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The changing face of global fisheries—The 1950s vs. the 2000s

Reg A. Watson [a,*], Daniel Pauly [b]

[a] Institute for Marine and Antarctic Studies, University Tasmania, Taroona, TAS 7001, Australia
[b] Sea Around Us Project, Fish. Centre, University of British Columbia, Vancouver, BC, Canada V6T 1Z4

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ABSTRACT

Spatialized catch and effort data, representing the world's marine fisheries in the 1950s and the 2000s are presented in form of cartograms, i.e., global maps in which the surface areas of continents are made proportional to the magnitude of the annual catches and fishing effort by their fleets. This is complemented by an analysis of the flows of seafood between the continents in whose waters the fish were captured, in the 1950s and the 2000s, and the continents where fleets originated. Such broad-brush analyses of temporal changes and trade patterns are helpful to understand major trends of fisheries, which, are increasingly dominated by scarcity of fish, and competition, notably off the coast of West Africa, and in newly accessed polar waters.

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1. Introduction

Modern humans have exploited marine resources since we emerged as a species (see, e.g., [1]). When harsh conditions threatened the small population of early humans, coastal marine resources allowed them to survive [2]. But since then, human have thrived, and have strongly impacted marine, and particularly coastal species and ecosystems [3], especially in the last 150 years, which saw the industrialization of fisheries [4]. Notably, global fishing patterns have strongly changed since the Food and Agriculture Organization of the United Nations published its first collection of global fisheries landings in the mid 1950s [5]. Fishing fleets have been challenged by stock collapses [6], while empowered by improved technologies and logistic support. Many fisheries are now multinational enterprises (see, e.g., [7,8]). Since the adoption, in the late 1970s/early 1980s of exclusive economic zones (EEZ) by maritime countries [9], the roving fleets of distant-water countries have had to negotiate coastal zone access arrangements. Though maps of where fishing occurs have always accompanied this activity, these documents were seen as commercially valuable, and were not willingly disclosed, as fishing is, of course, a very competitive business. Trying to see the big picture has therefore been extremely difficult, while increasingly necessary to examine potential impacts on marine ecosystems, and those commercial and non-commercial plants and animals embedded in them. Additionally, the impacts of climate change will challenge our ability to plan and mitigate [10].

The *Sea Around Us* project, which began in 1999 ([11,12]), has used publicly available fisheries landing statistics, to map where global landings were taken on a fine-scale [13,14]. Subsequently, this same project mapped global fishing effort as well [15–17]. These mapped databases allow fishing activity to be associated on a spatial scale of use to policy makers and ecologists alike, especially when the data they presented were refined to allow a breakdown by fishing country and associated fishing gear. Such data breakdowns allowed for comparison with oceanographic and satellite data such as primary productivity [18–20], as one of the most potent measures of fishing intensity is how much of local primary production is appropriated in form of fisheries catches. Mapping global fisheries catches has also been valuable in detecting irregularities, such as hidden or inflated catch reporting, as was the case for China [21]. Studying and understanding the trajectory of changes in the marine environment induced by anthropocentric activities, and particularly fishing, is important to formulating marine policy. Here changes that have occurred since global catch statistics began to be published annually in the 1950s are explored.

2. Material and methods

2.1. Global catch and effort data

The fishing landing data were sourced from the *Sea Around Us* project [12,13], as compiled from a range of sources including the FAO fisheries database, supplemented by regional datasets, and augmented in a few cases, with reconstructed datasets, e.g., from [22]. It is quality-checked, and mapped to a system of 30′ by 30′ spatial cells using a rule-based approach based on original spatial information, the access of fleets to coastal waters (through reports or explicit access agreements), and the distribution of the reported fish marine taxa, as inferred from geography and

* Corresponding author. Tel.: +61 3 6224 8574
E-mail address: rwatson@ecomarres.com (R.A. Watson).

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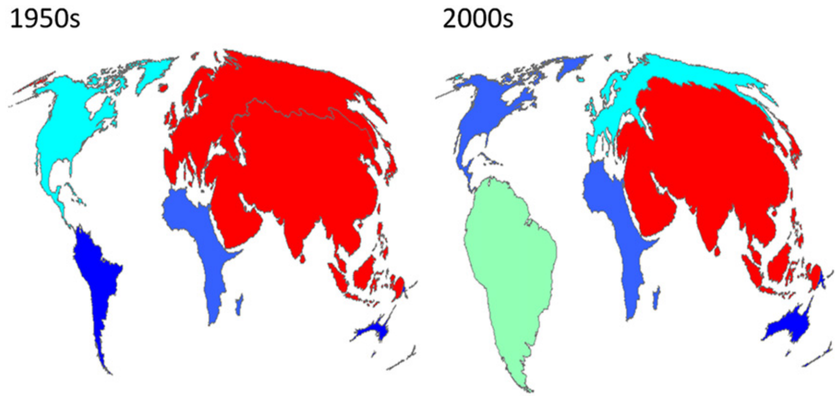

Fig. 1. Cartogram where the inflation or deflation of the area of a continental region is based on global fisheries landings averaged for the 1950s and the 2000s (see text for data sources and processing).

Table 1
Annual fisheries landings (kg per capita) and effort (Watts per capita) for fleets of continents in the 1950s and the 2000s.

	Landings		Effort	
Fleets	1950s	2000s	1950s	2000s
Europe	16.2	19.8	2.3	6.4
Asia	6.1	9.8	0.4	2.4
Africa	5.6	6.1	0.6	1.3
S. America	8.2	44.1	0.7	1.8
Oceania	7.8	39.2	1.4	31.0
N. America	15.5	16.2	1.0	3.9

habitat affinities in FishBase [23] for fishes, and SeaLifeBase [24] for invertebrates [25].

Fishing effort data was sourced from the *Sea Around Us* project [17]. This data was standardized and collated, based on engine power (Watts) and fishing days [16] from a range of public domain sources including the FAO's Coordinated Working Party on Fisheries Statistics (FAO-CWS), and European Union Common Fishing Policy Statistics (EU) for non-tuna fishing, the Secretariat of the Pacific Community (SPC), International Commission for the Conservation of Atlantic Tunas (ICCAT), Inter-American Tropical Tuna Commission (IATTC), Indian Ocean Tuna Commission (IOTC) and FAO's Atlas of Tuna and Billfish for tuna fishing (FAO-Atlas), and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) for fishing effort in the Antarctic region. The resultant harmonized global dataset was mapped to 30′ by 30′ spatial cells using a variety of processes, depending on spatial information present in the original sources. The data from SCP, ICCAT, IATTC, IOTC, FAO-Atlas, and the CCAMLR data provided spatial information, whereas, the FAO-CWS and EU statistics did not, and thus required further spatial modelling. Fishing effort was first apportioned to fleet-accessible ports, then mapped to spatial cells in adjacent waters using a two-scale gravity-model, based on the value of mapped landings taken from surrounding waters based on modelled landings from the *Sea Around Us* project's databases.

2.2. Cartogram

Global fisheries (landings and effort) data by continents were used to produce cartograms, i.e., maps where the land area of each continent was made proportional to some interesting quantity (here: catch weight and fishing effort). For this, ESRI's ArcMap 10 Cartogram Geoprocessing Tool Ver 2 [26] was used.

3. Results and discussion

3.1. Global landings

The global distributions of fisheries landings in the 1950s and early to mid-2000s are shown in Fig. 1.

Here, the area of continents is distorted by the share their fleets take of the global total. As can be seen in the 1950s, Europe and Asia dominated fisheries landings, while South America, Africa, and Oceania had relatively small catches. By the 2000s, massive changes have occurred: Europe's share had considerably shrunk, Asia was more dominant; and South America, and the fisheries for Peruvian anchoveta (*Engraulis ringens*) on its west coast, produced a large share of global landings. North America's share had dwindled, while Oceania's share had remained more or less constant.

On a per capita basis, the increases in landings between the 1950s and the 2000s in South America and in Oceania were more evident (Table 1).

Per capita increases in Europe and North America had not kept pace with those elsewhere, and this is the reason why they have become, with Japan, major importers of seafood [27].

As the catches from the world's oceans are ultimately related to solar-supported primary productivity in marine ecosystems [20,28,29] it is decidedly finite, and overall, global catches show signs of diminishing [21]. The highly mobile nature of global fleets, and competition for the rights to access the comparatively richer inshore areas now protected by exclusive economic zone declarations, has meant, that fleets dynamically compete on a global basis for their share of ocean production. Perverse subsidies can exacerbate matters by maintaining fisheries even when they are no longer profitable [30,31]. Many areas of the world's oceans are now fully exploited [17,20]. Foreign fleets are forced to move on once landings diminish.

It is worth examining how the flow of ocean production, manifested by fisheries landings, has changed since the 1950s. Table 2 shows the percent flow from each ocean basin to the fleets based in global continents. Here, one can see that in the 1950s, the powerhouse of fisheries were the European fleets in the northern Atlantic, and the East Asian fleets in the Pacific, which jointly accounted from nearly 2/3 of the flow of fisheries landings.

By the 2000s, landings were now more than three times annually what they were in the 1950s. By then, however, Europe's share of global fisheries production had halved, with a substantial portion now taken from the Indian Ocean by Asian fleets, and from the Pacific, by fleets from South America. Fleets from Asia, and China in particular, are now active in coastal African waters [32], while European fleets have also had to derive more and more

Table 2
Comparison of average percent of annual catch flows from ocean basins to fleets of continents in the 1950s vs. the 2000s. In each pair of numbers the first refers to the 1950s and the second to the 2000s. Flows over 10% appear in bold.

Fleets	Africa	Asia	Europe	N&C America	Oceania	S America	Total (x 10^3 t)
Antarctic		–/0.09	–/0.05	–/0.01	–/0.02		–/137
Arctic			0.08/0.01	0.02/-			23/10
Atlantic	4.33/5.13	0.13/0.62	**33.28/14.17**	**11.39**/4.35		1.26/2.58	11,677/21,405
Indian	0.72/0.51	4.94/**11.43**	–/.31	–/0.01	0.11/0.16		1,338/9,910
Mediterranean	0.28/0.46	0.40/0.61	2.55/0.91				748/1,577
Pacific		**31.30/32.35**	2.42/2.63	3.76/5.59	0.32/1.34	2.70/**16.64**	9,387/46,683
Total (× 10^3 t)	1,236/4,872	8,519/35,946	8,883/14,416	3,515/7,938	100/1,218	920/15,332	23,173/79,722

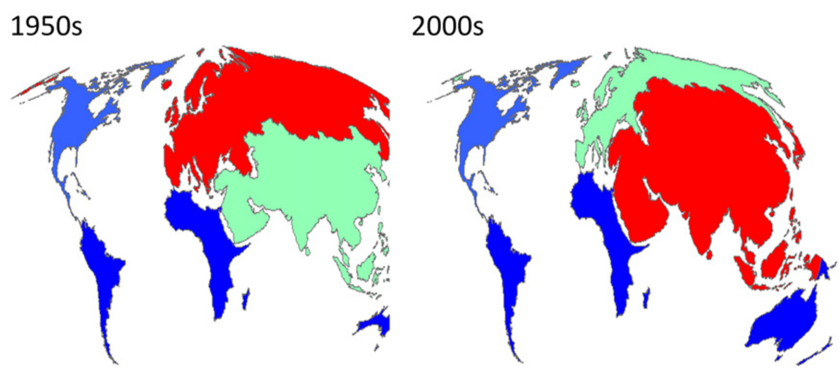

Fig. 2. Cartogram where the inflation or deflation of the area of a continental region is based on global fishing effort (annualized kilowatts) for the 1950s and the 2000s (see text for data sources and processing).

of their landings from the Atlantic areas bordering Africa [33]. Overall, the share of production taken from the Atlantic has been reduced, while that from the Pacific has increased. Distant-water fishing fleets now operate in more and more remote locations, notably in the southern hemisphere [17,19], all the way to the slope and shelf of the Antarctic continent [34].

3.2. *Fishing effort*

The global change in fishing effort is somewhat similar to that of fisheries landings, but there are important differences (Fig. 2).

As with fishery landings, the dominant fleets (based on the average deployment of vessel power) in the 1950s, originated from Europe and Asia. Since then, there has been an extraordinary increase in the relative power of the fleets from Asia. Though all fisheries fleets have expanded during this time, it is the huge increase in the larger vessels, especially purse seiners, pursuing oceanic tunas that have been most dramatic [17].

Looked at on a per capita basis, the capacity of the fleets from all continents has increased (Table 1), with most fleets increasing by 2–3 times since the 1950s. This is indicative of the highly competitive nature of global fisheries, and because fishing now occurs in increasingly remote locations, requiring greater processing on board, and greater vessel endurance. The deployment of large and high platforms of modern tuna purse seiners, augmented by helicopters, and the latest satellite data, has become more common. Some of the increase in the power of European fleets would undoubtedly have derived from the subsidized construction of huge trawlers, which could not be accommodated in the European waters, and now fish elsewhere.

Fisheries have, overall, moved southward since the 1950s [17,19], and the shelf and the slopes around the Antarctic continent have been reached [34], there in great interest in developing fisheries in the thawing Arctic [35]. In addition, continuing an age-old tradition, fleets from Europe, and now Asia, especially China, have become more and more active along the African coast [17,32,33] which can pose equity questions [36,37]. Recently, there was much controversy in southern Australia, after a 142-meter long, originally-Dutch, 'supertrawler' was invited (and then un-invited), after years of negotiation, to exploit Greenback horse mackerel (*Trachurus declivis*) and other pelagic fishes, which, due to a range of factors, including reportedly a change in distribution through ocean warming, were no longer viable for local fleets to target. Around the world, similar marine resources, deemed to be 'under-harvested', will receive more and more scrutiny by roaming global fleets. One common understanding related to the declaration of exclusive economic zones in marine areas, is that resources that are not harvested by national fleets in these areas, should be made available for harvest by foreign fleets. For all fisheries management agencies, this is a time for increased vigilance. They must not simply focus on issues relating to their own resources, but track carefully those of their region, and indeed those of a global nature. Changes wrought through climate change will alter the level and distribution of ocean catch potential [38]. More than ever, it is necessary to look at changes in the big picture, and act on the policy implications of their major trends.

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