Rationale for reconstructing catch time series

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Introduction

The 'FishBase' Project organised the second regional training course in Trinidad in May / June 1998. Colleagues from most Caribbean ACP countries participated (see also this Bulletin Vol. 10(1) March 1997 and Vol. 11(1) March 1998). Their course work on their own data and additional information accessed additional data sources in the library gave rise to discussions among participants and the following reasoning on the importance of historical data and their analysis.

Estimating catches from the catch / effort of selected gear and fishing effort is a standard method for fisheries management. Reconstruction of historic catches and catch compositions series may require interpolations and other bold assumptions, justified by the unacceptability of the alternative (i.e., accepting catches to be zero, or otherwise known to be incompatible with empirical data and historic records). Simple equations are presented from which the status of fisheries and their resources can be determined (Hilborn & Walters, 1992; Pauly, 1995).

It is thus evident that reconstructing past catches and catch compositions is a crucial activity for fisheries scientists and officers in the Caribbean or the Pacific, and that such activity is required to fully interpret the data emanating from current data collection projects. This may be illustrated by the following example: suppose that the Fisheries Department of Country A establishes, after a large and costly sampling project, that its reef fishery generated catches of say 5 and 4 t·km⁻²·year⁻¹ for the years 1995 and 1996, respectively. The question now is: are these catch figures high values, allowing an extension of the fishery, or low values, indicative of an excessive level of effort?

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A frequent response to this situation has been to set up intensive, but relatively short-term projects devoted to improving national data reporting systems. Their key products are detailed statistics covering the (few) years of the project. However, these data are usually hard to interpret, given the frequent absence of data from previous periods, from which changes could be evaluated. This is a major drawback, as it is the changes occurring within a contrast-rich dataset which provide the basis from which trends in the status of the resources supporting various fisheries can be determined (Hilborn & Walters, 1992; Pauly, 1995).

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Charge of Fisheries may be hesitant to accept conclusions based on comparative studies, and require local evidence before taking important decisions affecting the local fisheries. One approach to deal with this very legitimate requirement is to reconstruct and analyse time series, covering the years preceding the recent period for which detailed data are available, and going as far back in time as possible (e.g. to the year 1950, when the above-mentioned FAO statistics begin). With such data, covering the early period of fisheries, it is then possible to quickly evaluate the status of fisheries and their supporting resources, and to evaluate whether further increases of effort will be counterproductive or not (Box 1).

Methodology for catch and effort reconstruction

The key part of the methodology proposed here is psychological: one must overcome the notion that "no information is available", which is the wrong default setting if dealing with an industry such as fisheries. Rather, one must realise that fisheries are social activities, bound to throw large 'shadows' on the societies in which they are conducted. Hence, records usually exist that document some aspects of these fisheries. All that is required is to find them and to judiciously interpret the data they contain. Important sources for such undertaking are:

1. Old files of the Department of Fisheries;
2. Various publications,
3. Theses, Scientific and travel reports, accessible in departmental or local libraries or branches of the University of the West Indies or the University of the South Pacific, or through regional databases, such as the Fisheries Management and Information System (FISIMS; Department of Fisheries, Port of Spain, Trinidad & Tobago), or the Pacific Islands Marine Resources Information System (PIMRIS, University of the South Pacific Library, Suva, Fiji); etc. The national departments tasked with collecting census data (to estimate fisher numbers) and with economic information (to estimate incomes from fishing);
4. Records from harbour master and other maritime authorities with information on number of fishing crafts (small boats by type; large boats by length class and/or engine power);
5. Records from the cooperative or private sectors (companies exporting fisheries products, processing plants, importers of fishing gear, etc);
6. Old aerial photos from geographic surveys (to estimates numbers of boats on beaches and piers); and last, but not least
7. Interviews with old fishers.

Estimating catches

Analysis of the scattered data obtained from (1)-(7) should be based on the simple notion that catch in weight (Y) is the product of 'catch/effort' (U; also known as 'CPUE') times 'effort' (f), or

\[ Y = U \cdot f \]

This implies that one should obtain from (1)-(7) estimates of the effort (how many fishers, boats or trips) of each gear type, and multiply it with the mean catch/effort of that gear type (e.g. mean catch per year per fisher, or mean catch per trip). As the catch/effort of small boats, and of individual fishers will differ substantially from that of the larger boats, it is best to estimate annual catches by gear or boat type, with the total catch estimates then obtained by summing over all gear or boat types.

Moreover, as catch/effort usually varies with season, estimation of Y should preferably be done on a monthly basis whenever possible, by applying equation (1) separately for every month, then combining the monthly Y-values to obtain an annual sum. This should be repeated for every component of the fishery, e.g. for the small-scale, semi-industrial and industrial components.

Once all quantitative information has been extracted from the available records, linear interpolation can be used to "fill in" the years for which estimates are missing. For example, if one has estimated 1000 t as annual reef catch for 1950 and 4000 t for 1980, then it is legitimate to assume, in the absence of information to the contrary, that the catches were about 2000 t in 1960 and 3000 t in 1970. [This interpolation procedure may appear too daring; however, the alternative to this is to leave blanks, which later will invariably be interpreted as catches of zero, which is a far worse estimate than interpolated values].

Quick interpretation of catch and effort data

There is a huge literature dealing with the fitting of surplus-production models to time series of catch and effort data (see e.g., Hilborn & Walters, 1992). Strangely enough, one rarely finds quick assessments based on the presented here.

Two key predictions of the parabolic Schaefer model (Schaefer, 1957; Ricker, 1975) are (1) that catch/effort (U) declines linearly with effort (f), and that (2) a stock is biologically overfished if U, in the fishery exploiting that stock, has dropped to less than 50% of its level at the onset of the fishery.

Thus, with two estimates of U, a higher one pertaining to an early state of the fishery (Uthen), and a lower one pertaining to a later, or to the present state (Unow), and the corresponding levels of effort (fthen) and (fnow), one can assess the present status of a fishery by first calculating

\[ b = (U_{\text{then}} - U_{\text{now}})/(f_{\text{now}} - f_{\text{then}}), \quad \text{and} \]

\[ a = U_{\text{then}} + (b \cdot f_{\text{then}}). \]

then, using 'a' and 'b', one can calculate Maximum Sustainable Yield (MSY) and its associated level of effort (f_{\text{MSY}}) from

\[ \text{f}_{\text{MSY}} = a / (2b), \quad \text{and} \quad \text{MSY} = a / (b \cdot f_{\text{MSY}}). \]

Applied to the data from Philippine small-scale fisheries presented in Box 2, these equations lead to b = 0.00000073, a = 5.069, MSY 880,000 t/year, and f_{\text{MSY}} 547,000 fishers.

The theory and applications of surplus-production models have often been the subject of fierce debates, notably on how sustainable MSY really is (see e.g., Hilborn & Walters, 1992). However, it is generally agreed that a reduction by 50% or more of initial catch/effort indicates overfishing in about any stock, at least in economic terms. Hence the quick diagnostics suggested above should always be useful as the first approach.
Estimating catch composition

Once catch time series have been established for distinct fisheries (nearshore/reef, shelf, oceanic, etc.), the job is to split these catches into their components, i.e., into distinct species or species groups. Comprehensive information on catch composition allowing this to be done will usually be lacking. Therefore, the job of splitting up catches must be based on fragmentary information, such as the observed catch composition of a few, hopefully representative fishing units. Still, combining within periods of say five years all available anecdotal information on the catch composition of a fishery (i.e., observed composition of scattered samples) should allow the estimation of reasonable estimates of mean composition if use is made of the statistical principle that, in the absence of further information on their relative contributions, equal probabilities are assigned to the items jointly contributing to a whole. Thus, a report stating, say, that “catches consisted of groupers, snappers, grunts and other fish” can be turned into 25% groupers, 25% snappers, 25% grunts, and 25% other fish as a reasonable first approximation.

A number of such approximations of catch composition can then be averaged into a representative set of percentages, which can be applied to the catches of the relevant period. These percent catch compositions can be interpolated in time, e.g., for 1950-1954 with a composition of 40% groupers, 20% snappers, 10% grunts and 30% other fish, and 10%, 10%, 20%, respectively 60% for these same groups in 1960-1964. In this case, the values for the intermediate period (1955-1959) can be interpolated as 25% groupers, 15% snappers, 15% grunts, and 45% other fish.

Results and Discussion

There is obviously more to reconstructing catch time series than outlined above, and some of the available methods are rather sophisticated. They are usually not applied, however, because potential users do not trust themselves to make the bold assumptions required to reconstruct unseen quantities such as historic catches. Only by making such bold assumptions, however, can we obtain the historic catches required for comparisons with recent catch estimates and thus infer key trends in fisheries (see Boxes 1 and 2).

One example may be given here. The FAO catch statistics for Trinidad & Tobago for the years 1950-1959 start at 1000 t (1950-1952), then gradually increase to 2000 t in 1959. Of this, 500-800 t was contributed by ‘Osteichthyes’, 300-500 t by ‘Scomberomorus maculatus’ (now known as S. brasiliensis), 100-200 t by ‘Penaeus spp.’, and 0-100 t by ‘Perciformes’ (presumably reef fishes). On the other hand, the same statistics report, for 1950-1959, catches of zero for Caranx spp.; Clupeidae; Katsuwonus pelamis; Sarda sarda (not surprising since it does not occur in Trinidad and Tobago, though it reportedly yielded catches of 21-35 t in 1983-1984); Scomberomorus cavalla; Scomberomorus spp.; Thunnus alalunga; and T. albacares.

Despite their obvious deficiencies, these and similar data from other Caribbean countries are commonly used to illustrate fisheries trends in the region. Fortunately, it is very easy to improve on this. Thus, Kenny (1955) estima-
Changes in the catches of Philippine fishers

Overfishing of the nearshore areas accessible to small-scale fishers is widespread throughout the Philippines, particularly in areas with high industrial gear (especially bottom trawlers) is intense. Thus, the catch per fisher of only 1.42 t, with as many as 501,000 small-scale fishers operating (Smith et al., 1980).

This catch/effort is much less than at the beginning of the century when, in the absence of industrial gear, 119,000 fishers caught 500,000 t year⁻¹ (Anon., 1905, p. 564), or 4.2 t year⁻¹ per fisher (details in Pauly, 1986). Box 1 presents a set of simple equations from which, given these numbers, both MSY (880,000 t year⁻¹), and optimum level of effort (347,000 fishers) can be estimated. These lead to the conclusion, well supported by empirical studies (Smith et al., 1980; Tandog-Edralin et al., 1988; Pauly & Chua, 1988), that the small-scale fisheries of the Philippines were, as early as the 1970s, overexploiting the resources accessible to them.

The subsequent, massive increase of the number of small-scale fishers is what led to the phenomenon now known as 'Malthusian overfishing' (Pauly, 1988, 1997; Russ, 1991; McManus, 1996), and to the attendant destruction of coral reefs through widespread use of dynamite and cyanide. These pathologic forms of fisheries 'development' will appear in the Caribbean as well, if access to the fisheries remains open, competition from industrial gear is allowed to develop, and alternative employment is not found for a growing number of would-be fishers. Hence the importance of being aware of historic trends in the status of resources.

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References


