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# Beyond the unseen: a first collaborative model towards estimating illegal, unreported, and unregulated catches off Senegal

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## ABSTRACT

The marine waters of Senegal are very productive, and thus fisheries have become importance to the economy and food security of local populations in Senegal. Also, Senegalese fisheries resources are exploited by a number of Distant-Water Fleets, both legal (mostly reflagged to Senegal) and illegal. Illegal, Unreported and Unregulated (IUU) fisheries in Senegal, however, have never been formally estimated, nor examined from a historical perspective. Herein, IUU catches along the Senegalese coast between 1999 and 2011 were estimated for the first time at 2.6 million t. Legal catches by the industrial fleets reflagged to Senegal accounted for 1.7 million t between 1999 and 2011, three times the landings reported in the official reports of the Senegalese ‘Département des Pêches Maritimes’, and are presently stagnating. Illegal fisheries, on the other hand, which totalled an estimated catch of 714,000 t from 1996 to 2011, are steadily increasing. This increasing trend, besides implying a huge loss of potential revenue, threatens the food security of local populations in West Africa, many of them heavily relying on Senegalese seafood as a primary source of animal protein.

## INTRODUCTION

Senegal is located in Northwest Africa (Figure 1), and borders Mauritania from the North, Guinea



**Figure 1.** Map of Senegal showing the Exclusive Economic Zone and some coastal lagoons

Bissau and The Gambia from the South, and the islands of Cape Verde from the west. Senegal has one of the most important artisanal fleets of West Africa, with around 20,000 *pirogues*. Similarly, this country's Exclusive Economic Zone (EEZ) is one of the most exploited in West Africa in terms of industrial fishing, both by foreign fleets, and fleets reflagged to Senegal. Senegalese fisheries generate over 280 million \$US annually, and provide jobs for one out of six Senegalese (Greenpeace 2012). Indeed, the large EEZ (159,000 km<sup>2</sup>), including highly productive waters enriched by a seasonally strong upwelling, and an ever-increasing international demand for seafood have attracted the Distant-Water of several countries, operating under different kinds of access agreements, or simply operating without authorization from Senegalese authorities, i.e., illegally. Not surprisingly, when such operations are coupled with a poor monitoring capacity by the host country, including an inability to regulate quotas (Pramod and Pitcher 2006), it is difficult to assess the impact of these fleets on local stocks and economy. However, there are hints which help understand the dynamics and the extent of this impact. In 50 years, the number of legal industrial vessels grew by a factor of 22 from 1960 to the late 1990s, then decreased to a third in less than 10 years (Bonfil *et al.* 1998; DPM 2011), while still remaining very high. More recently, after 1996, observers were no longer admitted onboard Senegalese flagged vessels (Pramod and Pitcher 2006), which has most likely encouraged reflagging practices, and the 'senegalization' of fishing access agreements, under which observers were mandatory, to joint venture reflagging (Niasse and Seck 2011). Lack of observers generally produces unreliable catch data, especially when these vessels often land their catches in countries others than the ones in which they fish (Pramod and Pitcher 2006). Evidence of illegal practices by these vessels (UNEP 2004) supports the suggestion that relying only on a catch inspection scheme is not very effective. Indeed, some authors concluded that even with observers onboard, the Senegalese authorities struggled to ensure effective control of legal foreign fleets, including those from EU countries (Kaczynski and Fluharty 2002; Witbooi 2008).

While the legal foreign fishery has declined in the last 20 years (i.e., Russian vessels were asked to leave and EU-Senegal agreements cancelled), continued over-exploitation of the Senegalese fishery resources, all the way to the commercial extinction of some species (Pramod and Pitcher 2006) suggests high, and increasing unrecorded catches by foreign vessels. Numerous accounts by fishers and official reports document illegal vessels of different origins (Vidal 2012). Illegal fishing and unregulated fishing by legal industrial reflagged fleets are known to compete with the artisanal fisheries (Vidal 2012), and thus create conflicts with the local population.

Thus, the problem is that, in one hand, Senegal is reflagging foreign vessels called 'charters', which have a majority Senegalese ownership that is often nominal (Niasse and Seck 2011), while, on the other hand, Senegal owns a huge domestic artisanal fleet, which ought to be reduced because of overcapacity (Ferraro and Brans 2009). Frequent incursion by industrial fishing vessels into designated artisanal fishing zones and a large number of artisanal *pirogues* fishing beyond the limits of these legally established zones (Deme and Dioh 1994; Diallo 1995; Binet *et al.* 2012) (Pramod and Pitcher 2006; Greenpeace 2012), suggest the latter remain aspirational, which causes widespread conflicts. Moreover, Senegal is in the unique situation that neighbouring countries are heavily dependent on seafood supplied by the Senegalese

artisanal fleet, while Senegalese fishers are increasingly dependent on the resources in these neighboring countries for their catches (Niasse and Seck 2011).

Under these conditions, and given the possible impacts of illegal and unregulated activities in Senegalese waters, it is justified to estimate Senegalese illegal and unreported catches, instead of simply assuming them to be low (MRAG 2005; Pramod and Pitcher 2006).

## METHODS

In the present work, we attempt to quantify the catch (including discards) of illegal fishing (i.e., by unauthorized foreign vessels), and unregulated and unreported fishing by domestic industrial fleets suspected of regular transshipping. First, we estimated the catch per unit of effort (CPUE) per vessel, by country (or region) of origin of the fleet. Then, using the estimated number of vessels in operations (illegal and legal), we estimated the illegal catch and the unreported unregulated catch by the fleets authorized to operate in Senegal. Discards were then estimated for each fleet segment.

### Catch per Unit of Effort (CPUE)

We conducted a survey from the August 22 to September 5, 2012 at the most important fishing and landing harbour in Senegal (Dakar), where most industrial vessels land their catches. Twenty-five skippers representing a quarter of the fleet were randomly selected and interviewed under promise of anonymity. The sample covers vessels fishing in all industrial fishing zones of Senegal (North, South and Central Senegal) and the major targeted sectors, i.e., tuna, other fish and shrimp. These surveys had four major goals, i.e., to (1) identify issues around illegal fishing (2) identify the frequency of illegal activities observed by the skippers while at sea; (3) analyze the real (i.e., beneficial) ownership of the vessels via the nationality of the crew and/or skipper and (4) estimate catch per unit of effort (Appendix table A1).

On the other hand, the average daily catch was estimated at 50 t·vessel<sup>-1</sup> based on reported landings and the number of days for the Russian vessels during the pelagic campaign 2011-2012, surveyed by the *Direction de la Surveillance et de la protection de la pêche* (DPSP, Department of surveillance and protection of fisheries) (Appendix table A1).

The first step in estimating the CPUE was to determine the unit of effort. Since the effort description for illegal vessels is rarely available, we used the list of licensed vessels in Senegal from ([www.dpm.sgn](http://www.dpm.sgn) [2013]; [www.dpsp.sn](http://www.dpsp.sn) [2013]) to analyze the profile of vessels operating off Senegal.

We searched for the registration number of each vessel and/or the name in the online databases [www.maritime-connector.com](http://www.maritime-connector.com) [2013], [www.marinetraffic.com](http://www.marinetraffic.com) [2013], [www.vesselfinder.com](http://www.vesselfinder.com) [2013] and [www.grosstonnage.com](http://www.grosstonnage.com) [2013], and search for the last reported owner (by default the seat of the company managing the vessel), the former flag history and the GRT of each vessel documented. Based on each vessel's management and the history of its reflagging, we then inferred the origin and suspected ownership for all vessels (Appendix table A2). The main goal behind this exercise is to determine the GRT profile, by country of origin, of the industrial fleet

operating in Senegalese waters. Indeed, in Senegal, most industrial vessels over 20 m are of foreign origin operating under joint ventures, reflagged, or operating under access agreements. We identified six categories based on their inferred origin and GRT, and estimated the average GRT for each category by dividing the sum of the GRT for each category by the number of vessels from the same category (Table 1).

Herein, the CPUE is calculated as the daily catch for each unit of capacity (in  $\text{t} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$ ) that characterizes vessels from each fleet (by origin, Table 1). As suggested by Goffinet (1992) and Johnstone (1996), this measure is appropriate if we assume that fishing vessels would always tend to maximize their catch. The second step was then to establish an optimal CPUE using a Monte-Carlo method. The Monte-Carlo method allows generating the solution (herein the optimal CPUE), many times (10,000 times) by randomly choosing values from the probability distribution of the parameters, here ranging between a predefined maximal and minimal CPUE. The result is an optimal CPUE and an estimate of the uncertainty associated to it (Pauly *et al.* 2013).

#### *Minimal CPUE*

Herein it is reasonable to assume that the minimal CPUE would be that whose estimation is based on the officially reported catch, i.e.,  $50 \text{ t} \cdot \text{vessel}^{-1} \cdot \text{day}^{-1}$  for Russian vessels of an average GRT of 6,560 (Table 1). Therefore by dividing the daily catch by the average GRT, we obtained a CPUE of  $7.6 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$  set as a minimum in the Monte-Carlo model.

#### *Maximal CPUE*

Maximal CPUE is a difficult parameter to estimate as it sets the upper limit of unreported catches; therefore, it was based on several sources. While reported landings represent the portion of the catch declared by each vessel, Greenpeace (2012) reported that the catch by foreign (e.g., Russian) vessels could be as high as  $250 \text{ t} \cdot \text{day}^{-1}$ . The CPUE was then calculated at  $38.1 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$ . On the other hand, demersal Chinese vessels catch around  $1,200 \text{ t} \cdot \text{year}^{-1} \cdot \text{vessel}^{-1}$  for a GRT of 308 and 313 fishing trips (DPSP 2012), i.e.,  $12.44 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$ . Finally, ter Hofstede and Dickey-Collas (2006) observed a daily catch of  $102.32 \text{ t} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$  onboard Dutch pelagic trawlers for a GRT of 6,534, i.e.,  $15.65 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$ . We averaged the three estimates and obtained a maximal CPUE of  $22.06 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$ .

With a CPUE of  $7.6 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$  as lower bound and a CPUE of  $22.06 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1}$  as upper bound, the Monte-Carlo method allowed estimation to estimation of an optimal CPUE of  $14.78 \text{ kg} \cdot \text{GRT}^{-1} \cdot \text{day}^{-1} \cdot \text{vessel}^{-1} \pm 4.2$ .

We obtained to total daily CPUE by multiplying the CPUE per GRT by the average GRT for each fleet segment, where the ‘segments’ are the country of origin of the reflagged vessel investigated previously (Table 1).

**Table 1.** Suspected origin of vessels operating in Senegal including the domestic and foreign fleets, their average GRT and the corresponding CPUE for 2011.

| Origin         | Number of vessels <sup>a</sup> | Average GRT per Vessel | CPUE<br>(t·vessel <sup>-1</sup> ·day <sup>-1</sup> ) |
|----------------|--------------------------------|------------------------|------------------------------------------------------|
| Western Europe | 39                             | 240 ± 27.12            | 3.64                                                 |
| Senegal        | 18                             | 180 ± 29.86            | 2.74                                                 |
| Russia         | 0 <sup>b</sup>                 | 6,560 ± 1439.64        | 96.98                                                |
| China          | 14                             | 308 ± 21.97            | 4.55                                                 |
| Africa and FOC | 2                              | 225                    | 3.33                                                 |

a) Only vessels whose flag we could identify were taken into consideration, i.e., 66% of the so-called Senegalese fleet;

b) Although absent in the actual datasets of the *Département des pêches maritimes* (DPM, Department of fisheries), the need to establish a GRT profile to estimate past catches of Russian vessels in herein highlighted.

### Estimation of the Illegal effort and illegal catches

Illegal fishing, defined as a crime by INTERPOL (2010), is a fishing activity conducted in waters under a national jurisdiction, but for which a foreign vessel does not hold an authorisation of any kind. This, in the present study, would exclude any activities by domestic and authorized fleets that would be considered illegal under Senegalese law (fishing with un-authorized gear, fishing in prohibited zones etc. by the authorized fleets), these activities are rather considered unregulated. Also, catches of the domestic industrial fleet under 20 m would be already included in the statistics.

Illegal fishing effort in Senegalese waters is mostly occurring in form of incursions by foreign vessels legally or illegally operating in the waters of neighbouring countries (e.g., Russian vessels authorized to fish in Mauritania and operating illegally in Senegal from December to May, i.e. 150 days, which correspond to the North-South migration of *Sardinella* spp. and other small pelagics (Deme *et al.* 2012). Thus, vessels from Russia, Belize (FoC) and Panama (FoC) perform their incursions into Senegalese waters from the north (i.e., Mauritania), while Japanese, Chinese and Korean vessels, and from other FoC and European countries do this from the south (Gaudin and Groupement GOPA consultants 2011), where monitoring and control are absent for 305 days per year. Their GRT varies from 1,000 to 7,000 GRT (Gaudin and Groupement GOPA consultants 2011).

A list of these suspected vessels along with their origin was established through direct inspections and observations by the DPSP during the 2012 African Maritime Law Enforcement Partnership (AMLEP) operation from June 16<sup>th</sup> to July 07<sup>th</sup>, as well as a direct survey addressed to vessel owners alluded above, and summarized in Table 2.

**Table 2.** Number of suspected/ illegal vessels per flag of origin.

| Flag             | Russia | Europe | FoC <sup>a</sup> | Total |
|------------------|--------|--------|------------------|-------|
| Observed vessels | 9      | 7      | 20               | 36    |
| Percentage (%)   | 25     | 19     | 56               | 100   |

a) Mainly Chinese vessels based in Guinea-Bissau and Guinea (Anon. 2013).

The information above, which draw a clear picture of the profile of illegal vessels and their origin, covers only part of the illegal fishing fleet operating in the Senegalese EEZ. Based on an estimated 5 incursions per month by different vessels (Jibril

Jawara, Operation Manager, DPSP, per. comm.), we estimated a total of 60 incursions by different vessels per year. We allocated these vessels per flag of origin using the percentage of incursions per flag (Table 2) and identified a more realistic number of vessels responsible for illegal fishing in the Senegalese EEZ. We multiplied the percentage of contribution of each flag (Table 2) by the total number of vessels (60) and, using the estimated the number of vessels per country per origin (Table 3), we multiplied the CPUE per day by the number of days, then by the number of vessels, and thus obtained the total illegal catch for 2011, by country.

**Table 3.** Estimation of the annual illegal catch per vessel origin from the Senegalese waters in 2011.

| Flag                                               | Russia         | Europe      | FoC (China)  | Total           |
|----------------------------------------------------|----------------|-------------|--------------|-----------------|
| Estimated number of vessels                        | 15             | 12          | 34           | 61              |
| Number of fishing days                             | 150            | 305         | 305          | -               |
| CPUE (t·vessel <sup>-1</sup> ·year <sup>-1</sup> ) | 14,547         | 1,110       | 1,016        | -               |
| Annual catch (t·year <sup>-1</sup> )               | 218,211± 1,204 | 12,152 ± 67 | 34,495 ± 190 | 264,858 ± 1,461 |

### Change through time

The percentage of illegal fishing over total fishing activities was estimated for different years by different sources (Table 4). MRAG (2005) estimated IUU fishing activities in Senegal to be 8% of the total catch, while Kelleher (2002) estimated the total number of infractions to be 1% of the total fishing activities in 1996, 4% in 2000, and 9% in 2001. Although the latter observations were based on aerial surveys, these were occasional (due to limited funding) and covered only a small time period, and therefore could not be used here. On the other hand, data by the DPSP, shows the number of observed vessels involved in illegal activities, and the number of vessels licensed to fish within Senegalese waters, which allowed estimating the fraction of illegal activities over total fishing activities as a proxy to illegal fishing in Senegal from 2002 to 2011 (Table 4).

When numbers were inconsistent (e.g., when the same vessels were inspected and/or arrested several times, which leads to the number of inspections being lower than the number of vessels arrested), they were replaced by another proxy. Thus, for example, when the ratio vessel arrested/vessel inspected was not available, we used the ratio vessel arrested over the total number of authorized vessels. Based on this, we estimated the change in illegal fishing ( $V_i$ ) from year (t+1) to year (t) using the formula:  $V_i = [(Illegal_{t+1} - Illegal_t) / Illegal_t] \times 100\%$ . We then applied this variation to illegal catches in 2011, 2011 being the baseline, backwards and obtained a time-series for illegal and unreported catches from 2000 to present.

### Unreported catches by industrial fleets flagged to Senegal

Three transshipments of catches in the Senegalese EEZ were observed over a period of two weeks during the AMLEP surveys, which illustrates the extent of these operations. These transshipments were conducted by vessels authorized to fish in Senegalese waters, and thus it is reasonable to assume that transshipped catches were from the Senegalese EEZ.

**Table 4.** Historical variation of illegal fishing in the waters of Senegal from 1996 and 2011 from DPSP and Senegalese Navy, (unpub. data.).

| Year | Authorized vessels | Inspected vessels | Arrested vessels | Arrested/Inspected (%) | Arrested/authorized (%) | Annual variation (%) |
|------|--------------------|-------------------|------------------|------------------------|-------------------------|----------------------|
| 2000 | 270                | -                 | -                | -                      | 4 <sup>a</sup>          | 1.30                 |
| 2001 | 243                | -                 | -                | -                      | 9 <sup>a</sup>          | 0.50                 |
| 2002 | 159                | -                 | 21               | -                      | 13.2                    | -0.17                |
| 2003 | 221                | -                 | 24               | -                      | 10.9                    | -0.39                |
| 2004 | 195                | -                 | 13               | -                      | 6.7                     | 2.13                 |
| 2005 | 174                | 103               | 22               | 21                     | 12.6                    | -0.41                |
| 2006 | 155                | 7 <sup>b</sup>    | 19 <sup>b</sup>  | NA                     | 12.3                    | 0.23                 |
| 2007 | 132                | 0 <sup>b</sup>    | 21 <sup>b</sup>  | NA                     | 15.9                    | -0.43                |
| 2008 | 107                | 90                | 8                | 9                      | 7.5                     | 0.40                 |
| 2009 | 119                | 206               | 15               | 7                      | 12.6                    | 1.00                 |
| 2010 | 118                | 61                | 15               | 25                     | 12.7                    | -0.24                |
| 2011 | 113                | 95                | 18               | 19                     | 15.9                    | Base                 |

a) Kelleher (2002);

b) The number of inspected vessels was higher than the arrests, and thus was not used.

To estimate the segment of catches unreported under transhipments, we used the previous CPUE estimates per GRT per vessel per country of origin (Table 1), the number of fishing days per country of origin and the number of industrial vessels authorized to operate in Senegal from the DPM and DPSP reports (Table 5).

In the present study, only the vessels for which information could be found in the vessel databases cited above could be identified and taken into consideration, i.e., 73 over a total of 113 vessels with a Senegalese flag (65%). We further investigated the origin of some vessels; for example, using the databases mentioned above, we could identify only 5 Chinese vessels reflagged to Senegal, whereas other references (MEGAPESCA 2003; Auregan 2007; Mallory 2012; Vidal 2012) identified the Senegalese *Sénégal Pêche* as a subsidiary of China's *National Fisheries Corporation*, the largest fishing company in Senegal, which owns 12 to 14 industrial trawlers. Therefore, since the rest of the fleet is considered Senegalese, and their landings were not re-estimated, our estimate is likely conservative.

**Table 5.** Origin of vessels disaggregation per year.

|                                  | Senegal     | China       | Russia     | FoC and Africa | W. Europe   |
|----------------------------------|-------------|-------------|------------|----------------|-------------|
| <b>Percentage of each origin</b> | 24%         | 19%         | 0%         | 3%             | 53%         |
| <b>Number of fishing days</b>    | 167         | 313         | 230        | 330            | 318         |
| <b>Reference</b>                 | DPSP (2012) | DPSP (2012) | FAO (2003) | DPSP (2012)    | DPSP (2012) |
| 1999                             | 42          | 33          | 2          | 5              | 92          |
| 2000                             | 42          | 34          | 2          | 5              | 94          |
| 2001                             | 39          | 31          | 2          | 4              | 85          |
| 2002                             | 36          | 28          | 2          | 4              | 78          |
| 2003                             | 33          | 26          | 2          | 4              | 74          |
| 2004                             | 32          | 25          | 2          | 4              | 70          |
| 2005                             | 26          | 21          | 2          | 3              | 57          |
| 2006                             | 32          | 25          | 2          | 4              | 71          |
| 2007                             | 29          | 23          | 2          | 3              | 63          |
| 2008                             | 22          | 17          | 1          | 3              | 49          |
| 2009                             | 21          | 16          | 1          | 2              | 46          |
| 2010                             | 20          | 16          | 1          | 2              | 45          |
| 2011                             | 42          | 33          | 2          | 5              | 92          |

## Discards

Discards by the industrial sector in West Africa are high. This is particularly true for Senegal, especially by the demersal sectors (Emanuelsson 2008). In Senegal, the two main industrial fishing sectors generate relatively large amount of discards. These are documented in the literature as percentage of the total catch, i.e., total catch = landed catch + discards.

### *Demersal trawl discards*

Kelleher (2005) estimated Senegalese demersal trawl discards at 62% of total catches for 2000, which means the discarded catch was 1.6 times the landed catch. Emanuelsson (2008) estimated discards at 43% of total catches for 2005, i.e., discarded catches were equivalent to 74% of landed catches (Table 6). Emanuelsson (2008) suggested that discards were decreasing because of increasing retention of the bycatch. Thus, we extrapolated the trend from 2000-2005 to 2011 and estimated a discard rate of 37% in 2011 (when discards were equivalent to 62% of landed catches). We then interpolated linearly discard rates per year to bridge the anchor points (Table 6).

**Table 6.** Discard rate and contribution of the demersal trawl sector to total catches. Interpolations are italicized.

| <b>Year</b> | <b>Discard rate (%)</b> | <b>Reference</b>                                   |
|-------------|-------------------------|----------------------------------------------------|
| 2000        | 62                      | Kelleher (2005)                                    |
| 2001        | <i>58</i>               | -                                                  |
| 2002        | <i>54</i>               | -                                                  |
| 2003        | <i>50</i>               | -                                                  |
| 2004        | <i>47</i>               | -                                                  |
| 2005        | 43                      | (Emanuelsson 2008)                                 |
| 2006        | <i>42</i>               | -                                                  |
| 2007        | <i>41</i>               | -                                                  |
| 2008        | <i>40</i>               | -                                                  |
| 2009        | <i>39</i>               | -                                                  |
| 2010        | <i>38</i>               | -                                                  |
| 2011        | <i>37</i>               | Estimated by carrying the trend 2000-2005 forward. |

Assuming that illegal operation generate the same amount of bycatch, we multiplied the illegal demersal illegal catches (i.e., the illegal catches of the EU fleets) by the estimated discard rates, and thus obtained the discards of the illegal demersal fleet.

Similarly, we multiplied our estimated discard rates by the annual catch of the domestic demersal trawler fleet. (The domestic demersal fleet is not really Senegalese; most of the Senegalese vessels are small-pelagic purse seiners).

### *Pelagic trawl discards*

To estimate pelagic trawl discards, we used the discard rate provided by ter Hofstede and Dickey-Collas (2006) for pelagic Dutch trawlers in Mauritania, which is based on at-sea observations, i.e., 11% of the total pelagic catch of European pilchard (*Sardina pilchardus*), jack and horse mackerels (*Trachurus* spp.) and sardinella (*Sardinella* spp.). Thus, the discarded catch was equivalent to 12% of the landed catch of these species. We assumed the profile of pelagic trawl discards was homogenous for all foreign fleets, since most illegal pelagic catches were performed by vessels coming

from Mauritania (see above). Therefore, we applied the previous discard rate by 94.6% of the pelagic trawl catch, 94.6% being the percentages of the contribution of European pilchard, jack and horse mackerels and sardinella to total catches (ter Hofstede and Dickey-Collas 2006).

Discards of the Senegalese purse-seine fleet, which target small pelagic fishes are considered negligible (Moustapha Deme, CRODT, pers. comm.), and therefore not considered here. Furthermore, on-site observations indicate that, as is the tradition in West Africa, these vessels increasingly sell their low-commercial value bycatch to artisanal fishers.

### Sensitivity analysis of illegal catches

Given the furtive nature of illegal fishing, and the assumptions that are involved in its quantification, a sensitivity analysis is conducted here to gain insights into which of these assumptions are most critical, and how they affect the total estimated illegal catch. The CPUE estimated here is optimized based on a robust Monte-Carlo model that re-estimated the latter 10,000 times, which at the end resulted in a reasonable CPUE that fits observations and trends in the literature (e.g. Caverivière and Rabarison Andriamirado 1988). Similarly, the GRT estimated is based on observed effort data collected from different sources. Consequently, the two parameters that draw our attention were the number of fishing days and the number of incursions, i.e., vessels per month. While the latter (5) is based on the observations of the DPSP over 15 days of monitoring, it is reasonable to assume that the minimum number of incursion would not be lower than 4 vessels per month (-20%), as incursions are observed frequently, and over 6 vessels per month (+20%).

We also set the number of days at a minimum of -40% the current value and a maximum of +10% the current value. The number of days cannot be higher, as this would imply that illegal vessels operate all year long in Senegal. The number of days can hardly be lower than the minimum value set for the sensitivity analysis, given that pelagic trawl vessels (for example) follow migrations of small pelagic fish, which implies that their presence in the neighbouring countries would be economically beneficial only if (a) these vessels stopped operating during the time period where fish is migrating south, or (b) their fishing activity continues in the south (i.e., Senegal). These scenarios allow assessing the effect of two variable on illegal catches (Table 7).

**Table 7.** Parameter changes used in the Sensitivity Analysis.

| <b>Scenarios</b> | <b>Number of incursions (%)</b> | <b>Number of days (%)</b> | <b>Note</b>                    | <b>Change in catch (%)</b> |
|------------------|---------------------------------|---------------------------|--------------------------------|----------------------------|
| Scenario 1       | 20                              | 10                        | more vessels more days         | 32                         |
| Scenario 2       | -20                             | 10                        | Less vessels more days         | -12                        |
| Scenario 3       | -20                             | -10                       | Less vessels less days         | 33                         |
| Scenario 4       | -20                             | -20                       | Less vessels less days         | -36                        |
| Scenario 5       | -20                             | -40                       | Less vessels less days         | -52                        |
| Scenario 6       | 20                              | -10                       | More vessels less days         | 8                          |
| Scenario 7       | 20                              | -20                       | More vessels less days         | -4                         |
| Scenario 8       | 20                              | -40                       | More vessels less days         | -28                        |
| Scenario 9       | 20                              | 0                         | No change in number of days    | 20                         |
| Scenario 10      | 0                               | 10                        | No change in number of vessels | 10                         |

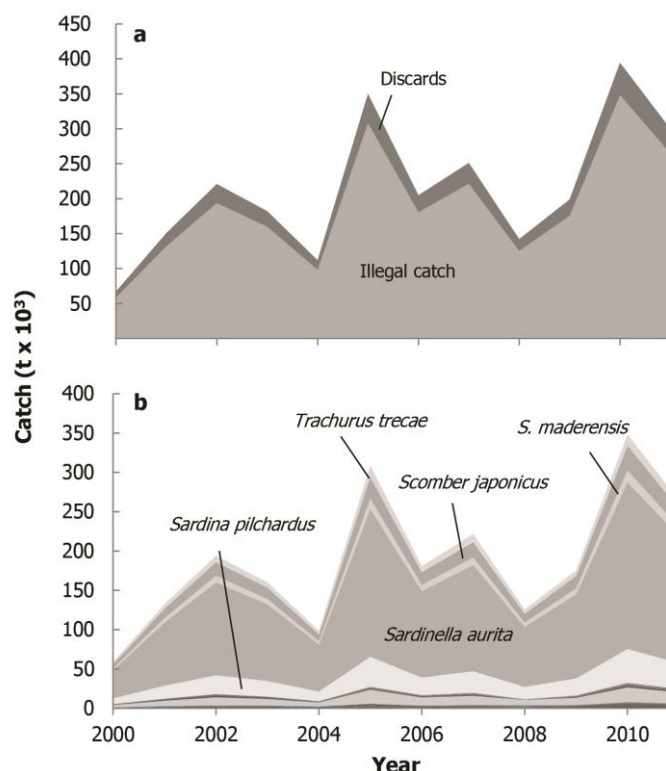
## Results

### Illegal catches

Illegal catches and their corresponding discards were estimated at around 2.6 million tonnes in the period from 2000 to 2011. Illegal catches increased by a factor of 5, after the cancellation of Senegal-Russia agreements in 1999, from about 67,000 t·year<sup>-1</sup> in 2000 (of which 8,400 t·year<sup>-1</sup> were discarded) to 400,000 t·year<sup>-1</sup> in 2010 (of which 46,000 were discarded).

Illegal catches declined in 2011 by around 100,000 t·year<sup>-1</sup>, after the re-authorization of Russian vessels (Figure 2a).

Of over 170 taxa identified in Senegalese catches (DPM 1999-2011), catches of sardinella, European pilchard and mackerels dominate illegal catches with over 2 million tonnes between 2000 and 2011, i.e., 39,000 t·year<sup>-1</sup> annually (Figure 2b).



**Figure 2.** Annual illegal catches and the corresponding discards by Distant Water Fleets from the Senegalese waters a) by sector and b) by taxon, 1996-2011.

### Domestic industrial catches by the fleet (re-)flagged to Senegal

Industrial catches by the fleet flagged or reflagged to Senegal were estimated at 1.5 million tonnes between 2000 and 2011, compared to 572,000 t in official reports of the DPM during the same period, i.e., 1 million tonnes went unreported. Catches decreased overall from around 179,000 t·year<sup>-1</sup> in 2000 to a minimum of 75,000 t·year<sup>-1</sup> in 2011 (Figure 3a). Re-estimated landed catches were herein twice to 4 times the reported catches to the DPM (Figure 3a). However, the under-reported component was higher in the early 2000s, when the re-estimated catch was over 3 times the reported catch on average, and decreased gradually to less than 2.2 times the reported catch in the late 2000s, which implies improvement in reporting (Figure 3a).

Discards on the other hand, were estimated at 633,000 tonnes between 2000 and 2011, which is the equivalent of 42% of the industrial retained catch by the fleet flying the Senegalese flag. Discards show a declining trend overall between 2000 and 2011 from 100,000 t·year<sup>-1</sup> to 25,000 t·year<sup>-1</sup> respectively, which is also applies when comparing the rate of discards, 55% of retained catches in 2000, with that in 2011, i.e., 14% (Figure 3a).

The retained catch includes many taxa; however, demersal species such as soles (*Cynoglossus* spp.), bigeye grunt (*Brachydeuterus auritus*) and octopus (*Octopus* spp.) and carangids dominate the catch, which further illustrates the predominance of a demersal Senegalese industrial fleet (Figure 3b).

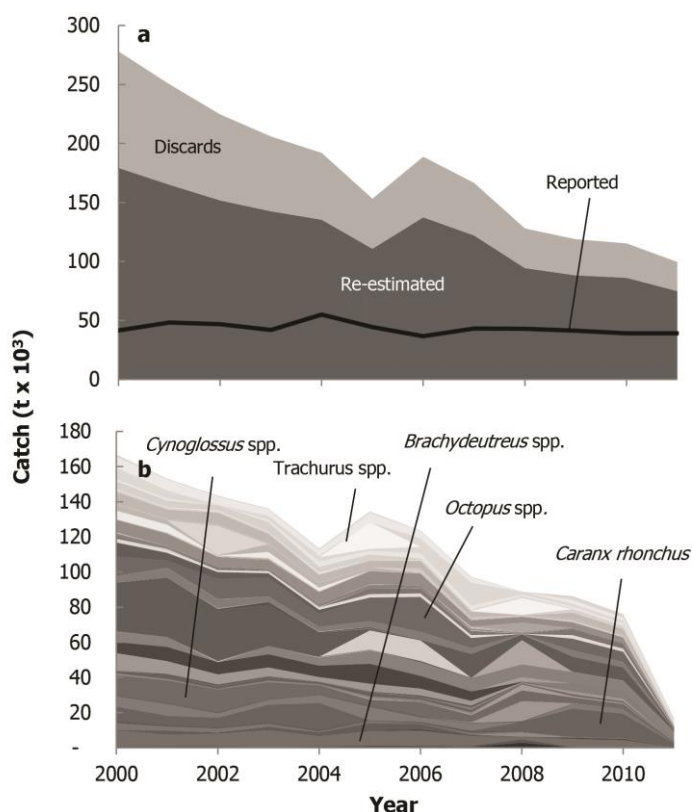
### Discards

Total discards were for both the legal and illegal sectors were estimated at over 938,000 tonnes between 2000 and 2011, of which 78% was generated by the legal fleet. Illegal fleets operating in Senegal discarded 175,800 t between 1999 and 2011.

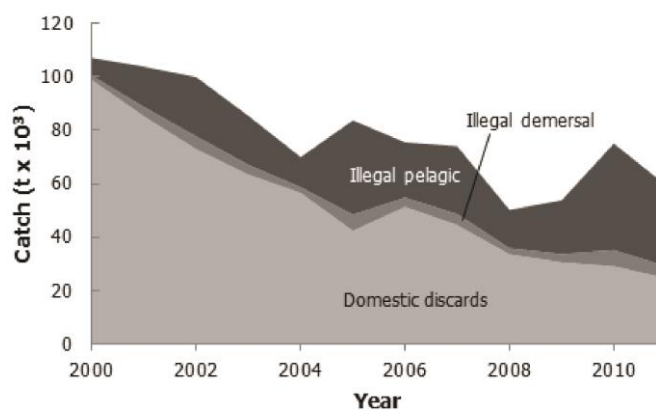
Discards decreased from around 107,000 t·year<sup>-1</sup> in 2000 to 50,000 t·year<sup>-1</sup> in 2008, and then increased slightly to around 60,000 t·year<sup>-1</sup> in 2011, mostly due to the high discard rate associated with demersal trawls (Figure 4). Discards generated by the foreign fleet reflagged to Senegal were much higher, with over 633,000 tonnes discarded between 2000 and 2011, compared to 305,000 tonnes by the illegal fleets (Figure 4).

### Total illegal unreported unregulated catches

Total IUU catches, i.e. the sum of illegal catches, unreported catches by the fleet reflagged to Senegal and discards, totalled 4.2 million tonnes between 2000 and 2011. Although IUU catches remained relatively constant over time (Figure 5a), illegal catches are shown to increase in contrast with catches by the legal fleet flying the Senegalese flag (Figure 5b).



**Figure 3.** Estimated total catches by the legal domestic fleet of foreign origin from the Senegalese waters and their corresponding discards a) compared to the industrial landing data supplied by DPM, and b) by taxon, 1999-2011.



**Figure 4.** Discards of the demersal and pelagic sectors by sector, 1999-2010.

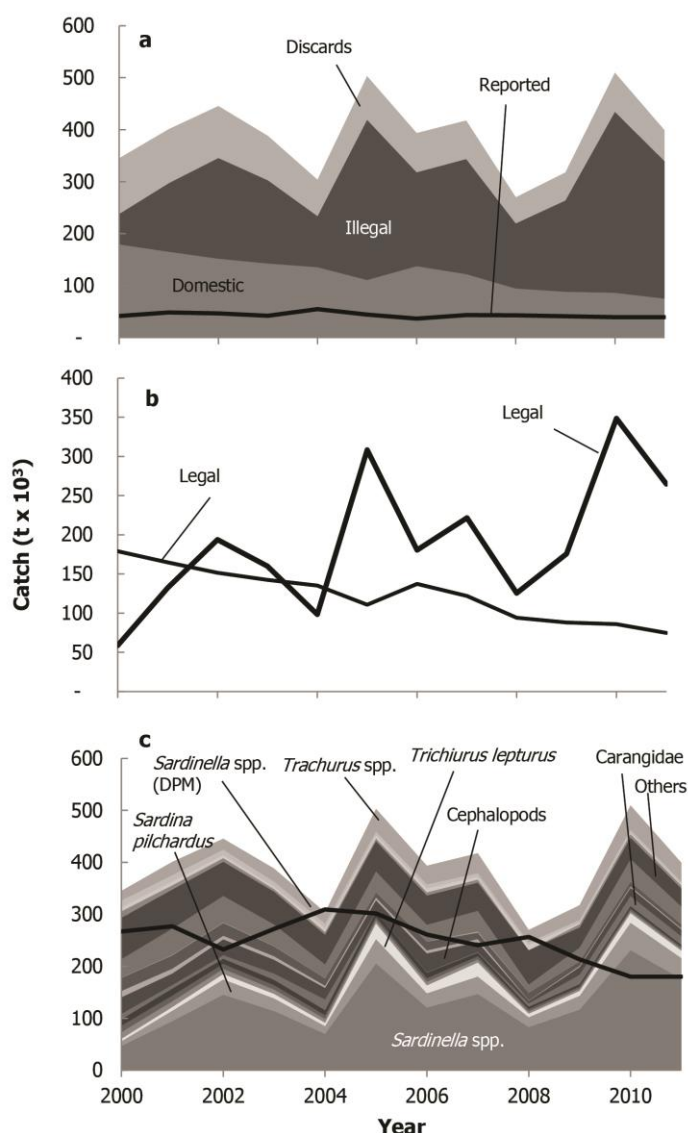
Total catches consisted mainly of sardinellas and of demersal species (Figure 5c). *Sardinella* catches were estimated at 1.6 million tonnes between 2000 and 2011, i.e., 34% of total catches, while the remaining 66% of the catch consisted a large number of taxa (Figure 5c).

Illegal industrial catches of sardinella were earlier equivalent to 20% of the reconstructed artisanal catches, but now, they have increased, and are as high as artisanal catches (Figure 5c).

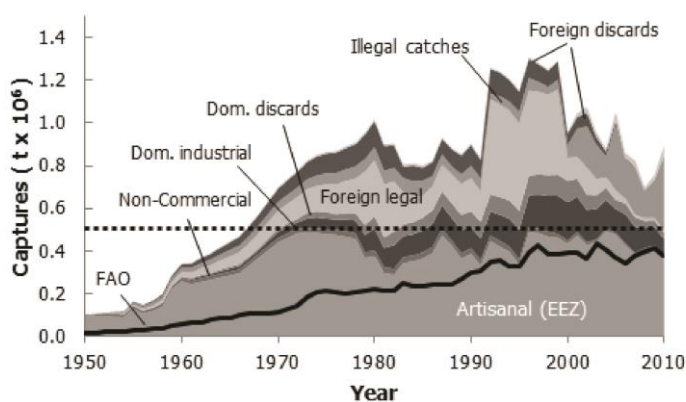
Jointly, the illegal and legal catches taken from the Senegalese EEZ (see also Belhabib *et al.* 2013) exceed the maximum sustainable yield estimated for Senegal by CRODT (2001), which ranged from 450,000 to 600,000 t-year<sup>-1</sup> (Figure 6).

#### Sensitivity analysis for illegal catches

The sensitivity analysis conducted for two of the parameters used herein showed that illegal catches are impacted strongly by the estimated number of incursions, but not the number of days these incursions last. The scenario of Table 7 that drove illegal catches to their highest values was when the number of incursion was 20% higher, i.e., one more incursion per month, along with a 10% increase in the number of

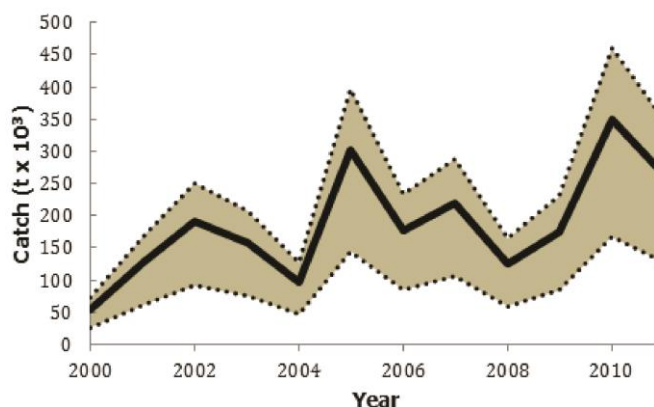


**Figure 5.** Legal and illegal fisheries in the Senegalese EEZ: a) Total illegal, unreported unregulated industrial catches; b) Comparison of legal and illegal catches; c) Comparison of the illegal catch with artisanal reconstructed catches of sardinella estimated by Belhabib *et al.* (2013), 2000–2011.



**Figure 6.** Total catches from the Senegalese waters, 1950–2010. The maximum sustainable yield (450,000 to 600,000 t-year<sup>-1</sup>) estimated by CRODT (2001) is also shown. ‘Non-commercial’ refers to recreational and subsistence catches.

days. In contrast, catches were at a minimum of 127,000 t-year<sup>-1</sup> when the number of incursions was lowered by 20% (to 4 incursions monthly) and the number of days was lowered by 40% (Figure 7). This scenario, although possible, is unlikely, given the low monitoring intensity in Senegalese waters, fish migrations which provides a good incentive for large pelagic trawl vessels to follow them, and a large almost entirely unmonitored continental shelf along with relatively high abundance compared to the southern neighbours of Senegal



**Figure 7.** Sensitivity Analysis of illegal catches in Senegal showing the upper and lower boundaries, 2000-2011.

### Value of Illegal Unreported and Unregulated catches

Total industrial catches in Senegal and the discards generated were estimated at 412,000 t-year<sup>-1</sup> in 2011, which when multiplied by the ex-vessel price of catches (on average) estimated at 366 CFAFr/kg (DPM, 2010)<sup>1</sup> would land a total value of \$300 million US annually. Illegal catches alone were worth \$194 million US ranging between at least \$93 million US and \$256 million US. The value of the transhipped catch and that of foreign flagged vessels was around \$33 million US.

## **DISCUSSION**

This work is the first attempt to estimate the IUU catches by industrial fishing fleets in Senegalese water and their temporal variation, and the countries of origin of the fleets in question. This illegal catches were estimated at around 350,000 t-year<sup>-1</sup> on average caught by both the illegal fleets and the legal fleet of foreign origin reflagged to Senegal, compared to official figures of 44,000 t-year<sup>-1</sup> on average during the 2000-2011 time period. When total removals are considered (including both the artisanal and industrial sectors), catches are dangerously above the potential yield estimated for Senegal (CRODT 2001). This endangers not only the already over-exploited stocks of Senegal (Diallo 2000), but also imperils an entire fisheries-based sector of the economy. This is particularly true for the artisanal sector, whose fishing ground overlaps the areas frequented by illegal industrial fishing vessels (Niasse and Seck 2011).

It is evident that the increase in illegal fishing is strongly related to the decrease in the number of vessels of foreign origin authorized to fish in Senegal. This suggests that the fleet formerly authorized to fish in Senegal, and which transferred parts of their operation to neighbouring countries (mainly Mauritania, The Gambia and Guinea-Bissau), also converted itself into an illegal fleet operating in Senegalese

<sup>1</sup> We used a conversion where 1000 francs CFA = \$ 2.25 US.

waters. On the other hand, the increase in illegal catches demonstrates the limited capacity for adequate control and monitoring along the Senegalese coast.

The assumptions made herein, and our estimates of illegal catches, are conservative for many reasons, notably because we did not consider numerous undocumented Chinese, Korean and Japanese vessels operating illegally in Senegalese waters. Secondly, the 2010 profile of fishing vessels likely underestimated unreported catches by the reflagged fleet, since vessels reflagged to Senegal in the past (before the expiration of the EU-Senegal fishing agreement in 2006) originated in countries outside of the EU, which would have contributed to the under-estimation of mean GRT and therefore CPUEs. Furthermore, the baseline CPUE used in the present study was conservative. For example, it generated a CPUE of 1,100 t-vessel-1-year-1 for the fleet of Chinese origin, while other estimates using the Monte-Carlo method estimated the average Chinese CPUE in West Africa at 1,252 t-vessel-1-year-1 for the demersal fleet showed higher a higher CPUE for the Chinese demersal trawl fleet (Pauly *et al.* 2013).

The high value of industrial illegal and unreported industrial catches estimated here at around \$300 million US annually would justify a rethinking of the monitoring policies of Senegal, which should aim at recovering at least a fraction of these \$ 300 million US per year.

The present study highlights the clear conflict between the industrial fleet and the artisanal fleet in Senegalese waters, notably as it affects the species most targeted by the illegal fleets, i.e., sardinella. This, along with increasing artisanal catches from outside Senegal (Belhabib *et al.* 2013) suggests that over-capacity by the artisanal fleet is not the only cause of increasing migrations by fisheries. Rather, our results suggest that the high level of competition for the same resources over the same fishing grounds caused the enormous increase of capacity in the artisanal fleet of Senegal, which then spilled over into the neighboring countries further North and South. This led to a the relationship between the foreign host to Senegalese fishers, which may have been characterized as 'symbiotic' to turn into a parasitic relationship, which then created conflicts between the domestic sector of the neighbouring host countries and migrant Senegalese artisanal fishers.

Considering the role that foreign fishing plays in these negative developments, we are heartened by the recent decision by the President of Senegal to maintain a ban on fishing for sardinella by Russian vessels. Furthermore, at the time this study was being finalized, Senegal is strengthening its Monitoring, Control and Surveillance capacity by acquiring new efficient monitoring vessels, one of which for the offshore waters of the Senegalese EEZ.

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## REFERENCES

- Anon. (2013) Industrial fisheries in Guinea Bissau. TransparentSea. Available at: [http://transparentsea.co/index.php?title=Guinea,Bissau:Industrial fisheries](http://transparentsea.co/index.php?title=Guinea,Bissau:Industrial%20fisheries) [Accessed: 17/05/2013].
- Auregan X (2007) Les enjeux géopolitiques de la "percée" chinoise au Sénégal. Master thesis, University of Institut Français de Géopolitique, Paris. 200 p.
- Belhabib D, Koutob V, Gueye N, Mbaye L, Mathews C, Lam V and Pauly D (2013) Lots of boats and fewer fishes: catch reconstruction for Senegal, 1950-2010. Fisheries Centre Working Paper #2013-03, Fisheries Centre, Vancouver. 34 p.
- Binet T, Failler P and Thorpe A (2012) Migration of Senegalese fishers: a case for regional approach to management. *Maritime Studies* 11(1): 1-14.
- Bonfil R, Munro G, Sumaila UR, Valtysson H, Wright M, Pitcher T, Preikshot N, Haggan N and Pauly D (1998) Impacts of distant water fleets: an ecological, economic and social assessment. pp. 11-111 *In* The footprint of distant water fleet on world fisheries. Endangered Seas Campaign. WWF International, Surrey.
- Caverivière A and Rabarison Andriamirado GA (1988) Captures secondaires et rejets de la pêche crevette à *Penaeus notialis* du Sénégal 111, CRODT, Dakar. 113 p.
- CRODT (2001) Potentiel et état d'exploitation des ressources halieutiques au Sénégal. p. 215 *In* Portudal S (ed.) Fisheries Access in West Africa. The promotion of sustainable and equitable fishing access agreements. Dakar.
- Deme M and Dioh BC (1994) Aménagement, législation et développement des pêches artisanales au Sénégal : bilan et analyse d'impact. pp. 25-42 (424) *In* Barry-Gérard M, Diouf T and Fonteneau A (eds.), L'évaluation des ressources exploitables par la pêche artisanale Sénégalaise: documents scientifiques présentés lors du symposium. Institut Français de Recherche Scientifique pour le Développement en Coopération, Symposium, Dakar, February 8-13, 1993.
- Diallo A (2000) Statut of fish stocks in Senegal. pp. 38-40 *In* Abban E, Casal C, Falk T and Pullin R (eds.), Biodiversity and sustainable use of fish in the coastal zone. ICLARM.
- Diallo M (1995) Analyse des interactions entre la pêche artisanale et la pêche industrielle. 199, CRODT, Dakar. 31 p.
- DPM (2011) Résultats généraux de la pêche maritime 2010. Direction des Pêches Maritimes Dakar. 93 p.
- DPSP (2012) Données sur les navires pelagiques: Compagne 2012. DPSP, Dakar. 1 p.
- Emanuelsson A (2008) Bycatch and discard in Senegalese artisanal and industrial fisheries for Southern pink shrimp (*Penaeus notialis*). SIK-report, University of Cothenburg. 26 p.
- FAO (2003) Rapport et documentation de l'Atelier de réflexion sur la gestion des capacités de pêche en Afrique de l'Ouest. Saly Portudal, Sénégal, 25-28 septembre 2001. Rapports sur les pêches 707, FAO, Rome. 89 p.
- Ferraro G and Brans M (2009) Policy reforms and the politics of nature. The case of marine fisheries in China and Senegal. Public Management Institute, Katholieke Universiteit Leuven Conference Paper, MARE Conference, Amsterdam 9th July 2009. 24 p.

- Gaudin C and Groupement GPA consultants (2011) Assistance aux pays en voie de développement dans l'application du règlement 1005/2008 sur la pêche illicite non déclarée et non réglementée. Rapport d'évaluation du pays Sénégal, Juin 2011 Europeaid/129609/C/SER/MULTI, Groupements GPA consultants. 3 p.
- Goffinet T (1992) Development and fisheries management: The case of northwest Africa. *Ocean & Coastal Management* 17(2): 105-136.
- Greenpeace (2012) The Plunder of a nation's birthright. The fishing license scandal: a drama in five acts: A survey on the looting of Senegal's maritime riches between March 2010 – April 2012. Greenpeace. 22 p.
- INTERPOL (2010) Resolution: sustainable environmental crime programme. General Assembly 79th session. Doha, Qata. 1 p.
- Johnstone N (1996) The economics of Fisheries Access Agreements: perspectives on the EU-Senegal case. Discussion Paper 96-02, IIED, London. 43 p.
- Kaczynski VM and Fluharty DL (2002) European policies in West Africa: who benefits from fisheries agreements? *Marine Policy* 26(2002): 75-93.
- Kelleher K (2002) Robbers, reefers and ramasseurs. A review of selected aspects of fisheries MCS in seven West African countries. Project FAO/GCP/INT/722/LUX (AFR/013). Sub-Regional Fisheries Commission, Dakar. 107 p.
- Kelleher K (2005) Discards in world's marine fisheries, an update. FAO Fisheries Technical Paper 470, FAO, Rome. 131 p.
- Mallory T (2012) China as a Distant Water Fishing Nation. Johns Hopkins School of Advanced International Studies. 12 p.
- MEGAPESCA (2003) Evaluation ex-post du protocole d'accord de pêche entre le Senegal et la Communauté européenne, et analyse de l'impact du futur protocole sur la durabilité, incluant une évaluation ex-ante. 169 p.
- MRAG (2005) Review of impacts of illegal, unreported and unregulated fishing on developing countries. Marine Resources Assessment Group Ltd, London. 170 p.
- Niasse M and Seck M (2011) L'accaparement des ressources marines ouest africaines: Sociétés mixtes de façade et licences de complaisance. Expériences du Sénégal et de la Mauritanie. CAOPA, Dakar. 32 p.
- Pauly D, Belhabib D, Blomeyer R, Cheung WWL, Cisneros-Montemayor AM, Copeland D, Harper S, Lam VWY, Mai Y, Le Manach F, Österblom H, Mok KM, van der Meer L, Sanz A, Shon S, Sumaila UR, Swartz W, Watson R, Zhai Y and Zeller D (2013) China's distant-water fisheries in the 21st century. *Fish and Fisheries* doi: 10.1111/faf.12032.
- Pramod G and Pitcher TJ (2006) An Estimation of Compliance of the Fisheries of Senegal with Article 7 (Fisheries Management) of the UN Code of Conduct for Responsible Fishing. p. 25 *In* Pitcher TJ, Kaliloski D and Pramod G (eds.), Evaluations of ompliance with FAO (UN) Code of Conduct for responsible fisheries. Vancouver.
- ter Hofstede R and Dickey-Collas M (2006) An investigation of seasonal and annual catches and discards of the Dutch pelagic freezer-trawlers in Mauritania, Northwest Africa. *Fisheries Research* 77(2): 184-191.
- UNEP (2004) Policy implementation and Fisheries Resource Management: Lessons from Senegal, Fisheries and Environment. 4, UNEP. 72 p.
- Vidal J (2012) Will overfishing by foreigners drive Senegalese fishermen to piracy? , *The Guardian*. Available at: <http://www.guardian.co.uk/global-development/poverty-matters/2012/apr/03/overfishing-foreigners-senegal-fishermen-piracy> [Accessed: 15/05/2012].
- Witbooi E (2008) The infusion of sustainability into bilateral fisheries agreements with developing countries: The European Union example. *Marine Policy* 32(4): 669-679.

**Appendix Table A1.** Estimation of the average CPUE by the fleet landing in Senegal (2011-2012, DPSP 2012).

| Vessel name          | Departure | Landing date | Landings (t) | Fish meal (t) | Number of fishing days | CPUE (t·day <sup>-1</sup> ) |
|----------------------|-----------|--------------|--------------|---------------|------------------------|-----------------------------|
| LAZURNYY             | 03/01/12  | 24/02/12     | 819          | 15            | 52                     | 15.75                       |
| ALEX KOSAREV         | 13/12/11  | 26/01/12     | 1,761        | 0             | 44                     | 40.02                       |
| KOVAS                | 29/11/11  | 09/01/12     | 2,012        | 0             | 41                     | 49.07                       |
| KAP BOGOMOLOV        | 27/12/11  | 02/02/12     | 1,704        | 0             | 37                     | 46.05                       |
| VASILY LOZOVSKY      | 03/01/12  | 09/02/12     | 1,748        | 0             | 37                     | 47.24                       |
| ADMIRAL STARIKOV     | 24/11/11  | 30/12/11     | 1,849        | 0             | 36                     | 51.36                       |
| ZAHKAR SOROKIN       | 20/02/12  | 27/03/12     | 1,734        | 113           | 36                     | 48.16                       |
| ZAMOSKVORECHYE       | 02/03/12  | 06/04/12     | 784          | 36            | 35                     | 22.40                       |
| CORAL                | 03/12/11  | 07/01/12     | 1,492        | 0             | 35                     | 42.62                       |
| VOLOPAS              | 31/12/11  | 02/02/12     | 1,588        | 0             | 33                     | 48.12                       |
| NORDIC (AT HEMPES)   | 09/03/12  | 10/04/12     | 2,215        | 79            | 32                     | 69.21                       |
| M VERBESKY           | 02/01/12  | 01/02/12     | 1,076        | 0             | 30                     | 35.86                       |
| KING RAY             | 02/02/12  | 03/03/12     | 1,098        | 85            | 30                     | 36.60                       |
| OLEG NAYDENOV        | 30/12/11  | 28/01/12     | 1,576        | 0             | 29                     | 54.34                       |
| ALEX MIRONENKO       | 12/12/11  | 09/01/12     | 924          | 0             | 28                     | 33.00                       |
| MARSHALL VASILEVSKIY | 18/01/12  | 13/02/12     | 1,007        | 0             | 26                     | 38.73                       |
| SOLEY                | 12/12/11  | 06/12/12     | 2,163        | 0             | 25                     | 86.52                       |
| BALANDIS             | 06/04/12  | 01/05/12     | 804          | 52            | 25                     | 32.16                       |
| IRVINGA              | 04/12/11  | 28/12/11     | 1,297        | 0             | 24                     | 54.04                       |
| BLUE WAVE            | 22/12/11  | 15/01/12     | 1,821        | 0             | 24                     | 75.87                       |
| RIBALKA SEVASTOPOL   | 09/03/12  | 02/04/12     | 1,158,330    | 56,800        | 24                     | 75.87                       |
| THOR                 | 13/12/11  | 06/02/12     | 2,024        | 0             | 24                     | 84.33                       |
| KING KLIP            | 21/01/12  | 14/02/12     | 1,210        | 0             | 24                     | 50.41                       |
| KING BORA            | 14/01/12  | 06/02/12     | 1,258        | 51            | 23                     | 54.69                       |
| KING FISHER          | 12/12/11  | 04/01/12     | 1,646,607    | 0             | 23                     | 54.69                       |
| GLORIA               | 14/12/11  | 05/01/12     | 1,069        | 0             | 22                     | 48.59                       |
| KIYEVSKA RUS         | 23/02/12  | 12/03/12     | 1,237        | 40            | 18                     | 68.72                       |
| KING DORY            | 16/01/12  | 03/02/12     | 1,035        | 0             | 18                     | 57.50                       |
| <b>Average CPUE</b>  |           |              |              |               |                        | <b>50.78</b>                |
| SOLEY                | 06/12/11  | 08/02/12     | 1,584        |               | 64                     | 24.75                       |
| ADMIRAL STARIKOV     | 30/12/11  | 08/02/12     | 2,263        | 0             | 40                     | 56.57                       |
| LAZURNYY             | 24/02/12  | 04/04/12     | 853          | 38            | 40                     | 21.32                       |
| BLUE WAVE            | 15/01/12  | 19/02/12     | 1,525        | 0             | 35                     | 43.57                       |
| ZAHKAR SOROKIN       | 27/03/12  | 30/04/12     | 987          | 97            | 34                     | 29.02                       |
| CORAL                | 07/01/12  | 10/02/12     | 1,428        | 0             | 34                     | 42.00                       |
| MARSHALL VASILEVSKY  | 13/02/12  | 16/03/12     | 1285         | 38            | 32                     | 40.15                       |
| KING FISHER          | 04/01/12  | 31/01/12     | 1,660        | 0             | 27                     | 61.48                       |
| KING KLIP            | 14/02/12  | 10/03/12     | 1,233        | 169,4         | 25                     | 49.32                       |
| VASILY LOZOVSKY      | 09/02/12  | 04/03/12     | 849          | 59            | 24                     | 35.37                       |
| GLORIA               | 05/01/12  | 28/01/12     | 1,276        | 0             | 23                     | 55.47                       |
| OLEG NAYDENOV        | 28/01/12  | 19/02/12     | 1,552        | 25            | 22                     | 70.54                       |
| KING DORY            | 03/02/12  | 25/02/12     | 848          | 34,6          | 22                     | 38.54                       |
| KAP BOGOMOLOV        | 02/02/12  | 23/02/12     | 1,347        | 28            | 21                     | 64.14                       |
| IRVINGA              | 28/12/11  | 18/01/12     | 826          | 0             | 21                     | 39.33                       |
| KIYEVSKA RUS         | 12/03/12  | 02/04/12     | 1,011        | 30            | 21                     | 48.14                       |
| VOLOPAS              | 02/02/12  | 18/02/12     | 452          | 29            | 16                     | 28.25                       |
| KING RAY             | 03/03/12  | 19/03/12     | 556          | 29            | 16                     | 34.75                       |
| NORDIC (At Hempes)   | 10/04/12  | 24/04/12     | 458          | 16            | 14                     | 32.71                       |
| M VERBESKY           | 01/02/12  | 15/02/12     | 1,297        | 0             | 14                     | 92.64                       |
| KING BORA            | 06/02/12  | 20/02/12     | 576          | 31            | 14                     | 41.14                       |
| RIBALKA SEVASTOPOL   | 02/04/12  | 10/04/12     | 163          | 16            | 8                      | 20.37                       |
| <b>Average CPUE</b>  |           |              |              |               |                        | <b>44.07</b>                |
| SOLEY                | 08/02/12  | 28/02/12     | 1,704        | 0             | 39                     | 43.00                       |
| VOLOPAS              | 18/02/12  | 23/03/12     | 1,050        | 79            | 34                     | 30.88                       |
| KING RAY             | 19/03/12  | 18/04/12     | 1,207        | 64            | 30                     | 40.23                       |
| BLUE WAVE            | 19/02/12  | 19/03/12     | 1,714        | 0             | 29                     | 59.1                        |
| KING FISHER          | 31/01/12  | 27/02/12     | 1,184        | 68            | 27                     | 46.35                       |
| VASILY LOZOVSKY      | 04/03/12  | 28/03/12     | 1,671        | 54            | 24                     | 69.62                       |
| M VERBESKY           | 15/02/12  | 09/03/12     | 678          | 38            | 23                     | 29.47                       |

|                                 |          |          |       |     |    |              |
|---------------------------------|----------|----------|-------|-----|----|--------------|
| Appendix Table A1. <i>Cont.</i> |          |          |       |     |    |              |
| ADMIRAL STARIKOV                | 08/02/12 | 29/02/12 | 1,546 | 10  | 21 | 73.61        |
| ALEX KOSAREV                    | 16/02/12 | 08/03/12 | 1,254 | 13  | 21 | 59.71        |
| GLORIA                          | 28/01/12 | 16/02/12 | 1,305 | 0   | 19 | 68.68        |
| KOVAS                           | 03/02/12 | 21/02/12 | 672   | 8   | 18 | 37.33        |
| RIBALKA SEVASTOPOL              | 10/04/12 | 26/04/12 | 657   | 82  | 16 | 41.06        |
| THOR                            | 12/03/12 | 28/03/12 | 477   | 0   | 16 | 29.81        |
| IRVINGA                         | 18/01/12 | 02/02/12 | 1,597 | 0   | 15 | 106.46       |
| KING KLIP                       | 10/03/12 | 02/04/12 | 1,158 | 62  | 13 | 89.07        |
| KAP BOGOMOLOV                   | 23/02/12 | 06/03/12 | 779   | 44  | 12 | 64.91        |
| CORAL                           | 10/02/12 | 18/02/12 | 601   | 113 | 8  | 75.12        |
| KING DORY                       | 25/02/12 | 04/03/12 | 303   | 28  | 8  | 37.87        |
| KIYEVSKA RUS                    | 02/04/12 | 08/04/12 | 162   | 9   | 6  | 27.00        |
| <b>Average CPUE</b>             |          |          |       |     |    | <b>54.17</b> |
| KOVAS                           | 21/02/12 | 29/03/12 | 1,410 | 38  | 37 | 38.10        |
| ADMIRAL STARIKOV                | 29/02/12 | 04/04/12 | 2,058 | 62  | 35 | 58.80        |
| BLUE WAVE                       | 19/03/12 | 22/04/12 | 1,641 | 34  | 33 | 49.70        |
| VASILY LOZOVSKY                 | 28/03/12 | 29/04/12 | 1,784 | 87  | 32 | 55.75        |
| CORAL                           | 18/02/12 | 20/03/12 | 1,157 | 88  | 31 | 37.32        |
| GLORIA                          | 16/02/12 | 16/03/12 | 1,184 | 28  | 30 | 42.28        |
| ALEX KOSAREV                    | 08/03/12 | 04/04/12 | 1,586 | 83  | 27 | 58.74        |
| KAP BOGOMOLOV                   | 06/03/12 | 31/03/12 | 1,900 | 50  | 25 | 76.00        |
| M VERBESKY                      | 09/03/12 | 02/04/12 | 751   | 29  | 24 | 32.50        |
| IRVINGA                         | 02/02/12 | 25/02/12 | 986   | 49  | 23 | 42.86        |
| SOLEY                           | 28/02/12 | 21/03/12 | 1,730 |     | 22 | 78.63        |
| KING FISHER                     | 27/02/12 | 17/03/12 | 690   | 57  | 19 | 36.31        |
| KING KLIP                       | 02/04/12 | 16/04/12 | 574   | 106 | 14 | 41.00        |
| KING RAY                        | 18/04/12 | 30/04/12 | 461   | 36  | 12 | 41.43        |
| VOLOPAS                         | 23/03/12 | 03/04/12 | 373   | 0   | 9  | 41.44        |
| OLEG NAYDENOV                   |          | 04/04/12 | 2,059 | 36  |    | 57.19        |
| <b>Average CPUE</b>             |          |          |       |     |    | <b>51.98</b> |
| <b>Overall average CPUE</b>     |          |          |       |     |    | <b>50.25</b> |

**Appendix Table A2.** Vessels reported by DPM and DPSP, their suspected flags and GRT for 2011-2012.

| Vessel name                 | Vessel flag | Registration | Vessel type      | Vessel origin | GRT     |
|-----------------------------|-------------|--------------|------------------|---------------|---------|
| ADJA FATOU SAKHO            | Spain       | DAK 865      | Shrimp trawl     | -             | -       |
| ADJA NDOUMBE II ex. SYLVIE  | Senegal     | DAK 844      | Shrimp trawl     | Spain         | -       |
| ADRIEMEX II                 | Senegal     | DAK 819      | Shrimp trawl     | Senegal       | -       |
| AITA FRAXKU                 | Spain       | SS-1-7-99    | Tuna             | Spain         | -       |
| ALMIRANTE AMADOR FRANCO     | Senegal     | DAK 958      | -                | Spain         | 453     |
| ANTA SARR ex. PUNTAMAR      | Senegal     | DAK 1131     | -                | Senegal       | 198     |
| ASBIYALAHOU                 | Senegal     | DAK 596      | Small pelagic    | Senegal       | -       |
| BADAOUI ex A. Amadou        | Senegal     | DAK 490      | Small pelagic    | Senegal       | -       |
| BAKURUS                     | Senegal     | DAK 1008     | Shrimp trawl     | Senegal       | 249     |
| BATTERIE                    | Senegal     | DAK 753      | Shrimp trawl     | Senegal       | 179     |
| BERRIZ SAN FRANCISCO        | Spain       | SS-1-7/03    | Tuna             | Spain         | 241     |
| Betty                       | Senegal     | DAK 706      | Shrimp trawl     | Senegal       | 228     |
| CAP ROUGE                   | Senegal     | DAK 427      | Shrimp trawl     | Senegal       | 139     |
| CAPO TRAMONTANA             | Senegal     | DAK 1075     | Shrimp trawl     | Italy         | 317     |
| CARVISA DOS                 | Senegal     | DAK 1120     | Shrimp trawl     | Senegal       | 235     |
| CHARDON BLEU II             | Senegal     | DAK 1038     | Shrimp trawl     | Senegal       | -       |
| CHIQUITA                    | Senegal     | DAK 990      | Shrimp trawl     | Spain         | 237     |
| CORONA DEL MAR              | Senegal     | BA 724 048   | Tuna             | France        | 370     |
| DAHLIA                      | Senegal     | DAK 781      | Shrimp trawl     | Senegal       | 155     |
| DAVID MANSOUR ex MARIE ROSE | Senegal     | DAK 1190     | Tuna             | Senegal       | -       |
| DOMENICA MADRE              | Senegal     | DAK 989      | Shrimp trawl     | Italy         | 160     |
| DONAKS                      | Senegal     |              | Shrimp trawl     | Senegal       | 249     |
| ELODIE/AISSATOU             | Senegal     | DAK 680      | Shrimp trawl     | Senegal       | 120     |
| FATIMA                      | Senegal     |              | Shrimp trawl     | Nigeria       | 125     |
| FAYAKO                      | Senegal     |              | -                | -             | -       |
| Fissel                      | Senegal     |              | Shrimp trawl     | Spain         | 314     |
| GAZTELUGAITZ                |             |              | Surrounding nets | Spain         | 155     |
| GOBER CINCO                 |             |              | -                | Spain         | 225     |
| GUEREO                      |             |              | Shrimp trawl     | France?       | 122     |
| HELENE                      | Senegal     | DAK 764      | Shrimp trawl     | Belgium       | 292     |
| HISPASEN II                 | Senegal     | DAK 1048     | Shrimp trawl     | Spain         | 266     |
| HISPASEN 6                  | Senegal     | DAK 1196     | Shrimp trawl     | Spain         | 287     |
| HISPASEN IV                 | Senegal     | DAK 1181     | Shrimp trawl     | Spain         | 299     |
| HISPASEN V ex. SORAYA II    |             |              | -                | -             | -       |
| ILE AUX FEES                |             |              | -                | -             | -       |
| ILE AUX MIMOSAS             |             |              | -                | -             | -       |
| ILE AUX OISEAUX             |             |              | -                | -             | -       |
| ILE DE CARABANE             | Senegal     | DAK 527      | -                | Italy         | 146     |
| IRIBAR ZULAIKA              | Spain       |              | Surrounding nets | Spain         | 252     |
| ISA                         | Senegal     | DAK 699      | Shrimp trawl     | Spain         | 116     |
| JEANE HELENE                | Senegal     | DAK 992      | Shrimp trawl     | France        | 160     |
| KANBAL II                   | Senegal     | DAK 1096     | Shrimp trawl     | Spain         | 365     |
| KANBAL III                  | Senegal     | DAK 1115     | Shrimp trawl     | Spain         | 284     |
| KENTIA                      | Senegal     | DAK 1108     | Shrimp trawl     | -             | 120     |
| KERMANTXO                   | -           | -            | Pole and Lines   | Spain         | 262     |
| KHADIMOU RASSOUL            | -           | -            | -                | -             | -       |
| KING CRAB                   | -           | -            | -                | -             | -       |
| KOLLARE                     | Senegal     | DAK 1127     | Shrimp trawl     | Spain         | 365     |
| LAGHEM I                    | Senegal     | DAK 1130     | Shrimp trawl     | Spain         | 359     |
| LAURENCE MARIE              | Senegal     | DAK 670      | -                | Senegal       | 119     |
| LIO I                       | Senegal     | DAK- 1143    | Shrimp trawl     | China         | 293     |
| LIO II                      | Senegal     | DAK- 1144    | Shrimp trawl     | China         | 293     |
| LOBELIA                     | Senegal     | DAK 715      | Shrimp trawl     | Senegal       | 156     |
| LOUBNA                      | -           | -            | -                | -             | -       |
| MANDIUS 1 ex. PETIT         | -           | -            | -                | -             | -       |
| MARIE JOSEPHE               | Senegal     | DAK 817      | Shrimp trawl     | France        | 256     |
| MARIKA                      | Senegal     | DAK 741      | Shrimp trawl     | France        | 150     |
| Mars                        | Senegal     |              | Shrimp trawl     | Russia/Panama | 677/325 |
| MARSOR PRIMERO              | Senegal     | DAK 1061     | Shrimp trawl     | Spain         | 387     |
| MOURIDE NDIQUEL             | -           | -            | -                | -             | 251     |
| MOURIDE SADIKH              | -           | -            | -                | -             | -       |

Appendix Table A2. *Cont.*

|                             |                    |           |              |                |      |
|-----------------------------|--------------------|-----------|--------------|----------------|------|
| NATA                        | Senegal            | DAK 1137  | Shrimp trawl | Spain          | 138  |
| NDEYE MARIEME               | Senegal            |           | Shrimp trawl | Senegal        | 198  |
| NIAM NIOKHO                 | Senegal            | DAK 698   | Shrimp trawl | France         | 228  |
| NIKOLAOS K                  | Senegal            | DAK 909   | -            | Greece         | 130  |
| NUEVO NOSO LAR              | Senegal            | DAK 1133  | Shrimp trawl | Spain/Portugal | 294  |
| NUEVO SAN LUIS              | Spain              | -         | Shrimp trawl | Spain          | 116  |
| NUOVO EURIPIDE              | Senegal            | -         | -            | Italy          | 317  |
| OCEAN PESCA II              | Senegal            | DAK 1046  | Shrimp trawl | Spain          | 299  |
| OCEAN PESCA III             | Senegal            | DAK 1114  | -            | Spain          | 349  |
| ONUDAK I/ISLA SALTES I      | Senegal            | DAK 1021  | -            | Spain          | 300  |
| ONUDAK II/ISLA SALTES II    | Senegal            | DAK 1025  | -            | Spain          | 300  |
| ORNON                       | Senegal            | DAK 628   | -            | -              | 156  |
| Pape MOUSSA                 | Senegal            | -         | -            | -              | -    |
| PAPMAR ex. PAPE             | -                  | -         | -            | -              | -    |
| PDT MAGATTE AYA DIACK II    | -                  | -         | -            | -              | -    |
| PDT MATAR NDIAYE            | -                  | -         | -            | -              | -    |
| PDT OUMAR DIALLO            | Senegal            | DAK 755   | -            | Netherlands    | 241  |
| PETITE MARILLOU             | -                  | -         | -            | -              | 250  |
| PILAR TORRE                 | Spain              | ST-2-4/96 | -            | Spain          | 177  |
| RAMATOULAYE                 | Senegal            | DAK 1141  | -            | -              | 250  |
| RIA DE DAKAR                | Senegal            | DAK 1142  | -            | Spain          | 157  |
| ROSSO ex. NAVIGANTE         |                    |           | -            | -              | -    |
| SAFINATOUL AMAN I           |                    |           | -            | -              | -    |
| SAMIRA                      |                    |           | -            | -              | -    |
| SANTANA ex. ANGE DES MERS   |                    |           | -            | -              | -    |
| SARAN/MARIE HELENE          | Senegal            | DAK 506   | -            | France         | 106  |
| SEGUNDO SAN RAFAEL          | Senegal            | DAK 1176  | -            | Spain          | 312  |
| SENER 14 ex. LES NOURRES II |                    | DAK 697   | -            | -              | -    |
| SENER 15                    |                    | DAK 1109  | -            | -              | -    |
| SERIGNE MOURTADA MBACKE     |                    |           | -            | -              | -    |
| SERIGNE SALIOU MBACKE       |                    | DAK 1057  | -            | -              | -    |
| SOACHIP 12                  | Senegal            | DAK 822   | -            | China          | 299  |
| SOLEIL 10 ex SOACHIP 10     |                    | DAK 941   | -            | -              | -    |
| SOLEIL 11 ex SOACHIP XI     | Senegal            | DAK 821   | -            | China          | 299  |
| SOLEIL 51 ex. CNFC 9514     | Senegal            | DAK 1178  | -            | China          | 327  |
| SOLEIL 61 ex. CNFC 9515     | Senegal            | DAK 1179  | -            | China          | 327  |
| SOLEIL 65 ex. YUAN YU 907   | Senegal            | DAK 1191  | -            | -              | -    |
| SOLEIL 66 ex. YUAN YU 908   | Senegal            | DAK 1193  | -            | -              | -    |
| SOLEIL 67 ex. YUAN YU 909   | Senegal            | DAK 1194  | -            | -              | -    |
| SOLEIL 68 ex. YUAN YU 910   | Senegal            | DAK 1195  | -            | -              | -    |
| SOLEIL 7 ex SOACHIP 7       | Senegal            | DAK 938   | -            | -              | -    |
| SOLEIL 8 ex SOACHIP 8       | Senegal            |           | -            | -              | -    |
| SOLEIL 9 ex SOACHIP 9       | Senegal            |           | -            | -              | -    |
| SONA                        | Senegal            | DAK 1138  | -            | Spain          | 138  |
| TADORNE                     | Senegal            | DAK 602   | -            | France         | 228  |
| TATY/SEDAR III/ADELINE      | Senegal            | DAK 517   | -            | -              | -    |
| TOUBA                       | Senegal            | DAK 995   | -            | Spain          | 139  |
| YA FAMA 3 ex. MOUSSA MBAYE  | Senegal            | DAK 673   | -            | -              | 243  |
| YA FAMA II/SAFINATOUL AMAN  | Senegal            | DAK 518   | -            | -              | 243  |
| ZIGUINCHOR                  | Senegal            | DAK 489   | -            | -              | 243  |
| ADMIRAL STARIKOV            | Russia             | 8607218   | -            | Russia         | 7765 |
| ALEXANDER KOSAREV           | Russia             | 8607153   | -            | Russia         | 7765 |
| ALEXANDER MIRONENKO         |                    |           | -            | -              | -    |
| ATLANTIC HEMPES             |                    |           | -            | -              | -    |
| BALANDIS                    | Lithuania          | 7610440   | -            | -              | 5953 |
| BLUE WAVE                   | Belize             | 8607191   | -            | Russia         | 7765 |
| CORAL V4GV                  |                    |           | -            | -              | -    |
| GLORIA                      |                    |           | -            | -              | -    |
| IRVINGA                     | Lithuania          | 8834639   | -            | Lithuania      | 4407 |
| KABITAN BOGOMOLOV           | Russia             | 8607402   | -            | Russia         | 7765 |
| KING BORA                   |                    | 8033297   | -            | Ukraine        | 4378 |
| KING DORI                   |                    |           | -            | -              | -    |
| KING FISHER                 | St Vinc. & Grenad. | 8832112   | -            | Ukraine        | 4407 |

Appendix Table A2. *Cont.*

|                    |                    |         |   |         |      |
|--------------------|--------------------|---------|---|---------|------|
| KING KLIP          | St Vinc. & Grenad. | 8721208 | - | Ukraine | 4407 |
| KING RAY           | St Vinc. & Grenad. | 8730132 | - | Ukraine | 4407 |
| KIYEVSKA RUS       | Ukraine            | 8138695 | - | Ukraine | 4407 |
| KOVAS              | Comoros            | 7610426 | - | Poland  | 5955 |
| LAZURNYY           | Russia             | 8729664 | - | Russia  | 4407 |
| MARSHAL VASILEVSKY | St Kitts & Nevis   | 8033869 | - | Ukraine | 4378 |
| MIKHAIL VERBITSKIY |                    |         | - | -       | -    |
| OLEG NAYDENOV      | Russia             | 8607309 | - | Russia  | 7765 |
| RIBALKA SEVASTOPOL | Ukraine            | 8826151 | - | Ukraine | 4407 |
| SOLEY              | Belize             | 8607270 | - | Russia  | 7765 |
| STARK              | -                  | -       | - | -       | -    |
| THOR               | -                  | -       | - | -       | -    |
| VASILY LOZOVSKY    | -                  | -       | - | -       | -    |
| VOLOPAS            | Russia             | 6405147 | - | Russia  | 2435 |
| ZAHAR SOROKIN      | Russia             | 8607256 | - | Russia  | 7765 |
| ZAMOSKVORECHYE     | Russia             | 8721129 | - | Russia  | 4407 |