PART I: BASIN SCALE ANALYSES

MAPPING FISHERIES LANDINGS WITH EMPHASIS ON THE NORTH ATLANTIC

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ABSTRACT

Fisheries landing statistics from broad statistical reporting areas were mapped as catches with a resolution of 30 minutes of longitude x 30 minutes of latitude. The procedure involved the progressive disaggregation of the statistics, firstly to provide poorly defined records with a better taxonomic identity, and secondly by using a rule-based process involving databases of known distributions of taxa, oceanographic features and of the areas where reporting countries are permitted to fish, in order to spatially disaggregate the data. Maps prepared for reporting years 1950 until 1999 showed trends in the spatial distribution of fisheries catches, provided a valuable means of examining other questions such as interactions between fishing and marine mammals, and provided descriptions of the global catch from large marine ecosystems. Catch maps prepared for the North Atlantic are illustrated and were used in the formation of ecological models and in the preparation of maps of catch value.

INTRODUCTION

Official statistics of fisheries landings are provided to the *Food and Agricultural Organization* of the U.N. (FAO) annually by member countries. These are reported for a range of species and aggregated taxa for each of FAO's statistical areas. Use of fisheries landings data in spatial models usually requires statistics on a finer spatial and taxonomic scale than typically reported to FAO. The shortcuts taken by reporting countries, whether due to their limited resources or other motivations, causes problems for users of the data. Most reporting countries break down the major portion of their statistics to the genus or species level of identification. This level of description is highly desirable if knowledge of the fish's distribution and habitat needs is to be used to aid the spatial disaggregation of statistics. Unfortunately, some countries provide the majority of their fisheries statistics broken down only to highly aggregated categories such as 'miscellaneous marine fishes'.

In the spatial disaggregation of these statistics a two-stage process is therefore required. The first attempts to disaggregate the statistics provided into taxa of lower levels such as families, genera or species. This process allows greater success with the second stage that combines aspects of the fish's biology and known distribution with the reporting country's documented access to fishing locations to produce a fine-scale spatial disaggregation of the reported landings. This process builds global maps of annual catches as each country's landing records are processed. The process described below is proving extremely useful in producing better information for modeling a variety of processes including changes in values of marine extractions, interactions between marine mammals and fishing operations, and in charting changes in marine ecosystems.

METHODS

Spatial resolution and spatial cell size

The process described in this report seeks to disaggregate landings from FAO's statistical areas to smaller units that can be used in a statistical model using oceanographic parameters. To facilitate this, spatial units of ½ degree latitude by ½ degree longitude were used. These will be referred to as spatial cells. The choice of this size was a balance between larger cells that would average many depths and other characteristics, and provide only a crude model of distribution, and a finer structure that would require intensive computing power and data at a scale not widely available. Over the world's seas and oceans the selected cell size requires a matrix with approximately 180,000 cells. Note the difference between the term 'area', which refers to the spatial extent of one of these cells (which are smaller nearer the poles), and 'statistical areas' or 'FAO areas', by which we mean FAO's statistical reporting areas.

Data sources

Fisheries landings

The fisheries data used were supplied by FAO (with one exception – see below). For all but annual tuna and billfish landings FAO's FishStat *(www.fao.org/fi/statist/FISOFT/FISHPLUS.asp)* was consulted. Landings of tuna and billfish were taken from FAO's Atlas of Tuna and Billfish Statistics (*www.fao.org/fi/atlas/tunabill/english/home.htm*). The totals were used unaltered. A documented process of taxa disaggregation, however, was used (described below) to allow landings to be identified sufficiently to facilitate the use of known distributional and biological information in the spatial disaggregation process. Only records of fishes and marine invertebrates were used in the analysis, i.e., data on marine mammals and algae were not considered. Data supplied were for 'official' reported landings only, and do not include discarding, nor do they make any attempt to correct for unreported, misreported catches or other errors. This will be done later, using the approach outlined in Watson *et al*. (2000) and Pitcher and Watson (2000). Landings data from the Canadian arctic, exclusively arctic char (*Salvelinus alpinus*), were taken from Crawford (1989).

Fish taxonomy, biology and distribution

FishBase (Froese and Pauly, 2000; *www.fishbase.org*) was used for information on fish taxonomy, their biology and distribution. This provided a framework for our databases and assisted with the process of spatial disaggregation by providing actual distributions or information on the limits to the distribution of many fish taxa.

Depth

Sea-floor elevations data were taken from the ETOPO5 dataset available on the U.S. National Geophysical Data Center's 'Global Relief' CD (*www.ngdc.noaa.gov/products/ngdc_products.html*) that provides elevation in 5-minute intervals for all points on Earth. Elevations below sea level (depths) were averaged for each spatial cell used in our database**.**

Primary productivity

Primary productivity data ($g \cdot C \cdot m^{-2} \cdot year^{-1}$) were provided by the Joint Research Centre (JRC), of the European Commission Space Applications Institute (SAI) Marine Environment Unit (ME) *(www.me.sai.jrc.it/me-website/contents/shared_utilities/frames/index_windows.htm*).It was developed using the Behrenfeld and Falkowski (1997) model that includes NOAA's satellite data on sea temperatures, chlorophyll a levels and light irradiance. The data were available on a spatial scale of approximately 0.176 degree and was averaged into ½ degree spatial cells. The time period averaged was for readings taken during 1999, and was taken to represent a basic climatology of primary productivity.

Coral reefs

Modeled data (Kleypas *et al*., 1999) on the presence or absence of coral reefs globally were made available from Reefbase (*www.reefbase.org)* on a 5-minute resolution which was accumulated into our ½ degree spatial cells to provide a reef spatial coverage index. This was used to locate catches of taxa whose life-history requires the presence of a coral reef.

Sea mounts

The gazetteer provided on the U.S. National Geophysical Data Center's 'Global Relief' CD (*www.ngdc.noaa.gov/products/ngdc_products.html*) was used to count the number of known sea mounts in each of the ½ degree global spatial cells. These were used to provide the basis for the distribution of taxa known to occur only in the proximity of sea mounts.

Permanent ice coverage

Data from the U.S. National Snow and Ice Data Centre, Boulder, Colorado (*nsidc.org/index.html*) provided the monthly limits of sea ice coverage. These were used to determine which spatial cells would not be available for fishing due to nearly permanent ice coverage.

Exclusive economic zones

Boundaries of Exclusive Economic Zones (EEZ) and declared national fishing zones were taken from the Global Maritime Boundaries CD (Veridian Information Solutions, 2000) (*www.maritimeboundaries.com/main.htm*) which uses existing claims and accepted rules to delineate these zones, even though several are still unresolved.

Fishing agreements

A database of fisheries agreements between countries (FARISIS), was made available by FAO (Anon., 1998). The search facility of this resource was enhanced by importing the contents to a Microsoft Access database, a process that required parsing the exported text file using a Microsoft Visual Basic program. This database allows the fishing agreements between countries to be listed so that the rules of fishing access required in the spatial disaggregation process could reflect current or historical arrangements.

Taxonomic disaggregation

Taxonomically highly aggregated landings statistics are problematic for any analysis including spatial modeling. Some countries report the majority of their landings under the 'miscellaneous marine fishes', 'miscellaneous marine crustaceans' and 'miscellaneous marine molluscs' categories (Table 1). Some of these countries, notably China, combine a large fraction of highly aggregated categories with large reported landings, to top the list with the total tonnage reported in this format. According to FAO statistics, China has reported approximately

Table 1. Countries reporting landings in taxonomically highly aggregated groups based on totals from FAO statistics from 1950 to 1998. Listed are the top 20 countries ranked by the total tonnage (million tonnes) of landings including 'miscellaneous marine fishes' (MM Fishes), 'miscellaneous marine crustaceans' (MM Crust.) and 'miscellaneous marine molluscs' (MM Moll.). The term 'miscellaneous marine' is abbreviated as MM. The average of all countries over the same period is also shown.

Country	Landings marine total	Landings MM				% MM			
		Fishes	Crust.	Moll.	Total	Fishes	Crust.	Moll.	Total
China, Main..	200.0	74.4	16.5	22.2	113.1	37.2	8.2	11.1	56.6
Korea, DPR	36.1	35.4	0.3	0.0	35.7	98.1	0.7	0.0	98.9
Thailand	68.2	32.2	0.0	0.1	32.3	47.2	0.0	0.2	47.3
Japan	375.2	21.6	0.3	0.0	21.9	5.8	0.1	0.0	5.8
Vietnam	24.0	19.1	0.0	0.6	19.7	79.5	0.0	2.6	82.1
Myanmar	18.3	18.1	0.0	0.0	18.1	98.9	0.0	0.0	98.9
Indonesia	64.1	10.3	0.1	0.0	10.3	16.0	0.1	0.0	16.1
Former USSR	209.9	8.1	0.1	0.6	8.8	3.9	0.1	0.3	4.2
India	67.5	7.7	0.6	0.1	8.4	11.5	0.8	0.1	12.4
Malaysia	26.1	7.7	0.2	0.0	7.9	29.3	0.7	0.1	30.0
Mexico	31.2	6.6	0.0	0.1	6.6	21.0	0.0	0.2	21.2
Korea, Rep.	68.0	5.7	0.0	0.3	6.1	8.4	0.0	0.4	8.9
Bangladesh	6.3	4.4	0.3	0.0	4.6	69.9	4.1	0.0	73.7
Brazil	21.9	4.3	0.0	0.2	4.5	19.6	0.1	0.7	20.4
Taiwan	29.5	4.2	0.0	0.1	4.3	14.1	0.0	0.3	14.4
Spain	56.0	3.4	0.2	0.2	3.8	6.0	0.3	0.4	6.7
Italy	16.9	3.0	0.1	0.3	3.5	18.0	0.8	2.0	20.8
USA	171.0	3.3	0.0	0.2	3.4	1.9	0.0	0.1	2.0
Iran	4.0	3.0	0.0	0.0	3.0	75.6	0.0	0.3	76.0
Hong Kong	6.4	2.4	0.0	0.1	2.5	37.5	0.0	2.0	39.5
Average all countries	-	-	-	-	***1.2***	***19.6***	***0.3***	***0.3***	***20.3***

113 million tonnes of marine landings this way since 1950, nearly three times that of any other country.

Because statistics supplied by China to FAO are such a large part of landings reported in FAO statistical areas 61 and 71 (34% since 1990) it was necessary to attempt to disaggregate these reported landings based on the more detailed records from neighboring states, namely Taiwan and South Korea. Though close to China, and undoubtedly sharing many taxa in its' fisheries catches, North Korea was not included in this analysis as it provides even less taxonomic detail for its landings than China does.

Disaggregation of landing records proceeded separately for each broad taxonomic category and were defined as fishes, crustaceans and other (mostly mollusc) taxa. Within each category the percent of the total landings that was assigned to the 'miscellaneous' category was assigned to more specific taxa based on the breakdown of landings reported by neighboring countries. This procedure was performed independently for each statistical reporting year.

In 1998, for example, China reported 27% of its total landings as 'miscellaneous marine fishes'. This same year the average proportion of total landings reported by its neighbors for this same aggregated taxa group was only 10%. Therefore, initially the procedure assigned 17% (the difference) of the Chinese 'miscellaneous marine fish' landing statistic to fish taxa identified at more specific levels than as 'miscellaneous' in the Chinese statistics or in those of its near neighbors. This difference was assigned step-wise in small fractions using a rule-based approach. The rules were that:

- China's proportion of landings assigned to any identified taxa would never be reduced regardless what neighboring states reported;
- the fraction of the difference remaining being assigned to a taxa during each iteration was in proportion to the difference between the proportion reported by China and that reported by its neighbors;
- all taxon levels were considered equally, i.e., fish families were treated the same as fish genera or species; and
- all taxa reported by neighbors could be used for reporting Chinese landings even if a taxon was not specifically reported in official Chinese landings statistics (but could be presumed to be a hidden portion of the 'miscellaneous' category).

In our example, this process continued until the additional 17% of 'miscellaneous' fish fraction reported by China but not by its neighbors had been assigned to nominated fish taxa.

Once this first stage was completed, the remaining proportion of Chinese landings still identified as 'miscellaneous marine fishes' were assigned to nominated fish taxa within the Chinese statistics in proportion to their presence at that stage. In this way all fish landings were assigned to taxa more informative than the 'miscellaneous' segment.

The same procedure was used for crustaceans, and for all remaining unidentified fractions (mostly molluscs). When completed, the total landing statistics for China for any year was unchanged overall and for each broad category (fishes, crustaceans, and others). These 'taxonomically disaggregated' landing records were used in the subsequent spatial disaggregation processes. Results of this procedure are presented in Watson and Pauly (2001). At the time of writing, the taxonomic disaggregation procedure had been applied only to landings reported by China; in the future it will be applied to landings from all countries.

Taxa distribution

The process of spatial disaggregation of fisheries statistics required a database of the global distribution of all taxa reported to FAO. The term 'taxa' is used in consideration that despite the process of taxonomic disaggregation described above, only a portion of the world's landings are reported by individual species, much of it is reported at higher or more general taxonomic levels of aggregation. For each taxon, the proportion of the world's known distribution was mapped to the spatial cells represented in the database. This information is provided in two ways. The first and preferred method, was to use maps of distributions prepared by experts. Many excellent texts such as Muus and Dahlstrøm (1974), Scarratt (1982) and Cohen *et al.* (1990) provide global distributional maps that augment the extensive set of distributions available from FAO (Anon., 2001). Some were provided to us as geographical information systems (GIS) compatible files. Most distributions, however, were available only as bitmaps (rasterized images) and had to be scanned, re-projected and otherwise processed before they could be added to our database. Most sources produce distributional maps using knowledge of fisheries landings, museum collections and generalized depth and temperature ranges of the exploitable ages and life history stages.

What is referred to here as 'depth' is the depth of water over which the species can be taken rather than the depth in the water column at which the species occurs. The reason for this is to allow generalizations on distributions from global bathymetry. This definition means that for taxa such as 'large pelagic fishes' there are no depth limits as these species may be found over the deepest parts of the world's oceans (though actually only occuring in the top hundred or so meters). If depth limits for a taxon were known then these were used in conjunction with distributional maps to restrict the distribution to a subset of the ocean's spatial cells when the spatial database record was created. That is, individual spatial cells included in broad distributional statistical areas on maps were not included if they were outside the known depth range for the taxa.

The database describing the distribution of marine taxa is not simply presence/absence for each spatial cell but rather the proportion of the world's distribution to be found in that cell. In this, it was assumed that regions that had a greater general primary productivity level would on average support greater populations of most marine fauna. Thus, spatial primary productivity data were used to apportion the distribution of each fauna between the cells that fall within the distributional limits.

Other methods were used when distributional maps were not available. The first was used exclusively for taxa identified to the genus level. Each of these used mapped distributions (if they existed) for any species in these genera that our database contains. Otherwise, like all other taxonomic levels, tabular limits to distribution were used next if these were available. There are several excellent sources of tabular information available describing the known distributions of marine fauna, notably FishBase (Froese and Pauly, 2000). This database includes contributions from global experts, and provides latitudinal and depth ranges for many species. Also included is the presence/absence of each species by FAO statistical areas. FAO's SpeciesDAB (Coppola *et al.*, 1994) was also used as a source of tabular distributional information and also covers marine invertebrates.

When tabular limits were used to construct distributions, the maximum and minimum depths were used as more than absolute limits. Rather, it was assumed that the maximum abundance occurred at depths $^1/_3$ of the way between the minimum and maximum depths, and a triangular distribution was assumed to calculate the proportions of the distribution found at each intervening depth. In a similar way the maximum distribution of taxa with latitudinal limits was taken to occur at a midpoint in the range, with a triangular distribution assumed.

The tentative distributional range, based on any known depth or latitude limits, was then further reviewed when presence/absence by FAO statistical data was available. That is, if a species had a wide distribution described by a range of depth and latitude but was not known to occur in FAO statistical area 21 then its distribution in our database would reflect this known limit, and spatial cells within FAO 21 were removed from its range.

Therefore, the final distribution of fauna for which maps were not preexisting, reflected the known limits imposed by depth, latitude and presence/absence, with a distributional gradient within reflecting the distributions assumed for depth, latitude and gradients of primary productivity. Reviews of this database of distributions by a number of experts have improved its reliability.

Fishing access

Each of the ocean's spatial cells was assigned to a country if the center of that cell occurred within the boundaries of the EEZ for that country according to the Global Maritime Boundaries database (Veridan, 2000). Cell that were not assigned to the EEZ of a country were considered to be on the high seas, and accessible to fleets of all countries.

Rules were developed to allow fishing access to the EEZ cells of one country by another. Initially only the country itself was allowed to access the cells assigned to its own EEZ. This was modified as more information became available on that country's fishing practices and the access rights it grants to other countries. 'Guilds' of fishing countries were defined, within which each guild country was presumed to have mutual access to the EEZ cells of all other countries within the guild. Such an arrangement (albeit with many specific limitations) exists between fishing vessels of the European Union. There are also many examples where countries with historical ties (former colonies or territories) allow fishing access to another country. On a case-by-case basis, and in consultation with national experts, the database of fishing access that is used in the spatial disaggregation process was extended by granting 'permission' to allow fishing access to the spatial cells defining the EEZ of one country by other countries.

The fishing access database was further enhanced by consulting with the FAO's FARISIS database (Anon., 1998), which records fishing agreements, and allows non-historical and distant-water fishing access rights to be included in our 'rules' of fishing access.

At present our rules for fishing access are static, and the transition from 12-mile territorial sea claims to the current 200-mile EEZ has not been included. Maps presented here assume that EEZ claims existed and were in force for the whole time series. These limitations will be addressed in future versions which will better reflect historical access arrangements. Similarly, in our current fishing access database, there is no detail on which specific fishing resources may be accessed by outside countries, which may only be limited to large pelagic species. This detail will be addressed by future enhancements.

Spatial disaggregation

Using landing records that were taxonomically disaggregated where necessary, a rule-based process was used to spatially disaggregate the landings statistics from their original large FAO statistical areas to a subset of much smaller spatial cells within that statistical area (Figure 1).

The official landings records for all countries fishing within the reporting year, as determined by FAO statistics (A in Figure 1), were processed as a set of database records by first disaggregating the large generalized group statistics into lower taxonomic records (B in Figure 1 – described above). These records were then processed individually though the spatial disaggregation process (C in Figure 1, detailed in Figure 2).

Each taxon described in a landings record was looked up in the database of taxonomic spatial distributions (produced by methods described above). This yielded a subset of the spatial cells of the worlds oceans and the proportion of the world's distribution that had been estimated for each cell. The country reporting (fishing) was used with the database of fishing access (described above) which records which spatial cells are available for that country to fish in (including the EEZ of other countries where arrangements exist). The FAO statistical area from which the landing was reported provided a third set of spatial cells, those that are within the nominated statistical area. These three sets of

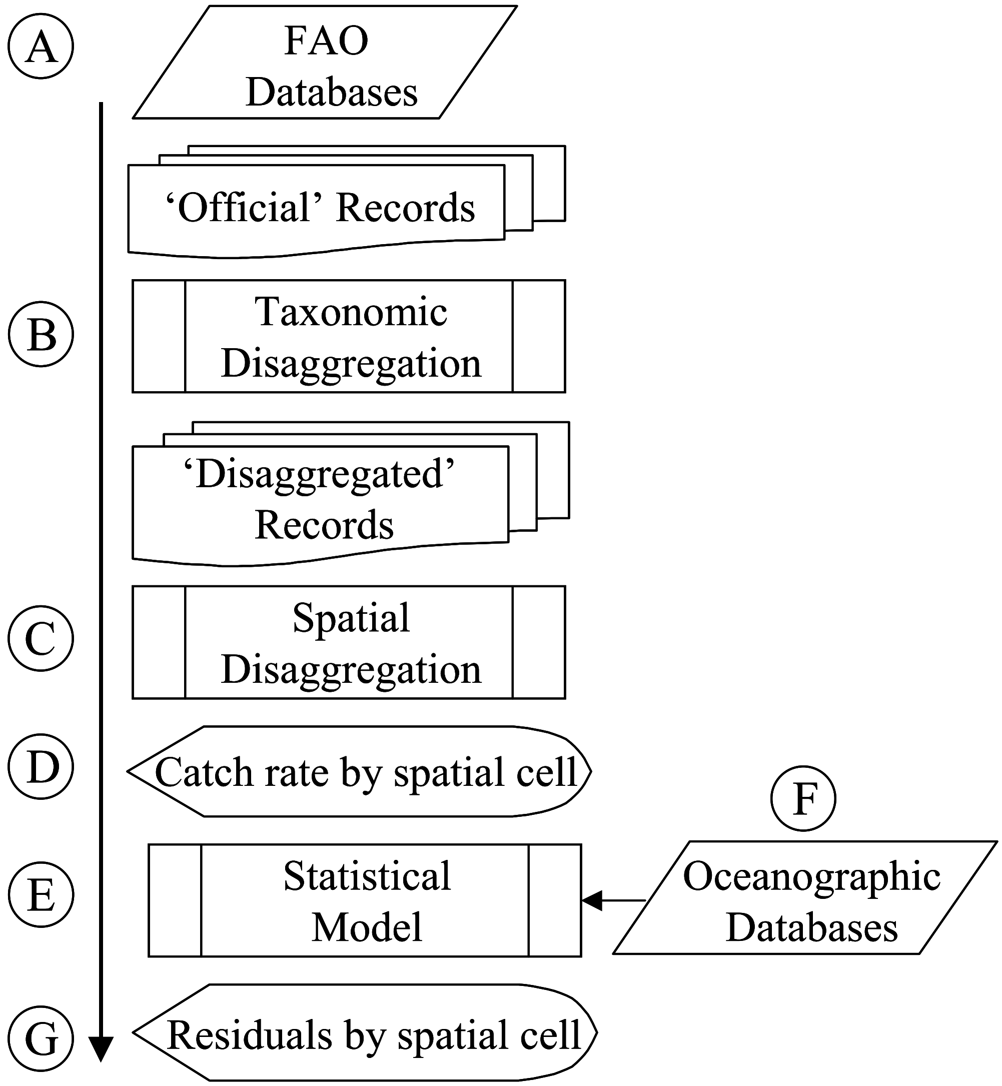

Figure 1. Schematic diagram of the data processing procedures used to produce landing rate maps.

spatial cells were then compared. If there was no overlapping cells then the landing was not allocated to spatial cells and an 'error' report was logged (Figure 2); otherwise the landing reported was assigned proportionally amongst the overlapping cells based on their areas (available in a general spatial database). In this way catches (t km^{-2} $year^{-1}$) were accumulated in each spatial cell as each record was processed.

Logging allocation errors proved very instructive in reviewing whether species distributions and country fishing access ranges were consistent with landings' records. This process allows for constant improvement of the underlying databases. At the time of writing approximately 5% of global landings records could not be mapped to a set of spatial cells because no overlap existed between the taxa's distribution, the reporting country's fishing access, and the statistical area for which the landing was reported. These 'unallocated' records, however, accounted for less than 1% of reported landings by weight. Some of these errors will be eliminated when access arrangements for fishing countries have been made more specific in time and by taxa, and when taxa distributions have been fully reviewed by experts. This process has already required a shift from the predominately depth-determined species distributions that FAO provides, which do not always allow catches in statistical areas where they are frequently reported (often these problems failed to be identified by experts in the fisheries involved).

Sometimes errors originate because countries do not report catches for all FAO areas they fish in, but simply report all the landings for their major statistical fishing areas or they may even report distant-water catches from closer fishing locations. Because the statistics more closely approximate landings rather than catches, sometimes what is reported incorrectly is the statistical area which encompasses the port where the catch was unloaded, rather than the statistical area in which the fish were caught.

Fortunately, for about 95% of landings statistics, there is an overlap between the species' distribution, the countries fishing access, and the range of the FAO statistical area the landings were reported from. Each of these overlapping spatial cells was then allocated a proportion of the reported landing, depending on their area (cells nearer the poles are smaller than those on the equator). In this way a grid map of catches is build up as each landing record is processed (D in Figure 2). Though each record is processed for the taxonomic level it is reported at (after disaggregation processes), for generalized output the results are usually re-aggregated and reported in 12 major groups: these being anchovies, herrings (defined as non-anchovy clupeiformes), perches (all perciformes taxa), tuna and billfish, cods, smelts, flatfishes, scorpionfishes (scorpaeniformes), sharks and rays, crustaceans, molluscs, and 'others'. However, for brevity the present report only presents the aggregate total of these 12 reporting groups.

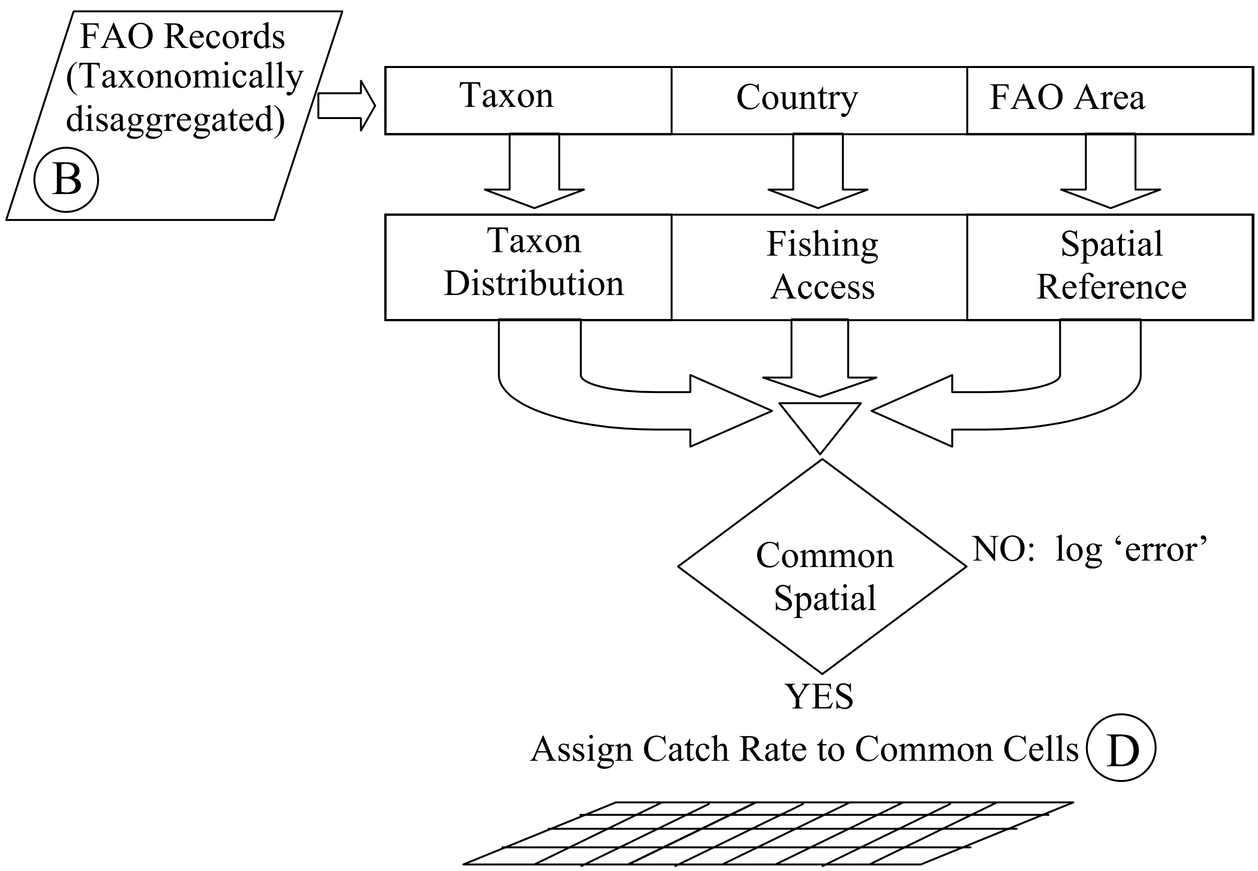

Figure 2. Schematic diagram of the spatial disaggregation process.

RESULTS AND DISCUSSION

The spatial disaggregation of FAO landings into ½ degree spatial cells allows for the totals for the 'North Atlantic', as defined in our project, to be calculated. The breakdown of the landings for the North Atlantic by group appears in Figure 3. Maximum landings were reported in the 1970s. In the late 1980s and early 1990s there was a significant reduction in cod catches which was mostly responsible for reduced landings in subsequent years.

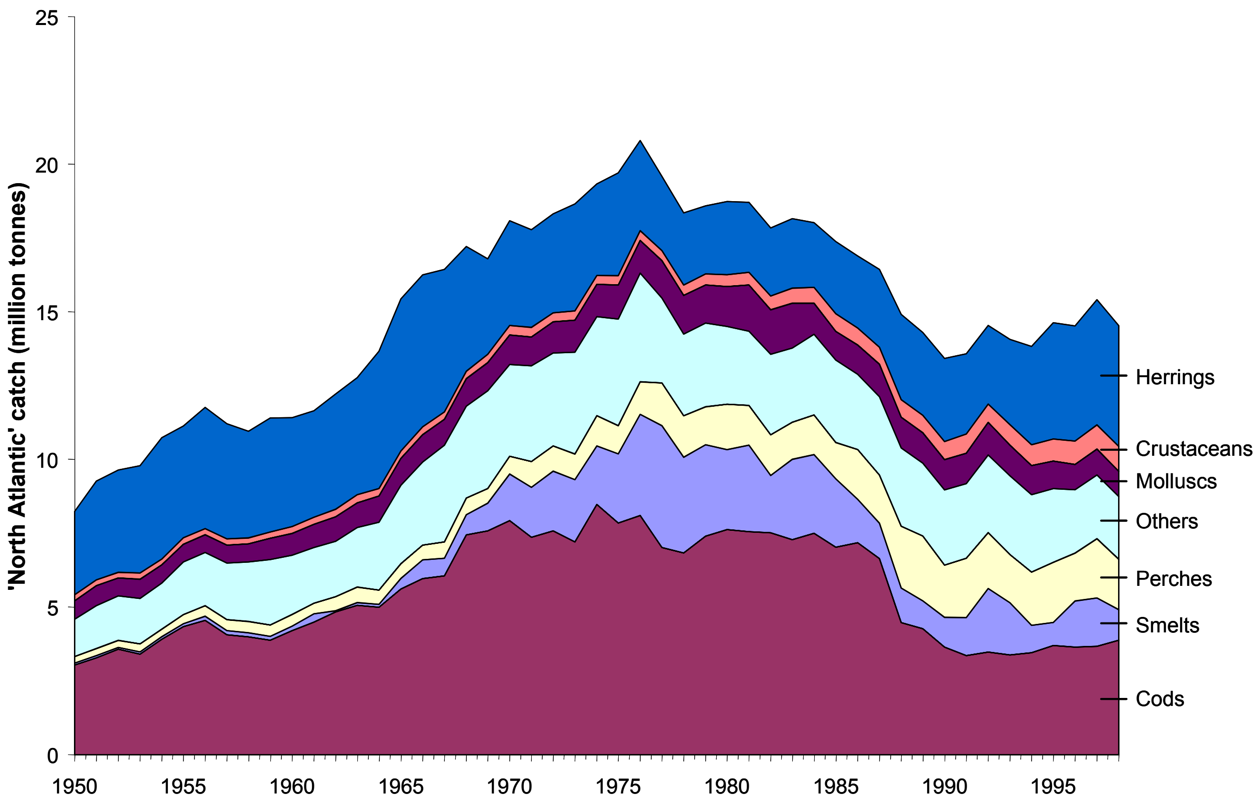

Figure 3. Annual landings of major fish groups for the North Atlantic area based on disaggregated FAO statistics. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

Results from the disaggregation of annual FAO landings data were averaged by decade for the 1950s, 1970s and the 1990s. The spatial pattern of fisheries catches evident in all decades is the very large proportion of landings that come from coastal shelf areas particularly the Scotian, Newfoundland, and Labrador shelves in the western North Atlantic, and the North Sea in the eastern North Atlantic (Figures 4 - 6). By the 1970s (Figure 5), the spatial cells with higher catches had extended along the eastern seaboard of the U.S., and to greater areas around Iceland and west of the U.K. in the eastern North Atlantic. There was also an area of the eastern Barents Sea north of Norway where there were notably high catches. By the 1990s (Figure 6) productive fishing areas were just as extensive, however, catches were generally lower particularly in areas where cod was the primary species taken.

Artifacts in the maps point out limitations which in part stem from those in the data reporting system. For example, abrupt changes in catch densities at statistical boundaries (Figure 6 in the mid Atlantic) are unlikely to represent changes in fishing practices or success, but result from a failure on some countries part to prorate catches by all statistical areas fished. Assumed jurisdictional boundaries to fishing, such as EEZs, resulted in a halo-like zone of higher catch rates around some countries (Figure 6 around Portugal). Better knowledge on fishing access would likely have exposed that there is more cross-border fishing, legally or not, than we have currently recognized in our analysis. There are large polar regions were the catch rates are zero. This is not unexpected given the year-around presence of pack ice in some of these areas, however, in Canada's Hudson's Bay, no catches are reported to FAO even in the summer. Those shown here were based on a specific report in the literature (Crawford, 1989), one of the few additions to FAO's landing database used at this time. In fact there were only a handful of landings reported from FAO's Arctic area (18) since 1950 and all were reported by the former Soviet Union. This indicates other limitations to the current landing records. Thus, this approach could prove very useful to agencies involved in gathering and interpreting fisheries data.

The present maps use mostly unadjusted landing records from FAO. The *Sea Around Us* project has, however, been continuously refining fisheries data from a number of regional and national sources. For example, data from European countries, reports from stock assessment working-groups, and reports we have commissioned from in-country consultants, have allowed us to augment landing statistics produced by the regional authorities, such as the *International Council for the Exploration of the Sea* (ICES). We have documented unreported landings (legal or otherwise) and discards allowing us to produce well-documented 'adjusted' catch statistics, which better reflect total marine resource extractions. As the statistical areas reported on by ICES correspond to FAO's statistical area 27, in future, we can substitute these adjusted ICES landings for FAO data from this area in our analysis. As ICES statistical reporting areas are only a fraction of the size of the FAO statistical area, future maps will reflect both a fuller and a more precise account of catch rates from this region. A similar procedure is underway for other regions of the North Atlantic, and will be extended step-wise globally.

Mapped landings produced through this process proved a very useful contribution to other studies within our project particularly those dealing with interactions between marine mammals and fishing (Kaschner *et al.*, this volume), fisheries economics, and estimates of biomass (Christensen *et al.*, 2001). Incorporating the trophic levels of landings in future analysis will produce maps of change in the trophic level of landings. It is very likely that many other uses for this information will be found.

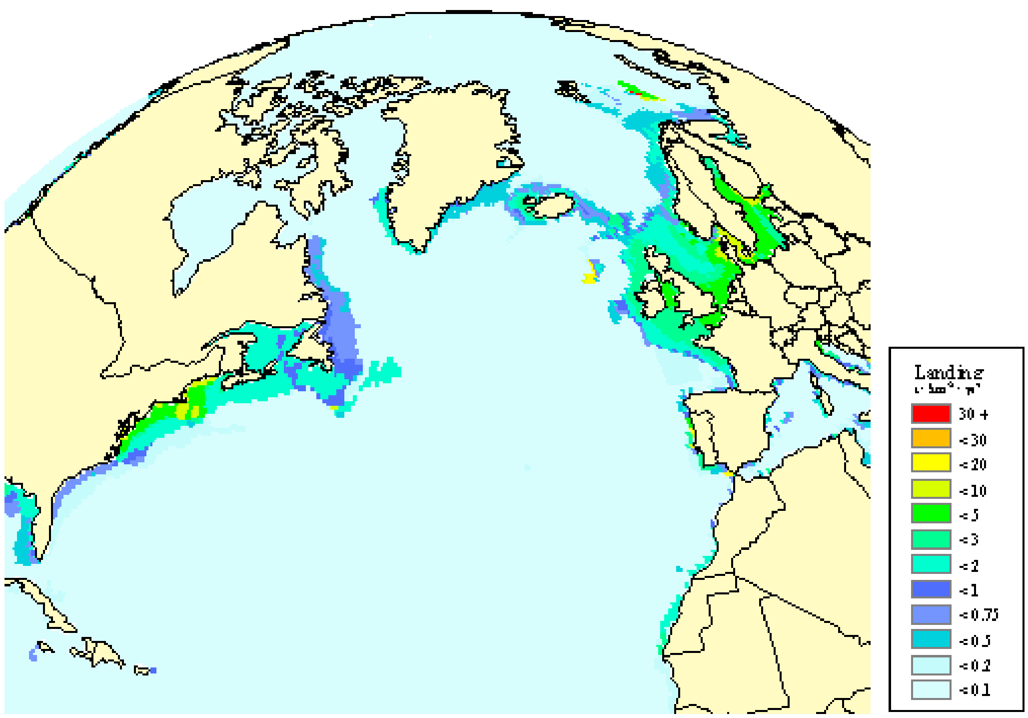

Figure 4. Map of average landed catch (t km^{-2} $year^{-1}$) of all taxa combined for the 1950s. The online version of this graph is in color (*see www.fisheries.ubc.ca/Projects/SAUP*).

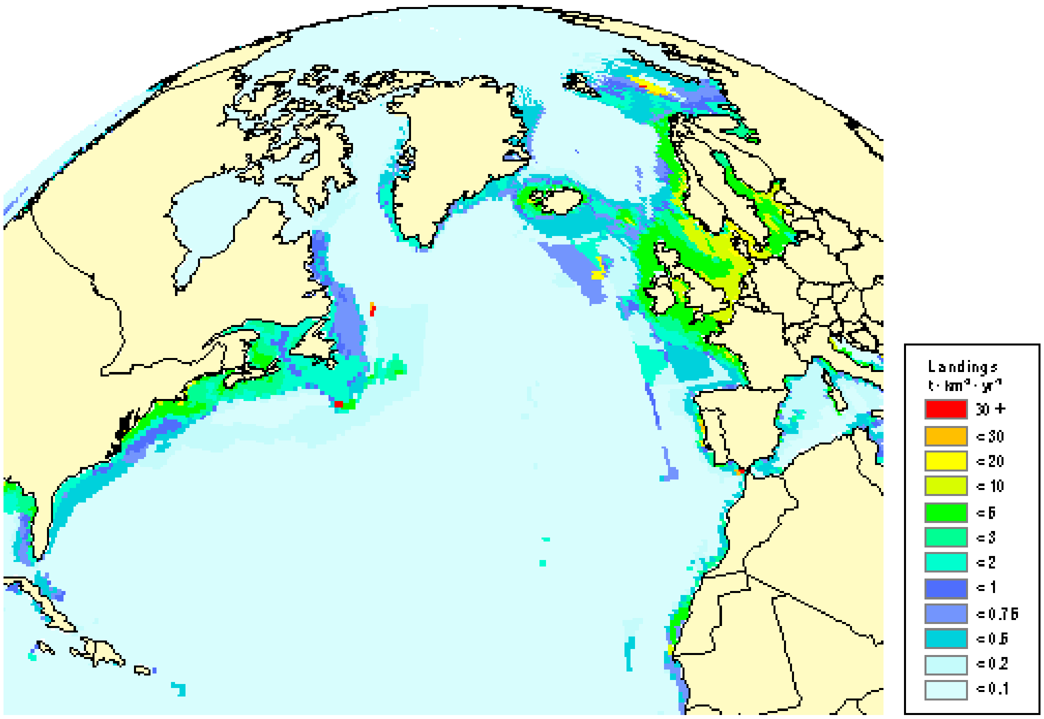

Figure 5. Map of average landed catch (t km^{-2} $year^{-1}$) of all taxa combined for the 1970s. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

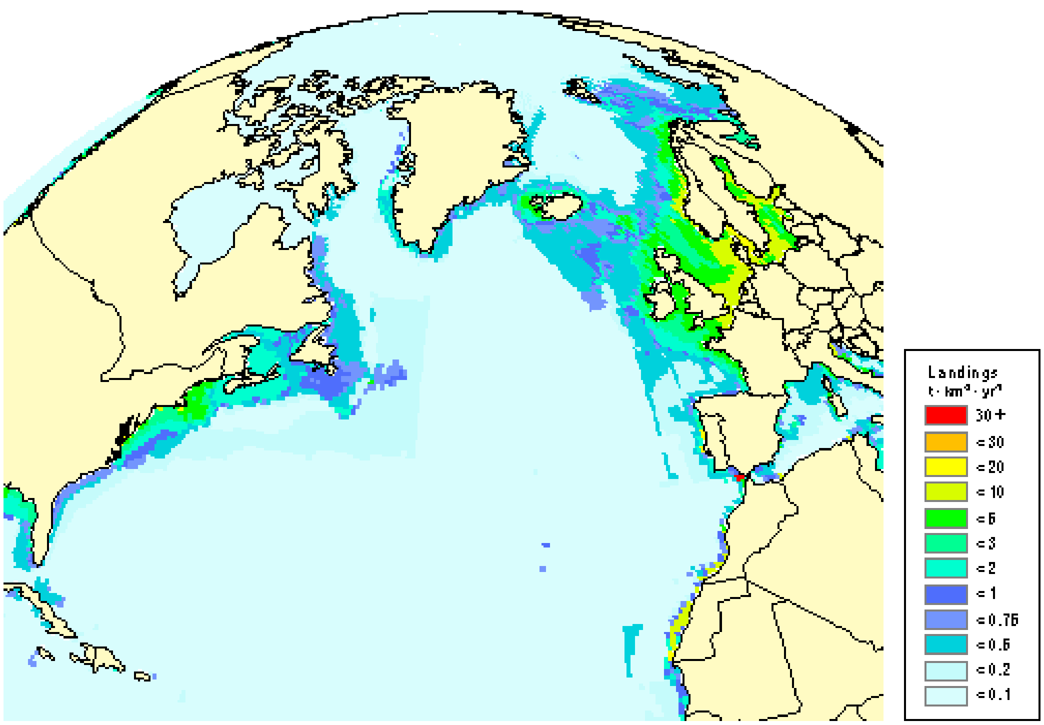

Figure 6. Map of average landed catch (t km^{-2} $year^{-1}$) of all taxa combined for the 1990s. The online version of this graph is in color (see *www.fisheries.ubc.ca/Projects/SAUP*).

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