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An empirical assessment of seaports as facilitators of FOC-flagged transshipment landings

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Abstract

Transshipment is one of the most common activities occurring between carriers and fishing vessels to exchange fish, as well as fuel, crew, and gear at sea or at port. While transshipment reduces the need for the fishing vessels to visit ports to offload their catches, thus increasing their efficiency, research has shown that this activity is also one of the major facilitators of IUU fishing. Research on transshipments is limited, and the few studies that are available on the subject focus on identifying hotspots of transshipment, and networks of actors involved. No study to date has examined the role ports play in facilitating transshipment activities, nor are there any studies that examine whether ports that are affiliated with China (the country with the highest IUU Fishing Index Score and 38% of the global share of distant-water fleets) are more likely to experience disproportionately higher volumes of FOC-flagged carrier vessel visits. Therefore, using the carrier vessel portal database from Global Fishing Watch, which contains information on the origin and destination ports of the carrier vessels involved in transshipment activities between 2015 and 2022, this research aims to (a) understand hot spots of FOC-flagged carrier vessel activity in the high seas and where such vessels offload their catches around the world; and (b) empirically test the characteristics of the ports (and the countries where these ports are located) used by these vessels to offload their catches. Findings suggest that ports that experience higher volumes of fishing vessel traffic, are in close proximity to high-seas transshipment activities involving FOC-flagged carriers, are designated ports of entry for foreign vessels, are Chinese-affiliated, as well as have low monitoring, control, and surveillance capacity are significantly more likely to be visited by FOC-flagged high-risk carrier vessels. This research proposes policy recommendations deriving from the findings of this research.

Keywords Port risk, IUU fishing, Transshipment, Risky facilities, Flags of convenience

Introduction

Illegal, unreported, and unregulated (IUU) fishing is one of the most serious environmental crimes, threatening global marine species and undermining conservation and sustainability efforts. It is estimated that if IUU fishing remains at the current rate, global fisheries will collapse by 2048 (Worm et al., 2009), causing significant ripple effects not only on global fisheries, but also on the livelihoods of coastal communities that depend on these fisheries as the primary source of sustenance. Considering that fish comprise 20% of the average per capita

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intake of animal protein for over 1.5 billion people and 15% average per capita intake for an additional 3 billion people (Petrossian et al., 2015), the collapse of global fisheries will affect over 57% of the global population, both directly and indirectly, not considering the individuals who are employed in the fishing industry.

Many factors contribute to IUU fishing, among which are the use of flags of convenience, the offloading of catches at ports of convenience, and illegal laundering at sea (i.e. transshipment involving IUU vessels or high-risk carriers). The use of flags of convenience (FOC), or the practice where "beneficial ownership and control of a vessel is found to be elsewhere than in the country of the flag the vessel is flying" (Alderton & Winchester, 2002), allows IUU fishing vessel owners to evade regulations and punishment, which effectively enables them to continue engaging in the illegal activity unabated (Petrossian et al., 2020). Ports of convenience, which are ports that have minimal or no legal standards or procedures established to ensure procedural compliance for inspection and offloading of fish (Palma, 2010), in turn, facilitate the offloading of illegally-caught fish. These ports either lack the resources to adequately inspect the vessels upon arrival, or effectively allow them to launder illegal catches by either offloading or transshipping fish at their premises (Long et al., 2020). Lastly, transshipment, which is the "act of transferring the catch from one fishing vessel to either another fishing vessel or to a vessel used solely for the carriage of cargo" (Sellen, 1996), allows (IUU) fishing vessels to remain in the high seas for long periods of time without the need to return to ports to offload their catches. This at-sea encounter not only effectively removes IUU fishing vessels' risk of potential detection at ports, but it also reduces the economic costs (e.g., related to fuel costs) associated with making these extended trips (Miller et al., 2018). Therefore, using a flag of convenience to offload catches at ports of convenience, or using transshipment carriers to assist them in laundering illegally-caught fish, creates the most opportune conditions for illegal fishing vessels to continue overfishing in the global oceans. Considering a significant proportion of fish is offloaded at ports using carrier vessels, understanding the behavioral patterns and characteristics of carriers is especially important.

This research makes three significant contributions. First, it is the first study to date to examine the spatial distributions and hotspots of FOC-flagged carrier vessels across global oceans. Knowing the locations where high-risk transshipment activities take place is vital for engaging in focused interventions to prevent such activities, and it can assist regional fisheries management organizations in their policy and management decisions. Second, guided by the crime science theoretical framework, more specifically the *risky facilities* concept (Clarke & Eck, 2007), this study is the first to empirically test the characteristics of the ports (and the countries where they are located) used by FOC-flagged high-risk carrier vessels to offload their catches. Among the various measures we test is a novel one focused on Chinese-affiliated ports. Considering that China has the highest IUU Fishing Index Score in the world (Hosch et al., 2023); is the world's main producer for both capture fisheries and aquaculture, supplying 36% of the worlds' fisheries production share in 2021 (FAO, 2023); and has 38% of the global share of distant water fleets (Pedrozo, 2022; Piesse, 2020), it is vital to examine the extent to which a port's affiliation with China has an impact on its vulnerability to be visited by FOC-flagged carrier vessels, which is what this study accomplishes. Lastly, this research examines both port- and country-level characteristics using a multivariate approach to understand the role of ports in facilitating potentially high-risk transshipment and IUU landings. Such an understanding will lead to targeted intervention strategies that will ensure compliance with international, regional, and national fisheries management regulations.

Review of literature on port risks for IUU landings

There is ample research suggesting that ports of convenience play a vital role in facilitating IUU landings (e.g., Kuemlangan et al., 2010; Long et al., 2020; Marteache et al., 2015; Petrossian et al., 2020), however, empirical research on the characteristics of these ports is scarce, and no research to date has examined these characteristics as they relate to the offloading of fish by FOC-flagged carrier vessels.

Among the first empirical studies exploring port characteristics include the Petrossian et al., (2015) study that applied the risky facilities framework to empirically test the "ports' traits that facilitate vessel entry and offloading of illegal catch" (p. 337). Using data from the Pew Environmental Groups' study that tracked blacklisted vessel movements and offloading patterns at ports worldwide, Petrossian et al., (2015) compared ports that were visited three times or less to those that were visited four or more times during the study period. Researchers used both country- and port-level predictors, including corruption, fish consumption, country-levels of illegal fishing, and score for catch inspection schemes, as well as port traffic (for both all vessels and fishing vessels alone), rate of vessels inspected at ports, access to transportation, free port status, and harbor size. Researchers found that the ports that were visited more frequently by blacklisted fishing vessels had almost double the overall daily vessel traffic and five times the fishing vessel traffic. These were larger ports in countries that were ranked high on the level of illegal fishing and corruption, and low on the effectiveness of fisheries inspection schemes. Lastly, if the port was listed as a 'free port', defined as a port with lax customs regulations and scrutiny, they were visited 5.71 times more than those that were not 'free ports'.

Similarly, Marteache et al., (2015) examined the port risk characteristics for IUU fishing vessels to offload their catches by comparing developed and developing countries. The goal of their research was to predict what factors influence IUU fishing vessel owners' decision to choose a country/port to offload their catches. The researchers applied the choice structuring properties construct to assess whether a country's governance effectiveness, strength of fisheries monitoring, control, and surveillance measures, and commitment to wildlife protection regulation, as well as convenience (e.g., port infrastructure) and concealability (e.g., vessel traffic) of its ports were significant predictors of the choices made by IUU fishing vessels to visit these ports. Their study found that a country's level of development was not a factor, but rather specific situational factors played a significant role in the decision to offload IUU catches. Specifically, these vessels were more likely to offload their catches at ports that afforded concealability because of high vessel traffic and had better port infrastructure, as well as countries that engaged in large amounts of fish imports and exports, experienced weak governance, and had poor monitoring, surveillance, and control measures in place.

Huntington et al., (2015) used global fish landing statistics from both the United Nations FAO FishStat database and national fisheries statistics databases, regional fisheries management organizations, and Organization for Economic Cooperation and Development Review of Fisheries country statistics to identify the top ports with the most landings, as well as the characteristics of the countries that made their ports attractive. The researchers found that the highest landings were at the ports of the countries that did not ratify the United Nations Port States Measures Agreement (PSMA), which is an international agreement that ensures countries that are party to this Agreement undertake mandatory reporting, monitoring, and inspection activities before and after arrival at ports designated to receive foreign vessels (Huntington et al., 2015).

In a more recent study, Hosch et al., (2019) developed a port state IUU risk index by developing both external and internal risk factors that are likely to predict IUU fish landings at these ports. *Internal risks* [1]incorporated measures of the performance of the port country to address potential IUU risk through such indicators as ratification of major international agreements (e.g., PSMA) and performance in regional fisheries management organizations as party States. The external risk [2] indicator provided a baseline for the exposure of the port country to potential IUU fishing operations and related transactions carried out in the country's ports (Hosch et al., 2019). The researchers found statistically significant relationships between the IUU fishing risk and PSMA agreement ratification, a country's corruption perception index, and the country's income (whereas countries with lower income were generally performing poorer than higher-income countries).

In a follow-up study, Hosch et al., (2023) used new data to replicate the findings of their 2019 study to update the ranking of the world's major fishing ports as well as reassess the port country's exposure risk to IUU fishing within its ports. In addition to separately measuring the external and internal risk scores, Hosch et al., (2023) developed a third indicator, overall port State IUU risk, which was the arithmetic average of the former two. Their overall assessments indicated an average of 1.83% drop in internal port country risk scores and an average of 0.96% increase in external risk scores from their initial rankings of these countries in 2019. Unlike in the 2019 study, researchers found statistically significant positive relationships between external and internal risk factors for IUU fishing, indicating that when external country-level risks increase so do internal port-level ones. Moreover, all three IUU risk indicators were associated with PSMA agreement ratification, corruption perception index, and gross national income.

Overall, the studies reviewed above collectively highlight the importance of considering both country- and port-level risk factors when assessing the risk of ports to IUU landings. Regardless of the outcome examined (i.e., IUU fishing vessel visits or examined overall landings of fish at countries' ports), these studies found that such country-level characteristics as corruption, PSMA ratification, income, rule of law, and the overall monitoring, control, and surveillance measures in place were significant predictors of the risk of the ports of these countries receiving illegally-caught fish. Moreover, studies that

[1] These include number of commercial fishing ports; party to the 2009 Agreement on Port State Measures; RFMO contracting Party or cooperating non-contracting Party; compliance record with binding RFMO's management measures; Transparency International's corruption perception index; and identification status of the port State by the EU, the United States, and within any RFMO.

[2] These include port visits by foreign fishing vessels; port visits by FOC-flagged vessels; average Flag State Governance Index of fishing vessels entering ports; IUU-listed fishing vessels entering ports; EU carded flag State fishing vessels entering ports; US carded flag State fishing vessels entering ports; and average internal port State risk of fishing vessels entering ports.

examined port-level characteristics found that such features as port size, overall traffic, and status as a free port are all important predictors of risk for IUU landings to occur at these ports. Nevertheless, few studies in the past have empirically tested these port-level characteristics, and ones that did use simple parametric or non-parametric statistical tests without controlling for competing explanations (Petrossian et al., 2015). Further, no study to date has examined the role of China's ownership and/or investment in these ports and its relationship to IUU fishing risk or offloading.

From this review, it is evident that while research has assessed port-level risks in relation to IUU fishing vessel visits, these risks as they relate to FOC-flagged carrier vessels have not been empirically tested. As stated earlier, transshipment plays an integral role in fishing operations in general, and in laundering IUU-caught fish specifically, therefore, filling this important gap in the literature by shifting the focus from fishing vessels to carriers and by examining whether the same risk dynamics apply to the carrier vessel operators' decision to offload the cargo at these ports is urgently needed. Apart from focusing on the unexplored topic of FOC-flagged carrier vessel port visits, this study will incorporate additional measures of port risk that have not been tested before and are specific to transshipment landings, such as communication, availability of supplies, and distance from known hot-spots of IUU transshipment activities, to evaluate the risk of ports. Finally, the present study is the first to examine the degree to which China's ownership or significant investment in ports across the globe (for the reasons outlined earlier) increases the risk of these ports receiving fish from FOC-flagged carrier vessels, an important aspect that has long been overlooked by prior research.

Theoretical framework

This research applies a crime science theoretical framework to assess the port risk factors associated with the offloading of fish by FOC-flagged high-risk carrier vessels. Crime science encompasses a family of theories that focus on the situational environmental factors (as opposed to the criminal dispositions of a motivated offender) that make crime possible (Clarke, 2012; Clarke, 2010). Specifically, these theories collectively argue that (1) criminal behavior is significantly influenced by the immediate environment in which it takes place; (2) the distribution of crime in time and space is rarely random; and (3) to effectively control and prevent crime one must understand the patterns of criminogenic environments and associated circumstances (Wortley & Townsley, 2016).

Within this family of theoretical approaches is the concept of risky facilities. Clarke and Eck (2007, p. 3) define 'facilities' as "places with specific public or private functions, such as stores, bars, restaurants, mobile home parks, bus stops, apartment buildings, public swimming pools, ATM locations, libraries, hospitals, schools, parking lots, railway stations, marinas, and shopping malls". The term 'risky' relates to unequal distribution in criminal events that such facilities experience. That is, when one examines a particular type of crime among facilities of the same kind (in this case, FOC-flagged carrier vessel visits to ports), a few facilities will experience most of the crime events, while most will experience little or none at all. The risks associated with these facilities include variation in size (e.g., larger facilities will have higher exposure/risk), number of hot products available at these facilities, location, design, and layout (with the assumption that poor design and layout is associated with higher risk), and effectiveness of management of these facilities, among others. In the context of ports used by FOC-flagged carrier landings, this framework not only provides useful guidance in formulating risk predictions, but also, if empirically supported, these risks can be modified to make FOC landings less desirable at these ports and ultimately decrease the likelihood of offloading illicitly obtained fish.

Data and methods

Data on all transshipment activities between August 2015 and August 2022 were extracted from the *Global Fishing Watch* (GFW) carrier vessel portal (see https://globalfishingwatch.org/). GFW is the authoritative data-gathering and generating research group concerned with ocean monitoring. This includes providing open-access vessel AIS data for both carrier and fishing vessels that can be used to detect potential vessel encounters at sea. Global Fishing Watch defines potential encounters between fishing and carrier vessels if these vessels were "continuously within 500 m from one another for at least two hours and traveling at less than two knots, while at least 10 km from an anchorage" (https://globalfishingwatch.org/datasets-and-code-transshipment/). These potential encounters can involve transfer of crew members, daily supplies, and catch products. Data from GFW has been used many times in past research and is rapidly becoming the standard regarding vessel activity detection (see Drakopulos et al., 2023; Tickler et al., 2018; Watson & Tidd, 2018; Welch et al., 2022).

During this period, a total of 53,580 transshipment activities were identified. However, these data included Russia-to-Russia transshipments (n = 23,948), which were removed from our analyses. First, this approach is in line with prior studies examining transshipment behavior (Greenpeace, 2020; Petrossian et al., 2022), and uses the same justification: Russia-to-Russia transshipments operate within a self-contained system, and these interactions do not involve other countries (Greenpeace, 2020; Petrossian et al., 2022). In fact, Miller et al. (2018) found that 98% of these activities occurred within the Russian EEZ, and 96% of these activities occurred between Russian fishing vessels and carriers. In essence, these would have also been excluded from our analyses in the second filtering phase, as the Russian flag is not one of the flags of convenience. Additionally, if data on the origin or destination ports for both the fishing and carrier vessels were unavailable, these transshipment incidents were removed from the study (n = 10,175). Additional data cleaning was performed during the port matching process to remove any names that could not be matched with ports (e.g., encounters with destination ports listed as "AAN", "ADAK", "AKUA GROUPER TUNA FARM", "C G Q", "JP HKT OFF" were removed). The final database that included all pertinent port data included a total of 18,589 potential encounters. Of these, 46% (n = 8,488) included potential encounters with FOC-flagged carriers. To better understand why some ports are at greater risk of experiencing landings by *risky carriers*, the total number of ports that were visited by FOC-flagged carriers (n = 117) (i.e., risky carriers) was combined with the total number of ports that experienced landings by non-FOC carriers (n = 130), making an initial sample size of 247. From here, the World Index port databases were searched to ensure that data on all predictor variables were available. Any port for which data could not be found or ports that missed significant data on these predictors was removed, leaving a final port sample of 139 ports. Of these, 70 ports had been visited by FOC-flagged carrier vessels and 69 ports had not.

The outcome variable of the model is the number of FOC-flagged carrier vessel visits by port. The predictor variables are grouped into two categories: country-level and port-level. Country-level variables include corruption, RFMO compliance, membership to PSMA, and score of MCS. Port-level variables include overall port traffic, traffic by fishing vessels, composite scores of port accessibility, communications, and supplies, as well as mandated entry inspection, proximity to the nearest potential transshipment encounter hotspot involving FOC-flagged carriers, and whether the ports were invested into, operated by, owned, partially or in whole, by Chinese state-owned or backed companies. Tables 3 and 4 in the Appendix include detailed overviews of all the variables used in this study, as well as the sources used to gather the data.

Limitations

Several limitations related to covariates and our outcome measure were unavoidable. Concerning the outcome measure, the original sample size of 247 ports was reduced to 139 because of missing information at the country-, meso-, and port-levels for many ports. Future research should attempt to fill these gaps of missing information, especially at the port-level, to incorporate all risky ports in a regression model. For example, we were unable to include 'free ports' because of substantial missing data. Data acquired for the covariates, *traffic* and *fishing vessel traffic*, do not account for seasonal changes, migratory patterns, and fishing seasons, nor random events, such as natural disasters or storms that may change the patterns of vessels. Finally, an in-depth investigation of Chinese-affiliated ports and their relationship to the potential illicit laundering of fish from FOC-flagged carriers is needed. Using a variety of sources and open databases, we made a diligent effort to document all Chinese-affiliated ports around the world that were operated by major Chinese government-backed companies, most of which are included in the present sample of 139 ports. However, other Chinese-affiliated ports may have been missed in our investigation because of the lack of public data on this subject matter.

Modeling

Our dependent variable is an event count which resulted in the use of count models. Excess zeros were present and the dependent variable was heavily skewed. Our independent variables are grouped into two levels (e.g., country and port). Collinearity diagnostics assessing variance inflation factors did not indicate any multicollinearity issues between the independent variables. Because of these conditions, we estimated using a generalized linear negative binomial mixed model. This model was preferred over other count models as confirmed by likelihood ratio tests. Additionally, this model can account for fixed and random effects while grouping independent variables into different levels (see "Statistical analysis" for expanded discussion on modeling strategy). Due to missing data, our final model analyzed 139 observations. The cleaned final dataset is available here (https://github.com/m-dylan-spencer/IUU-Fishing-2024-Crime-Science). [3]All models were estimated in R (version 4.3.1).

[3] This process included calculating the z-score and creating thresholds for the dependent variable. Multiple iterations of reducing and or eliminating all of the outliers were tested. To eliminate all outliers the sample size was greatly reduced and model convergence became an issue. Additionally, reductions in outliers also led to model convergence issues due to reduced sample sizes. The decision was made to keep the outliers both for statistical robustness and theoretical implications. That is, the ports with the most *FOC Visits*, the outliers, are as such because they are conducive to that type of transshipment behavior.

Findings

Spatial analysis

To better understand the spatial distribution of carrier transactions in the high seas relative to ports of interest, this research used ArcGIS Pro to conduct a Hot Spot Analysis (Getis-Ord Gi*), which was first executed for both FOC-flagged (n = 8821) and non-FOC-flagged carrier vessel activity (n = 9767) using KNN of 8 neighbors. The analysis used ½ °×½ ° latitude and longitude grid cells where the number of transactions per grid cell was tabulated for both types of activity independently. In Fig. 1, statistically significant hotspots are identified in red. Notably, many of the hot spots are consistent for both non-FOC and FOC-flagged carrier transactions for areas off the coast of Argentina and Peru, the northwest coast and the southeastern tip of Africa, the Arabian Sea, near the northeast coast of Japan, and in Micronesia, Polynesia, and more generally in the central Pacific Ocean. Some notable spatial differences between these two hot spot maps also exist. Non-FOC-flagged hot spots are more concentrated off the coast of Alaska, USA, the southeastern tip of Africa, near Japan, and northern Europe and in the Mediterranean Sea. FOC-flagged hot spots have larger concentrations off the coast of Peru and west of the Galapagos Islands compared to non-FOC-flagged hot spots. In fact, more than half of the FOC-flagged carrier transactions occurred within two of the five Tuna RFMOs—IATTC and WCPCF, specifically (Table 5, Appendix).

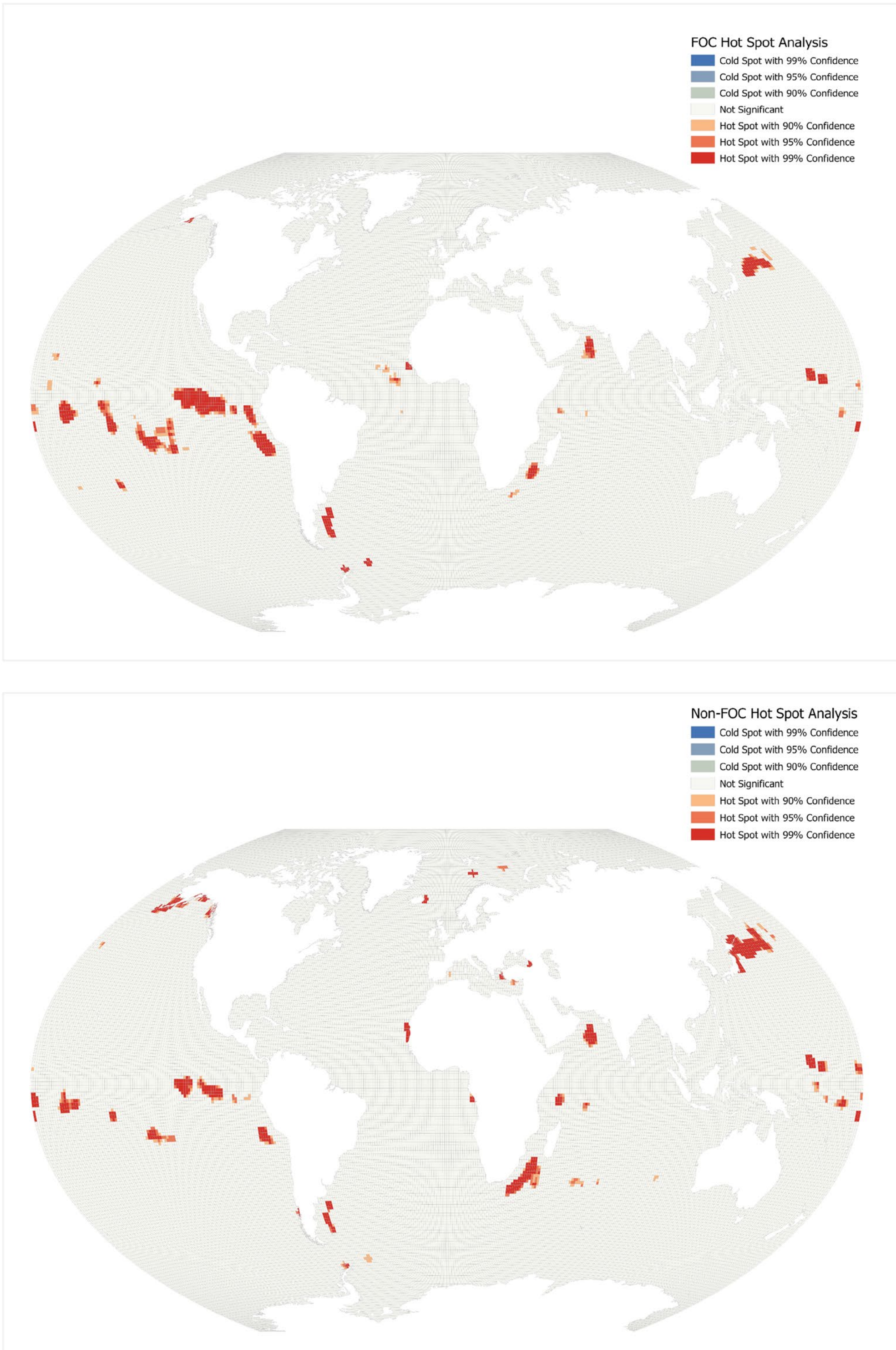
In Fig. 2, FOC-flagged hot spots for carrier transactions are mapped while taking into account where such vessels offloaded their catches around the world. While ports receiving landings from such carriers span the world, they are disproportionately concentrated in a small number of ports. Four of the top five ports that experience the greatest number of landings are concentrated in either East or Southeast Asia (i.e., Busan, Zhoushan, Kaohsiung, and Singapore). The only outlier is located on the island of Mauritius. Together, these 5 ports—out of 139 in this study—account for 36 percent of all landings. Further concentrations are located in smaller island ports throughout the Central and South Pacific Ocean, often near or within a hotspot. For example, the port of Pohnpei, Federated States of Micronesia, is in the middle of a hot spot and experienced 23 unique landings.

Statistical analysis

Table 1 presents descriptive statistics for our variables. Due to the aforementioned coding processes, few outliers were present in our variables. Variables with outliers included the dependent variable, *FOC Visits,* and independent variables, *Accessibility,* and *PSMA*. For the independent variables with outliers (one each), it was determined to have little to no effect on model outcomes. To address the outliers[4] present in the dependent variable a variety of coding schemas were tried before we settled on no schema. Because of the excess zero values in our dependent variable, we tested models that can handle the overdispersion present. Comparison of model fit using AIC and BIC statistics for negative binomial (generalized and linear mixed) and zero-inflated models indicated a preference for a generalized linear negative binomial mixed model. Additionally, zero-inflated models are often preferred when a theoretical explanation exists for the presence of overdispersion and excess zeros in the data. In our case, there is no such theory. A negative binomial model also provides for a more parsimonious explanation regarding results. We also confirmed there were no issues with multicollinearity. These final coded variables were deemed acceptable for inclusion in the final model.

We observed a statistically significant ($p < 0.10$) predictive relationship between seven of our twelve independent variables and our dependent variable. Table 2 presents the results of the generalized linear negative binomial mixed model using port-level and country-level variables to explain the variation of FOC-flagged carrier vessel visits at ports. Our findings indicate that higher overall traffic at ports leads to an increase in the number of carrier visits. Additionally, offloading of IUU products occurs more frequently at ports significantly closer to hotspots of transshipments. Contrary to our hypothesized relationship, we found that offloading is significantly more likely to occur at designated ports of entry. A novel finding, we also observed offloading was significantly more likely to occur at ports affiliated with Chinese government-backed companies. Unsurprisingly, we also observed that offloads are more likely to occur in ports of countries with lower scores on fisheries compliance regulations ($p = 0.06$). Transshipment vessels are also significantly more likely to visit countries that MCS practitioners think suffer from more compliance incidents and problems. Lastly, offloading occurs less frequently ($p = 0.07$) at ports in countries that did not ratify the Port States Measures Agreement designed to increase marine conservation and sustainable and legal fishing practices by safeguarding the ports through which foreign vessels offload their catches into countries of States different to the flag they carry.

[4] For example, one such vessel, Avunda Reefer, traveled from South Korea in November 2019 to commit transshipments near the coastline of Peru for approximately two months before traveling to the nearby port of Panama City, Panama to offload their catch.



A.

B.

Fig. 1 Hot spot analysis of FOC and non-FOC-flagged carrier vessel transactions from August 2015–August 2022

Discussion and conclusion

The objective of this study was to, first, understand the spatial distribution of FOC-flagged (risky) carrier vessel activity in the high seas and where such vessels offload their catches around the world, and, secondly, empirically test the characteristics of the ports used

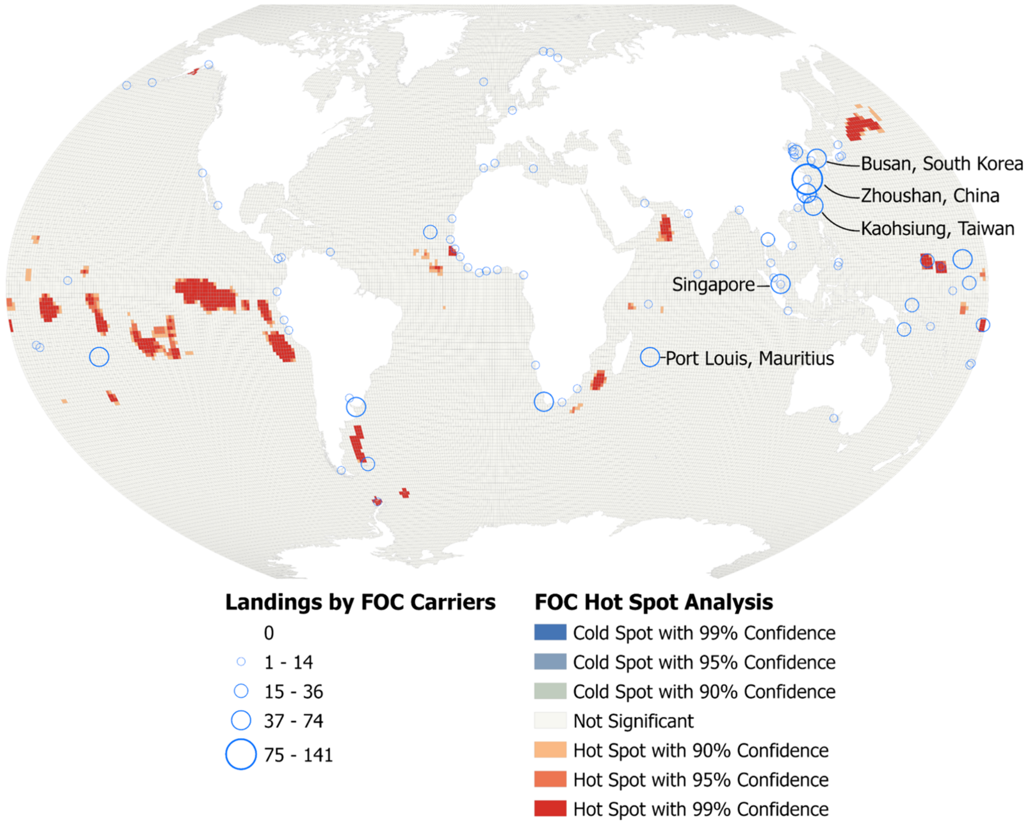


Fig. 2 Hot spot analysis of FOC-flagged carrier transactions and port landings of FOC carriers. *This figure only includes ports included in this study (n = 139)

Table 1 Descriptive statistics, N = 139

	Min	Max	Mean	SD	Variance
FOC Visits	0	141	6.072	17.633	310.922
Port-level Variables					
Traffic	1	4	2.518	1.112	1.237
FV Traffic	0	1	0.662	0.475	0.225
Hotspot	1	3	2.05	0.837	0.7
Entry	0	1	0.698	0.461	0.212
Comms	0	6	3.914	1.59	2.529
Accessibility	0	3	0.691	0.788	0.621
Supplies	0	5	3.245	1.508	2.273
Chinese-affiliated	0	1	0.252	0.436	0.19
Country-level Variables					
Corruption	21	90	52.662	17.782	316.211
Compliance	1	5	2.734	1.701	2.892
MCS	1	5	2.007	1.422	2.022
PSMA	0	1	0.791	0.408	0.166

by these vessels to offload their catches. A small body of research on IUU fishing vessels and the ports they offload their catches at (i.e., ports of convenience)

Table 2 Generalized linear negative binomial mixed model, N = 139

	β	Std. Error	*p*-value
FOC Visits	2.778	1.176	0.018**
Port-level Variables			
Traffic	0.876	0.235	0.000***
FV Traffic	− 0.262	0.51	0.607
Hotspot	− 1.324	0.254	0.000***
Entry	0.849	0.462	0.066*
Comms	− 0.043	0.165	0.792
Accessibility	− 0.102	0.295	0.731
Supplies	− 0.223	0.158	0.158
Chinese-affiliated	0.855	0.41	0.037*
Country-level Variables			
Corruption	− 0.016	0.012	0.197
Compliance	− 0.195	0.109	0.072*
MCS	0.408	0.189	0.031**
PSMA	− 0.915	0.475	0.054*

*$p < .05$; **$p < .01$; ***$p < .001$

has begun to uncover several country- and port-level factors associated with IUU fishing (e.g., Hosch et al., 2019; Hosch et al., 2023; Marteache et al., 2015; Petrossian et al., 2015). No research to date, however, has examined the role ports play in facilitating *transshipment* activities. Much of the fish offloaded at ports around the world is conducted by carrier vessels—a transporter—that can facilitate IUU fishing by transferring fish from fishing vessels to markets at ports. Whether the patterns found with IUU fishing vessels and frequently visited ports hold true for FOC-flagged carrier vessels is the basis of this study.

The contributions of this paper are threefold. First, this is the only study that maps the spatial distribution of FOC-flagged carrier activity relative to non-FOC-flagged carrier activity while quantifying the number of unique landings by each FOC-flagged carrier vessel. Second, guided by the criminological model, *risky facilities* (Clarke & Eck, 2007), this is the only study to empirically test why some ports experienced carrier landings while others experienced very little, or none at all. Finally, this study modeled all relevant country-, and port-level factors that could influence the decision-making process of carrier vessel operators to offload at particular ports while utilizing a multivariate model to control for competing explanations. Prior IUU fishing studies were either not focused at the port level (Marteache et al., 2015), used simple parametric or non-parametric statistical tests (Petrossian et al., 2015), or did not take into account all relevant factors (Huntington et al., 2015; Hosch et al., 2019; Hosch et al., 2023).

The first objective was to determine whether FOC-flagged carrier vessel activity is concentrated in the high seas, where it is concentrated, and where such vessels offload their catches. To this end, there were several spatial clusters identified that were generally consistent with the activity of non-FOC-flagged carrier vessel activity in the high seas (see Fig. 1). Consistency in spatial clusters between both types of carrier vessel activities suggests that much of fishing in the high seas is occurring in and around these spatial clusters, and carrier presence in such areas is a function of fishing vessel activity. Related, ports where FOC-flagged carrier vessels offload their catches also do not appear to be random. The top 5 ports, or about 4% of our sample, accounted for 36% of all landings, and these were largely concentrated in Southeast Asia. Like other risky facilities analyses both in the traditional criminological literature (Eck et al., 2007) and IUU fishing (Marteache et al., 2015; Petrossian et al., 2015), offloading of fish is significantly concentrated among a few ports regardless of the datasets used or whether it is focused on fishing or carrier vessels. In addition, some of the top ports found in the present study are also top ports visited by IUU fishing vessels, such as Singapore and Busan (Petrossian et al., 2015).

In the second part of the study, the regression analysis found the strongest association existed between hotspots and carrier landings at ports. That is, ports closer to hot spots for transshipment activity were more likely to experience landings by carrier vessels. Carrier vessel operators are traveling thousands of kilometers at sea for long periods, but even they are choosing more proximate ports to offload potentially illicitly-caught fish. Choosing more proximate ports reduces fuel costs and time spent at sea for employees. In other words, vessel operators are rational actors. Similar patterns are well documented in the traditional criminological literature with regard to offenders' 'journey to crime'. The vast majority of offenders do not travel very far to commit street crimes (Rossmo, 1999), and related to the present study, a similar pattern is beginning to be discovered for wildlife crimes. In the context of IUU fishing, Petrossian's (2018) study off the coast of West Africa found that proximity to a viable landing port was significantly associated with IUU fishing activity at sea. More broadly, several studies suggest that offenders are not willing to travel too far on foot to commit wildlife crimes. For example, poaching of rhinos (Eloff & Lemieux, 2014), elephants (Maingi et al., 2012), deer (Haines et al., 2012), and even redwood trees (Pires & Marteache, 2023) and their derivatives (Marteache & Pires, 2020) are highly associated with proximity to roads. Overall, this body of literature on proximity to crime locations suggests offenders rationally choose locations that are in closer proximity in accordance with the least effort principle (Zipf, 2016).

For Chinese-owned, invested, or operated ports, there is a positive association to port landings. To the authors' knowledge, this is the first time such an association has been empirically tested in the IUU fishing literature. Given that over one-third of distant water fleets are Chinese (Pedrozo, 2022; Piesse, 2020) coupled with the fact that China is known to be a problematic IUU fishing actor (Hosch et al., 2023), it may not be altogether surprising that Chinese-affiliated ports around the world are more likely to experience landings by FOC-flagged carriers. However, the underlying reason for this association remains unclear. It could be that such ports are located in countries that have weak governance and monitoring mechanisms, which are typically underdeveloped, and hence, why China has invested in such countries as part of their global Belt and Road Initiative (McBride et al., 2023). Such ports may experience more landings by FOC-flagged carriers largely because of governance and monitoring issues, and less to do with the role of the Chinese-backed companies at these ports. An alternative explanation is that Chinese-affiliated ports are strategically chosen around the world based on the demands of the market, proximity to fishing and carrier hot spots, and whether a country needs development aid, among other factors. From this perspective, landings in such ports by FOC-flagged carriers is by design, as typical inspections of vessel cargo and paperwork may be lax so as not to interfere with IUU fishing practices by suspect carrier vessels. Off the coast of West Africa, for example, there is a Chinese-affiliated port in Cape Verde, Porto Grande, which happens to be very close to a known hotspot of FOC-flagged carrier activity (see Fig. 1) and experienced 34 landings, or 12th highest in our sample. While these interpretations are ultimately speculative, future research should further unpack this association. It should also be determined if this relationship holds across *all* the ports of the world net of port- and country-level covariates.

Apart from the 'Chinese Affiliated' and 'Hot spot' port-level variables, this study also found the number of total vessels at ports and whether the requirement to undergo customs inspections were both positively related to offloading by FOC-flagged carriers. With more vessel traffic at ports, inspections of carrier vessels and paperwork may be less expected by vessel operators, which is consistent with what was found in prior studies (Marteache et al., 2015; Petrossian et al., 2015). However, fishing vessel traffic was not found to be associated with port landings in the present study, whereas it was in a prior study (Petrossian et al., 2015). This disparity may be a result of a more limited statistical analysis in the Petrossian et al., (2015) study that was not able to control for all vessel traffic or consider the continuous nature of the outcome measure. Contrary to expectations, ports that were designated ports of entry where foreign vessels undergo additional scrutiny (such as quarantine clearance) were more likely to be visited by FOC-flagged carrier vessels than those where such entry requirements were absent. This suggests that such additional scrutiny (e.g. clearing foreign goods and personnel) is unrelated to potential illegal fishing practices and bears no risk to carrier vessels who partake in such behavior and land at designated ports of entry.

At the country-level, and as expected, it was found that ports in countries that were the least compliant and participated less in PSMAs were more likely to experience landings by FOC-flagged carriers. Several studies had consistently found PSMAs to be related to IUU fishing and landings (Hosch et al., 2019; Hosch et al., 2023; Huntington et al., 2015), but no study had measured compliance according to the RFMOs independently of this measure. Related, several studies found countries that were more corrupt to be related to more IUU fishing and landings (Hosch et al., 2019; Hosch et al., 2023; Petrossian et al., 2015), but the present study did not find any relationship while controlling for all other relevant factors. This may suggest that nationwide levels of corruption may be independent of what occurs at a specific port. Finally, the MCS measure—or how compliant ports are according to practitioners—was significantly associated to FOC-flagged carrier landings. That is, ports that are thought to have more compliance problems experienced more landings by risky carriers. This suggests that carrier vessel operators may be aware of which ports are less compliant with rules and regulations, which is consistent with the findings above on PSMAs and compliance with RFMOs. Additionally, Spencer et al., (2021) found that anglers' knowledge of fishing regulations was positively correlated with likely regulatory compliance. While not explicitly observed, the opposite may also be true, that is, anglers (or, in the present case, shipping vessels) with increased regulatory knowledge select ports they know or suspect have fewer regulations and enforcement. This may suggest a well-known mantra exists among IUU fishing vessels that certain ports are more "*friendly*" towards their illegal activities compared to others.

Policy implications

Much has been written on interventions at the local, national, and international levels to combat IUU fishing practices that increase the risk and effort for potential offenders and reduce the rewards of illicit fishing consistent with situational crime prevention mechanisms (Spencer et al., 2021; Weekers et al., 2021; Marteache et al., 2020; Petrossian et al., 2015). With the transshipment problem at hand, several interventions can be implemented at the port- and national-levels, and at sea where transshipment activity occurs. At the port-level, ports that disproportionately experienced the most landings by FOC-flagged carriers should be prioritized for situational interventions to achieve the greatest reduction in risky offloading. Such ports, and port nations, should be encouraged to adopt the PSMA (if they have not done so already), which is a legally binding international tool to "empower port states to deny foreign vessels suspected of engaging in IUU fishing from using their ports and to land catches." (Hosch et al., 2023). In addition, "increasing inspections of vessels offloading their catch, requiring pre-entry notifications at port, confirming and certifying complete and accurate information on vessel monitoring systems before port entry/fish offload" (Petrossian & Marteache, 2022) would certainly increase the risk of IUU fishing practices.

At sea, strengthening formal surveillance of transshipment activity hot spots between high-risk fishing vessels (i.e., carrying FOC flags) and high-risk carriers (i.e., carrying FOC flags) could significantly increase the risk of deterring illicit transshipment to markets (see Petrossian et al., 2022). This is especially relevant to RFMOs that have experienced large volumes of FOC-flagged carrier vessel activities within their convention areas (e.g., IATTC and WCPFC). This could potentially be done by regional fisheries management organizations responsible for the activities taking place within their convention areas and beyond the jurisdictions of coastal states. Considering one of the central roles of these intergovernmental bodies is to address the problem of IUU fishing within their management areas (Petrossian, 2019), strengthening their governance and enforcement capacity to monitor both IUU fishing activities and those that facilitate such activities (i.e., transshipment) is if utmost urgency. One such tool could be the creation of blacklists for the FOC-flagged carrier vessels that interact with FOC-flagged fishing vessels identified in this research.

Notwithstanding the aforementioned limitations, the present study is an important contribution to the literature on IUU fishing by focusing attention on patterns of risky carrier activity, a long-ignored topic in this field and the vulnerabilities of the ports that receive them. Our findings shed light on potential avenues for policy interventions and regulatory measures to combat IUU fishing and promote sustainable practices in the maritime industry.

Appendix

See Tables 3, 4, 5 and 6.

Table 3 Variables, their descriptions, and the data sources

Variable and their levels of measurement	Description	Source/database & URL
Outcome variable		
FOC Visits (scale)	The number of visits by transshipment vessels that had interacted with FOC-flagged fishing vessels, gathered from *GFW-Carrier Vessels*	Global Fishing Watch—Transshipment [a] https://globalfishingwatch.org/transshipment/
Port-level variables		
Traffic (ordinal)	Ordinal ranking of the average number of total vessels listed at the port at a given time, coded 1 (least traffic) to 4 (most traffic)	Marine Traffic https://www.marinetraffic.com/
FV_Traffic (dichotomous)	Dichotomous listing of the presence of fishing vessels, coded as 0 (no fishing vessels at port) and 1 (fishing vessels at port)	Marine Traffic https://www.marinetraffic.com/
Accessibility (ordinal—index)	A composite of the physical factors that make a port easier to access, ranked ordinally from 0 (easiest to access) to 4 (hardest to access)	World Port Index https://msi.nga.mil/Publications/WPI
Entry (dichotomous)	If the port requires all arriving vessels to undergo customs inspections, rated 0 (not mandated) and 1 (mandated)	World Port Index https://msi.nga.mil/Publications/WPI
Supplies (ordinal—index)	A composite of the availability of provisions at the port, from 0 (no supply access) to 5 (access to multiple supplies)	World Port Index https://msi.nga.mil/Publications/WPI
Comms (ordinal—index)	A composite of the communication measures at the port, from 1 (only one type of communication technologies) to 6 (many communication types)	World Port Index https://msi.nga.mil/Publications/WPI
Hotspot (ordinal)	Proximity in kilometers to the closest FOC-carrier transaction hotspots, coded 1 (closest) to 3 (farthest)	N/A
Chinese Affiliated (dichotomous)	If the port has been invested in, is operated by, or is owned by Chinese state owned or backed companies	Newsweek, Voice of America, Center for Strategic & International Studies, Secure Free Society, Cosco Shipping, Council on Foreign Relations; Belt and Road Portal; https://www.newsweek.com/2022/10/14/chinas-stake-world-ports-sharpens-attention-political-influence-1749215.html; https://www.voanews.com/a/6224958.html; https://www.csis.org/analysis/assessing-risks-chinese-investments-sub-saharan-african-ports?fbclid=IwAR2ouheLQihqoLrGFWUBXvDANOKhCmsUwIVD3UkvowYSZLct0AOqUamnDMQ; https://www.securefreesociety.org/research/monitor28/; https://ports.coscoshipping.com/en/Businesses/Portfolio/#OverseasTerminals;,https://www.cfr.org/tracker/china-overseas-ports; https://www.yidaiyilu.gov.cn Indian Ocean (2021), COSCO Shipping..., Devermont et al. (2019), Funaiole et al. (2023), Jouan (2020), Menon (2021), Tatlow (2022), Marle (2015), VRIC Monitor No. 28 (2022), and Xie (2021)
Country-level variables		
Corruption (scale)	Perceived corruption level ranked from 0 (highly corrupt) to 100 (least corrupt) as rated by *Transparency International Corruption Perception Index*[b]	Transparency International—Corruption Perceptions Index (2021) https://www.transparency.org/en/cpi/2021
Compliance (ordinal)	Rating of a country's compliance to RFMO's ranked from 1 (most compliant) to 5 (least compliant)	Global Initiative/Poseidon https://globalinitiative.net/analysis/iuu-fishing-index-2021/
MCS (ordinal)	View of Global Initiatives' MCS practitioners[c] on port compliance ranked from 1 (most compliant) to 5 (least compliant)	Global Initiative/Poseidon https://globalinitiative.net/analysis/iuu-fishing-index-2021/
PSMA (dichotomous)	A country's participation in agreements on PSMAs coded 0 (no participation) and 1 (participation)	FAO—Party to the Port State Measures Agreement https://www.fao.org/port-state-measures/background/parties-psma/en/

[a] "Map & Data." *Global Fishing Watch*. (https://globalfishingwatch.org/map-and-data/)

[b] Transparency International (https://www.transparency.org/en/cpi/2021)

[c] Global Initiative (https://globalinitiative.net/analysis/iuu-fishing-index-2021/)

Table 4 In-depth descriptions of variables used in the current study

Variable	Explanation
Dependent variable	
Numberofvisits	The interactions between FOC-flagged vessels and transshipment cargo vessels were cataloged from the *Global Fishing Watch* database described above. The number of landings of the cargo vessels at the 139 ports that were identifiable and with sufficient data were counted and listed. The numbers ranged from 0 to 141 landings within the timeframe
Port-level variables	
Traffic/FV_Traffic	The variable "traffic" was measured by examining the number of vessels docked at the port at a specific time. Each port was found via *marinetraffick.com*, which lists the total number of vessels docked at the port, as well as the type of vessel and other identifying characteristics. The number of all vessels, as well as fishing vessels (separately) at the listed ports, were counted on three consecutive days in March of 2023, and then averaged to the nearest whole number creating the variables of *traffic* and *FV_traffic*, respectively
Accessibility	Accessibility: This variable is a composite score created by adding the scores of Entrance Restriction measures from the World Port Index (WPI), which include natural factors that are restrictions to the entrance of vessels such as adverse tides, heavy swells, and the presence of ice. Rated from one to three, higher scores indicate more difficulty in accessing the ports due to the presence of these natural restrictions
Entry	Indicates if the port mandates that all arriving vessels must enter and clear foreign goods and personnel through customs and immigration, mandatory vessel inspection, or other associated services. Coded dichotomously, this variable indicates mandate of inspection or otherwise (0 = no, 1 = yes), this can also include a mandatory quarantine clearance for the port
Supplies	This variable is a composite score created by adding the scores of Supplies measures from the WPI which include the access and ability to procure provisions, portable water, fuel oil, diesel oil, deck supply, and engine supplies from the port. Rated from one to five, higher scores indicate increased opportunity to gather supplies from the port
Comms	Comms: A composite score created by adding the scores of the Communications measures from the WPI which indicate that the ability to access certain types of communications are available at the port, including telephone, telefax, radio, radiotelephone, airport and rail communications, and very high frequency (VHF) radio. Rated from one to six, higher scores on communication indicate increased access to communication channels in the port
Hotspot	Some global ports may experience a greater number of landings by FOC-flagged carriers because they are in closer proximity to FOC-carrier transaction hot spots. To evaluate this, the nearest distance (in kilometers) a vessel could travel from each port to the nearest hot spot was measured using a network distance executed manually for each port in ArcGIS Pro 2.9
Chinese-affiliated	This variable represents whether or not a specified port is known to be operated, partially or fully owned, or invested in by Chinese state owned or government-backed companies, such as Chinese Ocean Shipping Company, or COSCO. Gathered through multiple sources and open databases, of the 139 analyzed ports 35 were identified as being owned, invested, or operated by major Chinese government-backed companies, including 13 within China
Country-level variables	
Corruption	The Transparency International Corruption Perception Index rates countries based on the perceived corruption of the governments or governing entities as assessed by their independent experts. The index is a measure of rank on a scale from 0 to 100, with 0 indicating highly corrupt and 100 indicating least corrupt
Compliance	This variable indicates a country's compliance to regional fisheries management organizations (RFMOs). Fisheries Management Organizations are a type of assorted regional entities set to ensure cooperation between neighboring countries in specific coastal regions to conserve shared fish and marine fauna populations through management of fishing levels and wildlife interaction as found on the 2021 IUU Fishing Index created by POSEIDON and the Global Initiative Against Transnational Organized Crime (GIATOC). Countries are ranked from one to five indicating the rating of signing and compliance to RFMOs of the respective country
PSMA	The Agreement on Port State Measures (PSMA) to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing, is an attempt to lessen the impacts of IUU fishing through the institution of state-standardized port measures to increase ecological and environmental sustainability efforts of marine resources on via international standards. As of 2020, each country that signed onto the agreement had agreed to implement measures to increase security, protection, and cooperation between domestic and international actors for preservation purposes, according to the UN FAO. This variable is measured dichotomously and coded as 0 to indicate no participation, and 1 to indicate participation
MCS	The views of a country's overall score on "monitoring, control, & surveillance" (MCS) as reported by practitioners on port compliance incidents is a ranking facilitated by the 2021 IUU Fishing Index created by The Global Initiative Against Transnational Organized Crime (GIATOC) and POSEIDON, which scores the country's overall compliance with MCS standards, including factors that benefit and contribute to overall security within the port and prevent illegal activity in the port, as well IUU fishing activities. MCS compliance measures rank from 1 to 5, indicating most compliant (= 1) and least compliant (= 5), respectively

Table 5 FOC-Flagged carrier transactions at sea by RFMO (Tuna)

RFMO	Count of FOC-flagged carrier transactions
IATTC	3341
WCPCF	2672
ICCAT	2133
CCSBT	1629
IOTC	1005

Some RFMO's overlap with each other resulting in some transactions above being double-counted. For example, the largest number of incidents falling within two RFMO's are CCSBT and IOTC, and IATTC and WCPFC

Table 6 Ports visited by FOC-flagged carrier vessels

Port	Number of Visits	Distance to hotspots (km)	Chinese government affiliation	Port	Number of visits	Distance to hotspots (km)	Chinese government affiliation
Zhoushan	141	1703	1	Akutan Harbor	0	551	0
Port Louis	74	904	0	Alanya	0	4089	0
Busan	67	1121	1	Amsterdam	0	3146	0
Kaohsiung	64	2029	1	Anacortes	0	1369	0
Cape Town	59	662	0	Batumi	0	4746	0
Fuzhou	57	1870	1	Calbuco	0	1663	0
Montevideo	52	367	0	Chignik	0	165	0
Weihai	36	1693	1	Choshi	0	398	0
Porto Grande	34	360	1	Cordova	0	229	0
Bangkok	17	4084	0	Craig	0	1150	0
Rabaul	17	772	0	Dillingham	0	812	0
Callao	14	149	0	Djupivogur	0	3584	0
Colon	14	611	1	Egegik	0	743	0
Balboa	13	898	1	Eregli	0	3631	0
Port Elizabeth	12	245	0	Hachinohe	0	282	0
Suva	12	619	0	Hanasaki	0	160	0
Levuka	9	527	0	Ho Chi Minh	0	3467	1
Victoria	8	311	0	Huelva	0	1855	0
Walvis Bay	8	1504	1	Ibiza	0	2323	0
Dalian	7	1715	1	Ijmuiden	0	3131	0
Shimizu	7	604	0	Ishinomaki	0	323	0
Tema	7	1269	1	Istanbul	0	3472	1
Honiara	6	775	1	Juneau	0	631	0
Punta Arenas	6	416	0	Karatsu	0	1169	0
Qingdao	6	1703	1	Kavkaz	0	3993	0
Yokosuka	6	533	0	Kenai	0	60	0
Bissau	5	6	0	Ketchikan	0	829	0
Conakry	5	89	1	Kirkenes	0	4849	0
Dutch Harbor	5	594	0	Kodiak	0	0	0
Yantai	5	1758	1	Kooh Mobarak	0	377	0
Durban	4	296	1	Korsakov	0	405	0
Manta	4	260	0	Kushiro	0	202	0
Monrovia	4	396	0	Las Palmas	0	1080	0
Quanzhou	4	1948	1	Luanda	0	2206	0
Sendai	4	337	0	Magadan	0	1020	0

Table 6 (continued)

Port	Number of Visits	Distance to hotspots (km)	Chinese government affiliation	Port	Number of visits	Distance to hotspots (km)	Chinese government affiliation
Songkhla	4	3823	0	Maizuru Ko	0	850	0
Abidjan	3	966	1	Matsuura	0	1196	0
Ningbo	3	1666	1	Nagasaki	0	1278	0
Zhangzhou	3	2015	1	Nakhodka	0	762	0
Bhavnagar	2	548	0	Naknek	0	783	0
Chimbote	2	229	0	Nevelsk	0	869	0
Dakar	2	132	0	Nouakchott	0	433	1
Mazatlan	2	1404	0	Onahama	0	355	0
Mokpo	2	1378	0	Palma De Mallorca	0	2404	0
Penglai	2	1761	1	Petersburg	0	741	0
Port Lincoln	2	3553	0	Petropavlovsk	0	373	0
Vacamonte	2	873	0	Port Hardy	0	1068	0
Adak	1	1032	0	Poti	0	4746	0
Algeciras	1	1873	0	Prince Rupert	0	839	0
Cartagena	1	2177	0	Puerto Chacabuco	0	1632	0
Chaguaramas	1	2095	0	Puerto Quemchi	0	1611	0
Chittagong	1	2688	1	Sakaiminato	0	915	0
Colombo	1	1115	1	Sao Tome	0	1959	1
Davao	1	2131	0	Seattle	0	1403	1
Eemshaven	1	3268	0	Sevastopol	0	3830	0
Ensenada	1	1975	1	Seward	0	113	0
General Santos	1	2210	1	Shanghai	0	1676	1
Hongkong	1	2404	1	Sitka	0	597	0
Honningsvag	1	4577	0	Skagen	0	3635	0
Jakarta	1	3244	0	Steveston	0	1299	0
Keelung	1	1762	0	Supsa	0	4283	0
Klang	1	2776	0	Tanger Med	0	1836	0
Male	1	878	0	Valdez	0	256	0
Malta	1	3098	1	Vladivostok	0	834	0
Murmansk	1	4845	0	Wewak Harbor	0	1029	0
Nouadhibou	1	567	1	Whittier Ak	0	207	0
Pulau Sambu	1	2941	0	Wrangell	0	741	0
St. Petersburg	1	4659	0	Zarubino	0	867	0
San Pedro	1	776	1	Zhuhai	0	2495	1
				Zonguldak	0	3661	0

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Availability of data and materials
Data for this research, along with the R code used for the final analysis are available via the GitHub link below.https://github.com/m-dylan-spencer/IUU-Fishing-2024-Crime-Science

Declarations

Competing interests
The authors declare that they have no competing interests.

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