly in the number of visits made by IUU fishing vessels (Table 2).

Multivariate analyses were performed to determine what factors influenced IUU fishing vessels' choice to offload their catch in a particular country. Given the sample size (72 countries), and the collinearity between the variables included in each construct, principal components analysis was used to combine related variables into factors for constructs with 3 or more variables. Details of the analysis can be found in "Appendix 2". Four constructs were converted into factors: concealability, fisheries MCS, governance, and wildlife protection regulation.

Negative binomial regression was chosen for the multivariate analyses due to two important characteristics of the dependent variable: (a) data were actual counts of the number of IUU fishing vessel visits to the countries, and (b) data were over-dispersed. Missing data for the factors "fisheries MCS" and "wildlife protection regulation" reduced the sample size beyond acceptable ratios.[3] For this reason, the analysis was performed with and without these predictors, with very similar results (see "Appendix 3" for a comparison of both models). Table 3 displays the final model without "fisheries MCS" and "wildlife protection regulation."

The difference between developed and developing economies on the number of visits by IUU fishing vessels was not statistically significant. That was confirmed by the bivariate, as well as multivariate analyses. The UN country development classification to which a country belongs (developed vs. developing or in transition) was not significantly associated with the number of visits by IUU fishing vessels. The three predictors that did explain why such vessels prefer to offload their catch in some countries versus others were concealability, quality of port infrastructure, and governance.

As expected, concealability and quality of port infrastructure are positively related to the number of visits to a country by IUU fishing vessels, while governance is negatively associated with it. According to Table 3, a unit increase in quality of port infrastructure is expected to double the number of visits, and a unit increase in concealability is associated with a 55 % increase in visits, while holding all other variables in the model constant. On the contrary, each unit increase in governance is expected to decrease the number of IUU fishing vessel visits by 57 %, holding all other predictors constant. The overall model explains 6.8 % of the variance in the dependent variable.

Discussion

IUU fishing vessels are more likely to visit countries in which they can enter and leave the port inconspicuously, thereby reducing the risk of detection. Countries where the infrastructure of ports facilitates the transfer of catch to markets are more convenient to offload illegally caught fish and move it to markets without being caught. Concealability and quality of port infrastructure are variables of a situational nature that structure decision making by IUU fishing vessels. They indicate that countries with higher volumes of general commercial flow, and better transportation networks in their ports, are more likely to be visited by IUU fishing vessels. This is particularly relevant for developed economies, as these countries have an average of 8 times more vessel traffic and between 13 and 14 times more volume of import and export than developing economies. Additionally, the port infrastructure of developed economies is, on average, 1.35 times better than that of the developing economies (see Table 2).

While the level of economic development does not seem to play a role in where IUU fishing vessels' decide to offload their catch, the stability and effectiveness of the country's government does. Crime is more likely to happen and go unnoticed or unpunished in countries at war, that are politically unstable, or where corruption is

[3] The inclusion of both predictors reduced the sample size to 35 countries (48.6 % of the total sample). Including either one of the two predictors still reduced the sample size to below 75 % of the original sample.

Table 2 Comparing developed and developing economies

Variables	Developed economies[a] n = 20	Developing economies or in transition n = 52	Sig.[b]	Effect size (r)	N
Number of visits of IUU fishing vessels[c]	5	3	0.366	0.17	72
Concealability					
Vessels in port[c]	407	52	*0.000*	0.50	71
% ports within top 125 ports in cargo volume[c]	15 % or less	0	*0.023*	0.23	72
Value fish imports[c]	1,390,025	97,636	*0.000*	0.51	72
Value fish exports[c]	1,590,743	121,364	*0.000*	0.43	72
Convenience					
Marine species commercial internationally	15	5	*0.011*	0.27	71
Quality port infrastructure	5.26	3.89	*0.000*	0.57	60
Fisheries MCS					
Illegal fishing in the country's waters	5.75	7.31	*0.014*	0.34	42
Catch inspection schemes	5.53	3.35	*0.001*	0.51	42
Observer schemes	4.69	2.08	*0.000*	0.55	42
Vessel monitoring schemes	5.75	3.40	*0.003*	0.44	42
Control of access to stop illegal fishing	4.56	3.35	*0.032*	0.29	42
Governance					
Political stability	0.68	−0.43	*0.000*	0.64	72
Government effectiveness	1.34	−0.27	*0.000*	0.79	72
Control of corruption	1.33	−0.39	*0.000*	0.76	72
Wildlife protection regulation					
# treaties and conventions[c]	43	22	*0.000*	0.61	68
% marine protected areas[c]	14.05	2.75	*0.000*	0.42	70
Environmental sustainability	1.06	0.95	*0.000*	0.69	62

Italic values indicate significant results

For the purposes of this study, the term "economies" as used by the UN (2009) refers to "countries"

[a] Means are reported for all normally distributed continuous measures. Medians are reported for non-normally distributed continuous and ordinal measures

[b] All non-normally distributed continuous and ordinal measures: Mann–Whitney test (one-tailed; except "Number of visits of IUU fishing vessels": two-tailed); normally distributed continuous measures: independent-samples *T* test (one-tailed)

[c] Non-normally distributed variable

Table 3 Negative binomial regression on the number of visits by IUU fishing vessels to a country

	B	(SE)	Sig.	IRR	95 % CI
Country development classification	0.073	(0.361)	0.841	1.075	[-0.636, 0.781]
Log # commercial marine species	0.045	(0.259)	0.861	1.046	[-0.462, 0.553]
Quality of port infrastructure	0.738	(0.184)	*0.000*	2.091	[0.377, 1.099]
Concealability	0.439	(0.180)	*0.015*	1.551	[0.087, 0.791]
Governance	−0.849	(0.279)	*0.002*	0.428	[-1.394, -0.303]
Constant	−1.499	(0.942)	0.111	0.223	[-3.346, 0.347]
Pseudo R^2	0.068***				
N	59				

Italic values indicate significant results

rampant, because, in those situations, the risk of detection and fear of consequences, if caught, are greatly diminished. Developing economies disproportionately suffer from these governance problems; therefore, it is likely that, when given the choice, IUU fishing vessels will most likely opt for the country with weaker governance.

One limitation of this research is that it was not possible to run separate multivariate models for developed and developing economies due to the sample size and the amount of missing data for some of the independent variables. Such analyses would have helped determine what specific factors influenced IUU fishing vessels' decision to offload their illegal catch in each of the two groups of countries. Second, data on the independent variables were not always available for the time period during

which the data on the dependent variable were collected (2004–2009). However, every effort has been made to use 2009 data whenever possible. Third, while the use of secondary data for our study has obvious advantages (access to a variety of data that would be impossible to collect due to time and money constraints, among others), our analyses are limited by the quality of the data gathered by other institutions. For this reason, only data collected by reputable agencies were deemed appropriate for inclusion in this research. Finally, the multivariate model discussed here only explains about 7 % of the variance in the dependent variable. However, models with small pseudo r-square values are not uncommon in criminal justice research (e.g. in Yu and Maxfield 2014, pseudo r-square ranges 7–9 %; in Stewart et al. 2004, pseudo r-square ranges 3–17 %). Given the paucity of research on this specific topic, this study constitutes a first step toward understanding what factors influence IUU fishing vessels' choice of country to offload their catch.

Future analyses could extend this study by using different methods and variables as new data become available. Another avenue for research would be to compare the 72 countries that were visited by IUU fishing vessels (that were examined in this research) to the remaining coastal countries that were not visited, to understand the differences between these two groups.

Conclusion

While developing economies experience higher level of IUU fishing in their waters (Black 2007), our findings indicate that there is no difference in the number of times IUU fishing vessels visit ports in developed versus developing economies. This suggests that the *offload* of illegally caught fish is actually a global problem that does not disproportionately affect developing economies.

Rather, it is situational factors that play a key role in IUU fishing vessels' decisions to offload in one country rather than another. These vessels prefer to visit those countries that facilitate an inconspicuous entry into the port and an easy disposal process for the catch, which reduce the chances of detection. Such ease of entry and disposal can take different forms. In developed economies, higher volumes of fish imports and exports and better infrastructure offer greater camouflage. For this reason, the countries with the most active ports in each region should be subject to special monitoring, as they constitute points of entry of illegally caught fish into the area. Some ways of blocking the opportunities afforded by those countries include the implementation of the 2005 FAO Port State Model Scheme, which would require that fishing vessels provide prior notice for port access that would include such information as vessel identification, fishing license, and information on catch and fishing trip, among other things (FAO 2007). This agreement reduces anonymity and makes it more difficult to offload illegal catch without detection, but should be strictly implemented in all countries and re-evaluated on a regular basis for maximum effectiveness. An increase in general port activity in a country should lead to enhanced security measures to detect and detain IUU fishing vessels, and prevention efforts should concentrate on the busiest countries.

In turn, in developing economies, political instability and high levels of corruption facilitate illegal activity in general, including the offload of illegal catch at port. If the existing mechanisms of formal surveillance cannot be trusted, other mechanisms could be put in place. External monitoring could be conducted by international organizations that operate independently from the country's governmental administration; and establishing surveillance and reporting practices among the community and the fishermen could help prevent offloading of illegal catch. Timor-Leste, for example, provides local fishermen with free GPS units that they can use to both anonymously report IUU fishing and send a distress signal in case of emergency. The information on location, date, and time of an IUU fishing report is automatically sent to maritime authorities for follow-up (IMCSN 2012).

Second, our results highlight that studying all the different steps that lead to the successful completion of a crime through, for example, script analysis, is essential to fully understanding how the crime is committed and how it should be addressed and prevented. In this case, although the act of illegally removing fish from a country's waters does affect developing economies to a greater extent, countries' level of economic development is not a determining factor for IUU fishing vessels when deciding where to offload their catch. Other factors intervene, and learning about them in greater detail can help disrupt the final step of the script of IUU fishing, thereby making it more difficult for these vessels to dispose of their catch.

IUU fishing is a significant global problem. It affects the marine ecosystem and disrupts the livelihoods of millions of people who depend on it for survival. Environmental criminology holds great promise for this issue because it helps understand the IUU fishing process in detail, while offering crime prevention interventions for every step and every context in which IUU fishing occurs. It is with this conviction that we hope to stimulate criminological interest in the topic and encourage criminologists to offer their training and skills to ensure that future generations conserve and continue to benefit from marine resources.

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Appendix 1

See Table 4.

Table 4 Countries visited by IUU fishing vessels between 2004 and 2009, by UN economic grouping

Country	Total number of visits by IUU fishing vessels, 2004–2009
Developed economies	
Australia	2
Denmark	8
Estonia	5
France	2
Germany	17
Greece	2
Iceland	1
Ireland	1
Japan	5
Latvia	5
Lithuania	8
Malta	4
Netherlands	9
Norway	10
Poland	4
Portugal	4
Spain	48
Sweden	1
United Kingdom	5
United States of America	13
Economies in transition	
Albania	1
Montenegro	1
Russia	20
Ukraine	18
Developing economies	
Algeria	1
Angola	1
Argentina	3
Benin	2
Brazil	3
Cameroon	1
Cape Verde	9
Chile	3
China	20
Colombia	16
Congo, D.R. of	1
Costa Rica	3
Djibouti	1
Ecuador	23
Egypt	10
Equatorial Guinea	1
Ghana	11
India	3
Indonesia	2
Iran	2
Ivory Coast	8
Kenya	1
Lebanon	1
Liberia	3
Madagascar	1
Malaysia	1
Mauritania	16
Mexico	1
Morocco	9
Namibia	3
Nigeria	7
Panama	59
Peru	1
Philippines	5
Sao Tome and Principe	1
Senegal	2
Singapore	34
South Africa	5
South Korea	14
Syria	1
Thailand	3
Togo	4
Tonga	1
Tunisia	1
Turkey	10
United Arab Emirates	2
Venezuela	1
Vietnam	1

Appendix 2

See Table 5.

Table 5 Principal components analysis of the constructs

Factor	Items			Factor loadings	Communality
Concealability N = 71	# vessels in port			0.912	0.832
	% ports within 125 top ports			0.689	0.475
	Value of fish imports			0.883	0.779
	Value of fish exports			0.850	0.722
	Kaiser–Meyer–Olkin = 0.790	Eigenvalue = 2.81			
	Bartlett's test = $p < 0.001$	% of Variance = 70.2	Determinant = 0.127		
Fisheries monitoring, control, and surveillance N = 42	Illegal fishing score[a]			0.727	0.529
	Catch inspection schemes			0.900	0.810
	Observer schemes			0.797	0.636
	Vessel monitoring schemes			0.844	0.712
	Control of access to stop illegal fishing			0.857	0.735
	Kaiser–Meyer–Olkin = 0.834	Eigenvalue = 3.42			
	Bartlett's test = $p < 001$	% of Variance = 68.4	Determinant = 0.059		
Governance N = 72	Political stability			0.858	0.736
	Government effectiveness			0.948	0.899
	Control of corruption			0.965	0.931
	Kaiser–Meyer–Olkin = 0.675	Eigenvalue = 2.57			
	Bartlett's test = $p < 0.001$	% of Variance = 85.5	Determinant = 0.058		
Wildlife protection regulation N = 57	# treaties and conventions for the protection of the environment			0.791	0.626
	% territorial waters that are marine protected areas			0.794	0.630
	Environmental sustainability			0.797	0.636
	Kaiser–Meyer–Olkin = 0.676	Eigenvalue = 1.89			
	Bartlett's test = $p < 0.001$	% of Variance = 63.0	Determinant = 0.581		

[a] "Illegal fishing score" was reversed prior to its inclusion in the Fisheries MCS factor

Appendix 3

See Table 6.

Table 6 Negative binomial regression on number of visits by IUU fishing vessels to the country: comparison of two models

	Model 1 With all predictors			Model 2 Without fisheries MCS and wildlife protection regulation		
	B	(SE)	IRR	B	(SE)	IRR
Country development classification	−0.551	(0.595)	0.576	0.073	(0.361)	1.075
Log # commercial marine species	−0.430	(0.408)	0.651	0.045	(0.259)	1.046
Quality of port infrastructure	0.702	(0.233)**	2.017	0.738	(0.184)***	2.091
Concealability	0.514	(0.230)*	1.671	0.439	(0.180)*	1.551
Fisheries MCS	0.069	(0.225)	1.072	–	–	–
Governance	−1.356	(0.426)***	0.258	−0.849	(0.279)**	0.428
Wildlife protection regulation	0.279	(0.260)	1.321	–	–	–
Constant	0.124	(1.380)	1.132	−1.499	(0.942)	0.223
Pseudo R^2		0.086**			0.068***	
N		35			59	

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

Received: 13 March 2015 Accepted: 13 October 2015
Published online: 27 October 2015

References

American Association of Port Authorities (2009). *World port rankings.* http://aapa.files.cms-plus.com/PDFs/WORLD%20PORT%20RANKINGS%202009.pdf. Accessed September 23, 2014.

American Association of Port Authorities. (2015). *About AAPA.* http://www.aapa-ports.org/About/?navItemNumber=495. Accessed September 9, 2015.

Black, R. (2007). *Action urged on illegal fishing.* BBC News. http://news.bbc.co.uk/2/hi/6602639.stm. Accessed October 21, 2014.

Bourguignon, F. (2000). Crime, violence, and inequitable development. In B. Pleskovic & J. E. Stiglitz (Eds.), *Annual World Bank conference on development economics 1999* (pp. 199–220). Washington, DC: The World Bank.

Cornish, D. B. (1994). The procedural analysis of offending and its relevance for situational prevention. In R. V. Clarke (Ed.), *Crime prevention studies* (Vol. 3, pp. 151–196). Monsey, NY: Criminal Justice Press.

Cornish, D. B., & Clarke, R. V. (1986). *The reasoning criminal: Rational choice perspectives on offending*. New York: Springer.

Cornish, D. B., & Clarke, R. V. (1987). Understanding crime displacement: An application of rational choice theory. *Criminology, 25*(4), 933–947.

Doughty, R. W., & Carmichael, V. (2011). *The albatross and the fish: Linked lives in the open seas*. Austin: University of Texas Press.

Duffy, R. (2000). Shadow players: Ecotourism development, corruption and state politics in Belize. *Third World Quarterly, 21*(3), 549–565.

EFTEC. (2008). *Costs of illegal, unreported and unregulated fishing in EU fisheries*. London: Economics for Environment Consultancy.

EJF. (2005). *Pirates and profiteers: How pirate fishing fleets are robbing people and oceans*. London: Environmental Justice Foundation.

EJF. (2010). *All at sea—The abuse of human rights aboard illegal fishing vessels*. London: Environmental Justice Foundation.

FAO. (2006). *The state of world fisheries.* Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/009/a0699e/a0699e00.HTM. Accessed January 14, 2014.

FAO. (2007). *Model Scheme on port State measures to combat illegal, unreported and unregulated fishing.* Rome: Food and Agriculture Organization of the United Nations. ftp://fao.org/docrep/fao/010/a0985t/a0985t00.pdf Accessed June 20, 2015.

FAO. (2009). *FAO yearbook of fishery statistics summary tables.* Rome: Food and Agriculture Organization of the United Nations. http://www.fao.org/fishery/statistics/global-consumption/en. Accessed November 16, 2013.

FAO. (2010). *he state of world fisheries and aquaculture.* Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/013/i1820e/i1820e01.pdf. Accessed June 7, 2014.

FAO. (2015). *About FAO*. www.fao.org/about/en/. Accessed September 10, 2015.

FAO Fisheries and Aquaculture Department. (2015). About us—Fisheries and Aquaculture Department. http://www.fao.org/fishery/about/en. Accessed September 10, 2015.

Felson, M., & Clarke, R. V. (1998). *Opportunity makes the thief: Practical theory for crime prevention*. London: Home Office.

Fuller, K. S., Hemley, G., & Fitzgerald, S. (1987). Wildlife trade law implementation in developing countries: The experience in Latin America. *Boston University International Law Journal, 5*, 289–310.

Hatchard, J. (2006). Combating transnational crime in Africa: Problems and perspectives. *Journal of African Law, 50*(2), 145–160.

HSTF. (2006). Closing the net: Stopping illegal fishing on the high seas. Final report of the Ministerially-led Task Force on IUU Fishing on the High Seas. High Seas Task Force. London, UK. http://www.high-seas.org.

International Monitoring, Control and Surveillance (MCS) Network for Fisheries-related Activities. (2012). *Timor Leste wins the first-ever stop IUU fishing award*. Retrieved from International MCS Network. http://www.imcsnet.org/wp-content/uploads/2012/06/Press-Release_Feb-20_English.pdf.

Kauffman, D., Kraay, A., & Mastruzzi, M. (2010). *The worldwide governance indicators: Methodology and analytical issues.* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130. Accessed October 21, 2014.

Lafree, G., & Tseloni, A. (2006). Democracy and crime: A multilevel analysis of homicide trends in forty-four countries, 1950–2000. *Annals AAPSS, 605*, 26–49.

Lin, J. (2005). Tackling southeast Asia's illegal wildlife trade. *Singapore Yearbook of International Law, 9*, 191–208.

Lipman, Z. (1999). Transboundary movement of hazardous waste: Environmental justice issues for developing countries. *Acta Juridica, 1999*, 266–286.

Marine Traffic. (2015). *Marine traffic AIS ship tracking on Google Maps.* http://www.marinetraffic.org/marine-traffic/. Accessed September 10, 2015.

Marteache, N. (2012). *Employee theft from passengers at U.S. airports: An environmental criminology perspective*. (Ph.D.), Rutgers University, Newark, NJ.

MRAG. (2008). Study and analysis of the status of IUU fishing in the SADC region and an estimate of the economic, social and biological impacts. Volume 2-Main Report. Marine Resource Assessment Group. A link to the full document is available at: http://www.stopillegalfishing.com/doc/study_of_the_status_of_IUUfishing_in_sadcregion_n_estimate_ESBI_vol2_eng.pdf.

National Geospatial Intelligence Agency. (2009). *World port index*. Nineteenth Edition. http://www.dtic.mil/dtic/tr/fulltext/u2/a510220.pdf. Accessed September 2, 2014.

National Geospatial Intelligence Agency. (2015). *About NGA*. https://www.nga.mil/about/pages/default.aspx. Accessed September 8, 2015.

Olken, B. A., & Pande, R. (2011). *Corruption in developing countries*. *Working Paper 17398* (pp. 1–48). Cambridge, MA: National Bureau of Economic Research.

Palma, M. A. (2010). *Promoting sustainable fisheries: The international legal and policy framework to combat illegal, unreported and unregulated fishing*. The Hague: Martinus Nojhoff.

Petrossian, G. A. (2015). Preventing illegal, unreported and unregulated (IUU) fishing: A situational approach. *Biological Conservation, 189*, 39–48.

Petrossian, G. A., & Clarke, R. V. (2014). Explaining and controlling illegal commercial fishing: An application of the CRAVED theft model. *The British Journal of Criminology, 54*(1), 73–90.

Petrossian, G. A., Marteache, N., & Viollaz, J. (2015). Where do "undocumented" fish land? An empirical assessment of port characteristics for IUU fishing. *European Journal on Criminal Policy and Research, Special Issue on Wildlife Crime, 21*(3), 337–351.

PEW Charitable Trusts, The. (2010). *Port state performance*: *Putting illegal, unreported and unregulated fishing on the radar.* http://www.pewtrusts.org/uploadedFiles/wwwpewtrustsorg/Reports/Protecting_ocean_life/Port%20State%20Performance%20report.pdf?n=6316. Accessed October 13, 2014.

Pires, S. F. (2011). *The illegal parrot trade in the neo-tropics: The relationship between poaching and illicit pet markets*. (Ph.D.), Rutgers University, Newark, NJ.

Pitcher, T., Kalikoski, D., & Pramod, G. (2006). *Evaluations of compliance with the FAO (UN) Code of Conduct for Responsible Fisheries (Fisheries Centre Research Report 14(2))*. Vancouver: University of British Columbia.

Popescu, C. F. (2013). Environment protection and illegal trafficking in wildlife fauna and flora. *Public Security Studies, 2, 4*(8), 51–56.

Sachs, A. (1984–1985). Environmental law and policy in developing countries: Annotated bibliography. *Ecology Law Quarterly, 12*, 1075–1087.

Sea Around Us, The. (2015). *About Us.* http://www.seaaroundus.org/about/. Accessed September 10, 2015.

Segopolo, S. M. A. (1992). Mutual assistance in criminal matters—Developing country perspectives. *Commonwealth Law Bulletin, 18*, 1538–1543.

Standing, A. (2008). *Corruption and industrial fishing in Africa.* Anti-Corruption Resource Center, Corruption and Governance Programme, Institute for Security Studies, South Africa.

Stewart, E. A., Elifson, K. W., & Sterk, C. E. (2004). Integrating the general theory of crime into an explanation of violent victimization among female offenders. *Justice Quarterly, 21*(1), 159–181.

Svensson, J. (2005). Eight questions about corruption. *Journal of Economic Perspectives, 19*(5), 19–42.

United Nations. (2009). *World economic situation and prospects.* http://www.un.org/en/development/desa/policy/wesp/wesp_archive/2009wesp.pdf. Accessed December 15, 2014.

United Nations. (2015). *About the UN.* http://www.un.org/en/about-un/index.html. Accessed September 10, 2015.

United Nations General Assembly. (2000). *Millennium declaration.* http://mdgs.un.org/unsd/mdg/Resources/Static/Products/GAResolutions/55_2/a_res55_2e.pdf. Accessed October 3, 2014.
United Nations Office on Drugs and Crime. (2006). *Trafficking in persons: Global patterns*. New York: United Nations.
United Nations Office on Drugs and Crime. (2011). *Transnational organized crime in the fishing industry: Focus on trafficking in persons, smuggling of migrants and illicit drugs trafficking*. Vienna: United Nations.
University of British Columbia, Fisheries Centre. (2015). *About Us.* http://www.fisheries.ubc.ca/contact-us. Accessed September 10, 2015.
University of the Aegean. (2015). *About*. http://www.aegean.gr/aegean2/index.html Accessed September 10, 2015.
Wolf, A., Gray, R., & Fazel, S. (2014). Violence as a public health problem: An ecological study of 169 countries. *Social Science and Medicine, 104*, 220–227.
World Bank, The. (2009). *The worldwide governance indicators.* http://info.worldbank.org/governance/wgi/index.aspx#home. Accessed October 10, 2014.
World Bank Group, The. (2015). *What we do.* http://www.worldbank.org/en/about/what-we-do. Accessed September 10, 2015.
World Economic Forum. (2009). *Global competitiveness report.* http://www.weforum.org/pdf/GCR09/GCR20092010fullreport.pdf. Accessed October 3, 2014.
World Economic Forum. (2013). *Global competitiveness report.* http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2012-13.pdf. Accessed October 3, 2014.
World Economic Forum. (2015). *About Us.* http://www.weforum.org/world-economic-forum. Accessed September 10, 2015.
Worm, B., Hilborn, R., Baum, J. K., Branch, T. A., Collie, J. S., Costello, C., et al. (2009). Rebuilding global fisheries. *Science, 325*(5940), 578–585.
Yu, S. V., & Maxfield, M. G. (2014). Ordinary business. Impacts on commercial and residential burglary. *British Journal of Criminology, 54*, 298–320.