MULTISCALE DECISION SUPPORT FOR AQUATIC PROTECTED AREA PLACEMENT

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Abstract

Successful placement of aquatic protected areas (APAs) not only relies on a myriad of local social factors relating to ‘resource’ users and jurisdictional boundaries, but also on the relevant-scale spatial distribution and movement of species, ecosystems and habitats for which protection is sought. Equitable protection can be viewed as a problem with many spatial scales, and conventionally for some there have been few data available. A data-mapping process (SimMap) was developed to support a large study on the effects of fishing on marine ecosystems ('The Sea Around Us' project; http://seaaroundus.org); this provides critical data at several scales, linking fine-scale ecosystem models (EcoPath/EcoSim/EcoSpace) in a nested fashion to whole ocean-basin, and even global distributions of taxa and oceanographic processes. This system supports the spatial ecosystem modelling used to evaluate the impacts of APAs, and also allows work within these ecosystems to be extrapolated over larger areas and allows investigation of temporal changes.

Keywords: fisheries, global, spatial, statistics, marine

INTRODUCTION

Most marine planners charged with the responsibility of delimiting aquatic protected areas (APAs) would not usually envisage using large-scale fisheries data in the decision-making process. Nor is this information considered useful to ecosystem modelers in the form in which it is usually supplied. The problem is one of mismatched scale. Fisheries data reported by national and regional commissions is often reported as port landings, with no spatial origin confirmed, or by statistical areas that are much too large to be directly useful. The problem of spatial precision can be addressed by new approaches that reduce the scale of available fisheries landing data using a process of spatial subtraction. Areas that do not fit with known biological or jurisdictional/access information are removed as potential catch locations from the statistical areas from which the catch is reported. After evaluating where catches could not have been taken within the reporting area on the basis of the distributional limits of the taxa landed, and the access agreements in effect between the reporting country and coastal states in the area, the catch can then be ‘allocated’ differentially to the remaining portion of the statistical reporting area on the basis of habitat suitability and primary productivity levels. This process results in relatively fine-scale maps of fisheries catches where only vague landings data officially exist.

In addition to problems of spatial scale, many areas of the world’s oceans are outside the jurisdictional waters of coastal states, with no statistics available except those supplied voluntarily to the Food and Agriculture Organization (FAO) of the United Nations by fishing nations. This leaves many areas vulnerable to overfishing with newer technologies (Roberts 2002), and leaves critical habitats such as seamounts without representation in management processes because offshore ‘high seas’ areas usually have not been subject to governmental protection. Large-scale fisheries data made available from the FAO and regional bodies may be used to fill these gaps once the spatial allocation process has been completed.

METHODS

The example described here starts with global fisheries data available from FAO (FishStat). The production data-set (which does not separate capture landings from aquaculture production) starts in 1950. After 1970, a separate capture data series is available from the web (http://www.fao.org/fi/statist/fissoft/FISHPLUS.asp).

There are, however, limitations to these data that need to be understood, if they are to be used. Firstly, the identity of the taxon reported can be vague, and 15% or more of FAO’s world catch is currently reported only by larger aggregations such as ‘miscellaneous marine fishes’, rather than by species. Secondly, though regional bodies supply data by smaller statistical areas, the majority of the world’s statistics are reported by large areas averaging 19 million square km in size.
(Fig. 1). Thirdly, fisheries data are supplied voluntarily to the FAO and though not without error they represent the ‘official’ statistics. In some instances FAO staff must make educated breakdowns of data supplied by statistical areas or taxa.

As daunting as these limitations are, there are ways of overcoming them. The taxonomic identity of catches from reporting countries can often be deduced by the more detailed reports produced by neighbouring countries and by lists of common taxa known to occur in the area in a process referred to as ‘taxonomic disaggregation’ (Watson et al. 2001; Watson 2001). The process of identifying the spatial location of fisheries landing reports is a process we call ‘spatial allocation’ (Fig. 2) and will be discussed in more detail below. Once the catch has assigned to spatial cells by use of defined taxonomic groups it is possible to investigate and correct aberrations in the ‘official’ data. For example, computer models identified over-reporting by China in recent years (Watson and Pauly 2001; Watson 2001).

Marine planners should have access to the best possible time-series data rather than those constrained by official sanction or blurred by vague reporting schemes. While all means should be exploited to secure better, more comprehensive data, it is necessary to make better use of the existing data sources.

The spatial allocation process relies on supporting databases and rule-based procedures to locate reported landings from large statistical areas into the most probable distribution of catch amongst a global system of approximately 260,000 spatial cells measuring 30 minutes latitude by 30 minutes of longitude (Fig. 2). There are two main types of databases involved. The first relates to the global distributions of the reported taxa (be they by species, family or higher levels of aggregation). Fishbase (Froese and Pauly 2000), SpeciesDab from FAO (FAO 2000; http://www.fao.org/fis/Species.asp) and other sources provide general information on the distributional range of fish taxa based on depth, latitude, presence or absence by FAD statistical area, etc.

Secondly, it is also possible to use maps detailing proximity to critical habitats such as coral reefs or seamounts identified by the World Conservation Monitoring Centre and other sources to constrain potential catch areas. Information for invertebrates is also available from sources such as CephBase (http://www.cephbase.utmb.edu). In total, information was compiled on the distribution of all taxa reported in FAO landings statistics and hundreds of others reported by other agencies.

Fig. 1. Fisheries statistics mapped by FAO statistical areas (catch from 1950 to 2000 combined with darker areas representing higher catches).
More challenging even than compiling information on species distribution is gathering information on the fishing access arrangements and known areas of fishing access by the nations reporting statistics to FAO and other bodies. For some years, FAO has kept a registry of these agreements (Farisis) that documents many existing arrangements. Unfortunately, this database does not include all arrangements, because these are viewed as confidential by many parties and are not always reported in trade papers. Therefore, in addition, it has been necessary to research the known fishing patterns of all major maritime states in all literature available, grey and otherwise, in order to document where reporting nations may have fished. While some nations fish almost exclusively in their own waters, others, e.g. Japan, Russia and Korea, have bilateral fishing arrangements covering the Exclusive Economic Zone (EEZ) waters of other countries. Knowledge of these arrangements is very useful because most taxa are taken within continental-shelf areas that lie almost exclusively within the EEZs of nations.

In the spatial allocation process, the distribution of each taxon was used, in combination with the known access of the reporting fishing nation, to determine which part of the large statistical area reported in the landing statistics could have yielded the reported catch and in what proportion. By processing fisheries database records in this fashion, many inaccuracies were discovered in the reported distributions of the different taxa, in the identification of each taxon, and in the accounts of fishing arrangements. Each statistical landing record that could not be spatially allocated because of these inconsistencies was investigated and the underlying databases improved or the data in the landing report modified to reflect the most likely circumstance (these are carefully documented). This process of refinement is ongoing but at present nearly 99.5% of global landings (by weight) reported by FAO can be spatially allocated. That is, the reported landing can be distributed amongst the \( \frac{1}{2}^\circ \) spatial cells. FAO's capture database comprises more than 7000 records annually (more than 235,000 since 1950). Though computationally demanding, each is spatially allocated and composite maps of global landings are developed. The resulting spatial databases allow queries to produce maps of such attributes as trophic levels, catch composition or catch value.

RESULTS AND DISCUSSION

It has been possible to produce maps of global fisheries landings with a resolution of \( \frac{1}{2}^\circ \) latitude by \( \frac{1}{2}^\circ \) longitude (e.g. Fig. 3). At such scales, historical catch time series have been used to investigate catch reporting anomalies (Watson and Pauly 2001), to allow ecosystem models of the North Atlantic to be extrapolated to basin-wide
R. Watson

studies of biomass and fishing intensities (Christensen et al. 2002), to look at diet overlaps between marine mammals and commercial fishing (Kaschner et al. 2002), to partition global coastal catches by large marine ecosystem (http://seaaroundus.org/lme/lme.asp), to examine changes in the trophic level of commercial landings (Pauly and Watson, 2003), and to estimate catch values by each nation's EEZ.

Marine planners face tremendous challenges. While commercial fisheries desperately attempt to expand and maintain profitability, their biological assets dwindle (Pauly et al. 2002). Public support for APAs to maintain marine systems has been growing but the hidden nature of marine resources makes denial relatively easy compared with terrestrial systems. Our impact on global climate, dangerous in its own right, is held by some to be the probable cause of biomass declines, and unfortunately to be sufficient justification for delayed action. Single-species management, long held to be sufficient to protect our marine resources, now appears incapable of capturing many critical processes such as trophic cascades. Unfortunately, 'management by ecosystem' has yet to be realized by most agencies. Ecosystem management is still believed by many managers to be too hard, unproven or unnecessary. Jurisdictional conflicts make decisions about large-scale marine closures difficult, and high-seas areas have little protection now that technologies exist for their exploitation (Roberts 2002). As always, it is easy to blame lack of political will or public ignorance for slow progress. Today, the signs of large-scale change can be seen in every ocean and sea. Trophic level decline in our capture fisheries is now well documented (Pauly et al. 1998; Pauly and Watson 2003). The challenge is for marine researchers to 'retool' quickly. Program suites such as Ecopath/EcoSim/Ecospace (Walters et al. 1999; Watson et al. 2000) now have many practitioners worldwide, and our experience and expertise is building.

Unfortunately, to provide managers with the tools to perform 'what if' examinations of management scenarios will require more than better tools. It will require better data. Many of us believe that there is precious little time to wait for this, all the worse because time-series data are required to provide likely trajectories for biomass and other vital measures. The approach described here provides a way of using currently available large-scale data to study spatial process on the scale of proposed APAs. These datasets were designed decades ago to track only broad economic development of nations' fishing industries, but must now serve other more demanding purposes. By coupling powerful existing databases on biological taxa with others dealing with fishing access arrangements, it is possible to improve the value of existing fisheries landing data, and to provide input of the type that ecosystem modelers urgently need to provide managers with vital information required for planning. The processes of taxonomic disaggregation and spatial allocation available within the SimMap program will assist by sharpening the spatial resolution of landings data sufficiently to be useful in the smaller-scale management decisions being investigated in the context of APAs.

Fig. 3. Catch Rates (all taxa) based on spatial allocation of FAO fisheries data for 1999.
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REFERENCES


