Application of Length-Based Stock Assessments to Kuwait's Fish Stocks

Traditional Kuwaiti fishing vessel with fish traps. Photo by R.S.V. Pullin.

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As in many other developing countries, historical data on Kuwait's fisheries are sparse with few reliable historical records being available of either catch or fishing effort. Stock assessment methods which utilize such data cannot therefore be used and as a result reliance has necessarily been placed on stock assessment techniques which use the growth and mortality characteristics of fish stocks to predict their response to changes in fishing effort and/or changes in size at first capture.

The usual methods for such assessments follow the work of Beverton and Holt and of Ricker and involve, among other things, estimating the age structure of the commercial catch. For a single species such regular age composition sampling, which is usually performed by examining the otoliths or scales of samples of fish, can be time consuming and costly. If a large number of species needs to be examined (as is usually the case in the tropics) the workload often becomes unmanageable.

The Multispecies Problem

Since Kuwait's finfish fisheries land 40-50 different species of fish with 10 species accounting for about 75% of the landings, regular ageing of samples of all of these species to an acceptable level of precision is beyond the present manpower availability of the Fisheries Management Project of the Kuwait Institute for Scientific Research (KISR). In addition, since samples usually have to be purchased, the costs involved in such sampling are considerable. It was for these reasons that an examination of the suitability of length-based methods for providing regular assessments of the stocks of the more important commercial fish species in Kuwait was carried out.

To date, comparisons of age-based and length-based methods have been carried out for three species. These are the croaker, *Otolithes argenteus* (locally known as newaiby), red snapper, *Lutjanus coccineus*, (hamra) and the grouper, *Epinephelus tauvina* (hamoor). The three species comprise a range of longevity in the fishery with newaiby being a relatively short-lived, fast growing species (maximum of three year-classes in the fishery) while at the other extreme hamra is a very long-lived, slow growing species (fish up to 46 years old have been identified). In addition hamra and hamoor are captured by fish traps while newaiby is primarily taken by trawling and gillnetting.

Technique

Length composition data were collected for each species on a monthly basis from the two major fish markets in Kuwait. In addition, a subsample of each of these monthly samples was taken and aged by means of the otoliths. A seasonally oscillating growth curve of the form:

$$L_t = L_\infty\left(1-e^{-[K(t-t_o) + \frac{K}{2\pi} \cdot \sin 2\pi(t-t_s)]}\right)$$

was then fitted to data on length at age for the aged sample and to the monthly series of length-composition data using the ELEFAN I technique of Pauly and David (see ICLARM Newsletter, July 1980, p. 13-15). Total mortality rates were estimated using a catch-curve method for the aged samples and a length converted catch curve (as incorporated in ELEFAN II, see ICLARM Newsletter, July 1981, p. 10-13) for the length samples. For both the length and age data, the appropriate linear regression fitted to the right hand limb of the catch curve was extrapolated backwards and the ratio between the observed y-values and the expected values calculated for those points which were not used in the derivation of the linear regression. When these ratios were plotted against the midlength of the appropriate size group, curves approximating to selection curves were generated from which mean selection lengths were estimated for the two data sets.

Using the appropriate growth, mortality and selection parameters, together with a length-weight relationship and natural mortality value for each species, values of yield per recruit at various values of fishing effort and at various sizes of first capture were calculated for each species from both the age and length composition data.

Results

Table 1 shows the comparison between the various parameter estimates derived from the age data and the length data. In most instances, there is close similarity between the estimates and this is particularly noticeable for newaiby, the species with the shortest life span. Estimates of the growth parameters for the older, slow growing species of hamoor and hamra were more divergent (particularly the estimates of asymptotic length) and this was a result of difficulty in identifying a single optimum value of the "goodness of fit" parameter in the ELEFAN I technique since age groups in the slower growing species tended to show more overlap. Since these growth parameters are the cornerstone of further analyses of the length-composition data, total mortality and selection lengths also differed in these species.

Despite the differences in the various parameter estimates for each species, the length composition data provided the same conclusions as to the state of exploitation of each stock as the age composition data. The management advice which would have been provided

Table 1. Comparison of stock assessment parameter estimates for three fish species from Kuwait waters from length and age data.

Parameter	Newaiby Length data	Newaiby Age data	Hamoor Length data	Hamoor Age data	Hamra Length data	Hamra Age data
L_∞) growth	69.6 cm	68.0 cm	148.0 cm	99.9 cm	92.5 cm	73.1 cm
K) growth	0.240	0.258	0.088	0.131	0.135	0.135
t_o) growth	−0.534	−0.470	−0.060	−0.509	−1.847	−3.47
C) growth	1.00	0.992	0.88	1.00	0.99	1.00
t_s) growth	−0.20	−0.112	0.50	0.42	−0.49	0.089
Total mortality, Z	1.594	1.459	0.384	0.302	0.366	0.411
Natural mortality, M	0.526	0.555	0.221	0.320	0.333	0.386
Fishing mortality, F	1.068	0.904	0.163	N/A	0.033	0.025
Selection length, l_c	25.8 cm	N/A*	46.3 cm	N/A	27.8 cm	24.2 cm
Optimal yield per recruit at relative F of	1.0	1.0	2.0	2.0	2.0	2.4
Optimal yield per recruit at age of first capture of	2.0 yr	2.0 yr	4.3 yr	3.5 yr	2.0 yr	2.5 yr

*N/A – could not be calculated.

on the basis of the length composition data alone was therefore identical to that based on the age composition data.

Advantages

The greatest advantage in using length composition rather than age-composition data is the saving in both manpower and capital. Table 2 provides estimates of the relative costs in Kuwait of collecting monthly size-composition and age-composition data for each species so far examined. It is readily apparent that, except for newaiby, collection and analysis of age-composition data for stock assessment purposes involves considerable more operating and capital expense than does the collection of size-composition data. This is particularly relevant for hamoor, a high priced species, where the purchase of fish for age determination purposes represents the most significant item of operating expenditure. For newaiby, the cost advantage of using size composition data is not so apparent since less time is usually required for both age determination and data analysis in this short-lived species than is required for hamra and hamoor. In addition, cost savings are achieved by collecting newaiby for age determination purposes from research vessel trawl catches. It should be emphasized that the cost comparisons shown in Table 2 apply to the current situation in Kuwait and may differ in other localities depending on such circumstances as manpower costs, fish costs and computer availability.

Throughout the world, considerable attention is now being focused on length-based stock assessment methods as a tool for providing rapid, reliable analyses of fish stocks at minimum cost. The initial experience in Kuwait appears to indicate that the ELEFAN techniques do indeed provide realistic assessments of fish stocks with some (often considerable) saving in both manpower and cost. However, since much of the value of already collected age-composition data is lost if such sampling is discontinued, caution is being exercised and further examination of the length-based stock assessment techniques is being undertaken, particularly with regard to their sensitivity to changing mortality rates and to gear-selection effects. ●

Table 2. Comparison of monthly costs (US$) of collecting and analyzing length and age data for three fish species in Kuwait to provide stock assessments. The comparison does not include the costs involved in collecting ancilliary data such as catch and fishing effort.

Item	Hamra Length data	Hamra Age data	Hamoor Length data	Hamoor Age data	Newaiby Length data	Newaiby Age data
a) Manpower costs						
Collection of samples	137	55	137	55	137	55
Examination of otoliths	–	165	–	220	–	55
Analysis of data	110	110	110	110	110	83
Total manpower costs	247	330	247	385	247	193
Total man-days	4.5	6.0	4.5	7.0	4.5	3.5
b) Fish costs	–	257	–	685	–	100
Total operating costs	247	587	247	1,070	247	293

Item	All species Length data	All species Age data
c) Capital costs		
Grinder	0	170
Microscope	0	850
Measuring board	68	68
Miscellaneous	20	20
Total capital costs	88	1,108