All Fish for China?

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Abstract In this paper we examine the effect of Gross Domestic Product (GDP) on the level of fish intake in China in comparison with the rest of the world. We also analyse the origin and destination of China's seafood products in order to understand the main patterns during the last decades. The results show that in the 1961–2011 period the rate of growth of the GDP in China doubled that of other developing regions, while the daily fish intake of China increased fourfold, making China the largest fish consumer in the world. Given the size and scale of China's role in production, consumption, and global transformation of seafood markets, China is shaping a new era of industrialization in the history of the fishing industry.

Keywords Economic growth · Global seafood supply · Marine social–ecological systems · Sustainability · China

INTRODUCTION

Wild fisheries and aquaculture in 2011 supplied the world with about 154 million tonnes of fish of which about 131 million tonnes were utilized as direct food for people (FAO 2012). Moreover, the global seafood supply has increased at an annual average rate of 3.1 % since 1961 (from 9.9 kg live weight equivalent per capita in the 1960s to 18.4 kg in 2009), while the world population has increased by 1.7 % annually for the same period (FAO 2010, 2012). Such an increase in fish supply was induced by the growing demand due to rising standards of living and prosperity in

developing countries (Hall et al. 2011). This growth in fish supply since 1985 was mainly based on the increase in aquaculture production, rather than wild-capture production that has levelled since then (FAO 2012).

Fish trade can bring a range of benefits (revenues from exports, job creation, healthier diet, etc.), but its potential impact on fish stocks, social equity, and economic development must also be considered to minimize negative impacts and promote sustainable development (McClanahan et al. 2013). Fish is also pre-eminent as an internationally traded animal source food. Seafood exports from wild fisheries and aquaculture in 2008 had a combined value of US\$102 thousand million (FAO 2010), an 83 % increase from 2000 (Hall et al. 2011). Fish and seafood products prices doubled in the last decade, which highlights in the case of capture fisheries increasing scarcity of wild species (Tveterås et al. 2012). This is because most of fishing vessels are competing for the same fish stocks and, hence, the more fish one catches, the fewer remain for others (Folke et al. 2011). Thus, the final outcome is a massive overuse relative to the fisheries management that would generate the greatest economic value from a given fishery (Antelo et al. 2012; Da Rocha et al. 2012).

Under this context, China's meteoric economic rise over the past three decades is an unprecedented 'growth miracle' in the economic history (Zeng 2010). The emergence of China as a new power in the world economy growing at an average annual rate of 9.5 % during the 2000–2009 period (World Bank 2013) highlights the need to analyse its strategies for growth and expansion in natural resources acquisition (Yao 2006; Zeng 2010; World Bank 2013; Haltmaier 2013). Its size, production capacity, consumer needs, competitive advantages, and large domestic market make China an exceptional actor in the global economic and geostrategic context, which has undergone very

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significant changes in recent years. Therefore, gaining a comprehensive understanding of different aspects of the Chinese seafood consumption is of a high relevance for efforts to maintain marine resources at sustainable levels (Fabinyi 2012).

Given that little (if any) research has been done on the Chinese seafood consumption, the objectives of this paper are two. a) to investigate the relationship between Chinese's Gross Domestic Product (GDP) and its level of fish protein intake as compared with other regions in the world, and b) to track the origin and destination of China's seafood products, in order to better understand the main patterns of this trade during the last decades.

The Role of China in the International Trade

As indicated in Fig. 1 the world global GDP, excluding China, amounted to US\$1030 thousand million in 1960 and to US\$8753 thousand million in 2011, multiplying by almost 9 in that period, despite the negative impact of the economic crises of the 1980s, 1990s, and 2000s. At the same time, China's GDP has increased from US\$51 thousand million in 1960 to US\$1250 thousand million in 2011, which is 25 times more than in 1960.

The development of GDP by region (Fig. 2) shows that the overall distribution of wealth creation has changed substantially during the last 50 years. Although North America, together with Europe, still accounted for the

majority of the global GDP, Asia excluding China (that accounted for 10 % of global GDP in 1961 and 20 % in 2011), and China (from 1.5 % of the global GDP in 1993 to 13 % in 2011) have become the main actors in the global economy.

Two historic and mutually reinforced transformations—the market reform and the urbanization process—have influenced China's economic expansion (Liu et al. 2002; World Bank 2013). Gradually, China has shifted from a closed, centralized, and command-based economy to a more open and market-based one (World Bank 2013). Rapid urbanization—the largest peacetime movement of people in history has transformed China from a rural, agricultural economy into an increasingly urban and economically diversified one (World Bank 2013). However, there are some signals revealing that these changes are not completed in China. In 2011, China's gross national income per capita of US\$4940 ranked 114th in the world, and more than 170 million people still live below the US\$1.25-a-day international poverty line. With the second largest number of poor in the world after India, poverty reduction remains a fundamental challenge (World Bank 2013).

The structural changes in the economy of China represent a crucial starting point to investigate the role of China in global fisheries. China has been responsible for most of the increase in world per capita fish intake, owing to the substantial increase in its fish production, particularly from

Fig. 1 Constant GDP over time (China vs. rest of the world). *Source* own elaboration from World Bank (2013)

Fig. 2 Constant GDP by regions. *Source* own elaboration from World Bank (2013)

aquaculture, despite a downward revision of China's production statistics for recent years (FAO 2012). Imports are also being fueled by robust domestic demand for species not available from local sources, leading China to become the third largest importer (in volume) in the world in 2011 (FAO 2012). Fish consumption in China has increased dramatically since the 1980s due to both the increase in nation's GDP and a corresponding substantial increase in citizens' real income, from ~5 kg per capita in the 1980s to 35 kg in 2010s, mainly based of aquaculture supply (FAO 2012).

Fisheries and aquaculture also provide livelihoods and income for million people engaged in the primary sector of fish production in 2010 (FAO 2012). According to Teh and Sumaila (2013), the number of direct and indirect employees in the Chinese fisheries sector was 42.4 million in 2010, which accounts for 17.7 % of the total employment of the fisheries sector worldwide.

MATERIALS AND METHODS

Countries and Territories

Although this study does not include information for every country in the world, it is globally representative since the 54 countries considered account for 95 % of the total seafood supply from fisheries and aquaculture as reported

in the Sea Around Us and FAO Databases in 2011 (FAO 2012). In addition, the 54 countries, which are grouped following the United Nations classification of macro-geographical (continental) regions, account for about 85 % of the worldwide volume of imports and 92 % of exports in 2010 (FAO 2012). Our analysis is based at the country level because countries are legally responsible for fisheries and aquaculture systems within their Exclusive Economic Zones (EEZs) and for their vessels on the High Seas according to the United Nations Law of the Sea Convention (UNCLOS). The 54 countries included in our study are summarized in Table 1.

Data Collection and Compilation

Data of GDP were gathered from the database World Development Indicators published by the World Bank.¹ In order to calculate the net supply of seafood products both globally and country-by-country, data on aquaculture production, fisheries catches (in all EEZs and the High Sea areas), imports and exports were considered. Data of catches were gathered from the FAO database FishStatJ,² which

¹ See <http://data.worldbank.org/indicator/NY.GDP.MKTP.CD>. As well known, the GDP at purchasers' prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products (World Bank 2013).

² See <http://www.fao.org/fishery/statistics/software/fishstatj/en>.

Table 1 Regions (and countries) included in the study

Geographical region	Countries
Africa (11)	Angola (AGO), Democratic Republic of the Congo (COD), Egypt (EGY), Ghana (GHA), Morocco (MAR), Namibia (NAM), Nigeria (NGA), Senegal (SEN), Sierra Leone (SLE), South Africa (ZAF), Tanzania (TZA)
Asia (18)	Bangladesh (BGD), Cambodia (KHM), China (CHN) ^a , India (IND), Indonesia (IDN), Iran (IRN), Japan (JPN), Malaysia (MYS), Myanmar (MMR), Pakistan (PAK), Papua New Guinea (PNG), Philippines (PHL), Republic of Korea (KOR), Sri Lanka (LKA), Taiwan (TAI), Thailand (THA), Turkey (TUR), Viet Nam (VNM)
Europe (13)	Denmark (DNK) ^b , France (FRA), Germany (DEU), Iceland (ISL), Ireland (IRL), Italy (ITA), Netherlands (NLD), Norway (NOR), Portugal (PRT), Russian Federation (RUS), Spain (ESP), Sweden (SWE), United Kingdom of Great Britain and Northern Ireland (GBR)
Latin America and the Caribbean (8)	Argentina (ARG), Brazil (BRA), Chile (CHL), Ecuador (ECU), Mexico (MEX), Panama (PAN), Peru (PER), Venezuela (Bolivarian Republic of) (VEN)
North America (2)	Canada (CAN), United States of America (USA)
Oceania (2)	Australia (AUS), New Zealand (NZL)

Source Pitcher et al. (2009) and FAO (2012)

^a Taiwan is not recognized as country by the United Nations and is included in China. ^b In Denmark we include both Faeroe Islands and Greenland. The United Nation country codes are written in parenthesis

provide information of catches, species and countries (in volume) (1950–2011). We also gathered data from FAO Global Aquaculture Production³ to collect aquaculture production data in volume and value from China (1950–2011).

In turn, for the analysis of the weight of China in world trade of fish products we used the database FAO Fishery Global Commodities Production and Trade (1976–2011),⁴ which reports data of imports and exports in volume and value by countries and species. Using these data allow us to calculate the net supply (catches in EEZs and High Seas, plus imports minus exports) of seafood products. This information is also combined with data on the evolution of China's population from United Nations (UN) Population and Vital Statistics Report.⁵

³ See <http://www.fao.org/fishery/statistics/global-aquaculture-production/en>.

⁴ See <http://www.fao.org/fishery/statistics/global-commodities-production/en>.

⁵ See <http://unstats.un.org/unsd/demographic/products/vitstats/>.

A key relevant issue lies in the origin and destination of seafood flows to and from China. Since FAO statistics do not report the origin and destination of these flows, it is not possible to know directly the main countries that trade with China. Hence, we built a database with information of the origin and destination of seafood flows from UN data CommTrade,⁶ which provides information on the number of countries, as well as fish, crustaceans and molluscs species that have been traded (either in volume or in value) from and to China.⁷

Some Criticisms to Chinese Statistics

Accurate and appropriate knowledge of fisheries and fishery resources, including the socio-economic aspects, is a prerequisite for design of sound policy-making and for responsible fisheries management and governance (FAO 2012). Determining the exact extent and patterns of catches and seafood consumption is fraught with difficulties (Fabinyi 2012). For example, in 2001 the fishery scientists Watson and Pauly (2001) presented evidence about the massive over-reporting of Chinese catches in its EEZ.

Chinese over-reporting of its domestic catches was evidenced by three factors. First, the major assessed populations of fish along the Chinese coast having been classified as over-exploited decades ago, while fishing effort continued to climb. Second, estimates of the so-called catch per unit of effort (based on official catch and fishing effort data) for domestic waters is constant during the 1980s and early 1990s, i.e., a period of continuous increasing fishing effort and reported catches, in contrast to survey data showing declining abundances. Third, catches per area are far higher than would be expected if they were compared with areas similar in oceanographic and production factors (Watson and Pauly 2001).

However, despite FAO's efforts, available fishery data are not fully reliable. The data are far from perfect in terms of coverage, timeliness, and quality. In other words, and in spite of the efforts made during the last decade, little progress has been made in opening the historical secrecy in Chinese fisheries data (Blomeyer et al. 2012). In this respect, it is important to highlight that we do not intend to report the exact volume of the seafood trade from and to China. Rather, we try to offer an improvement over what has been made and better understand the scale of the

⁶ See <http://comtrade.un.org/db/default.aspx>.

⁷ Including all species TARIC code 03 'Fish and crustacean, mollusc and other aquatic invertebrates', those who have undergone to some form of manipulation or treatment included in the TARIC code 16 'Meat, fish and seafood food preparations nes', and code 08142 'Flours and meals of fish, crustacean, etc., unfit for human (for further details, see the Electronic Supplementary Material).

Chinese fisheries sector. In a sense, the current paper can be considered as the starting point to further discuss about the role of China in global seafood markets.

RESULTS

The Chinese Domestic Catches and the Chinese Distant-Water Fishing Fleet

The East Asia marine ecosystem is probably one of the most productive fishing grounds in the world (Cheung and Pitcher 2008). However, there is lack of information concerning fishing effort and index of biomass. In the absence of official and publicly available information concerning direct fishing effort exerted on given fish stocks provided by FAO fishery statistics, reported catches could be used to represent a first reasonable proxy that allows us to know the impact of fishing to be quantified (Pauly et al. 2013). But catches should also be complemented with another index of abundance in order to avoid a probable misleading message to the scientific community (Pauly et al. 2013). In the case of Chinese's EEZ, this is an urgent task that the Chinese government needs to improve in the short time.

In spite of the limited information about the index of abundance currently available, most Chinese coastal fisheries are depleted (Mu 2006), while proportion of species of low trophic level and of immature fish that are exploited is increasing (Cheung and Pitcher 2008). This is partially due to the high excess of capacity as a result of the ineffective 'zero growth' policy of fishing vessels (Yu and Yu 2008; Blomeyer et al. 2012), the high level of pollution (Zhang et al. 2011) and the lack or poor regional funding and implementation of existing laws (Goldstein 2013).

The Chinese government has made an effort in the conservation of domestic fisheries resources through seasonal moratoria on fishing, vessel decommissioning, and alternative employment programs, though with positive and negative results (Mallory 2013). The ratification of the UNCLOS Convention by the Chinese government in 1996 also promoted the crisis of the Chinese domestic fishing industry due to the restrictions imposed adopted by third countries (Mallory 2013).

The activity of the Chinese fishing fleet was not restricted to their national waters and the fleet expanded to operate worldwide (Pauly et al. 2013). As pointed out by Blomeyer et al. (2012) and Pauly et al. (2013) the activities and catches of the Chinese offshore fleet are almost completely undocumented and unreported.

Since 1985 China has also made a substantial effort to develop its offshore fishing fleet, while restricting at the same time the development of coastal and inshore fisheries in response to over-exploitation and substantial reduction

of China's offshore fishing grounds (Xue 2006). Initially, the strategy of China was simply to export its fishing capacity to the still productive foreign fishing grounds (Pauly et al. 2013). As a result, China now has the largest international fishing fleet in the world (Mallory 2013). To illustrate, in 2005 it was reported that China had 90 firms engaged in international fisheries with 1700 vessels operating throughout the world (Xue 2006). In a recent study, Pauly et al. (2013) conservatively estimated that while the Chinese government over-reports its domestic catches (Watson and Pauly 2001), the country substantially under-reports both the size and catches of its distant-water fleet around the world. The annual average catches reported by China for the 2001–2011 period were 4.6 million tonnes per year outside its domestic fishing grounds and their economic value was estimated at an annual ex-vessel value of almost US\$9 thousand million, which is 12.5 times higher than that of catches officially reported by FAO (Pauly et al. 2013).

Fish Protein Intake and Household Income: Why China is Different?

Since the Second World War, the countries' economic policies have been designed to promote GDP growth. It was supposed that an increase in per capita income would affect human well-being positively (Arrow et al. 2004; Oken et al. 2012). Not in vain, it is quite common that economists investigate the effects that GDP have in a given economic sector in order to test its contribution to the human welfare.

Figure 3 depicts how the global fish daily intake followed a slight upward trajectory since 1976. In the case of China, it experienced a prominent fall in the 1976–1983 period after which the daily fish intake in China has shown an exponential growth, which help to decrease the difference between the global fish intake and the Chinese fish intake until 1993.

Once examined the development of GDP in China and in the rest of the world, it is worth to investigate the effects of such increase on the evolution of fish demand. Put differently, we examine whether the Engel curve⁸ that emerges follows, or not, a similar pattern for China and for other regions in the world. This also allow us to assess the potential impact of China and other region's GDP growth on fish intake in the future, and if this impact will be of the same magnitude across different regions of the world.

Data on Chinese DGP per capita and Chinese fish intake per capita allow us to describe the (quadratic) Engel curve given by

⁸ The Engel curve describes how household expenditure on a particular product varies with the level of household income, other variables being equal.

Fig. 3 Net seafood supply and fish intake (China vs. rest of the world). *Source* own elaboration from FAO (2012)

$$D_{CH}(x) = 270\,802x^2 - 21\,430x + 493.45 \quad (R^2 = 0.9196), \quad (1)$$

where D denotes fish intake per capita, x the level of GDP per capita, and subscript CH stands for China.⁹ Analogously, for the rest of the world (denoted by subscript RW) we have the Engel curve

$$D_{RW}(x) = 8 \times 10^8 x^{4.7264} \quad (R^2 = 0.8707), \quad (2)$$

which is largely different from that reported for China in (1) as illustrated in Fig. 4. Figure 4 shows that GDP per capita in the rest of the world increased from US\$551 in 1961 to almost US\$1844 in 2011. However, the per capita fish intake has only increased from 0.05 g capita⁻¹ day⁻¹ in 1961 to 0.066 g capita⁻¹ day⁻¹ in 2011. On the other hand, GDP per capita in China increased from US\$76 to US\$664, but in this case the daily fish intake increased threefold, from 0.03 g capita⁻¹ day⁻¹ in 1961 to 0.09 g capita⁻¹ day⁻¹ in 2011.

In a sense, seafood products can be considered as a luxury good for Chinese population, but a necessity good for the rest of the world. Moreover, Fig. 4 also indicates that, as happens with many other products, the Engel curves for fish protein intake show a saturation point and the gradient tends to reduce at high-income levels (high GDP per capita levels here). This result suggests the

existence of an absolute limit to the expenditure on fish protein intake regardless of GDP per capita increases.

A more detailed analysis disaggregating per capita GDP and daily intake of fish by region allows us to highlight the growing role of China in the global fish protein intake. Figure 5 shows that Asia (excluding China), Latin America, and China had a lower per capita daily fish protein intake if compared to other world regions in the 1961–2008 period. Only North America presents values (0.02 g capita⁻¹ day⁻¹) close to those observed in Asia (excluding China), Latin America, and Oceania. In this context, Asia, Europe (and even Africa) showed the highest per capita fish protein intake in the world in 1961.

The results in Fig. 5 allow us to highlight a series of patterns of per capita GDP and fish protein intake per capita based on the following Engel curves:

$$D_O(x) = 536\,760x^2 + 52\,985x + 789.95 \quad (R^2 = 0.7364), \quad (3)$$

$$D_{NA}(x) = 836.46e^{44.784x} \quad (R^2 = 0.8867), \quad (4)$$

$$D_{LAC}(x) = 397\,741x^{1.8463} \quad (R^2 = 0.5295), \quad (5)$$

$$D_E(x) = 9 \times 10^6 x^2 - 921\,026x + 24\,228 \quad (R^2 = 0.5888), \quad (6)$$

$$D_{AS}(x) = 10^{11} x^{7.0951} \quad (R^2 = 0.6661), \quad (7)$$

and

⁹ The determination coefficient is in parenthesis.

Fig. 4 Relationship between GDP per capita and fish protein intake (China vs. rest of the world). *Source* own elaboration from World Bank (2013) and FAO (2012)

$$D_{AF}(x) = 93.619e^{15.736x} \quad (R^2 = 0.5622), \quad (8)$$

for Oceania (O), North America (NA), Latin America and the Caribbean (LAC), Europe (E), Asia (AS), and Africa (AF), respectively. The equations stated in (3)–(8) allow us to derive the following patterns. First, when the GDP of any region of the world rises there is an increase of fish protein intake per capita in such region, which means that fish is not an inferior good but a necessity one. This seems quite reasonable in countries where the development of economic strategies focused on fisheries is recent, in particular due to their previous strategies based on other primary sectors. Although with different paths, all regions experienced a GDP growth coupled with an increase of fish protein intake. For example, the North American GDP increased by 2.8 in the studied period and the daily per capita fish protein intake rose by 1.56; while in Latin America the GDP increased by 6.36 and its fish protein intake rose by 1.54; in Oceania the GDP increased by a factor of 4.8 and the fish protein intake was doubled. In Europe the GDP grew 9 times but the per capita fish protein intake increased by only multiplying by 1.3. Finally, the African GDP was multiplied by 2.42 while the annual fish protein intake increased by 1.7. In the case of Africa, the pattern described is not so much the increase in GDP that is causing the increase of fish protein intake but other factors such as the high availability of access to fish on its coasts, the secular tradition of consuming fish and/or

lack of alternative employment by coastal populations who find fishing the main source of economic livelihood and socioeconomic support in coastal communities (Bené et al. 2010).

Second, we need to consider that the starting point of per capita GDP and fish intake in each region of the world was quite different. At the beginning of the period, the per capita GDP in developed regions (Europe, North America, and Oceania) was obviously substantially higher than in developing ones. However, the per capita fish intake showed a different pattern of that showed by GDP, since Europe presented the highest fish protein intake in the world by more than doubling the rest of developed regions (North America and Oceania).

Third, the evolution of China in relation to other developing regions in the world shows that at the beginning of the 1961–2011 period both the per capita GDP and fish intake have a similar pattern as in other developing regions, except for Africa. However, during the 1961–2011 period the per capita GDP of China doubled that of other developing regions while the per capita daily fish intake of China was multiplied by almost four. This means that, except for Africa, fish is considered a necessity good in developing countries, but a (normal) luxury good (at least so far) in the case of China. Such an increase of fish intake in China is explained not only by the growth of the catches of its distant-water fishing fleet (Pauly et al. 2013) but also to the large increase of aquaculture production (FAO 2012).

Fig. 5 Relationship between GDP per capita and fish protein intake per capita by regions. *Source* own elaboration from World Bank (2013) and FAO (2012)

Fourth, it is noteworthy that the above represents a simplification of what happens when trying to provide a global perspective, since the absence of official statistics at regional or local level worldwide precludes a study with greater level of disaggregation. Other factors may lead to a given population consume more or less fish in relation to others (Bené et al. 2010; Fabinyi 2012; Oken et al. 2012). For example, the current anthropologic, social, cultural, and economic characteristics of fishing communities around the world are often given and shaped due to the complex interaction between the human dimension and marine coastal resources (Folke et al. 2011; Fabinyi 2012; Oken et al. 2012; Villasante et al. 2012).

Likewise, factors such as different levels of marine governance (Coll et al. 2013), the diverse regulations of trade (FAO 2012), the distinct patterns of fish consumption (Oken et al. 2012) and consumer preferences (Wang et al. 2008), the degree of specialization in primary economic activities such as aquaculture and fisheries sectors (Norman-López 2009), the proximity and availability of access to fishery resources (Brewer et al. 2009) or cultural issues (Urquhart et al. 2013) are all aspects that will undoubtedly be taken into account at the time not only to understand the dynamics of fish protein intake but also to make recommendations in the field of fisheries governance and public health.

The Role of China in the International Seafood Market

China has a surplus trade in fisheries products. Exports amounted to US\$13.2 thousand million in 2010 while imports only to US\$6.2 thousand million. Both imports and exports have increased over the past few years, except in 2009 when they fell, before picking up again in 2010 (WTO 2012).

With respect to imports, at the beginning of the 1990s Japan and USA clearly dominated the worldwide market of seafood products with more than 3906 million tonnes in 1990 and a total value of US\$16 thousand million. However, two decades later, China's growth broke Japan's and the USA's hegemony to finally become a key player in the international seafood market in 2005 as the main importer (by volume) and exporter (by volume and value) of seafood products as illustrated in Fig. 6.

Unlike what happened in the 1990s, currently several developing countries such as Republic of Korea, Russian Federation, and Thailand are in prominent positions in the world ranking of world exporters (Fig. 6). Despite the enormous growth in volume of imports from China, both USA and Japan continue concentrating more than 27 % of the total value, and China ranked 5th in the global ranking of exporters (in volume), which emphasizes the fact that

Fig. 6 Imports and exports (both in volume and value) from top countries in the 1990–2010 period. *Source* FAO (2013a, b)

China's growth strategy has been based primarily on the imports of low-value species to provide food for their aquaculture industry. In fact, the main category of imported fishery products is 'Fish meals, nei', which concentrates more than 36 % of the total import volume (53 million tonnes) in the 1976–2010 period.

In 1990, Japan, USA, France, and Spain were the major exporters of fish by volume, while USA, Thailand, Denmark, and Norway accounted for more than 27 % of the total value of exports in that year (Fig. 6). Other world leading exporters (by value) are Norway and Thailand with US\$6.5 and 6.2 million, respectively, in 2008. Of the ten world's leading exporters (in volume) in 2008, 40 % come from Asian countries (Fig. 6). However, at present China occupies the first place in the world ranking of leading exporters (in value), with approximately 3 million tonnes in 2008 and more than US\$10 thousand million per year.

Mapping Flows of Seafood from and to China

Here we examine the origin and destination of the main fishery products in China. Our goal is not to provide an

exact figure of the seafood trade (either in volume or in value) of China, but rather to assess a reasonable estimate of China's seafood flows on the basis of which to identify key steps requiring further examination.

The value of Chinese imports experimented a spectacular growth from US\$196 million to 6.4 thousand million in the 1990–2010 period. Figure 7 illustrates the main commercial partners or customers of China, showing that the origin of imports that in 1990 was concentrated in only three countries (Peru, Russian Federation, and Democratic Republic of Korea) accounted for over 70 % of the total value of China's imports from around the world.

This concentration on a limited number of fish suppliers changed significantly in 2010, where both the quantity of imports and the number of countries increased and diversified considerably. The number of countries that export to China changed from only three countries in 1990 to ten countries in 2010. The vast majority of these are developed countries: USA, Norway, Japan, Canada, Netherlands, South Korea, and New Zealand. An analysis of the type of seafood products imported by China shows that frozen fish (TARIC Code 0303) of low economic value in seafood

Fig. 7 Origin and destination of China's seafood products in the 1990–2010 period. *Source* own elaboration from UNComtrade (2013)

markets ranked first with an annual value of US\$4.4 thousand million in 2010, which accounts for 68 % of total value of imports (UNComTrade 2013).

In the 1990s China expanded its fishing operations not only to West Africa (Pauly et al. 2013) but also to South America's fishing grounds, which are considered one of the richest regions in marine biodiversity (Villasante and Österblom 2013). The Chinese strategy is based on the development of a highly diversified composition of seafood supply by harvesting or importing a high volume of forage fish (Antarctic krill and Peruvian anchoveta), which have a key role in the dynamics of the oceans (Naylor et al. 2000), but with low ex-vessel value to feed China's aquaculture. In addition, the Chinese strategy also consists in harvesting or importing a low volume of high valuable commercial species (Argentinean hake and Patagonian toothfish) to satisfy the increasing fish consumption in the country (Clarke 2009; Hanson et al. 2011).

In addition, since the 1950s the majority of Peruvian anchovy catches were destined for the production of fish-meal for the European and U.S. markets of poultry and pigs and, more recently, for aquaculture production. In fact, the recovery of the Peruvian anchovy population in the 1990s coincides with the boom of aquaculture growth in Asia together with the growing number of aquaculture species (Milena Schreiber, pers. comm.). Since then, the traditional destinations of Peruvian anchoveta were replaced by China and other Asian countries, currently accounting for over 75 % of the Peruvian anchovy exports (UNComTrade 2013). In this context, it is important to highlight the trend of increasing prices for fish and oil meal in international

seafood markets, which in turn can increase the pressure on the stock and put at risk the sustainability of the Peruvian anchovy fishery (FAO 2012).

Figure 7 also indicates the large growth of Chinese exports which have increased 12 times from 1990 to 2010 (from US\$1 thousand million to US\$12.7 thousand million). The most important destinations of exports from China in 1990 were Japan and USA. In 2010, Japan and USA are still the two main customers of fishery products from China, multiplying by 6 and 10 times, respectively, the value of their purchases with respect to 1990.

As in the case of seafood imports, the magnitude and diversity of customers of Chinese seafood exports increased enormously. While in 1990 only Japan and USA imported for more than US\$100 million in seafood products from China, in 2010 China exports more than US\$100 million in seafood products to 22 countries. As observed in the pattern of seafood imports, exports of frozen fish (TARIC code 0303) ranked first with an annual value of US\$13 200 million in 2010, which accounts for 93 % of total value of Chinese exports (UNComTrade 2013).

As a result, China has become the world's largest fish producer and exporter and it has increased significantly its fishery imports, partly as a result of outsourcing. Chinese processors import raw material from all major regions, including South and North America and Europe, for re-processing and export. Thus, the total throughput of the processing industry in China increased from 1 million tonnes in 2001 to 8.1 million tonnes in 2011 worth US\$2000 million and US\$2600 million, respectively

(Chinese Yearbook 2001, 2012). This means that China's manufacturing industry is becoming a major world power because it multiplied by 8 its production in volume. Despite these global statistics, details of the fish reprocessing industry (i.e., from imported materials) are not well known due to a lack of publicly available data (Clarke 2009).

DISCUSSION

GDP Growth and Social Development: How Far China Can Go?

People's lifestyles in China have changed remarkably over the last 50 years due to economic development with higher income levels, accentuated urbanization and other socio-economic benefits (Liu et al. 2002; Feng et al. 2009a). At the same time, the rising prices of primary commodities, food, and energy have decreased consumption levels and increased the poverty levels in urban areas. In fact, despite the general increase in wages, consumer price inflation (5.4 % in 2011) became a pressing social and economic issue (WTO 2012).

Recent studies (Wen and Chen 2008; World Bank 2013) also showed that the economic growth of the Chinese economy is generating enormous environmental impacts. For example, China is now the world's largest energy consumer and green house gas emitter (World Bank 2013). China's social development has been equally impressive. Since the reform and opening up in the late 1970s, China has solved the problem of adequate food and clothing for over 200 million impoverished people (Zhang et al. 2011), and accomplished the UN Millennium Development Goal of eradicating poverty and hunger ahead of time (WTO 2012). However, this fast economic improvement had also negative impacts on its fish production in recent years. For example, in 2010 aquaculture production in China suffered losses of 1.7 million tonnes (worth US\$3.3 thousand million) due to disease outbreaks (295 thousand tonnes), natural disasters (1.2 million tonnes), and pollution (123 thousand tonnes) (FAO 2012).

Some environmental progress has been made, shifting focus from a pollution control policy to a combination of pollution control and ecological protection (Zhang et al. 2007). Nevertheless, if China continues with the rate of GDP growth during the next decades, the potential impacts on the planet would be irreversible due to the environmental damage to ecosystems (Wen and Chen 2008).

A natural question emerges from the described patterns: Can China continue growing at this rate? Eichengreen et al. (2011) state that empirical evidence from other studied countries suggests it cannot. In fact, the Chinese economy

has already slowed down in the past couple of years but even under the most probable scenario of under-estimation of economic performance of China, it is expected that the country will continue to have the highest GDP growth rate in the world during the next years. China is also projected to surpass the Euro Area in 2012 and the USA in a few more years, to become the largest economy in the world (Johansson et al. 2012).

The Role of China in Global Seafood Supply

How does all the above-mentioned affect fishery resources? For the first time, China is the largest fish producer (including wild catches and aquaculture production) in the world. Driven by growing GDP and an increase in the diversity of fish available, the per capita fish protein intake in China has increased dramatically (FAO 2012). China, the world's largest fish producer and exporter, has also significantly increased its fishery imports, partly as a result of outsourcing. The Chinese processors import raw material from all major regions, including South and North America and Europe, for re-processing and exporting higher economic value of seafood products (Clarke 2009; FAO 2012).

In a recent study of long-term global growth prospects, Johansson et al. (2012) estimated that in spite of population projections over the next 50 years will be particularly rapid in Asia and Eastern European countries, the oldest cohort of the population in these regions will also be more than doubling, and even quadrupling in the case of China. The potential consequences are a very large fall in the Chinese saving rate of around 40 % of GDP to 2060. And this will probably help to at least maintain the fish protein intake in the cohort of the population with the highest preference to eat (cheaper) fish.

In addition, the massive investments of the Chinese government in education will contribute to the increase of average years of schooling of the adult population, which will also mean more educated, higher productive workers and, likely, more sophisticated (and informed) consumers when eating fish. This ultimately would mean that million Chinese middle class would consume more luxury types of seafood than before.

China can meet its food supply goals by increasing reliance on international markets, establishing stable trading relationships with the rest of the world, and by exploiting its agricultural comparative advantages (Jikunn et al. 1999). In fact, China's nutritional status has improved significantly over the period, especially since the 1978 economic reforms.

However, the higher levels of seafood consumption within China have also undesirable environmental impacts for other regions (Gerth 2010), which unmask the magnitude of the interactions between local needs and global

drivers (Walker et al. 2009). Increasing levels of seafood consumption in China have the capacity not only to significantly impact on marine resources across the planet (Fabinyi 2012), but also to convert itself as one of the main drivers of stocks decline (Clarke et al. 2007).

Recent events related to Chinese's consumers have brought the issue of food safety to the attention of the Chinese public and the Government, who are taking actions towards improving deficiencies of the system (Broughton and Walker 2010). The events also evidenced that Chinese's consumers are far from knowing a complete understanding of the value chain of seafood products in the country (Clarke 2009). The consumption of fish products in China is affected by people's traditional customs and consumers' income level. Usually more consumers eat at home, preferring to purchase whole fresh fish or primary processed fish products (Feng et al. 2009b). However, seafood consumer's awareness of fish products indicates that the majority of consumers are anxious about food safety diseases (Wang et al. 2008).

China is Shaping a New Era of Fishing Industrialization

The high demand of the Chinese's consumption of goods and services is promoting a new era of industrialization under the modern capitalism. This new era is characterized by the exceptional increase of production and the growth of productivity rates of the Chinese economy. The rapid growth of the country has also been accompanied by large investment and progresses in health, education, science, and technology (World Bank 2013).

Given the size and scale of China's role in the production, consumption, trade, and global transformation of seafood markets, here we conjecture that China is shaping a new era of industrialization in global fisheries in which the seafood markets are local and globally interconnected under highly complex anthropological, ecological, institutional, and socio-economic factors. In the past, fishing strategies of countries and companies (namely North America, Europe, and Japan) have focused primarily on increasing their catch and expand their fishing-operation areas. This was done by providing greater technology into their fleets.

However, we are currently witnessing the creation of a new fishing industrialization era that began in the middle-1980s and intensified in the 1990s and 2000s. This new fishing era present a series of specific characteristics. First, while the scale and magnitude of the increase of Chinese seafood supply is enormous (FAO 2012), the increase of catches outside its EEZ is also very large over time (Pauly et al. 2013; Villasante et al. 2014). Second, the exponential growth of the Chinese seafood trade and fish protein intake is also unique in the history of fishing industry. Third, this

rapid seafood supply is happening under a global stagnant trend of fish catches for the first time after World Wars I and II, with an unprecedented increasing number of over-exploited and collapsed fish stocks over time. Fourth, the paradigm of exploitation of fisheries is now more focused on the ecosystem approach and marine conservation rather than the increase of catches and employment (Hilborn 2007). Fifth, the traditional economic strategies of fishing companies to only access fishing grounds were complemented (or even replaced) towards market-oriented strategies. In these new strategies the innovation and competitive advantage consist in controlling the channels of commercialization through vertical integration and/or logistic networks with fishing and other companies (food, services, machinery, energy, etc.). The fishing companies that participate in this process have not necessarily homogeneous characteristics in terms of production needs, seafood markets, and regulations of trade.

It is important to highlight some limitations of our study. First, the lack of good fishery statistics for China represents a major problem to evaluate the desirable and undesirable effects of China in global fisheries. Second, we analyzed the seafood supply of the Chinese fisheries sector, but we did not include all the economic subsectors such as the canning and transformation sectors which are in fact acting as a global distributor of seafood products. Third, we particularly addressed on the main patterns of the Chinese seafood supply to satisfy the increasing demand of its aquaculture and fishing industries. However, it is also necessary to examine the economic strategies of the key actors (countries and fishing companies) who are establishing seafood public and private agreements with China to better understand how the Chinese growth is (or is not) generating desirable and/or undesirable outcomes in their national fishery resources, industries and coastal populations. Fourth, there are other relevant dimensions related to the Chinese seafood markets such as the development of the marine governance, traceability system, and how China addresses the impacts of climate change on their seafood value chain, which are also highly important to examine for the future of global fisheries. These issues open an avenue for future research.

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