METHODS FOR STANDARDISATION OF CATCH/EFFORT AND DATA REQUIREMENTS

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Abstract

For a number of important species in Australia, stock assessment depends on abundance indices derived from commercial logbook catch rates. In most fisheries the gear used, methods employed or grounds fished have changed through time, and changes in these factors should be accounted for in the analysis of the catch rates. A number of methods are available for effort standardisation which may be classified into the categories: (1) derivation of an abundance index from a subset of the available data which excludes effort measures which may have varied; (2) calculation of the relative efficiency of fishing units for the adjustment of effort measures; and (3) decomposition of fishing effort according to the values of measured attributes. Each of these methods have different data requirements, and potential sources of bias and error in the analyses are many.

Introduction

In fisheries where there are no fishery-independent measures of abundance, the commercial catch rate is commonly used as an abundance indicator. Even for those few fisheries where a time series of catch at age information has been collected, either fishing effort or catch per unit effort (CPUE) from the commercial fishery are often used to tune age-structured population models. In all such models the usual assumption is that CPUE directly reflects relative abundance, or that a unit of fishing effort maintains the same ability to catch fish through time. In reality, for most fisheries the gear used, methods employed or grounds fished have changed through time leading to changes in the relationship between catch rates and true abundance. Where the nature of such factors has changed, some form of effort standardisation is required. A number of methods are available for such an analysis, and the purpose of this paper is to classify the methods into broad categories, to investigate the data requirements for each and to present a list of problems which may be encountered with this form of analysis.

Methods of standardisation

I have categorised standardisation methods into the three broad categories of subset, relative, and statistical decomposition. Particular methods may not fall simply into such a classification, there is some overlap between them, and all may be used as part of a single analysis, but this serves a useful purpose when considering the associated data requirements.

Subset

The simplest form of effort standardisation is the selection of a subset of the available catch and effort data which most reflects true abundance changes rather than other effects such as changes in the fishing power of the fishing fleet. For example, if one or a group of vessels are known to have fished in a consistent manner (same areas, little gear change) over a number of years, catch rates for those vessels may be selected for examination.

This commonly used method was applied to the South East Fishery (SEF) to examine CPUE for the 16 quota species. The current logbook contains information from 1985 by fishing operation by depth and position. This allowed catch and effort by species from small areas and depths which had been consistently fished in all years to be used as a standardised CPUE.

Relative standardisation

Relative standardisation methods are commonly used to determine the fishing efficiency of fishing units such as vessels or vessel classes. A number of studies (e.g. Beverton and Holt 1957; Haynes and Pascoe 1988) have used direct and indirect comparisons of the fishing performance of individual vessels at the same place and time to derive fishing power estimates without resorting to more formal statistical methods. This only requires information on relative catch rates and does not require information on other factors such as fishing gear used if it is assumed that vessels have fished in a consistent manner through time.

These methods provide a relative indication of individual fishing vessel performance which are used to adjust catch rates to produce a standardised CPUE.

Statistical decomposition

For fisheries where attributes which affect the observed catch rate have been measured, there are a number of statistical techniques which can be used. Statistical methods are used to fit models incorporating the measured attributes and the observed catch rates to quantify the effect of the attributes on the catch rates. Examples are ANOVA (e.g. Kimura 1980), and generalised linear modelling (GLM - e.g. Stocker and Fournier 1984; Punsley 1987).

The most accepted and widely used statistical method at present is the fitting of GLM models to catch rate data (see Table 1). The use of generalised additive models (GAM - e.g. Swartzman *et al.* 1992) are a refinement of GLM which has not been used widely to date, but may become more accepted in future.

Data requirements

Good knowledge of the nature of the fishery

For a researcher contemplating any form of standardisation of fishing effort, the principal requirement is a knowledge of which factors are most important in influencing catch rates within the fishery. This is usually gained by observing the fishing operations of the industry, and by talking to individual operators. Information of this type may be gathered in a form suitable for more detailed analysis - for example, a survey was designed for the SEF which allowed individual operators to nominate the relative importance of a number of factors which may have affected their catch rates through time.

Logbook

Most of the information is collected primarily to allow effort to be standardised. For fisheries on species which range over a large area and have cyclical behaviour patterns, CPUE will vary according to areas and times fished. In such a case (all of the major fisheries in Australia), I believe that the minimum information that should be collected would include position, depth fished, date, time, fishing unit i.d. (e.g. vessel), search time (particularly for pelagic fisheries) and the catch by individual species by fishing operation. This minimum set of information allows considerable scope for the more powerful standardisation procedures.

Other details often collected, and varying in importance depending on the fishery include: skipper identification, gear configuration, installed electronic equipment, storage capacity, crew details, towing or setting power, bait used, local weather or sea conditions, sea surface or fishing depth temperature, and measures of the level of cooperation or interference between vessels on the grounds.

Additional data

Much information is available for most fisheries which may be collected independent to the fishery but having important influences on catch rates. These include current market prices, weather conditions, moon phases, el Niño events and oceanographic conditions. Where such factors are suspected to have an influence, they can be included as parameters in the statistical standardisation procedures and their effects measured.

Case studies: problems

CPUE from the fishing operations does not reflect abundance

In some fisheries, or at certain stages of a fishery, the catch rates may not indicate abundance regardless of the standardisation carried out. An example may be a species such as orange roughy that forms dense predictable aggregations which are targeted by the commercial fishery. In such a case, if fished in a consistent manner, it is plausible that CPUE (from such aggregations) may remain constant as true abundance declines to a low level. Where this is believed to be a problem, alternative indices such as catch rates from fish in their non-aggregated phase or abundance estimates provided by fishery independent acoustic or egg surveys are required.

Incomplete or inaccurate statistics

Where commercial logbook information is used, only the landed catch is often recorded. If the catch is graded, small fish may be discarded, or in a multi species fishery, certain species may not be retained. In the SEF for example, assessment of the stock status for redfish is complicated by a variation in the rate of discarding for the species through the years.

Misreporting of details such as catch position or true total catch are influenced by the existing level of cooperation between the data gatherers (fishers) and the analysts (managers or scientists). This may be caused by factors such as changing enforcement levels or changes in management strategy from fishery input (effort) control to output (catch) control.

Where the true details of fish killed may not be recorded by commercial operators, observers are often used to independently collect catch details which reflect the true impact of fishing operations more precisely. Such observer information may be used independently to determine abundance indices, or may be used to make corrections to more spatially and temporally comprehensive commercial logbook data.

Unmeasured factors influencing catch rate

(1) Availability

The availability of a species indicates the portion of the stock which is susceptible to fishing given consistent fishing methods. In the calculation of abundance indices it is usually assumed that the entire stock or a constant portion of it is susceptible to fishing through time.

Availability of a species may fluctuate naturally according to changing environmental conditions which could result in a change in schooling , feeding, migration or spawning behaviour. In some cases a correlation can be found between abundance and a measurable environmental effect such as el Niño. Such a correlation is difficult to prove absolutely as the causative mechanism is not usually understood in detail. For fisheries such as Australian jack mackerel, availability does fluctuate but the cause is unknown at present. To statistically test correlation between availability and measured environmental conditions with a reasonable degree of certainty, a long time series of abundance estimates is required.

In species where availability is known to fluctuate in a systematic but unpredictable way due to unmeasured factors, CPUE can not be reliably standardised to provide an index of abundance. In such cases, age-structured population models are required to provide information on the dynamics of the stock. As previously mentioned, an index of abundance is often needed to tune such age-structured population models (Catch 22). Where abundance indices show a trend consistent with trends in fishing effort, and without scientifically quantifiable information on changes in availability, the conservative approach is to attribute changes in the abundance index to fishing mortality.

(2) Vulnerability

The vulnerability of a species measures how easily it is caught given constant availability. Vulnerability varies with the fishing methods employed and may be caused by changes to such things as vessel characteristics, gear efficiency and fisher behaviour. If important factors which affect vulnerability are not measured, the quality of a calculated abundance index is reduced.

In the SEF, for example, kort nozzles have been added to many vessels in recent years which improve their towing power. Rubber rolling (bobbin) gear has also been added to the trawl nets to allow fishing of grounds which proved to be unfishable previously. Records of the timing of these important changes in fishing methods have not been collected, making interpretation of catch rates more difficult. In such cases the importance of such changes should be recognised early and appropriate records kept.

In some cases it is difficult or impossible to attribute changes to either availability or vulnerability. For example, sometimes catch rates show consistent changes which can not be easily explained or tied to a measurable factor. In a number of fisheries (e.g. SEF blue grenadier, SEF tiger flathead, southern bluefin tuna) catch rates consistently fall at a higher than expected rate in developing areas of the fishery. Although unsatisfactory, the initial development period in such cases is often excluded from catch rate analyses.

References

Beverton, R.J.H. and S.J. Holt (1957). On the dynamics of exploited fish populations. *Fisheries Invest., Lond. Ser. 2*, **19**.

Haynes, J. and S. Pascoe (1988). A policy model of the Northern Prawn Fishery. Australian Bureau of Agricultural and Resource Economics Occasional Paper 103.

Kimura, D.K. (1980). Standardized measures of relative abundance based on modelling log (c.p.u.e.) and their application to Pacific perch (Sebastes alutus). *J. Cons. int. Explor. Mer* **39**, 211-218.

Punsley, R. (1987). Estimation of the relative annual abundance of yellowfin tuna, *Thunnus albacares*, in the eastern Pacific ocean during 1970-1985. *Inter-American Tropical Tuna Commission Bulletin* **19**, No. 3, 265-306.

Stocker, M. and D. Fournier (1984). Estimation of relative fishing power and allocation of effective fishing effort, with catch forecasts, in a multispecies fishery. *Int. North Pac. Fish. Comm. Bull.* **42**.

Swartzman, G., C. Huang and S. Kaluzny (1992). Spatial Analysis of Bering Sea Groundfish Survey Data Using Generalised Additive Models. *Can. J. Fish. Aquat. Sci.* **49**, 1366-1378.

Table 1. Example GLM model structures

The CPUE at time period t for vessel i can be characterised by the following example linear relationships:

(a) model with simple discrete effects

$$\log(CPUE_{ti}) = \log(CPUE_{11}) + \log(y_t) + \log(v_i) + e_{ti}$$

(b) model with discrete effects and interactions

$$\log(CPUE_{ti}) = \log(CPUE_{11}) + \log(y_t) + \log(v_i) + \log(yv_{ti}) + e_{ti}$$

(c) model with discrete effects, interactions and a continuous effect s

$$\log(CPUE_{ti}) = \log(CPUE_{11}) + \log(y_t) + \log(v_i) + \log(yv_{ti}) + \log(s\ ) + e_{ti}$$

where t = 1 to number of time periods
i = 1 to number of vessels
e = a residual error term with an assumed (often normal) distribution
y = year
v = vessel
$CPUE_{11}$ = a standard CPUE for vessel 1 in time 1

The values of y from 1 to t provide the standardised index of abundance.