Fisheries Centre

The University of British Columbia

Working Paper Series

Working paper # 2005-01

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Year: 2005

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CONSTRUCTION, SPATIAL AND TEMPORAL APPLICATIONS

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Abstract

We describe the first effort at creating a global ex-vessel fish price database, which is required for understanding the economic behaviour of participants in the world's fisheries. We demonstrate potential applications of the database by linking it to a spatially defined catch database, which makes it possible to attach landed values to species in both time and space. This is the first database available publicly where interested members of the public, researchers and managers can easily find and access ex-vessel prices of the world's major commercial fish species. Preliminary results indicate that the average real price of a number of species have declined between 1950 and 2002. The estimated landed value of fish globally, in year 2000 dollars, was about US$24 billion in 1950. It increased steadily to about US$90 billion in the early 1970s, reached a peak of US$100 billion at the end of the 1980s, and declined to about US$80 billion in 2000. The top 15 fishing countries cumulatively account for 79% of total real landed value, with Japan leading, even though the value of its landings has been declining.

Introduction

The lack of adequate and appropriate information about both the human and natural systems of fisheries has often been cited as one reason for the problems in efforts to sustainably manage these valuable natural resources (see e.g. Pontecorvo, 1988 and 2001). Price information is clearly one such type of information, since it is an important variable in determining fishing behaviour.

Global fisheries statistics are available from only very limited sources. The main source of these data is the United Nations Food and Agricultural Organisation (FAO). The FAO publishes processed and product fish prices (see www.fao.org), but not ex-vessel prices, i.e., the prices that fishers receive when they sell their catch. For analysing fisheries management and economics, ex-vessel prices are clearly more relevant, since these are the prices that motivate commercial fishers to go fishing.

The new global ex-vessel price database described here will enable researchers to extend their studies of global fisheries from landings reported in weight to those based on landed values. This will enhance the ability of researchers to determine and isolate the local, regional and global economic and social impacts of different management policies.

Currently, a number of price databases for fish and fish products exist but are widely scattered and incomplete. They are generally not available in the public domain and are therefore very difficult for researchers to retrieve. We tackled these two problems by working with our international partners to pull together existing but scattered data into a global database. A rule-based decision process allowed missing prices to be estimated, regional, and global prices to be calculated. The database is available freely on the internet (www.seaaroundus.org).

Combining the Sea Around Us project (SAUP) catch database (Watson et al., 2004), the price database described herein, and consumer price index (CPI) data, we derive estimated real landed values spatially in cells of ½ degree of longitude by ½ degree of latitude for each year from 1950 to 2002, for all of the world's marine ecosystems and claimed exclusive economic zones (EEZ).

By making information on landed values from the ecosystems and EEZs of the world readily available, we intend to lay a solid foundation for various types of social and economic analysis of fisheries globally. For instance, with such information, researchers can proceed to address issues such as: where do the landed values from an ecosystem go? Who are the stakeholders, and what portion of the total landed value accrues to each of them? In addition, this tool will make it possible to make better predictions of the economic impacts of fisheries failures, fisheries closures and of the creation of marine protected areas.

Methods

The method consists of (i) raw data collection and (ii) filling the gaps in the raw database using a rule-based approach.

Data collection, compilation and preliminary analysis

We relied mainly on secondary data, the goal being to add value by taking the data already available, but widely scattered in the grey literature of many different countries, to a higher level. We concentrated our efforts on collecting and compiling data for the major fishing nations in each of the six large regions of the world as defined by the FAO.

In this way, we developed a database that covers the major fisheries of the world, while putting in place a database structure that will allow further inclusion of data for additional countries, taxa and years as we they become available.

The six FAO regions are: (i) Africa; (ii) Asia; (iii) Europe; (vi) North America; (v) Oceania; and (vi) South and Central America plus the Caribbean. Countries within each region were sorted according to the total landed values of all fish, using catch data from the SAUP catch database and 1997 US ex-vessel prices to approximate the true landed values. We then targeted our data collection effort on the countries that collectively contributed about 80 - 90% of cumulative landed value. We thereby focused our efforts on the smallest possible number of countries that would allow us to account for the majority of fisheries in each region.

The current time horizon of the database is 1950 to 2002. It should be noted that 1950 is the year that the FAO started collecting and compiling global fish catch data. Hence, many analyses of global fisheries begin with this year (see e.g., Pauly et al., 1998).

The first step in our data collection effort was to identify available sources of price data, including FAO (2001) and FAO-Globefish, the statistics office of the Organisation for Economic Co-operation and Development (OECD), the European Commission, Fisheries and Oceans Canada, the US National Marine Fisheries Service, Statistics Norway, the Southeast Asia Fisheries Development Centre (SEAFDEC). We also widely searched the internet and published literature (e.g., Anon. 2002a,b, 2003a,b and 2004). The second step was to contact our partners around the world who helped locate data in their particular regions, mainly in the form of grey literature.

Ex-vessel prices were usually calculated from reported landed values and landings obtained from national sources. A significant part of the work consisted of matching the scientific names of species and species groups to their common names in different countries, and making these consistent with the SAUP catch database naming system.

To allow comparison, we converted local currencies into US$ for all years using the International Monetary Fund database of currencies (IMF 2005). We were careful to check the data to ensure consistency of price trends for each species, and identify errors in data entry and reporting. Where the reason for the detected inconsistency in data was not obvious, we contacted the originator of the data for clarifications.

Filling the gaps: A rule-based approach

The price database described above was used with an interpolation process to ensure that all catch records in the SAUP global catch database (Watson *et al.* 2004), regardless of taxon, country and year, were assigned prices.

We began with what can be thought of as a three dimensional matrix of price data (i.e., a cube), with the three dimensions representing taxa (all fisheries taxa), years (1950-2002) and countries (world-wide). Each cell in the matrix represents the price for a given taxon in a given year in a given country. Initially, most of the cells were blank because we did not have raw price data for many taxon-year-country combinations.

The interpolation process began by computing an overall weighted (by catch) average price from all taxa, countries and years, using the raw data that we had available. This average overall price was then assigned to all cells in our matrix that did not already have a price assigned. The result of this first step was a complete matrix of data, with raw data in cells where raw prices were available, and the global weighted average in every other cell.

In subsequent steps, new average prices were computed to try to obtain what we expected to be more accurate estimates for each cell. For example, the second step involved taking the average price across all countries and taxa, but for the specific year in question. Subsequent steps then calculated prices at more specific levels of taxonomy (by ISCAAP groups, order, family, genus and species) within a given country.

We used a system of penalties as a measure of the uncertainty or 'quality' of each data element. The raw prices had a penalty of zero. Each estimated price was assigned a penalty depending on (1) how far it was extrapolated from the range of years for which true prices are provided, (2) whether it was based on taxa that are markedly dissimilar from the taxon whose price is being estimated, and/or (3) whether it was based on a cross-country average rather than an average within the country in question. Whether the algorithm left a given price in place or replaced it depended on the total penalties assessed; it only replaced the price in a particular cell as the process proceeded if the penalty for the newly computed price was lower than the penalty on the previous price. At each step in the interpolation process, the penalty was documented. In this way, all catch records in the global database were matched with the most specific and relevant record in the price database or weighted averages thereof when several prices were available.

The end result was a full matrix of prices for all taxa in all countries and all years. The original raw data were left as they were in the original database, while all other cells were filled with estimated prices of varying specificity. The source of the price (raw data, or a particular step in the interpolation process) and its associated penalty was also recorded for every cell in the matrix.

Results and Discussion

Ex-vessel prices

Raw data

The raw data in the SAUP/Fisheries Economics Research Unit (FERU) database consists of 31,675 observations of prices covering the years from 1950-2002 in 35 countries and 875 taxa. The unweighted mean price per tonne for the observations is US$2,354. Tables

1-3 summarize the distribution of price records in the raw data by country and region, by taxonomic groups, and by year.

Table 1 demonstrates that each region of the world is represented, even though the developed world is where we have most data records in the raw data.

We see in Table 2 that all major fish and invertebrate groups are represented in the raw data. The representation here is better than in the case of the regions, which is beneficial for the development of our database because there is increasing evidence that fish prices are becoming more and more global as prices of traded fish continue to converge on the global fish markets.

Table 3 documents that, in general, more raw price data are recorded in recent than in earlier years. Note that only two years are covered in the last period of the database, namely, 2000-01, and not 5 years as in other periods.

Estimated price database

Figure 1 plots the real prices of a number of key species groups from the database. This shows a downward trend in real price over time for a number of species groups. This is contrary to an earlier price trend reported by Sumaila (1999), which analyzed trends in only (actual) U.S. fish prices for highly aggregated data, at the level of ISSCAP groups.

Landed values

To examine landed values of fisheries, we multiplied our prices by landings found in the SAUP database. Total real landed values from the world's fisheries (in constant 2000 US dollars) was about US$24 billion in 1950, increased steadily to about US$90 billion in the early 1970s, then increased more slowly to a peak of US$100 billion at the end of the 1980s, and started to decline to about US$80 billion in 2000 (Figure 2). The peak in landed values corresponds to the peak observed in total catch volumes in the mid 1980s (Watson and Pauly, 2001).

The value of small pelagic fisheries increased from US$7 billion in 1950 to US$30-40 billion in the 1970s and 1980s, and then declined to about US$25 billion in 2000. The value for demersal fisheries increased in value from US$10 billion in 1950 to a peak of US$33 billion in 1987, but then declined to US$25 billion in 2000. The value of tunas and swordfish increased steadily from US$2 billion in 1950 to US$10-12 billion in the 1970s and 1980s, then decreased to US$8-9 billion in the 1990s. Shrimp, squid, lobster and crab values all increased more or less steadily throughout the period.

The top five landed-value-producing EEZs in 2001 were those of Japan, the Russian Federation, mainland China, USA and Peru (Figure 3).

Real landed values from the top 15 fishing countries from 1950-2001 cumulatively accounted for 79% of total landed value. Japan alone had 36% of the total landed value over the entire period, more than five times as much as the landed value of the next top country. In 1960, Japan accounted for half of the total global landed value. At its peak in 1977, Japan’s landed value was US$46 billion, but this started declining in the late 1970s, reaching US$13 billion in 2000. As would be expected, Peru shows sharp peaks and troughs in landed value caused by fluctuations in the anchoveta fishery. The USSR's landed value increased from 1960 through the 1980s, but then the Russian Federation's landed value fell off sharply in the early 1990s, presumably because of economic issues relating to the fall of the USSR, and not just its dissolution, and distributed its fleet among former USSR republics.

Mapping real landed value

The spatialized landed values presented in this paper were averaged for each 10-year period to create decadal maps of real landed values per km^2 per year. Figure 5 presents three examples of these decadal value maps, which show the spatial distribution of landed values in the world in 1950, 1970 and the 2000. As such, they permit the location of landed values within ecosystems or management jurisdictions. While the values are plotted for spatial cells of 30 minutes of longitude by 30 minutes of latitude, we scaled them as real value per sq km to make them consistent. Concentrations in catch value can be seen in the productive coastal areas of Europe and Asia, as well as along areas of major upwelling such as the western coast of South America. By the 1980s, the areas with high values per area expanded particularly in Asia, but also along the Chilean coast where large quantities of anchoveta were taken. By 2000, there was a contraction of the high value areas. The spatial extent of fisheries increased over the years studied. Between the 1970 and the 2000 there was a general reduction in landed values, especially, in the more northerly fishing grounds.

Concluding remarks

We have shown in this paper that it is possible to develop a reasonably sound global ex-vessel fish price database by combining available data with an innovative rule-based algorithm. We have also demonstrated how such a database can be applied to address interesting fisheries questions and problems. Since this kind of database can only continue to be useful by updating and improving it through time, we encourage the fisheries research community, government fisheries institutions, NGOs and all interested parties to explore it, scrutinize it, and send the authors feedback on how best to improve it.

The database will serve as a research tool for analysing fisheries policy issues at the local, national and global levels. The tool will thus support the implementation of the broad principles of, for example, the Canada Oceans Act (see www.dfo-mpo.gc.ca/index.htm), the FAO Code of Conduct for Responsible Fisheries (www.fao.org), and the Johannesburg Summit on marine resource sustainability (WSSD 2003).

To make the database even more useful, we plan to develop it further to include fishing costs in the next round of our research effort. In this way, we will provide the remaining half of what is needed, i.e., the costs of fishing, to determine the economic rent from a given fishery.

Acknowledgements

We thank Yajie Liu, Eny Buchary and Louise Teh for research assistance. We would also like to thank the Environment Project of The Pew Charitable Trusts, Philadelphia, for their funding of the Sea Around Us Project.

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Table 1: Data records by country and regions of the world.

Region	Country	Number of records	Region	Country	Number of records
North America	USA	15186	Asia	Japan	1193
	Canada	2696		Indonesia	922
	Mexico	127		Philippines	305
Europe	UK	2338		Korea Rep	250
	Denmark	1616		Thailand	152
	Greece	1028		Brunei Darsm	92
	Italy	753		Malaysia	76
	Norway	731		Turkey	68
	Iceland	653		India	49
	Finland	267	South America	Brazil	1225
	Portugal	239		Chile	317
	Ireland	237	Africa	Namibia	187
	France	183		Mauritania	57
	Spain	179		South Africa	22
	Germany	145		Morocco	7
	Sweden	99	Oceania	Australia	96
	Netherlands	84			
	Poland	68			
	Belgium	28			

Table 2: Data records by taxon (species groups).

Taxon	Number of records
Demersal	16781
Small Pelagic	3687
Clam and Oyster	2731
Tuna & Swordfish	2423
Lobster and Crab	1896
Shark and Rays	1311
Miscellaneous	1135
Shrimp	1025
Squid	686

Table 3: Data records by year.

Period	**Number of records**
1950-54	1600
1955-59	1760
1960-64	1745
1965-69	1959
1970-74	2249
1975-79	2710
1980-84	3965
1985-89	4357
1990-94	4047
1995-99	5674
2000-04	1609

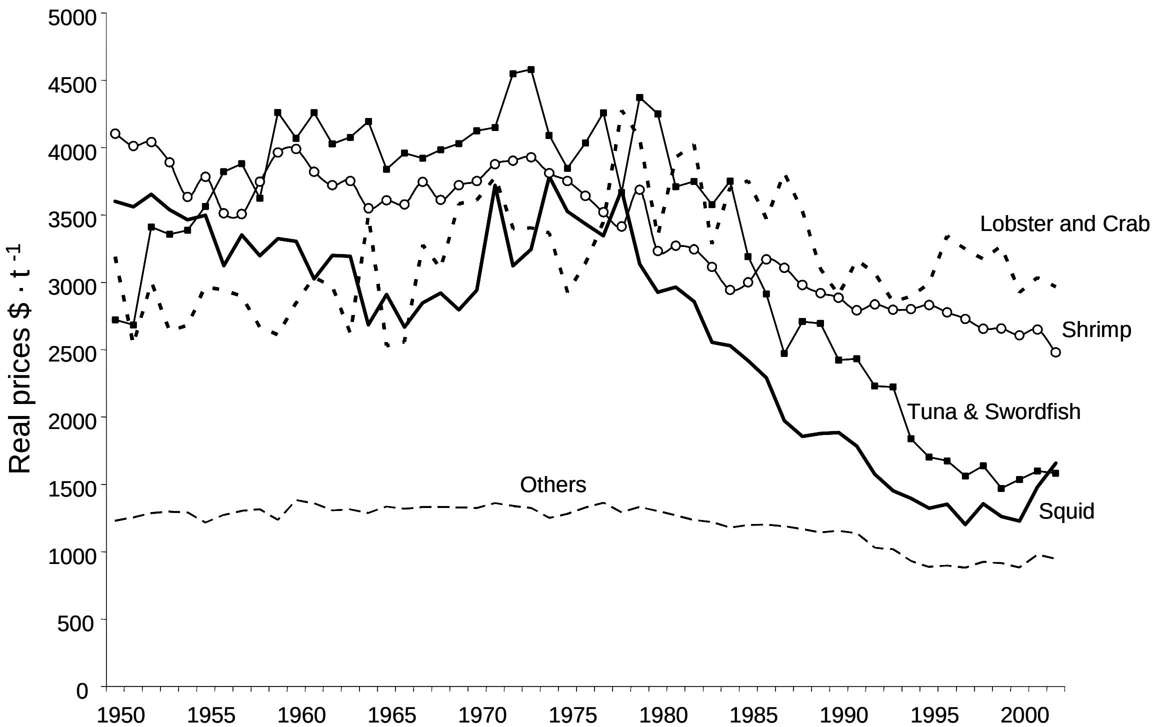

Figure 1: Plot of real prices of selected taxa from a number of countries.

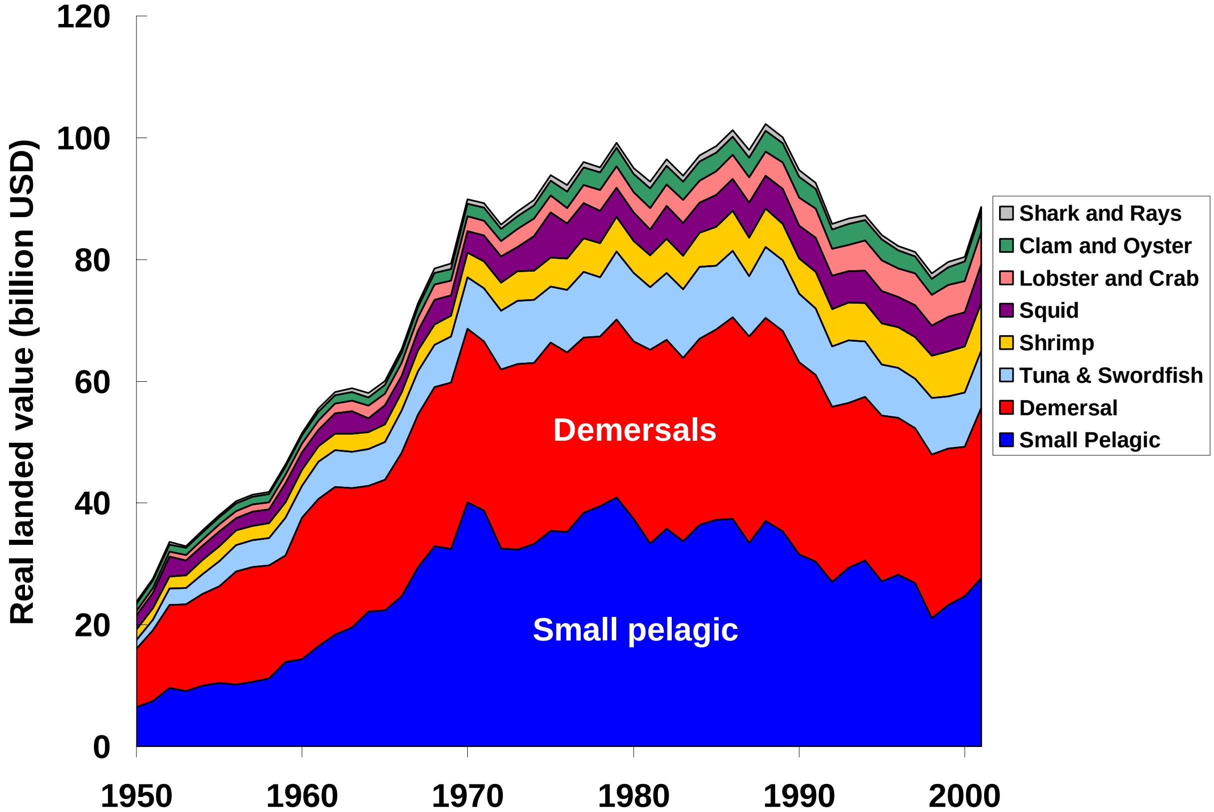

Figure 2: Total real landed values for the major taxonomic groups.

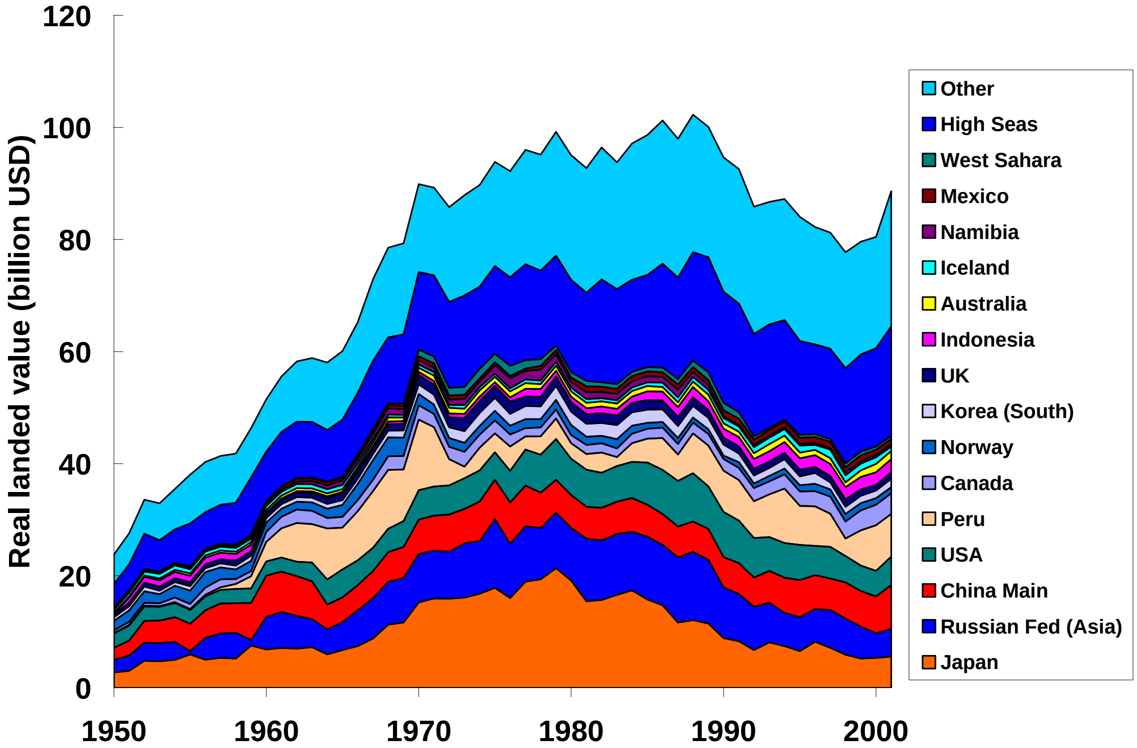

Figure 3: Total real landed values by EEZ/Area of catch.

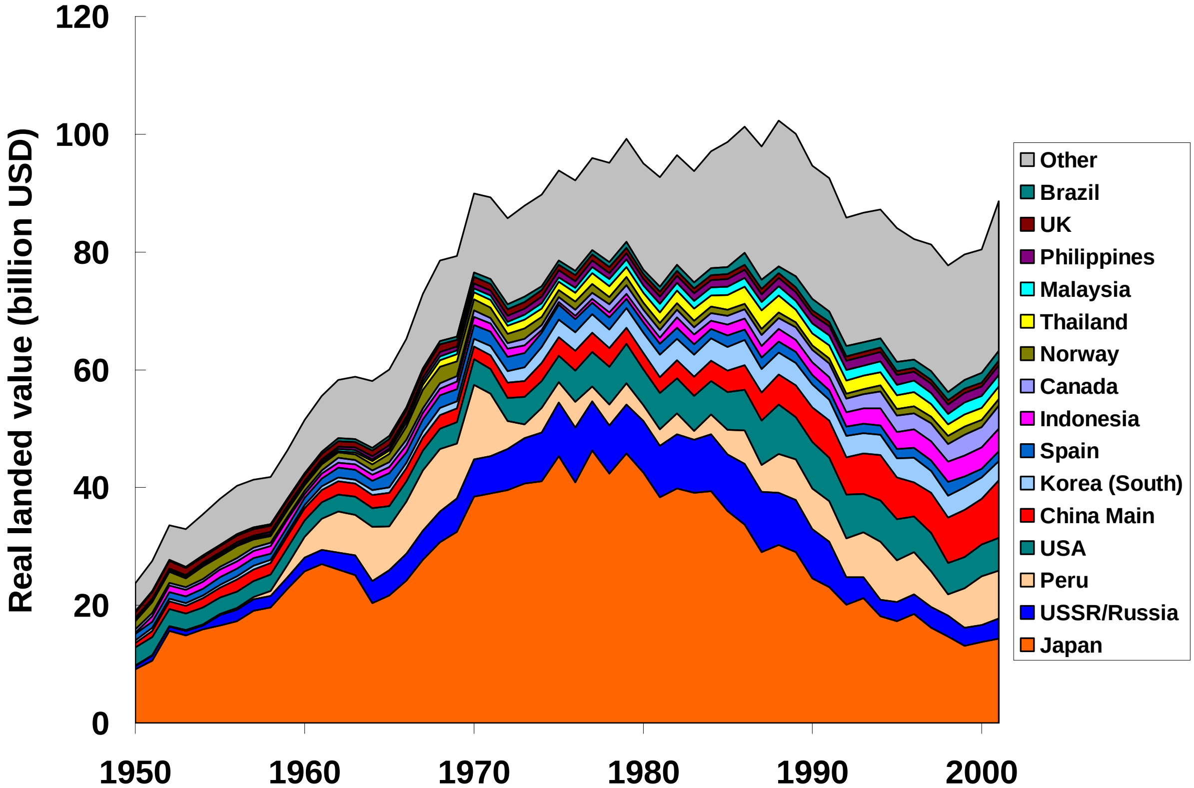

Figure 4*:* Total real landed values by fishing country.

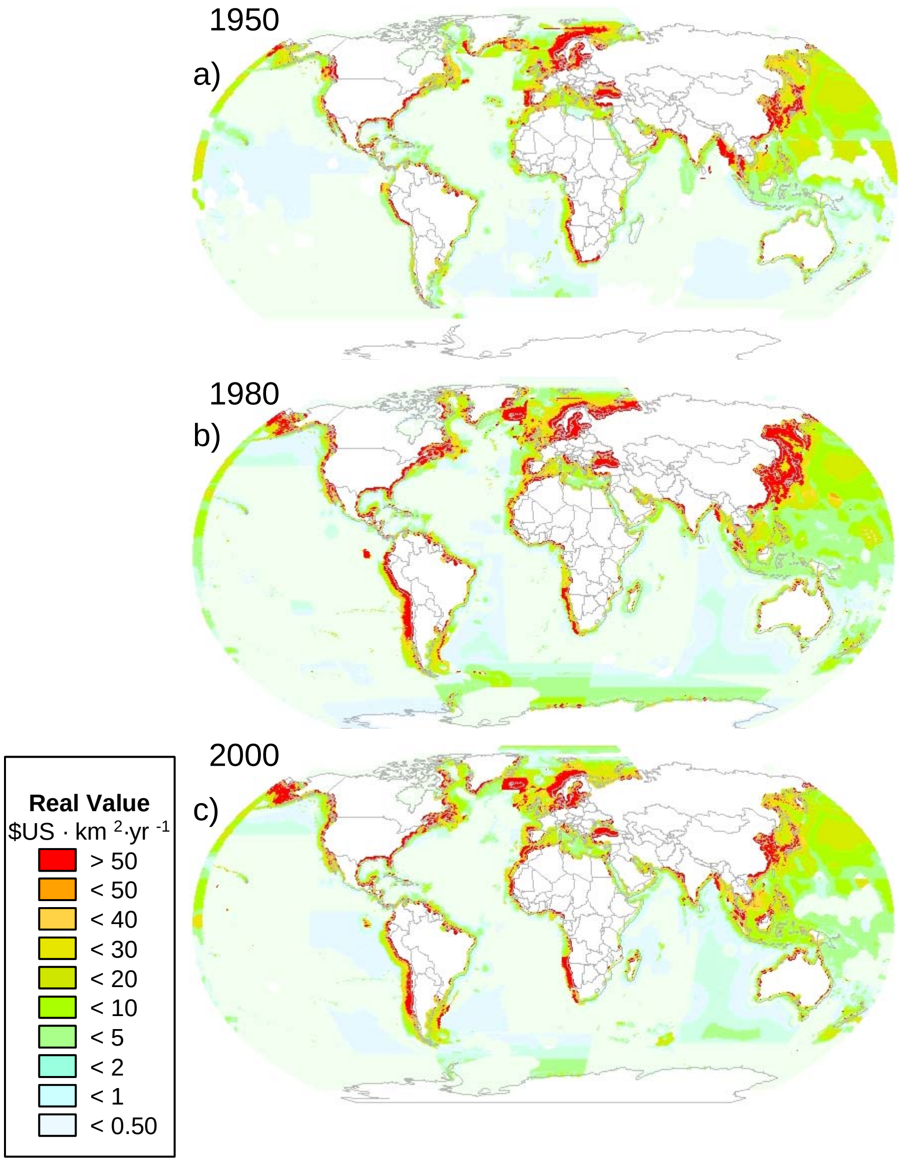

Figure 5: Real landed value per km^2 in a) 1950, b) 1980 and c) 2000.