Some methods of calculating catch at age from the directed fisheries for red snapper in the Gulf of Mexico, 1984-2002.

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Introduction

Schirripa and Legault (1999) estimated the age composition of Gulf of Mexico red snapper using the probabalistic aging method developed by Goodyear (1997). That method uses an index of year class strength, estimates of mortality, a growth equation and observed size samples to develop a probability distribution of age composition. That method also permits the estimation of discard catch at age under the assumption that selectivity is age based and assumptions about fishery specific release mortality rates. Schrippa and Legault (1999) noted differences between fishery specific probabilistic age composition and age composition computed from observed age samples available for the last year in their data (1998).

The purpose of this note is to describe the approach used for developing the catch at age used in most recent assessment and to briefly note alternative approaches (use of age-length keys and calculation of observed age composition directly from aged samples) which might be considered by the red snapper SEDAR data workshop.

Probabilistic aging

With the probalistic method age composition is calculated primarily from the observed length samples, the annual harvest or yield, a growth curve, an index of recruitment and estimates of fishing and natural mortality rates (Goodyear 1997). The procedure employed also produces estimates of the numbers of fish discarded dead (Schirripa and Legault 1999) using information on the annual minimum size and several assumptions such as that selectivity is age based and release mortality rates. Additionally the calculations for the recreational fishery involve information on the proportion of the recreational catch that is released and an assumed selectivity pattern in the absence of management.

For each sampled length (L) the probability of observing a fish of close to that length given and age ($p_{L,a}$) is assumed to be from a normal distribution with mean $\bar{L}_a$ (computed from the von Bertalanfy growth equation and taking into account the date when the sample was taken), and the standard deviation of length at age, s_a [derived from the product of a constant coefficient of variation of length at age (0.10), and the mean length at each age]. The value of $p_{L,a}$ in each year ($p_{yL,a}$) is obtained from the difference in cumulative probabilities of age for lengths slightly above and below the sampled length:

$$p_{ya,L} = \frac{[prob(L+0.05s_a - \bar{L}_a) - prob(L-0.05s_a - \bar{L}_a)]W_{ya}}{\sum_{a=1}^{30}[prob(L+0.05s_a - \bar{L}_a) - prob(L-0.05s_a - \bar{L}_a)]W_{ya}}$$

where W_{ya} is a weighting factor derived from an annual recruitment index (I) and fishing (F_{ya})and the natural mortality (M_a) rates (the index values and mortality rates were all assumed constant for this assessment):

$$W_{ya} = I_{y-a} \exp-(F_{ya} + M_a)$$

The frequency at age was then calculated from all the length samples:

$$f_{yak} = \sum_{a=1}^{30}\sum_{L} p_{a:L} m_{Lk}$$

where m_{Lk} is the number of fish measured at each length, for gear (or mode), k, and L represents each length in the samples.

The landed catch at age for the commercial fishery is calculated as:

$$C_{yak} = f_{yak}\frac{Y_{yk}}{w_{yk}}$$

where Y_{yk} is the landed yield by year and gear group (longline, east handline plus other gears and west hnadline plus other gears) and w_{yk} is the total weight of the of the measured fish by year and gear group..

For the recreational fishery the harvested (A+B1 for MRFSS and landings for the Texas and headboat data sets) catch at age is calculated as:

$$C_{yak} = \frac{f_{yak}}{\sum_{a=0}^{30} f_{yak}} H_{yk}$$

where H_{yk} refers to the number of fish harvested by year and mode.

In addition to calculating the number of fish landed at age, the approach approximates the number of fish discarded at age. The average probability, g, that a fish of age, a, would be greater than the minimum size (msize) in year, y, is computed as

$$g_{ya} = \frac{\sum_{d=1}^{n} p(\bar{L}_{ad} \geq msize_y)}{n}$$

where n is the number of days, d, in the months when the fishery was open and $\bar{L}$ is the mean length

at age computed from the growth equation.

Commercial discards

The number estimated to have been discarded dead from the commercial fishery, D_{yak}, is modeled as:

$$D_{yak} = G_{yak}\left(\frac{1-g_{ya}}{g_{ya}}\right)d_k$$

where d_k is the discard mortality rate for gear or mode, k, (0.33 for the commercial) and G_{yak} is the landed catch of fish greater than or equal to the minimum size in year, y, at age, a, by gear, k. For all commercial discard estimates the youngest age considered vulnerable to fishing was age 3 by Schirripa and Legault (1999).

Recreational discards

For the recreational fishery an estimate of the discards (B2) was available from MRFSS estimates. The fraction that those discards represented of the total is used in estimating the total dead discards for all recreational fisheries. The total number of recreational fish released alive is then calculated as:

$$R_{yk} = H_{yk}\left(\frac{r_y}{1-r_y}\right)$$

where H_y is number of fish harvested (A+B1 for MRFSS, landings for headboats, and landings for Texas) and r_y is the proportion released alive from MRFSS (B2/(A+B1+B2)).

The average probability that a fish of a given length at an age is below the minimum size (s_{ya}) is the reciprocal of g_{ya} given above. It is then weighted by (1) the an input selectivity at age (S_{ya}, with values of 0.67, 0.92 and 0.99 for ages 1-3 years, then 1.0 for the ages 4 and older) and (2) the weighting developed from the mortality rates and the juvenile abundance index and re-normalized

$$Q_{ya} = \frac{s_{ya}S_aW_{ya}}{\sum_{a=1}^{30} s_{ya}S_aW_{ya}}$$

Total recreational dead discards by year and age are then computed as

$$D_{yak} = R_{yk}Q_{ya}d_k$$

The probabilistic catch at age is developed with an iterative process in which the estimates of fishing mortality are updated with virtual population analyses (Goodyear 1997). Schirripa and Legault (1999) used three iterations to develop the final catch at age used in the previous assessment.

Catch at age was developed for multiple strata by Schirripa and Legault (1999). Those strata were the commercial handline fishery in the eastern Gulf of Mexico (statistical areas 1-10), the handline fishery in the central and western Gulf of Mexico (statistical areas 11-21), the longline fishery (all areas), and the entire recreational (though state and mode were accounted for in developing that catch at age)

Observed age composition

The increased numbers of age observations available from the directed fisheries allows for calculating the age composition just from those observations rather than through the use of growth curve based methods such as the probabilistic method (Goodyear 1997) described above. Chih (SEDAR7_DW 43) points out that sampling intensity may differ among strata; if observed age composition is to be calculated for the entire U.S. Gulf or sub regions, such differences will likely have to be taken into account. Chih further notes concerns about sample size effects on estimates of size composition for at least some of the sampled strata. If observed age composition is to be developed the generality and implications of Chih's results will have to be investigated and if necessary taken into account.

Age composition estimated from age-length keys

Chih (SEDAR7_DW 43) suggested that consideration be given to calculating age composition through the use of age-length keys. Fitzhugh *et al.* (SEDAR7_DW 35) note that age-length keys for some sizes of red snapper may be highly imprecise because of the large number of ages (> 50) represented in samples within a relatively small interval (10 cm). Such a conclusion appears to be supported for younger ages as well by wide range of ages indicated for various size ranges as seen in Alman *et al.* (SEDAR7_DW 33).

Issues

If possible the data workshop should develop recommendations related to calculation of the catch at age for the assessment:

1. Which method(s), should be used for calculating age composition

2. Which stratfications should be used in developing age compostion.

Literature Cited

Goodyear, C.P. 1997. Fish age determination from length: an evaluation of three methods using simulated red snapper data. Fish. Bull. 95: 39-46.

Schirripa, M.J. and C.M. Legault. 1999. Status of red snapper in U.S. waters of the Gulf of Mexico: updated through 1998. Nat. Mar. Fish. Serv. SEFSC, SFD-99/00-75. 57p.