

## 2 CATCHES

### KEY FINDINGS

- The People's Republic of China, which tends to over-report its domestic marine catch massively under-reports (to FAO) the catch of its distant-water fleets.
- We estimate that China has a distant water fleet of around 3,400 vessels, including its fleet fishing in neighbouring Japan and South Korea, or just under 900 vessels excluding Japan and South Korea.
- The catch of China distant water fleet is estimated here at 4.6 million tonnes per year ( $\pm$  687,000 tonnes per year) for the 12 year period from 2000 to 2011, including Japan and South Korea corresponding to an ex-vessel value of 8.93 billion €/year ( $\pm$  1.53 billion €/year).
- A first-order estimate of potential IUU catches around the Africa region shows around 2.5 million tonnes per year, of the estimated Chinese distant water catch of about 3.1 million tonnes per year in the African region, may be unreported.
- Similarly, the disposition of this catch is unclear, though there is evidence that some of it ends up on international markets, notably in the European Union.
- Finally, in the spirit of fairness, we should re-iterate that our methodology does not allow for distinguishing legal from illegal catch, and that newspaper accounts of 'illegal fishing' may refer to vessels that are fishing legally, but under access agreements which have not been made public.
- Thus, in analogy to our suggestion not to use the extremes of our confidence intervals to summarize our findings, we urge readers not to infer from the large fraction of IUU catches by the Chinese distant-water fleet estimated here that its catches consist only, or even mainly, of illegally caught fish.

### 2.1 Introduction

By the end of the 20th century, the People's Republic of China (herein referred as PRC or 'China', and excluding Taiwan, Hong Kong and Macau) had become a major distant-water fishing nation. However, at first it was lacking the specialized vessels required for distant-water fishing, and the infrastructure required for supplying such vessels. Thus, initially, China simply 'exported' its coastal fleet, mainly consisting of bottom trawlers, to whichever foreign country it was operating in (Pang and Pauly, 2001).

At the onset of the 21st century, however, this had changed, as specialized 'catcher' vessels (bottom trawlers still, but also purse seiners, squid jiggers, longliners, etc.) supplied by mother ships deliver their catch to strategically located freezer facilities, supplying local, international and its own domestic markets. These are all remarkable achievements in technology, logistics, and business, mirroring other sectors of the Chinese economic expansion into the rest of Asia (Gauillier *et al.*, 2007), Africa (Zafar, 2007; Beuret *et al.*, 2008), Latin America (Ferchen, 2012) and Oceania (Wesley-Smith, 2007).

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<sup>9</sup> This section is based on work performed by a team from the *Sea Around Us* Project, i.e.: Daniel Pauly, Dyhia Belhabib, William Cheung, Andrés Cisneros-Montemayor, Sarah Harper, Vicky Lam, Yinying Mai, Frederic Le Manach, Ka Man Mok, Liesbeth van der Meer, Soohyun Shon, Wilf Swartz, U. Rashid Sumaila, Reg Watson, Dirk Zeller and Leilei Zhai. Henrik Österblom from the Stockholm Resilience Centre, University of Stockholm, also contributed to this section.

Unfortunately, what did not improve in the transition to the 21st century – occasionally seen as the start of an age of transparency (Sifry, 2011) – is the tendency toward secrecy in fisheries data, and the near complete disregard for public accountability of the use of public fisheries resources. Thus, there are no publically accessible databases of access agreements between China (or Chinese companies) and the countries in the Exclusive Economic Zone (EEZ) of which Chinese fishing vessels operate, unlike the European Union (EU), which provides in its law database (<http://eur-lex.europa.eu>) all texts related to fishing access agreements with other countries, even if the agreements themselves are often questionable (Kaczynski and Fluharty, 2002; Kalaidjian, 2010).<sup>10</sup> Therefore, the activities and catches of the Chinese distant-water fleets are almost completely undocumented and unreported, and often, as we shall see, may actually be illegal, thus spanning the entire gamut of IUU fishing (Bray, 2000).

China's massive over-reporting of its domestic marine fisheries catches was clearly illustrated by Watson and Pauly (2001). Chinese over-reporting of its domestic catches was evidenced by 1) the major assessed populations of fish along the Chinese coast having been classified as overexploited decades ago, while fishing effort continued to climb; 2) estimates of catch per unit of effort (based on official catch and effort data) being constant for domestic waters during the 1980s and early 1990s, i.e., a period of continually increasing effort and reported catches, in contrast to survey data showing declining abundances; and 3) catch per area being far higher than would be expected, when compared with areas similar in oceanographic and production factors (Watson and Pauly, 2001). The factors driving such over-reporting were discussed in Pang and Pauly (2001), and essentially are a perverse result of a planned centralized economy that rewards Chinese officials for appearing to fulfil the plan (thus providing a powerful incentive for over-reporting production) combined with the absence of a government-independent statistical system. These factors continue to be at work in the Chinese marine fisheries sector, still dominated by state fishing companies, although private companies have made major inroads in the last decade. One notable example is Pacific Andes, one of the largest private fishing companies on the planet (also see box on section 5.4). These factors are also the reasons why it will take a long time until China submits to the Food and Agriculture Organisation of the United Nations (FAO), of which it is an influential member, catch statistics with connections to reality (Figure 2.2), despite some recent attempts at cosmetic corrections (FAO, 2010).<sup>11</sup>

In contrast to over-reported domestic catches, the secrecy alluded to above, together with the absence of an independent statistical system, combine to foster non-credible low catch reports – about 368,000 tonnes on average (by China to FAO) for all Chinese vessels operating outside FAO Statistical Area 61 (Western North Pacific), where China is geographically located (Figure 2.1).<sup>12,13</sup>

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<sup>10</sup> There is, in recent years, a trend toward private companies from EU countries negotiating private agreements with host countries, or host country companies, which are, as well, generally not publicly available. These agreements are not officially condoned by the EU.

<sup>11</sup> These attempts slightly modify the domestic marine catches, which had been declared constant since 1998 under the 'zero growth' policy, and in no way make these official catches closer to reality (see Pauly and Froese, 2012).

<sup>12</sup> An alternative explanation could be that the reported Chinese catches were simply partially misallocated in terms of FAO statistical areas by either the Government of China and/or FAO statistical staff.

<sup>13</sup> We shall not deal here with the fact that the People's Republic of China, because of the huge size of its claimed Exclusive Economic Zone (EEZ; see Figure 2.1), is in dispute with Japan, South Korea and Taiwan, and with all Southeast Asian countries bordering the South China Sea, i.e., Brunei Darussalam, Indonesia, Malaysia, the Philippines and Vietnam (see, e.g., Smith (1986), especially p. 28-29, on how EEZ ought to be designed and disputes resolved). Also note that Taiwan makes essentially the same vast claims as China, but does not attempt to enforce them.

Given these circumstances, obtaining an estimate of the actual catch of Chinese distant-water fleets must be based entirely on non-official sources. Consequently, we used here methods which could accommodate unconventional sources, relying on the fact that any collective activity of the scale considered here is bound to generate a 'shadow' on the societies it is embedded in, and which it impacts (Pauly, 1998). From this 'shadow', the scale of the activity in question can be inferred, if often imperfectly and thus requiring further examination.

The second conceptual tool at our disposal is the concept of a (large) Fermi solution. In physics, when faced with the need to estimate unknown quantities from limited data, an approach is often used named after the physicist Enrico Fermi. This is commonly illustrated by his estimation of the number of piano tuners in Chicago, in the absence of specific data.<sup>14</sup> For this, he broke the problem down into parts about which he did have data - number of pianos per households, number of households in Chicago, frequency with which pianos needed to be tuned, etc., then computed his estimate (von Baeyer, 1993). What is obtained with this method is not a definitive number, but rather a reasonable estimate, on the basis of which one can then identify critical steps requiring further examination.

Fermi solutions can be made vastly more reliable by combining their parameter approach with the Monte Carlo method (Buckland, 1984), which considers the uncertainty associated with each parameter (or terms of the equations in question), and which is extensively used in fisheries research, where high uncertainties are the norm (see, e.g., Rosenberg and Beddington, 1987; Uhler, 1979), especially regarding catch levels (Ainsworth and Pitcher, 2005; Tesfamichael and Pitcher, 2007). Herein, the solution is recomputed thousands of times, by randomly selecting different values for each parameter drawn from the probability distribution specified for each parameter. This helps to quantify the range of values and the level of uncertainty of the estimates from the Fermi solution.

Thus, we shall here present the data which allow a preliminary estimate of the catch of Chinese distant-water fleets, explain our computational methods, assess their uncertainty, outline the results and finally discuss some of their implications.

## 2.2 Methodology

We define 'Chinese vessels' as boats with officers and crew from the People's Republic of China (and not Taiwan), irrespective of their flag. Due to the widespread use of 'flags of convenience' as well as 'charter' and 'joint venture' arrangements, which tend to obscure actual beneficial ownership, control and proper compensation through access fees, the flag a vessel is flying may have little bearing on the actual targeted disposition and associated profit ownership of the landed catch (Gianni and Simpson, 2005; Griggs and Lutgen, 2007). We found no instance of Chinese officers and non-Chinese crew, in stark contrast to the often mandated practice of EU vessels having EU officers and local (i.e., non-EU) crew.<sup>15</sup> This is a reasonable assumption, as there are likely few (if any) instances in which a fishing boat that is not owned, directly or indirectly, by a Chinese firm (irrespective of the flag flown) is operated by Chinese officers and crew.

<sup>14</sup> Another example of this is the 'Drake Equation', used to estimate the number of extraterrestrial civilizations (for example in our galaxy) based on the number of stars, the number of potentially life-bearing planets per star, the fraction of such planets with some forms of life, etc. Some versions of the Drake Equation lead to high estimates of the number of extraterrestrial civilization, which gives weight to Fermi's question, when confronted with these results: 'Where are they?'

<sup>15</sup> We found only one reported instance of a Taiwanese vessel, operating off the Pacific Coast of Costa Rica being crewed and captained by mainland Chinese (<http://www.protect-the-sharks.org/shark-finning/chen-chieh-21/>).

The procedure used here to estimate the catch by Chinese distant-water fleets consist essentially of 5 steps:

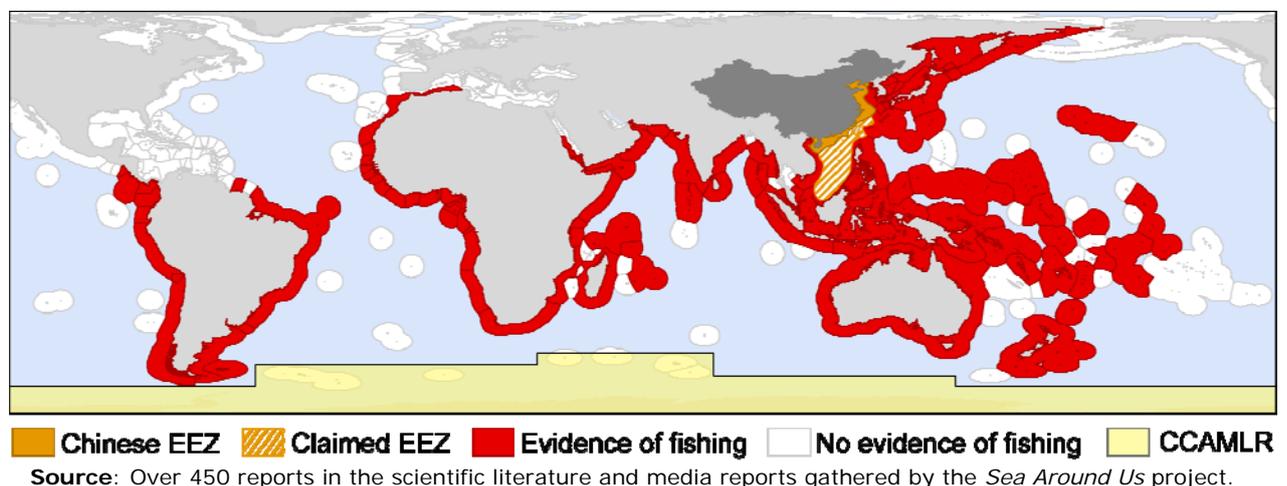
1. Establish the presence of Chinese vessels in the EEZ of a given country and year;
2. For countries and years where such presence was established, record the number of vessels involved, or assign a likely number of vessels to that country and year, given the nature and contents of the available document(s);
3. Assign an annual catch and catch value to each vessel, by vessel type;
4. Repeat (3) for all countries and years, and add up catches and catch values across countries and territories;
5. Conduct a Monte Carlo simulation by repeating step (4) 10,000 times for input values (number of vessels by country, catch per vessel, etc.) drawn from distributions whose shapes are determined by the values obtained in steps (1-3) or independently. Probability distributions of the estimated total catches and catch values of the Chinese distant water fleets are then calculated, from which we compute the mean and associated uncertainty of the final result.

Details on these five steps are shown in Annex I.

## 2.3 Results and discussion

Overall, more than 450 reports were obtained from the scientific literature, newspapers, magazines, other media outlets and websites, both Chinese and non-Chinese, which attested to the presence, legally sanctioned or not, of Chinese vessels in the Exclusive Economic Zones of 79 maritime countries and/or their overseas territories, and in Antarctica (Figure 2.1).

**Figure 2.1: Exclusive Economic Zones of countries or territories where Chinese vessels were reported to operate (legally or not) in 2000-2011.**



As illustrated by Figure 2.1, the only large regions of the world where Chinese distant water vessels do not appear to operate is the Arctic, the coast of North America, the Caribbean, and European waters.

### 2.3.1 Catches

Table 2.1 presents our key results, i.e., estimates of the catch by Chinese vessels in different regions of the world, with a measure of their uncertainty. Note that we do not present results by country as these are too uncertain; only in the aggregate is our method likely to generate reasonable results. We also abstained from presenting separately the

result for 2000-2005 and 2006-2011, as there were, at the regional level, no significant differences between these two periods. There were significant differences in the number of vessels of various types for these two periods, and hence estimated catches at the country level, but as mentioned before, we consider our method to be less reliable when results are disaggregated.

**Table 2.1: Estimated annual catch by vessel type of the Chinese distant-water fleets from the Exclusive Economic Zones of maritime countries and territories (and adjacent high sea areas), 2000-2011.**

Region	Annual catch by gear (1000 tonnes)					Total (± st. dev.)
	Miscellaneous boats	Bottom trawlers	Purse seiners	Tuna longliners	Tuna purse seiners	
West Africa	15.0	2,355.0	554.7	11.4	4.7	<b>2,941 ± 631</b>
East Africa	2.7	119.0	18.0	11.7	29.5	<b>181 ± 59</b>
Asia (excl. Japan and South Korea)	32.5	697.0	127.0	24.1	67.5	<b>948 ± 241</b>
Japan and South Korea	See Table A.I.2 in Annex I for details on catch by vessel type <sup>1</sup>					<b>106 ± 16</b>
Oceania	3.5	18.4	0.0	84.3	91.9	<b>198 ± 31</b>
Central and South America	34.0	109.7	31.7	7.0	0.0	<b>182 ± 53</b>
Antarctica	1.0	0.0	46.6	0.0	0.0	<b>48 ± 26</b>
Total	--	--	--	--	--	<b>4,604 ± 687</b>

<sup>1</sup> Standard deviation based on the same coefficient of variation as total catch without Japan and Korea.

Source: *Sea Around Us Project*

As might be seen in Table 2.1, overall, Chinese fleets catch an estimated 4.6 million tonnes per year outside their domestic waters. In terms of regions, Africa is where Chinese distant water fleets extract the largest catch, about 3.1 million tonnes per year, followed by Asia (948,000 tonnes per year excluding Japan and South Korea, slightly over 1 million tonnes per year with Japan and South Korea), Oceania (198,000 tonnes per year), Central & South America (182,000 tonnes per year), and Antarctica (48,000 tonnes per year).<sup>16</sup>

### 2.3.2 IUU catches

These catch estimates can be compared with the catches that China officially reports for its distant water fisheries, which can be done using two different approaches. The first is by relating our estimates to the catch that China reports to FAO, or more precisely, to the Chinese catch that are assigned (by China and/or the FAO) to all FAO Statistical Areas other than Area 61 (i.e., the Northwest Pacific, which also includes Japan, North & South Korea and the Russian Far East). On average, this was 368,000 t/year (see Figure 2.2), or 8% of the global Chinese distant-water catch estimated (Table 2.1), minus their average

<sup>16</sup> The uncertainty surrounding these catch estimates is relatively high (Table 2.1). This is an expected feature of our results, given the underlying data used. We do hope that the readers will not choose one of the extremes of the 95% confidence intervals that can be calculated from our results to support preconceived notions about Chinese distant-water catches (We remind the reader that 95% confidence intervals can be obtained by subtracting from, and adding to the mean the standard deviation times 1.96). Rather, we insist, it is the midpoint estimate that should be used for reference

catch in Japan, (North &) South Korea (Table 2.1) and the Russian Far East (an estimated 42,217 t/year). This leads to a hypothetical reporting rate of 8%, which is too low, because, as mentioned above, the Chinese distant-water fleets report some of their landings as 'national catch' of the countries in whose EEZ they operate (e.g., as joint ventures or charters), or as catch of the countries providing them with flags of convenience.

We can derive a first-order estimate of potential IUU catches by Chinese vessels around the Africa region by comparing our distant water catch estimate (Table 2.1.) with the sum of Chinese FAO reported catches for this area and the Chinese component of joint-venture/charter/reflagging catches reported by African countries (Table 2.2). This suggests that around 2.5 million tonnes per year of the estimated Chinese distant water catch of about 3.1 million tonnes per year in the African region may be unreported. However, it is feasible that a fraction of these unreported catches may be spatially misreported as Chinese FAO area 61 (NW Pacific) catches, and hence partially account for the massive over-reporting from this area (see Figure 2.2).

**Table 2.2: Potential Chinese IUU catch for the African and West Asian region for 2000-2011 (FAO areas 34, 47 and 51), based on contrasting the estimated Chinese distant-water catches in that region (as derived from Table 2.1) with Chinese FAO data and African joint venture/charter and re-flagging data reported by African countries as 'national' catches but deemed Chinese catches based on our definitions.**

Region (FAO area)	Average annual catch 2000-2011 (1000 t)			
	China DWF <sup>1</sup>	China FAO <sup>2</sup>	Joint-venture/charter/reflagged catch <sup>3</sup>	Difference (= Chinese IUU catch) <sup>4</sup>
North West Africa (34)	2648 ± 62	17.8	457.4	2172.8
South West Africa (47)	293 ± 15	2.4	38.8	251.8
East Africa <sup>5</sup> (51)	181 ± 59	8.7	13.7	129.9
West Asia <sup>6</sup> (51)	165 ± 66		32.6	128.1

<sup>1</sup> Based on the present study, see Table 2.1;

<sup>2</sup> Landings from FAO areas 34, 47 and 51 reported by China to FAO;

<sup>3</sup> Catches by Chinese vessels under joint-venture/charter/reflagged arrangements and reported by the host country to FAO as 'national' catches;

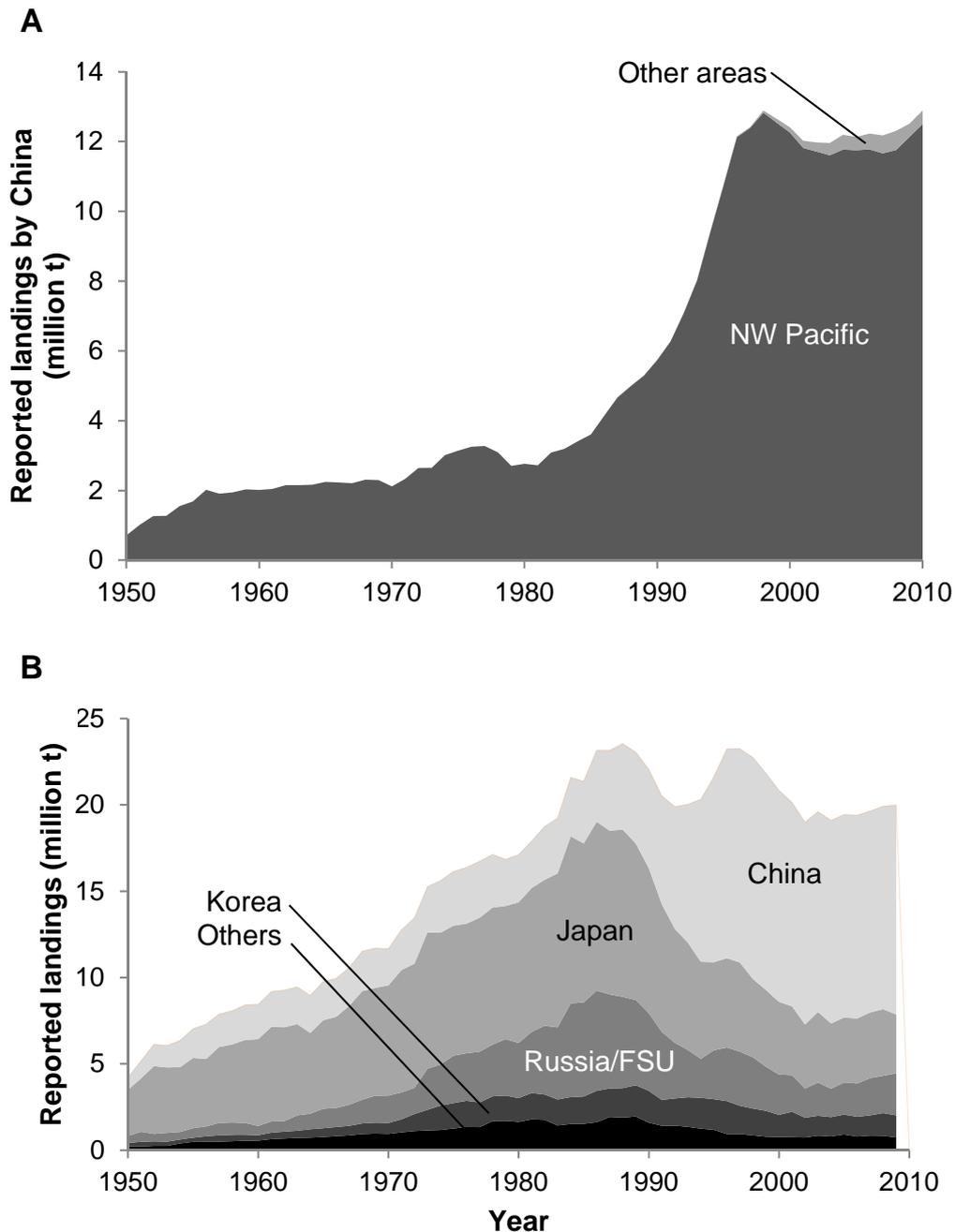
<sup>4</sup> Derived as the subtraction of FAO China and Joint-venture/charter/reflagged from the Chinese distant-water catches as reported in Table 2.1;

<sup>5</sup> From eastern South-Africa to Sudan including the islands of the Western Indian Ocean;

<sup>6</sup> North Western Indian Ocean from the Red Sea (Saudi Arabia), the Gulf of Aden, Persian Gulf and Gulf of Oman to the Maldives and western half of India.

Source: *Sea Around Us Project*

**Figure 2.2: Marine fisheries landings as reported by FAO on behalf of its member countries.**



**A:** Marine fisheries catches of China, as reported to FAO, featuring the small (13%) correction to the flat domestic catches decreed by the Chinese central government since 1998, which followed on a non-credible increase from the mid-1980s to 1998 (Watson and Pauly 2001), and the equally non-credible low catch that China reports for its distant-water fisheries, i.e., outside of FAO area 61 (Northwest Pacific). **B:** Catches of the four major fishing countries and 'others' in the Northwest Pacific (FAO area 61), illustrating how radically the trajectory for the Chinese reported catch differs from that of the other countries in its region.

**Source:** *Sea Around Us* Project (modified from Pauly and Froese, 2012).

The other approach is to rely on the official data in Table 2.3, which suggest that the distant-water fishery catch of China from 2000 to 2010 was about 1.1 million tonnes per year, i.e., less than one quarter of our estimate.

**Table 2.3: Official catch of the Chinese distant water fishery, 2000-2010 (based on successive editions of the China Fishery Statistical Yearbooks (2000-2010), with provincial data aggregated to all-China level.**

Year	Total catches (t)	Landing in foreign countries (t)	Landing in China (t)	Number of vessels
2000	865,182	-	490,604	1,719
2001	884,878	-	482,614	1,897
2002	1,096,445	243,948	705,476	2,043
2003	1,157,653	370,373	792,049	1,997
2004	1,451,074	471,799	997,459	1,996
2005	1,438,084	516,282	717,141	2,122
2006	1,090,663	482,228	403,774	1,599
2007	1,075,151	487,422	588,540	1,496
2008	1,083,309	457,240	629,069	1,462
2009	997,226	497,813	479,413	1,815
2010	1,116,358	511,014	605,344	-
Mean	1,114,184	448,680	626,498	1,815

Source: *Sea Around Us* Project

Our knowledge of the disposition of this catch is also spotty. For the West African region, we inferred (from an interview we conducted with a Chinese national who did a tour of duty with a Chinese fishing firm operating in that region, and from scattered newspaper accounts) that roughly one-third is landed locally, one third (mainly invertebrates and high value fish) goes to the international markets (notably the EU and Japan), with the remaining third (mostly medium and large demersal fish, and shark fins) going back to China.<sup>17</sup>

Occurrence of IUU fishing has been positively correlated to governance capacity of affected countries (Agnew *et al.*, 2009). Several organisations for governance of high seas fisheries are performing poorly (Cullis-Suzuki and Pauly, 2010) and likely have a limited capacity to collect information on IUU activities. The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), with a mandate to manage fishing in the Southern Ocean, includes many countries with high governance capacity (Österblom *et al.*, 2010), score high on several performance measures (Cullis-Suzuki and Pauly, 2010) and have a relatively high capacity to detect IUU fishing. Despite these conditions, CCAMLR illustrates the need to include complementary information on IUU fishing from non-official sources. For example, four vessels associated with private Chinese companies have been officially blacklisted for IUU activities in the Southern Ocean (CCAMLR, 2009, 2012). However, reports from the licenced fishing industry suggest that several additional vessels from the same companies were actively engaged in IUU fishing in the region (COLTO, 2003). Court proceedings show that these vessels were operating in well-coordinated fleets, where the least valuable vessels could be sacrificed for the benefit of the fleet (ITLOS, 2002). Such coordination has implication for economical analyses investigating the incentives for engaging in IUU fishing (Sumaila *et al.*, 2006).

### 2.3.3 Landed value

The uncertainty of the landed value of the estimated catch presented in Table 2.4 is also rather high. The midpoint estimate for catch value of all catches of the Chinese distant-water fisheries is €8.93 billion, i.e., nearly 10% of the estimated global total ex-vessel

<sup>17</sup> This person prefers to remain anonymous

landed value of the world catch of roughly €92.4 billion (Sumaila *et al.*, 2007). However, this percentage is elevated because our estimate of the Chinese distant-water landed value includes IUU catches, while the Sumaila *et al.* (2007) estimate of the ex-vessel value of global marine catch does not. Yet we now know, from the work of Zeller *et al.* (2006a, 2006b, 2007, 2008, 2011a, 2011b) and contributions in Zeller and Harper (2009) and Harper and Zeller (2011), that the catches reported by countries to the FAO, which formed the basis of the Sumaila *et al.* (2007) estimate, are systematically underestimated, by about 30-50% in developed countries, and more than 100% in many developing countries. The estimates of gross revenues or landed values of the Chinese distant-water fleet presented in this study should eventually allow further economic analysis, such as determining the profitability of the fleets involved, the level of impact through value lost to 'host' countries, and the food security implications for these countries as a result of Chinese distant-water fishing activities.

**Table 2.4: Estimated annual landed value by vessel types of the Chinese distant-water fleet from the Exclusive Economic Zones of maritime countries and territories (and adjacent high sea areas), 2000-2011.**

Region	Landed (ex-vessel) value (€ billion / year)					Total (± st. dev.)
	Miscellaneous boats	Bottom trawlers	Purse seiners	Tuna longliners	Tuna purse seiners	
West Africa	0.03	4.74	0.70	0.03	0.01	<b>5.52 ± 1.40</b>
East Africa	0.01	0.24	0.02	0.03	0.09	<b>0.39 ± 0.13</b>
Asia (excl. Japan and South Korea)	0.06	1.40	0.16	0.07	0.20	<b>1.89 ± 0.53</b>
Japan and South Korea	not estimated by vessel type <sup>1</sup>					<b>0.17 ± 0.03</b>
Oceania	0.01	0.04	0.00	0.23	0.28	<b>0.55 ± 0.10</b>
Central and South America	0.06	0.22	0.04	0.02	0.00	<b>0.34 ± 0.11</b>
Antarctica	0.002	0.00	0.06	0.00	0.00	<b>0.06 ± 0.04</b>
Total	--	--	--	--	--	<b>8.93 ± 1.53</b>

<sup>1</sup> The standard deviation of the catch value for Japan and South Korea was estimated based on the coefficient of variation of the catch value without Japan and South Korea.

Source: Sea Around Us Project



## ANNEX I – ESTIMATION OF THE CATCH BY CHINESE DWF<sup>55</sup>

This annex shows the procedure used to estimate the catch by Chinese distant-water fleets outlined in section 2. The procedure consists essentially of 5 steps:

### Step 1 - Establish the presence of Chinese vessels in the EEZs of maritime countries

While, in most cases, access agreements providing the legal background of Chinese operations in the waters of a given country could not be found, there was ample documentation on the presence of Chinese vessels, ranging from newspaper articles to websites, and from scholarly articles to academic research theses. This was ascertained via a comprehensive search of online and hardcopy literature by the authors and colleagues, using resources in Arabic, Chinese, Danish, Dutch, English, French, Italian, Japanese, Korean, Norwegian, Portuguese, Spanish, Swedish and Russian. This yielded, for the period considered here (2000-2011), over 430 sources with positive records, covering 74 countries and their overseas territories, as well as the High Sea in the Atlantic, Indian and Pacific Oceans (Figure 2.1). Although it is widely recognized that absence of evidence is not evidence of absence, we are fairly confident that if we missed countries whose EEZ hosted Chinese vessels in 2000 to 2011, these operations were limited in scope, as they left no 'shadow' in the mass media of the countries in question, nor on the website of Chinese firms or government entities.<sup>56</sup>

### Step 2 – Establishing the number of vessels involved

In numerous cases the documents used to establish the presence of Chinese vessels in countries' EEZs or adjacent high seas areas also indicated the number of boats (or their catch and/or catch composition). Thus, using the documents that attested to the presence of Chinese vessels in a given country, and the less abundant documents which estimated their numbers and other information on the world's maritime countries (notably their nationally reported catches, see [www.fao.org](http://www.fao.org) and [www.seararoundus.org](http://www.seararoundus.org)), we conducted 'country scoring' sessions. We ran 5 such scoring sessions of several hours each, where at least 10 of the *Sea Around Us* project members (and mostly co-authors of this contribution), many of who have lived in or worked on these respective regions, reviewed the available evidence for a country, and then independently 'scored' that country in terms of the number (and type) of vessels expected to be operating in that country's or territory's EEZ using a blind scoring approach.<sup>57</sup> The individual estimates thus generated were averaged, and their standard deviation (st. dev.) was computed, as also required for the Monte Carlo simulations. The entire procedure was run twice, once for the period 2000 to 2005, and once for 2006-2011.

<sup>55</sup> This annex is based on work performed by a team from the *Sea Around Us* Project, i.e.: Daniel Pauly, Dyhia Belhabib, William Cheung, Andrés Cisneros-Montemayor, Sarah Harper, Vicky Lam, Yinying Mai, Frederic Le Manach, Ka Man Mok, Liesbeth van der Meer, Soohyun Shon, Wilf Swartz, U. Rashid Sumaila, Reg Watson, Leilei Zhai and Dirk Zeller. Henrik Österblom from the Stockholm Resilience Centre, University of Stockholm, also contributed to this section.

<sup>56</sup> In cases where our team's expert opinion suggested that Chinese vessel were likely present, despite absence of evidence (e.g., Nigeria), we estimated a very conservative number of vessels, and hence a very low catch.

<sup>57</sup> The high number of project members involved in this estimation process (always >10; including many of the authors of 'catch reconstructions' [*sensu* Zeller *et al.*, 2007] in the region of interest), and the independence of their individual estimates prior to computing the averages was to allow for the 'wisdom of crowd' effect to work, i.e., the ability for a large number of informed estimates to converge to the correct values, as they will do when they are truly independent (see Surowiecki (2004) for a detailed account, Galton (1907) for the first well documented case, and Herzog and Hertwig (2009) for recent methodological improvements). The approach is closely related to the 'Delphi method' (Linstone and Turoff, 1975), which, from rather shady beginnings (Dalkey and Helmer, 1951), graduated to a method ideally suited for fisheries research (Zuboy, 1981), in which it has been frequently applied for estimating fisheries catches (see e.g., Miller and Davidson, 1984; Pauly, 1986), or various biological parameters of fish (see, e.g. Barrett, 2009).

Step 3 – Estimating annual catch per vessel type

The annual catch per vessel type was derived, along with its confidence interval, from the data assembled by Lam *et al.* (2011) for their study of fishing costs of global fishing fleets. Specifically, the data available for 5 types of gear/boat combinations (miscellaneous gear vessels [including gillnetters, non-tuna longliners, squid jiggers etc.], bottom trawlers, non-tuna purse seiners, tuna purse seiners and tuna longliners) were assembled and analysed, yielding 5 distributions of mean annual catch (Table A.I.1; Figure A.I.1). Also, the mean ex-vessel price (€/t) and its likely range was estimated from the ex-vessel price database documented in Sumaila *et al.* (2007) and the average catch composition of the above 5 gear/vessel type combinations (Table A.I.1).

**Table A.I.0.1: Fishing vessel statistics used for estimating the catch of Chinese distant-water fisheries. Prices are in 2005 real value.**

Gear/boat type	Catch per vessel (t/year)			No. of vessels	Ex-vessel price (€/t) <sup>5</sup>		
	Mean	Min.	Max.	N	Mean	Min.	Max.
Miscellaneous gear boats <sup>1</sup>	221	5	1,211	52	1,493	439	3,617
Bottom trawlers <sup>2</sup>	1,256	16	26,135	269	1,501	466	3,965
Purse seiners (non-tuna) <sup>3</sup>	6,230	14	40,500	62	915	83	2,723
Tuna longliners <sup>4</sup>	284	57	1,277	21	2,195	724	5,183
Tuna purse seiners <sup>4</sup>	4,640	30	7,762	40	2,326	697	5,913

<sup>1</sup> Including gillnetters, non-tuna longliners, squid jiggers etc. Targeting medium- and high-value fish (but not tuna), and squid (for squid jiggers);

<sup>2</sup> Targeting mainly demersal fish and bottom invertebrates, notably shrimp;

<sup>3</sup> Targeting mainly small to medium fish, such as sardine, herring, and mackerels;

<sup>4</sup> Targeting tuna, but with a large amount of by-catch, notably shark, in the case of longliners;

<sup>5</sup> Converted from real (2005) US\$, using an IMF exchange rate for 2005 (<http://www.imf.org>; accessed 25 April 2012).

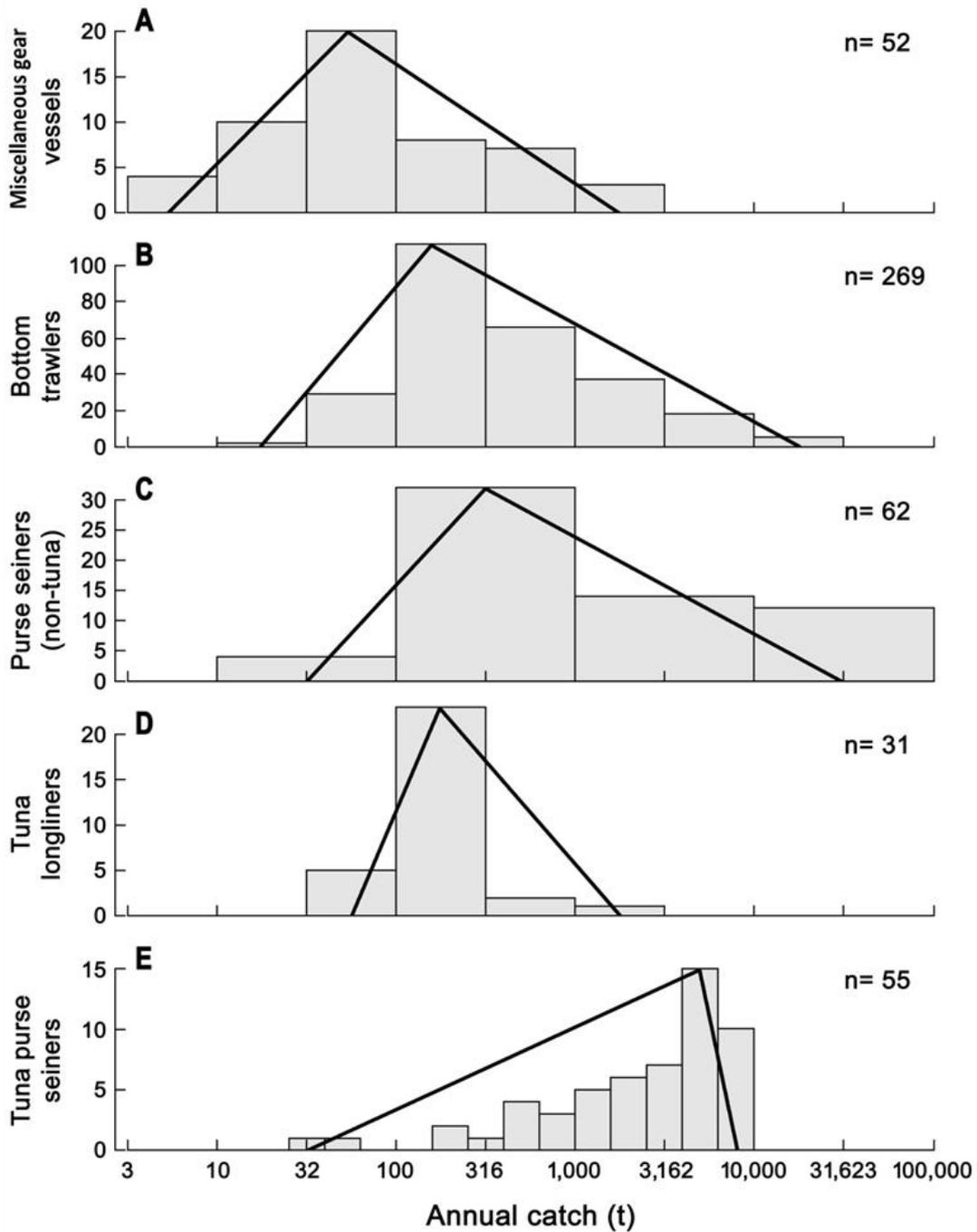
**Source:** *Sea Around Us* Project. Extracted from the database documented by Lam *et al.* (2011)

The distributions of the mean annual catch rates (Figure A.I.1) and ex-vessel price ranges (Table A.I.1) for each vessel type are rather wide; this is mainly because the catch and catch values of these vessels were not standardized for the size and other characteristics of the vessels. This should have a magnifying effect on the confidence intervals of the final, aggregate estimates of catch and catch value, but not on their midpoint estimates (i.e., means), at least not if they are normally distributed (as is the case here, see below).

Step 4 – Estimating Chinese distant-water catch by period and country

The annual catch of Chinese distant-water fleets, by country or territory (except Japan, and North & South Korea, see below), was estimated by multiplying the number of vessels of a given type (as obtained in Step 2) by the annual catch for that vessel type (as obtained in Step 3), by country and year, and adding up the catch of the different vessel types to regional sums. A similar procedure was applied to the catch value through multiplication of the catch tonnage taken by each gear/boat combination by the corresponding ex-vessel prices in Table A.I.2. Note that we do not deal here with discarded catches.

Figure AI.1: Distribution of annual catch (in tonnes) by the 5 gear/vessel types common in Chinese distant-water fisheries.



Note logarithmic scales, and the broad overlap of the five distributions, which tends to reduce the sensitivity of the overall results of this analysis from the country-specific assignments of vessel numbers to gear/vessel combinations. Based on vessel characteristics from multiple countries in the database assembled by Lam *et al.* (2011). The triangular distributions are those used for the Monte-Carlo simulations (see text).

Source: Sea Around Us Project.

***Step 5 – Estimating the global catch of the Chinese distant-water fleet and its uncertainty***

Following standard Monte Carlo procedures, step (4) was repeated 10,000 times, each with a different set of inputs drawn randomly from the distributions associated with the different parameters. The distribution of these 10,000 estimates was then used to calculate the standard deviation of the midpoint estimates of catch and catch values.

Due to their proximity to China, Japan and North & South Korea are known to host (legally and likely illegally) large numbers of Chinese vessels in their claimed EEZ waters. Thus, we treated these three countries separately as follows:

- For the Chinese fleet authorized to fish in the Japanese EEZ, we used the mean of the quota specified in Chinese-Japanese agreements (Japanese Fisheries Agency 2006, 2007, 2008, 2009a, 2009b, 2011, 2012) from the years for which they were available, and treated these as realized catch. We assumed that catch in the years preceding these quotas was the same as in the first year with a quota;
- For South Korea, we similarly assumed that the quotas issued by the Korean Fisheries Information Service (2012) were equal to the realized catch. We also assumed that the catch in the years preceding the issuance of these quotas were the same as in the first year with a quota; and
- For North Korea, which has only a very small EEZ on the side of its coast that faces China, we assumed that the catch by Chinese vessels is negligible. Hence, we do not mention North Korea further below.

Combined, the assumptions we made regarding the Chinese catches in Japan, South and North Korea, generated estimates (Table A.I.2) which are most likely conservative. We also assumed that Chinese vessels are not fishing in Taiwanese waters, which is why we excluded Taiwan from all further considerations.

**Table A.I.0.2: Authorized number of Chinese fishing vessels and their annual quotas by gear type in Japan and South Korea from 2000 to 2011.**

Year	South Korea				Japan			Total	
	N° of vessels	Annual catch (t)			N° of vessels	Annual catch (t) <sup>1</sup>		N° of vessels	Catch
		Bottom trawl	Squid jigger	Net		Bottom trawl	Squid jigger		
2000	2,086	52,686	4,141	20,893	655	68,859	4,141	2,741	150,720
2001	2,086	52,686	4,141	20,893	655	68,859	4,141	2,741	150,720
2002	2,086	52,686	4,141	20,893	655	57,859	4,141	2,741	139,720
2003	2,086	52,686	4,141	20,893	655	49,859	4,141	2,741	131,720
2004	2,086	52,686	4,141	20,893	655	42,859	4,141	2,741	124,720
2005	2,086	52,686	4,141	20,893	658	8,570	4,141	2,744	90,431
2006	1,968	48,402	4,141	20,449	636	8,256	4,141	2,604	85,389
2007	1,926	47,992	4,141	20,449	570	8,256	4,141	2,496	84,979
2008	1,836	46,701	4,141	19,647	508	8,000	4,141	2,344	82,630
2009	1,793	45,359	4,141	20,500	450	7,600	4,141	2,243	81,741
2010	1,686	43,357	4,141	19,991	408	6,600	4,141	2,094	74,089
2011	1,785	44,733	4,141	19,843	366	6,131	4,141	2,151	78,989
Annual mean	1,959	49,388	3,796	20,520	573	21,812	4,141	2,532	106,321

<sup>1</sup> For Japan, the total quota for bottom trawlers and squid jiggers combined was available for 2001-2004, and separately for 2005-2011. It was assumed that the quota for squid jiggers remained constant between 2001-2004, and adjusted the bottom trawler quota accordingly. We assumed the same catch for 2000 as for 2001.

**Source:** *Sea Around Us* Project. Based on Japanese Fisheries Agency (2006, 2007, 2008, 2009a, 2009b, 2011, 2012) and Korean Fisheries Information Service (2012). Values in italics are backward projections of first values in the series (see text).

High seas and Antarctica were dealt with differently than for other areas. We treated Antarctica, i.e., the area of responsibility of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR; [www.ccamlr.org/](http://www.ccamlr.org/) and [www.seaaroundus.org/RFMO/1.aspx](http://www.seaaroundus.org/RFMO/1.aspx), see also Figure 2.2 in section 2) as if it were a 'country', with its own estimate of vessel numbers of various types, and catch and catch values. For the other high sea areas, we assumed that the vessels reported as fishing in the 'high seas' of the Atlantic, Indian and Pacific Oceans were the same ones that were reported to fish, legally or not, in the EEZs of adjacent coastal states, or their territories. This avoids potential double counting, and will tend to make our results more conservative.