



Assessing Guinea Bissau's Legal and Illegal Unreported and Unregulated Fisheries and the Surveillance Efforts to Tackle Them

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Fisheries in Guinea Bissau contribute greatly to the economy and food security of its people. Yet, as the ability of the country to monitor its fisheries is at most weak, and confronted with a heavy foreign fleet presence, the impact of industrial foreign fleets on fisheries catches is unaccounted for in the region. However, their footprint in terms of catch and value on the small-scale sector is heavily felt, through declining availability of fish. Fisheries in Guinea Bissau are operated by both legal (small-scale and industrial), and illegal (foreign unauthorized) fleets, whose catches are barely recorded. In this paper, we assess catches by both the legal and illegal sector, and the economic loss generated by illegal fisheries in the country, then attempt to evaluate the effectiveness of Monitoring Control and Surveillance (MCS) of Guinea Bissau's fisheries. Two main sectors were identified through official reports and a literature review, the large-scale (industrial) sector, which between 2011 and 2017 included exclusively catches by foreign owned and flagged vessels, and catches by the small-scale sector, which remain largely unmonitored in official statistics. We use the available data on the number of legal and illegal vessels and/or fishers, and their respective catch per unit of effort to estimate catches, and we analyze monitoring outcomes against the registered industrial and artisanal fleets. We find that of the legal industrial vessels, 20% were linked to criminal activities in the past 7 years. These activities range widely from using an illegal mesh size, to fishing in a prohibited area, to labor abuse. Overall, total small-scale and industrial catches were estimated at 370,000 t/year in 2017, of which less than 2% is ever reported to the FAO. Small-scale catches represented 8% of the total catch, and this contribution was found to be declining. Industrial fisheries generate over \$458 million US, or which \$75 million US is taken illegally, falling under the category trans-national fisheries crimes. The slight negative relationship between the number of monitoring days at sea illegal catches suggests increasing MCS efforts may play an important role in reducing illegal fishing in the country.

Keywords: illegal fishing, reconstruction data, industrial fishing, social economics, surveillance efforts

INTRODUCTION

The fisheries sector in Guinea-Bissau contributes to the livelihood of an important portion of the country's population with over 255,000 people employed by the small-scale fishing sector alone (Belhabib et al., 2015b). Guinea-Bissau's waters are considered one of the wealthiest biodiversity zones of West Africa, and is home to an estimated one million tons of fisheries resources, of which, optimistically, 350,000–500,000 tons can be extracted annually (Anon, 2009). This wealth is determined by an extensive shallow continental shelf; environmental variability, and estuarine coastline with numerous islands and rivers, and mangroves lining the coast (Belhabib and Pauly, 2015). This resource wealth is partly driven by coastal upwellings, river nutrient discharges, and the influence of the Canary Current large Marine Ecosystem (Aristegui et al., 2009; Belhabib et al., 2016b; CCLME Project, 2016).

According to official figures (Government of Guinea Bissau, unpub. data), the fishing sector is composed of two sub-sectors: artisanal and industrial fisheries. Small-scale fisheries play an important role in the livelihood of the majority of the Bissau-Guinean population, offering permanent and seasonal jobs, contributing to economic output with 6% of the Gross Domestic Product (Belhabib et al., 2015b), and providing 35% of the animal protein intake of Bissau Guineans (Government of Guinea Bissau, unpub. data). Artisanal fisheries in Guinea Bissau are prevalent in terms of vessels and employment with some 883 active pirogues and nearly 5,600 fishers, multispecies using a large variety of gears, and operated by the two main groups: Nhominkas and Pailão. They inherently use small pirogues whose length does not exceed 18 meters, and are either operated by sail or operate engines of less than 60 HP (Belhabib et al., 2015b, Government of Guinea Bissau, unpub. data). Little is known on their catch footprint in amount and value except for a comprehensive reconstruction conducted by Belhabib and Pauly (2015). Industrial vessels, vessels that operate engines of over 60 HP, are allowed in the area beyond 12 nautical miles from shore, the legislation delimiting the 12 nautical miles zone for small-scale fisheries. Their catches, mainly taken by distant water fishing fleets, remain unaccounted for, for the vast majority (Belhabib et al., 2015a; Doumbouya et al., 2017). In contrast to artisanal fisheries, industrial fisheries, through some 200 trawlers, purse-seiners, and longliners, offer only but a few job opportunities to Bissau Guinean fishers. Industrial fishing is primarily conducted by foreign fleets operating under agreements with other countries such as the European Union (sustainable) Fisheries Partnership Agreements. Some of these foreign vessels are chartered and fly the flag of Guinea Bissau (Iheduru, 1995; Kaczynski and Fluharty, 2002; Belhabib et al., 2015a). Belhabib and Pauly (2015) conducted an investigation of the beneficial ownership of 97 industrial vessels operating in Guinea Bissau in 2010, and found that 58% were of European origin, 20% were of Chinese origin, 14% were of Korean origin, 4% were of Japanese origin, and 4% of Russian origin.

A thorough literature search revealed the existence of other sectors, i.e., subsistence fishing, conducted mostly by women¹ (Garcia, 1992; Said, 2007; Anon, 2009; Belhabib and Pauly, 2015), and recreational fishing, popular among expatriates in Guinea-Bissau, and occurring in over 20 islands of the Bijago Archipelago (Anon, 2010). These sectors are mainly unregulated in Guinea Bissau (Belhabib et al., 2016a), however, coupled with the artisanal sector, they provide employment for over 226,000 people and their dependents in the country (Belhabib et al., 2015b). Subsistence and recreational fisheries are operated mainly by hand (gleaning for oysters), and from the beach using handlines, respectively. Recreational fisheries, operated by some 1,500 in 2010 (Belhabib and Pauly, 2015) target mainly barracudas (*Sphyraena barracuda*), Carangidae, and cobia (*Rachycentron canadum*) amongst other species, and are highly dependent upon the tourism sector (Belhabib et al., 2016a).

In the absence of a regular monitoring system for fisheries in Guinea Bissau, with the exception of sporadic and intermittent surveys conducted by the Department of Fisheries in 1998, 2001, and 2003 (Belhabib and Pauly, 2015), which included the number of pirogues and fishers, and estimates of the artisanal catch, the veil over unreported and unregulated fisheries footprint in terms of catches has yet to fall. Indeed, reporting takes the form of two processes. In the first one, the industrial sector is required to report all its catches (per individual vessel) to the Monitoring, Control, and Surveillance (MCS) agency through observers on-board. In the second, Guinea Bissau gathers all fisheries data (industrial, and small-scale) and report them to the Food and Agriculture Organization of the United Nations (Belhabib and Pauly, 2015; Pauly and Zeller, 2016). In addition, with a limited MCS system, which mainly operates with a few occasional patrols at sea and ranking the lowest in the sub-region of West Africa (Doumbouya et al., 2017), illegal fisheries in Guinea Bissau have been assessed to generate tremendous loss to the country in value assessed at 60,000 tons per year (Doumbouya et al., 2017). These fisheries compete directly with the small-scale sector by targeting similar species, and entering areas that are otherwise reserved to small-scale fishing operators. In addition, their impact on fish stocks—mainly fully to over exploited (CCLME Project, 2016) is barely known, jeopardizing the food security, livelihoods and income of around a quarter million people in a country that heavily depends on fish for its animal protein (Belhabib et al., 2015b). Hence, in the paper, we hypothesize that, given the lack of monitoring, a large part of the fisheries in Guinea Bissau is unaccounted for, and we attempt to answer the question: what is the impact of industrial and artisanal fisheries in Guinea Bissau in terms of catches and value, and how effective is the monitoring control and surveillance (MCS) system by analyzing both the under-reporting of catches, and the total lost value to IUU, and by looking into vessel arrest trends obtained from official data. We hence assess the footprint (in catch and value) of Illegal, Unreported, and Unregulated fisheries

¹Locally unregistered fishers, fishing primarily to meet the protein needs of the household. Catches may be marketed to acquire other food staples.

in Guinea Bissau by quantifying their catches both on the large-scale and small-scale levels, and assess the MCS efforts spent at tackling illegal fishing in the country, and provide a first insight into the MCS of Guinea Bissau through government shared data.

METHODS

Study Area

Guinea-Bissau (**Figure 1**) is a small country located on the West African coast between Senegal to the North and Guinea to the East and South and the Atlantic Ocean to the west. Its covers an area of 36 125 km² located between the Cape Roxo (12°20'N) and the Cajete (10° 59' N), where 22% are fluvial areas, with numerous islands along the coastline. The continental platform of Guinea-Bissau is one of the widest in West Africa and has an Exclusive Economic Zone (EEZ) of 106,000 km². Guinea-Bissau is also located within the CCLME considered one of the most productive ecosystems in the world and an important reservoir of marine biological diversity (Sherman and Hempel, 2008; Arístegui et al., 2009; Belhabib et al., 2016b). The CCLME is believed to be generating a landed value of \$10.6 billion US (Belhabib et al., 2016b). Of the 18 important coastal demersal stocks and pelagic resources (sardinellas *Sardinella* spp., horse mackerel *Trachurus trachurus*, chub mackerel *Scomber colias*, anchovy *Engraulis encrasicolus*, and bonga shad *Ethmalosa fimbriata*), 15 are fully or over-exploited (CCLME Project, 2016).

Assessing Large-Scale Legal and IUU Fisheries

Industrial Fisheries Catch Data

Industrial fisheries in Guinea Bissau are mainly operated by foreign vessels chartered or reflagged to Guinea Bissau, under

private or partnership agreements. None of the industrial vessels operating in Guinea Bissau are considered domestic (Gomes Barbosa, 2009). Their catches are generally landed elsewhere, notably in the Canary Islands (Spain) and Senegal (Anon, 2009) and are mainly not reported to Guinea Bissau (COPACE, 1981; Anon, 2010), nor anywhere else, despite the presence of observers on board some of the vessels (Anon, 2009). Belhabib and Pauly analysis of catches per origin of the fleet reveals over 33 groups of species targeted and caught by the industrial sector, clearly overlapping with small-scale targeted species, such as sardinellas, Scianids, Penaeus shrimps, and cephalopods, amongst others.

Industrial fisheries in Guinea Bissau are often straddling between the illegal, unreported and unregulated components of fisheries, as even legally operating vessels commit fisheries violations in the country. Most commonly from foreign origin, they can be illegal in the absence of a valid fishing authorization, or unreported and unregulated as most of their catches are unaccounted for. We consider legal, all vessels that have an authorization to fish within Bissau Guinean waters (presented in summary by flag in **Table 1**), and illegal all those that are otherwise. Not all the vessels that operate without authorization are caught or observed, and the analysis of the effectiveness of monitoring herein relies in part on those that were caught, and the illegal catch (footprint) of the entire fleet that operates illegally (caught or not). Herein, we estimate legal catches as all catches by industrial licensed vessels, and illegal catches as those taken by industrial vessels that did not hold authorizations to fish in Guinea Bissau, and count the number of infractions in the country. To reconstruct industrial legal fisheries catch data, we used data from Belhabib and Pauly (2015), along with effort data extracted from the General Direction of Industrial Fishing (DGPI) (2015). We then calculate catches as the product

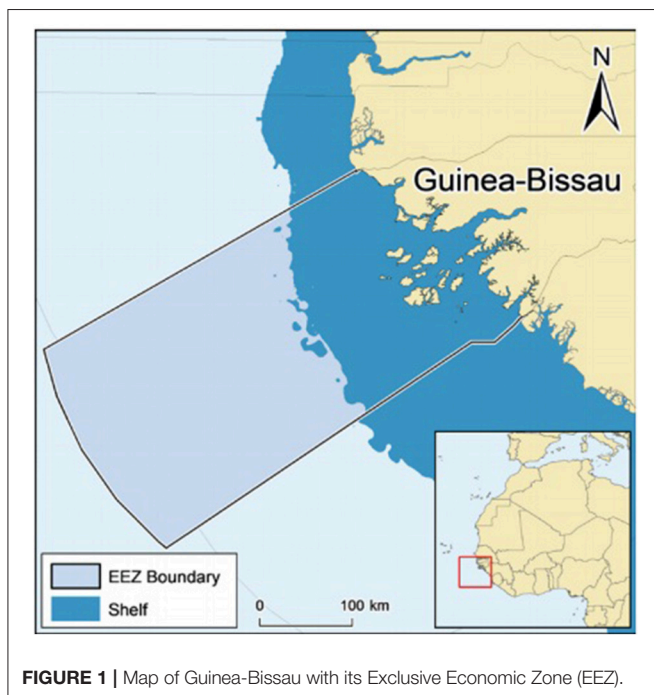


TABLE 1 | Fleet operating in Guinea Bissau by flag in 2017 and their respective offense history since 2010.

Flag country	Fishing vessels authorized	Authorized vessels that have an IUU record
Belize	1	0
Cape Verde	4	0
China	82	24
Comoros	4	3
Curacao	4	2
El Salvador	2	0
Spain	41	1
France	10	1
Gambia	3	0
Greece	2	0
Guatemala	2	0
Guinea	1	0
Italy	1	0
Panama	2	0
Portugal	1	0
Senegal	19	1
South Korea	2	2

of the fishing effort and the catch per fishing effort. The fishing effort was defined as the number of vessels for demersal and shrimp trawlers and tuna vessels, per flag, given the convergence of the CPUE around an average of 1,200 t/boat/year, and 414 t/boat/year, respectively (Belhabib et al., 2014; Pauly et al., 2014), and as the capacity of fishing vessels in haul size (gross Registered Tonnage) and fishing days for larger pelagic trawlers (Belhabib and Pauly, 2015). Effort data on EU vessels under the Guinea Bissau/EU fishing agreement for 2011, 2013, 2014, and 2015, were obtained from www.whofishesfar.org (Accessed on 25/07/2016), combined with national data obtained from the department of fisheries (Government of Guinea Bissau, unpub. data) by flag (Table 2). We extracted CPUE information from various regional studies, assuming the same vessel profile would have a similar catch per unit of effort (Belhabib et al., 2014, 2016b; Pauly et al., 2014). We assumed the CPUE for Eastern European and Russian pelagic trawlers was 14.8 kg/grt/day, and 150 fishing days per year (Belhabib et al., 2014, 2016b). We assumed a CPUE of 1,200t/boat/year for demersal and shrimp trawlers and 414t/boat/year for tuna vessels (Belhabib et al., 2012; Pauly et al., 2014; Belhabib and Pauly, 2015). We then multiplied the CPUE by the number of vessels by gear type between 2011 and 2015. We then compare the resulting data to the data on reported industrial catches provided by the Government of Guinea Bissau (unpub. data).

Monitoring Control and Surveillance of Industrial Fisheries

In this section, we assess catches by illegal industrial vessels, i.e., those that are not registered or licensed to fish in Guinea Bissau's waters. MCS in Guinea Bissau is mainly performed by armed patrols of the navy and coast guards at sea, but also targeted operations through the use of Vessel Monitoring Systems, and radars. In some instances, external support is acquired from the Sub-Regional Fisheries Commission where patrol vessels² are made available to the country, and also Non-Governmental Organization efforts such as Greenpeace³ with presence of national authorities on board. Government data (Government of Guinea Bissau, unpub. data) on monitoring operations show 22

surveillance operations in 2013, 5 surveillance operations in 2014, 21 surveillance operations in 2015, 33 surveillance operations in 2016, and 19 surveillance operations as per August 2017 (Table 2). Whenever possible apprehended vessels are boarded by the navy, and investigated. Those that do not cooperate fall under the “refusal of cooperation” violation and are hence issued a fine. Only observed vessels can be interdicted. There are only a few instances where vessels were detected as committing an infraction through Vessel Monitoring System (e.g., entering a prohibited area) and are interdicted or sanctioned accordingly. As of 2017, 203 fishing vessels were granted licenses to fish within the Bissau Guinean EEZ⁴. Of these, 34⁵ had a history in fishing crimes and related IUU activities in the world, i.e., there is 20% chance that the vessels operating in Guinea Bissau under a legitimate license, will commit an offense under the country's legislation (Table 1).

To estimate illegal catches, we extrapolated the trend of the two last years of data presented by Doumbouya et al. (2017) forward to reflect upon the improvement of the monitoring system in terms of days at sea. This method follows the rationale that the variation in monitoring will be proportional to the monitoring outcome (Belhabib et al., 2014), subject to external factors such as the capacity of the patrol vessels to reach fishing grounds on industrial vessels. We then analyzed the data on observed vessels, inspected vessels, and arrested vessels provided by the Department of Surveillance of Guinea Bissau for the years 2013 to 2017 (as of September), to detect any patterns in illegal fishing, i.e., variation over time.

Assessing Small-Scale Legal and IUU Fisheries

Artisanal Fisheries Catch Data

In contrast to its neighbors, notably Senegal, Guinea Bissau does not have a long-standing fishing tradition (Campredon and Cuq, 2001), and while in the past, Nhominkas were commonly used, artisanal fishing by locals started only in the mid-1970s (Tvedten, 1990; Chavance, 2004). Thus, here the artisanal sector is divided into two categories, distinguished by the craft used, Senegalese Nhominka pirogues and local dug-out canoes, or pailão, which

²<http://www.spcsrp.org/en/warfp-guinea-bissau>

³<http://www.greenpeace.org/africa/en/Press-Centre-Hub/13-infractions-found-in-twenty-days/>

⁴Data obtained from the government of Guinea Bissau.

⁵Data compiled independently from various sources: unpublished (Doumbouya et al., 2017), and the Criminal Record of Fishing vessels © 2018 Dyhia Belhabib.

TABLE 2 | Total licensed industrial fleet, and total monitored and arrested vessels, 2011–2017.

Year	Number of authorized vessels	Number of operations	Observed	Inspected	Arrested	Days at sea	Illegal catch*
2011	241						26,708
2012	200						37,145
2013	134	22	40	40	7	33	48,812
2014	249	5	75	75	8	23	62,294
2015	365	21	153	138	8	66	62,087
2016	181	33	85	294	13	85	61,880
2017	203	19	72	326	31	72	61,673
Average/operation					0.85	3.12	

Source of vessel, and monitoring information: Government of Guinea Bissau (unpub. data), and www.whofishesfar.org. *Estimated by Doumbouya et al. (2017) for 2011–2015.

have a capacity that is a third of that of the Senegalese *nhominka* pirogue (Tvedten, 1990). There is an area reserved for artisanal and other small-scale sectors that is comprised between shore and 12 nautical miles off-shore, however, it is not restricted in nature, meaning that artisanal pirogues can legally venture beyond this point.

There are limited reported data for the artisanal fishing sector in Guinea-Bissau. Most of the data compiled relate to foreign fishers, or communities of foreign fishers, called “*Nhominkas*” (Belhabib and Pauly, 2015). Fishing by local artisanal fishers is conducted on a seasonal basis, as they cease their fishing activity during the agricultural and rainy season (Tvedten, 1990), and targets mainly bonga shad (*E. fimbriata*), meager (*Argyrosomus regius*) and shrimps (Belhabib and Pauly, 2015). Artisanal catches are calculated as the product of the fishing effort, i.e., number of vessels for each category, and the catch per boat per year. Belhabib and Pauly (2015) estimated artisanal catches for these two categories between 1950 and 2010 increasing from 7,100 tons in 1950 (all *Nhominka*) to 32,000 tons in 2000, declining to nearly 15,000 tons in 2010 with equal contribution from *Nhominka* and *pailão* fishers. We, hence, update catch estimates from Belhabib and Pauly (2015) by using effort data obtained from the Direction of artisanal fishing, between the years of 2010 and 2015, and the CPUE estimated by Belhabib and Pauly (2015). We assumed this CPUE was constant between 2010 and 2015 (8.67 t/boat/year for non-*Nhominkas*, and 30 t/boat/year for *Nhominkas*), as the total artisanal fishing effort declined, in addition to the lack of indication (anecdotal or not) that the CPUE has declined during 2010–2015 time period. We multiplied the number of boats by the CPUE and interpolated between anchor points to fill in the missing gaps (Table 3).

Monitoring Control and Surveillance of Artisanal Fisheries

As of 2015, over 880 pirogues were authorized to fish within the artisanal sector⁶ (Table 4). We analyze the surveillance results data provided by the government of Guinea Bissau and assess observed vs. inspected vs. arrested pirogues against the total number of pirogues authorized to fish in the country.

TABLE 3 | Artisanal fishing effort in Guinea Bissau, 2010–2015.

Year	<i>Nhominkas</i> pirogues	<i>Pailão</i> pirogues	Source
2010	215	1280	Belhabib and Pauly, 2015
2011	282	874	Interpolated
2012	348	467	Government of Guinea Bissau, unpub. data
2013	587	875	Government of Guinea Bissau, unpub. data
2014	354	601	Government of Guinea Bissau, unpub. data
2015	312	571	Government of Guinea Bissau, unpub. data

⁶Data obtained from the government of Guinea Bissau

Unregulated Subsistence and Recreational Catches

Some authors report that most of the coastal population practice subsistence fishing (Said, 2007), others allude to thousands of women and subsistence fishers operating in Guinea Bissau (Garcia, 1992) and providing more animal protein than any other sectors for local consumption (Anon, 1994). This is compatible with the observation that almost all the animal protein consumed in Guinea Bissau comes from fish (Anon, 2009). To estimate subsistence catches in Guinea-Bissau (Table 5), we multiplied the population recorded by the World Bank in 2011 to 2015 (www.worldbank.org; Accessed 25/07/2016) by the amount of fish that comes from subsistence fishing per capita, i.e., the consumption derived from Belhabib and Pauly (2015). According to Dia and Bedingar (2001) the rate of consumption of fish in Guinea-Bissau is 26 kg/person/year, but taking into account the industrial fishing, artisanal fishing imports and exports, the value of consumption derived corresponds to 11 kg/person/year (Belhabib and Pauly, 2015), which we assume remained constant. Catches for 2016 and 2017 were projected based on the trend from 2011 to 2015. The 2011–2015 catch trend was then extrapolated to estimate subsistence catches for 2016 and 2017. We chose 2011 as a baseline year, which captures the visible change in the trajectory of subsistence catches.

Estimating Unregulated Recreational Fisheries

Sport fishing is apparently a notable segment of tourism in the Bijagos archipelago (Anon, 2010), but little information is available on the number of visitors to the archipelago, or the number of tourists using the services of fishing ‘safaris’ (Belhabib

TABLE 4 | Total artisanal fleet, and total monitored and arrested pirogues, 2010–2017.

Year	Observed	Inspected	Arrested	Days at sea	<i>Nhominkas</i>	<i>Pailão</i>
2010					215	1280
2011					282	874
2012					348	467
2013	0	197	89	33	587	875
2014	0	28	1	23	354	601
2015	17	88	54	66	312	571
2016	0	250	49	85		
2017	0	29	36	72		

Source of vessel, and monitoring information: Government of Guinea Bissau (unpub. data).

TABLE 5 | Data from subsistence has been interpolated between 2010 and 2015.

Year	Population	Total subsistence catch (t)
2010		16,700
2011	1,673,509	18,408
2012	1,714,620	18,861
2013	1,757,138	19,329
2014	1,800,513	19,806
2015	1,844,325	20,288

et al., 2016a). For 2012, the camps established for tourists in Guinea Bissau were visited by 1,200 persons, of which only 50% went fishing. There also were between 150 and 350 fishers (250 on average) for each of 4 other camps, and 500 visitors per year to a near-shore hotel, of which only a minority (20%) went fishing (Pierre Campredon, IUCN Guinea Bissau, pers. comm.). Therefore, the overall number of recreational fishers for 2012 was estimated as the sum of fishers for each camp and/or hotel, i.e., 1,500 fishers. Recreational catches were estimated as the product of the number of recreational fishers and the catch per unit of effort – expressed in number of fishers and number of days—extracted from Belhabib et al. (2016a). Using the 2007 anchor point (1,440 fishers) in Belhabib and Pauly (2015), we interpolated the trend between 2007 and 2012 to complete the estimate for 2011. We then calculated the number of fishers for 2013, 2014, and 2015 by multiplying the total number of visitors to Guinea Bissau (obtained from the World Bank database) by 4%, which corresponds to the number of visitors who practice fishing in Guinea Bissau (Belhabib and Pauly, 2015). We then multiplied the total number of fishers by a CPUE of 18 kg/tourist/day (Belhabib et al., 2016a). The 2012–2015 catch trend was then extrapolated to estimate recreational catches for 2016 and 2017. We chose 2012 as a baseline year, which captures the visible change in the trajectory of recreational catches.

Total catches were estimated as the sum of all catches (industrial, artisanal, recreational, and subsistence) then compared to the reported catch, i.e., the catch submitted by the Government of Guinea Bissau to the Food and Agriculture Organization of the United Nations (FAO) for all domestic catches, and those reported to the government of Guinea Bissau for all industrial foreign catches, as the law requires all vessels registered or licensed to fish in Guinea Bissau to report their catches to the Government of Guinea Bissau, regardless of their flag. We present below large-scale legal and IUU fisheries catches, and small-scale legal and IUU fisheries catches, which in turn includes artisanal, recreational and subsistence fisheries catch assessment. We then calculate the economic loss from IUU foreign fisheries in Guinea Bissau by multiplying the average annual ex-vessel price of fish by the total IUU industrial foreign catch in the country per year for 2017, as used in various other studies (Belhabib et al., 2014; Doumbouya et al., 2017). This estimate does not include catches by small-scale fisheries sectors, which are in theory captured by the local economy, knowing that small-scale catches are mainly kept for domestic use.

RESULTS

Large-Scale Legal and IUU Fisheries Catches of Large-Scale Legal and IUU Fisheries

Overall industrial by the legal fleet catches in the waters of Guinea Bissau were estimated at 252,352 tons in 2011, increased to a peak of 487,456 tons in 2015 before decreasing to an estimated 280,620 tons in 2017 (Figure 2). These catches are taken by vessels which illustrate the same variation in number than the total catch. Overall, the number of unique vessels licensed to operate in Guinea Bissau has varied between 134 and 365 (maximum observed for 2015). Catches by the legal fleet are dominated by

Chinese (20%) and Russian (30%) fleets, followed by EU fleets, notably Spain, France, Italy, Greece, and Portugal with 15% of the total catch between 2011 and 2017 (Figure 2).

The industrial fleet operating in Guinea Bissau reports around 41% of its catches to the government of Guinea Bissau (Figure 3). Reporting levels vary during the period 2011–2017 (Figure 3), putting most of the industrial catch in the unreported category.

Monitoring Control and Surveillance Results for Industrial Fisheries and Illegal Catches

Total illegal catches increased from 26,708 t/year in 2010 to around 62,100 t/year in 2015, after which they plateaued at around 62,000 t/year in 2016 and 2017 with a slight decline (Figure 4). Overall, illegal industrial catches, i.e., catches taken by unauthorized vessels from the waters of Guinea Bissau, constituted the equivalent of 22% of the legal industrial catch in 2017.

The number of days of surveillance at sea has overall increased from 33 days in 2013 to 72 days in 2017 [We note that information for 2017 covers only the period January to September]. The number of surveillance operations, which depend on the availability of patrol boats, has varied with a minimum in 2014 (Table 2). The number of patrol days at sea per operation remained low at 3.12 days on average per year, however, the effectiveness measured as the number of arrested vessels per day at sea has improved from 0.21 in 2013 to 0.43 vessels in 2017. On average, each operation yields 1 arrested vessel (Table 2). The number of arrested vessels follows the same pattern than the number of inspected vessels with an increase by 7-fold and 3-fold, respectively (Figure 4). The number of days at sea follows the reverse pattern than the estimated illegal catches, the latter decline when the number of days at sea increases (Figure 4). We note that while patterns are revealed, conclusions could not be drawn as a longer MCS time series is needed to perform an adequate statistical significance analysis of the results.

Small-Scale Legal and IUU Fisheries Catches of Artisanal Fisheries

Artisanal fisheries catches declined since 2010 from 15,272 t/year in 2010 to less than 14,311 t/year in 2015, and projected to decline further to reach less than 6,500 tons by the end of 2017 (Figure 5). Virtually, none of these catches are monitored, or reported to the FAO.

Monitoring Control and Surveillance of Artisanal Fisheries

MCS campaigns also encompass the artisanal sector. Overall between 2013 and 2017 (September), around 840 pirogues were observed at sea, 820 were inspected, which resulted in 230 arrests over the same time period (Figure 6). The lowest number of operations, and days was performed in 2014, which explains the low number of arrested pirogues. On average, and with the exception of exceptionally high numbers in 2013, each day spent monitoring at sea, 1 pirogue gets arrested. Inspection activities result in the arrest of 1 in every 3 pirogues on average (Table 4), which is an indication that monitoring of coastal waters is

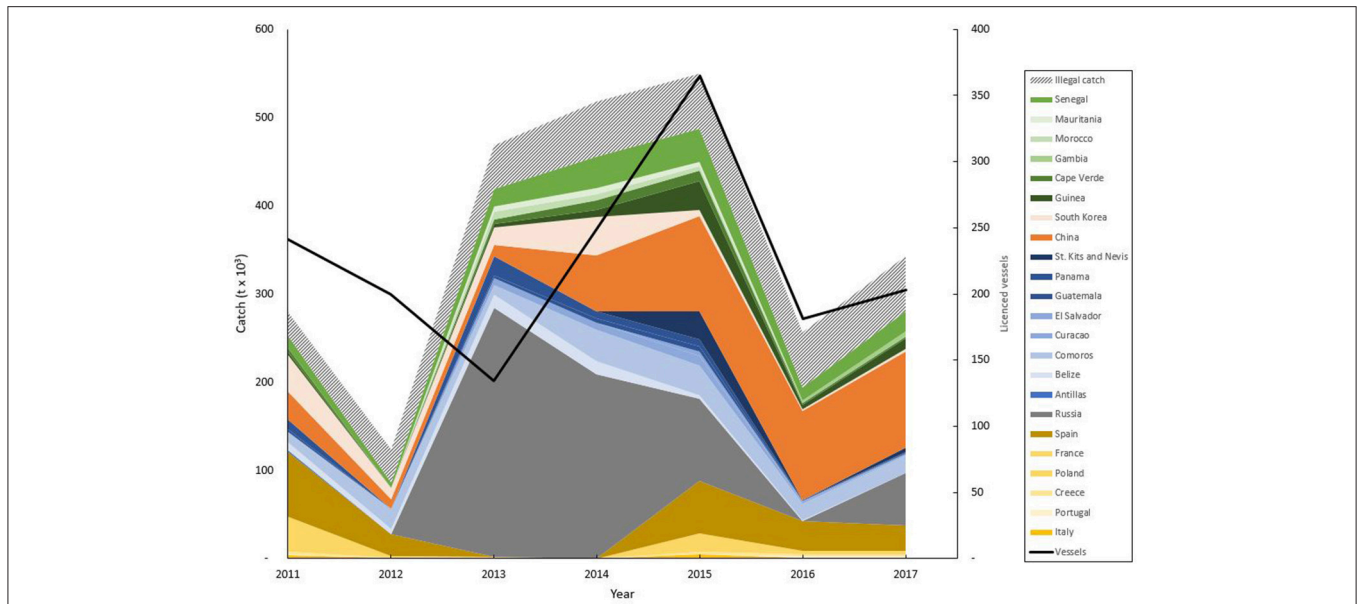


FIGURE 2 | Industrial legal and illegal catches from the waters of Guinea Bissau, 2011–2017.

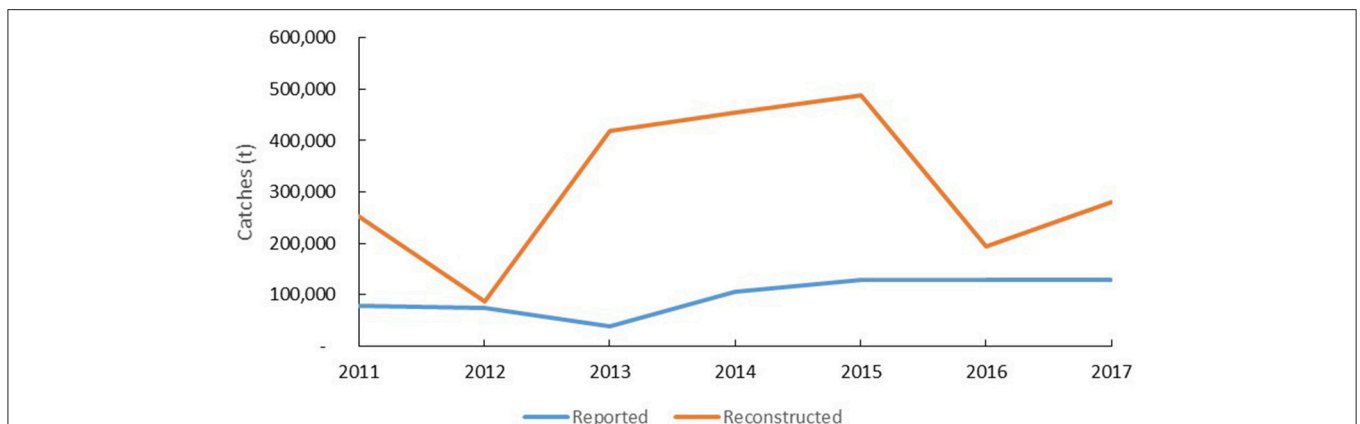


FIGURE 3 | Industrial legal catches of Guinea Bissau as compared to officially reported data to the government of Guinea Bissau, 2011–2017.

more effective than monitoring of industrial fisheries in Guinea Bissau.

Overall, over the total number of pirogues licensed to fish in the waters of Guinea Bissau, around 4% on average is ever arrested for infringing upon local regulations (Figure 7).

Unregulated Subsistence and Recreational Fisheries Catches

Reconstructed subsistence catches for Guinea Bissau illustrate a continued increase from 16,700 t/year in 2010 to 21,236 t/year in 2017 (Figure 8). Reconstructed recreational catches were estimated at 200 tons in 2010 increasing to 146 tons in 2017 (Figure 8). None of the recreational and subsistence catches are ever reported officially.

Total Small-Scale Fisheries Catches

Total small-scale catches, comprising artisanal, subsistence, and recreational fisheries, increased from 32,170 t/year in 2010 to a peak of around 44,700 t/year in 2013, driven by a peak in small-scale commercial (artisanal) fisheries catches, which constituted 56% of the total small-scale catch, then. Small-scale catches declined thereafter to around 27,800 t/year in 2017.

Total Reconstructed Catches vs. Reported Catches

Total catches from the waters of Guinea Bissau were estimated at 313,600 tons in 2011, increased to over 584,000 tons in 2015 and then declined to 370,000 tons in 2017 (Figure 9). Officially, only 6,700 tons are ever reported to the FAO (extracted from the FishStat database). Small-scale catches

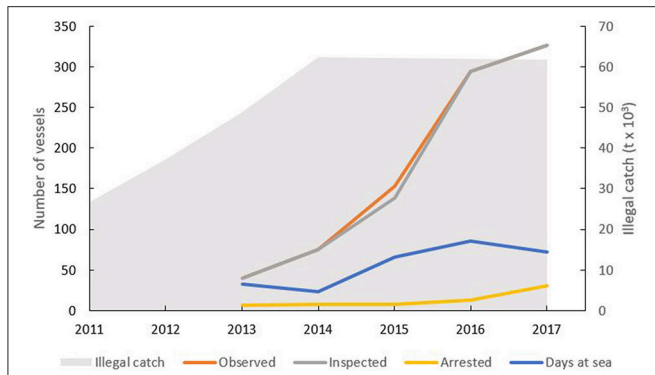


FIGURE 4 | Monitoring, Control and surveillance of industrial fisheries, results from Guinea Bissau, and the illegal catch within the EEZ of Guinea Bissau, 2013–2017.

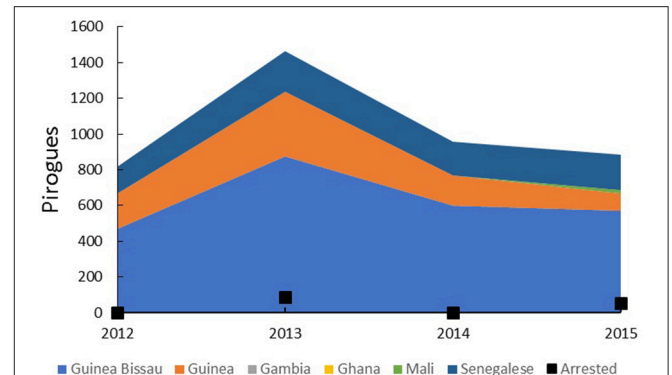


FIGURE 7 | Authorized vs. arrested pirogues in Guinea Bissau, 2012–2015.

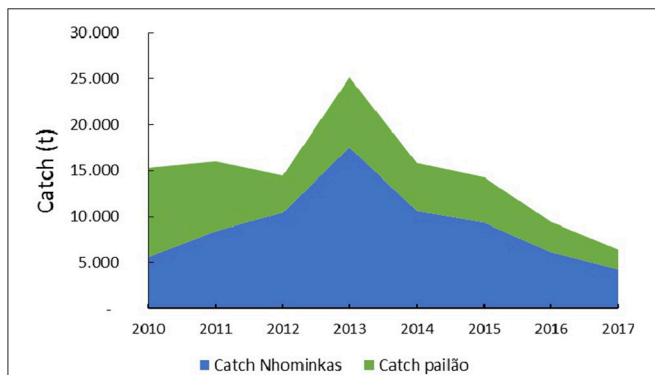


FIGURE 5 | Reconstructed artisanal catches in Guinea-Bissau, 2010–2015.

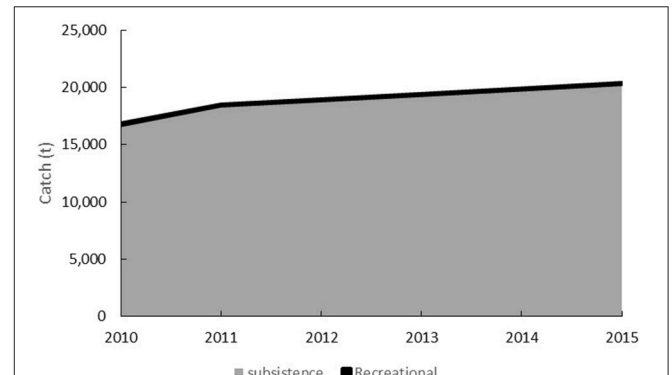


FIGURE 8 | Reconstructed subsistence catches in Guinea Bissau, 2010–2015.

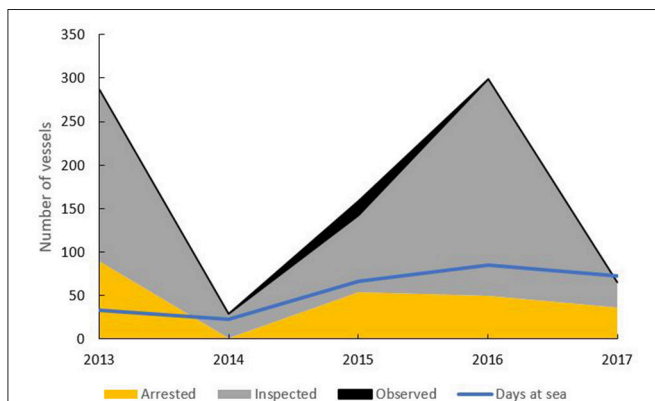


FIGURE 6 | Monitoring, Control and surveillance of artisanal fisheries, results from Guinea Bissau, 2013–2017. MCS data were not available between 2010 and 2012.

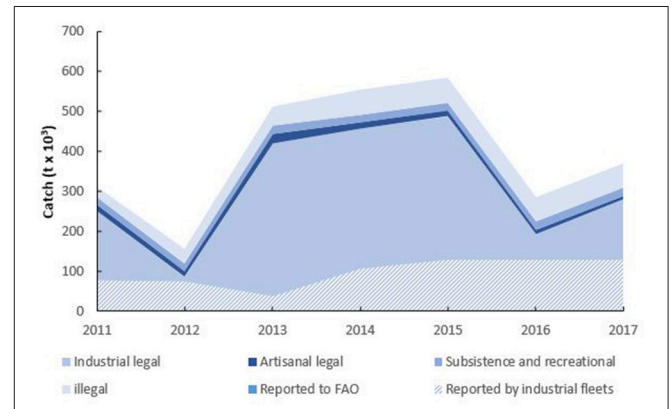


FIGURE 9 | Total illegal unreported and unregulated fisheries catches from Guinea Bissau. Catch data reported to FAO are of the order of 6,700 tons per year and cannot be displayed in the chart. Artisanal catches for 2016 and 2017 were estimated by extrapolating the trend for 2013–2015, subsistence catches for 2016 and 2017 were estimated by extrapolating the trend from 2011 onwards. Reported landings for 2016 and 2017 were assumed constant since 2015.

(artisanal, subsistence, and recreational) represented less than 8% of the total catch in 2017, compared to 21% (their peak contribution) in 2012, whereas industrial legal catch contribution to the total catch remained overall constant during the 2011–2017 time period at 80% of the total catch. Only 40% of

the foreign industrial catch is ever reported to Guinea Bissau by the fleets operating therein to the government of Guinea Bissau. Overall, 17% of the total catch (on average) is taken

illegally by foreign fleets operating in the country's waters (Figure 9).

Economic Loses and Fisheries Flow From Illegal Unreported and Unregulated Fisheries

Overall, if all fisheries of Guinea Bissau were accounted for and their landed value was captured by the country, fisheries could generate \$458.2 million US in 2017 alone. This value, calculated using the average ex-vessel price (extracted from the Sea Around Us database www.seaaroundus.org) includes \$341.2 million US in landed value generated by the foreign fleets operating in Guinea Bissau, of which only 15%⁷ (\$49.5 million US) is paid to the country in the form of fishing fees and through access agreements. The remaining is captured by foreign beneficiaries. Another \$75 million US is taken by fleets fishing illegally in the country, constituting a total loss for the country. Small-scale fisheries generate around \$33.8 million, part of which is captured by the formal economy, and the remaining by the informal economy. Overall, industrial fisheries in Guinea Bissau take a value of \$416.2 million US in landed value, of which \$260.7 million US is illegal and unreported, and only 31% of the remaining is captured by the local economy through fishing fees and fishing agreements.

DISCUSSION

The fisheries of Guinea Bissau are subject to extensive illegal, unreported and unregulated fishing operations. Herein, we answer the questions raised above by illustrating the impact of industrial and small-scale fisheries in Guinea Bissau in terms of catches (and value of IUU industrial fisheries), and analyzing the effectiveness, which is rather poor, of the monitoring system. We find that the total catch taken from the EEZ reached 370,000 t/year in 2017 of which only 2% is ever reported to the FAO. Despite their high socio-economic importance (Belhabib et al., 2015b), small-scale fisheries contributed a meager 8%, far outweighed by industrial legal, and illegal fisheries. We also find that while virtually no small-scale catch data are reported to the FAO, industrial fishing fleets fail to report around 60% of their catch to the Government of Guinea Bissau, which denotes of a major weakness in the monitoring system. In addition, we estimated the potential total value of fisheries in the country at \$429.2 million US annually, of which over \$239.8 is lost to industrial foreign fleets in the form of IUU fisheries that is 56% of all fisheries in the country are IUU. Under-reporting and the lack of monitoring of small-scale fishing sectors can be of major concern, given their coastal operational range which often overlaps with key sensitive areas, but also contributes to shadowing their economic impact on coastal communities (Pauly and Zeller, 2016). In addition, the widespread nature of landing sites in the country and their inaccessibility prevents monitoring measures from detecting the use of illegal gear (e.g., explosives). These trends can be attributed to an underdeveloped

data collection system in Guinea-Bissau, and an overall lack of capacity to monitor the waters of the country. This in turn reveals dangerous when establishing management plans that prioritize industrial fisheries, given that the economic impact of small-scale fisheries goes undetected (Belhabib et al., 2015b). This study reveals a clear inconsistency in the level of monitoring of artisanal and industrial fisheries over time, with a historical minimum in 2014, and a peak in 2016 in the number of operations and fishing days. These variations may be explained by the availability of patrol days at sea. In addition, the lack of information sharing regionally, has resulted in increasing the risk of illegal fishing, as over 205 of the industrial vessels authorized to operate in the country have a criminal or an IUU record associated with them (criminal history obtained from the Criminal Record of Fishing Vessels © 2018 Dyhia Belhabib). Therefore, despite increasing MCS campaign operations in 2016, the risk of exposure to illegal fishing is increased by the lack of information sharing between the countries of the sub-region (Doubouya et al., 2017). Under-reporting of fisheries catches is facilitated by the fact that foreign fishing fleets land most of their catches in foreign ports, while artisanal fisheries catches are virtually unmonitored due to the lack of capacity. Under national laws and regulations, all fishing vessels have to carry an observer aboard to collect quantitative information, including catch data within the EEZ of Guinea Bissau. The data collected by the observer are then compiled by the Department of Fisheries, and sent to the Department of Statistics (J.F.I., pers. obs.). During this process, there are several steps, which may decrease the reliability of the data, including: little collaboration between the administrative entity and observers, which decreases accuracy during the process of data collection, little training of observers or unqualified observers, and a conflict of interest between the boat captains (who hire the observers) and the department of fisheries (J.F.I., pers. obs.).

Overall, the discrepancy between estimated IUU catches and reported catches suggests there is room for improvement in the current statistical system of the country, but also with regards to license granting to vessels associated with criminal activities in the past.

Analysis surveillance campaigns for Guinea Bissau from 2013 to 2017, illustrates some key patterns denoting of successes and failures of MCS activities. Despite the lack of data, comparing the results of the surveillance campaigns with the trends in illegal catches shows a negative relationships⁸ between the number of days at sea of MCS and the total illegal industrial catch, which in turn has resulted in a higher number of inspected and arrested vessels. The number of inspected vessels and the number of arrests follow the same pattern, which denotes of a potential increased efficiency by increasing the number of inspections at sea. In addition, the amount of illegal catch follows the opposite pattern than the amount of days spent at sea in MCS activities. This shows that given higher financial and human resources, increased MCS presence at sea, along with increased sanctions, may result in a drastic decline in IUU activities in the country, a

⁷Value calculated from Belhabib et al. (2015a) as the average percentage between EU and China.

⁸to be confirmed with more comprehensive and longer time series data.

pattern that mirrors the findings by other studies (Sumaila et al., 2006; Doumbouya et al., 2017).

There is a level of uncertainty that is associated with the lack of alternative data sources, and the assessment herein. This uncertainty may be linked to the use of an average constant CPUE for the whole time period, that is associated to every sector. However, the issue that poses itself here, is that of bias and not of accuracy, given the unique alternative is the data provided by the government of Guinea Bissau under-reports a major part of the catch, masking trends and impacts of the fishing sector in the country. Avenues for improvement include the creation of a system that accounts for artisanal catches, and the enforcement of the legislation that requires observers on board industrial fishing vessels. The use of Automatic Identification System and human intelligence in tracking the movements and operations of industrial fishing vessels (legal and illegal), can prove efficient in obtaining a clearer picture of the amount of fishing effort exercised by industrial fleets.

Given the importance of fisheries for Bissau Guineans, providing over 255,000 jobs to local people (Belhabib et al., 2015b), and contributing 6% of the national GDP (Belhabib et al., 2015b), there is an overall sense of urgency to tackle the impacts of illegal, unreported and unregulated industrial fisheries in the country, by increasing sanctions, reducing the risk of illegal

fishing by denying licenses to vessels associated with criminal activities in the past, and regional information sharing.

AUTHOR CONTRIBUTIONS

Jl and DB collected and analyzed the data, Jl, DB, and RT wrote the manuscript.

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- Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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