CERT
Comité d'évaluation des ressources transfrontaliéres
Document de travail 2014/7
Ne pas citer sans autorisation des auteurs

TRAC
Transboundary Resources Assessment Committee
Working Paper 2014/7 Not to be cited without permission of the authors

Length-based mortality estimates for Georges Bank yellowtail flounder (*Limanda ferruginea*)

Deborah R. Hart

NOAA/Northeast Fisheries Science Center
Woods Hole, MA 02543

Ce document est disponible sur l'Internet á:

This document is available on the Internet at:

http://www.mar.dfo-mpo.gc.ca/science/TRAC/trac.html

Introduction

The Beverton-Holt (1956) length-based mortality estimator (hereafter referred to as BHZ):

$$Z = K \frac{L_\infty - \bar{L}}{\bar{L} - L_c} \tag{1}$$

where $\bar{L}$ is the mean length of fish $\geq L_c$, and L_∞ and K are von Bertalanffy growth parameters, is a simple way to infer mortality from length information and a growth curve. Because mean length in surveys is typically more stable than abundance data, it can be applied on a substock level. The purpose of this paper is to present BHZ mortality estimates for Georges Bank yellowtail flounder from survey data. In addition to mortality estimates for the entire stock, it was also possible to obtain mortality estimates within an area closed to fishing, thus allowing for some inferences regarding natural mortality.

Methods

For yellowtail flounder, von Bertalanffy growth coefficients have been estimated as $L_\infty = 50$ cm and $K = 0.335$ (Lux and Nichy 1969). Unless otherwise specified, L_c was taken to be 30 cm, roughly the length at which yellowtail recruit to the fishery; sensitivity of the results to this parameter will be explored. Length data was obtained from the NEFSC spring and fall trawl surveys and the NEFSC scallop survey, which is conducted during the summer using an 2.44 m New Bedford scallop dredge with 5.1 cm rings and a 3.8 cm plastic liner. The scallop survey has a much higher density of tows within the Georges Bank yellowtail flounder stock area than the trawl survey, and thus is very useful for analyzing effects of closed areas on yellowtail population dynamics.

BHZ is based on an equilibrium length distribution, and thus can be biased in any given year due to non-equilibrium conditions such as variations in recruitment and fishing mortality. BHZ is a lagging indicator of mortality, since the mean length reflects the mortality from previous years as well as the present year; the lag is less evident in stocks that have relatively high mortality such as yellowtail flounder. Strong year classes will first cause BHZ to be biased high when this year class is of lengths only slightly greater than L_c but then biased low as this year class ages. Both of these effects can be mitigated by using moving average smoothers. Here, I used a three year forward moving average smoother, i.e., the moving average for year i is given by $\bar{z}_i = z_i + z_{i+1} + z_{i+2}$, where z_i is the BHZ for year i. A forward moving average smoother was used to compensate for the fact that the BHZ is a lagging indicator of mortality. The BHZ estimates were compared to those from the current VPA model (Legault et al. 2013), computed as $Z_{\text{VPA}} = F_{2-4} + M$, where F_{2-4} is the estimated fishing mortality from the VPA model (Legault et al. 2013), averaged over ages 2-4, and natural mortality M is taken to be 0.2, as in the current VPA model.

BHZ estimates were also calculated from the scallop survey in the southern portion of Closed Area II, where there was evidence of buildup of yellowtail after this area was closed in December 1994, and areas that remained open to fishing after the closed areas were implemented in 1994. These were also calculated when L_c was reduced to 25 and 20 cm, in order to see if the BHZ was lower when some fish not of commercial size were included. The scallop survey is more suited to reductions in L_c than the trawl survey, because it should retain full selectivity well below 20 cm, due to its 5.1 cm rings and 3.8 cm liner.

Results

BHZ estimates were generally highest during the 1985-1994 period, and lowest during the late 1990s through 2003 (Figure 1). Estimates from the spring and fall trawl surveys and the scallop survey were reasonably similar. Mortality estimated from the VPA generally agreed with the BHZ estimates during 1985-2005, but were somewhat higher prior to 1985, and lower during the most recent period. BHZ estimates in the southern portion of Closed Area II were about 0.5 during the 1997-2003 period, but then increased due to a brief but intensive fishery within this area in 2004 and a large 2005 year classs (Figure 2, Table 1). In the most recent years, total mortality in the closed area has been about 0.8. By comparison, BHZ estimates in the open areas were considerably higher than inside the closed area since the 1994 closure in all but the most recent years.

When L_c was reduced to 25 cm and 20 cm, the mean BHZ between 1999-2003 inside the closed area was 0.32 and 0.3, respectively compared to 0.53 when $L_c = 30$ cm (Table 1). During the more recent period (2010-2012), the estimates of BHZ inside the closed area ranged from 0.35 when $L_c = 20$ to $L_c = 0.91$ when $L_c = 30$.

Discussion

BHZ estimates generally agree with VPA estimates for the middle converged portion of the VPA time series, lending support to VPA total mortality estimates for this time period. However, VPA fishing mortality and biomass estimates are dependent on the accuracy of its natural mortality estimate of $M = 0.2$.

BHZ estimates within a closed area can give insights on natural mortality. Because some exchange between closed and fished areas is to be expected, these estimates should be considered upper bounds on natural mortality, rather than unbiased estimates. Movement between open and closed areas would cause the calculated BHZ in the closed areas to increase with L_c as observed, because the lengths of commercial sized fish would be reflective of some fishing mortality. The closed area BHZ estimate therefore suggests that natural mortality was no higher than about 0.3 during the 1999-2003 period. Comparison of this estimate with the open BHZ at $L_c = 30$ cm during this time period indicates that fishing mortality in the open areas was at least 0.7.

The BHZ estimates in the closed area were higher during 2010-2012, and closely resembled their corresponding values in fished areas. The similarity between the estimates in the closed and open areas during this period suggests substantial mixing between these areas so that, unlike during the first decade of closure, few yellowtail remained in the closed area year-round. The fact that the increase in mortality only occurred in closed areas also supports this idea. A change in movement patterns may have been induced by increased temperatures, which may cause yellowtail to move to deeper water outside the closure. Temperature changes may have similarly reduced the effectiveness of the North Sea Plaice Box (Beare et al. 2013). The increased closed area BHZ could alternatively explained by a substantial increase in natural mortality at larger sizes. While the mechanism for this is very unclear, an increase in natural mortality in recent years would be at least a partial explanation for the observed retrospective pattern in the VPA assessment (Legault 2009). One final possibility for the observed changes is that they were caused by reduced growth rates, which would cause BHZ estimates to be biased high. However, there appears to be no strong trend in age-at-length (Figure 3), so this can likely be dismissed.

References

Beverton R.J.H., Holt S.J. 1956. A review of methods for estimating mortality rates in fish populations, with special reference to sources of bias in catch sampling. Rapports et Proces-verbaux des Reunions, Conseil International pour l'Exploration de la Mer 140:6783

Beare D., Rijnsdorp A.D., Blaesberg M., Damm U., Egekvist J., Fock H., Kloppmann M., Rckmann C., Schroeder A., Schulze T., Tulp I., Ulrich C., van Hal R., van Kooten, T., Verweij, M., 2013. Evaluating the effect of fishery closures: lessons learnt from the Plaice Box. J. Sea Res. 84, 4960.

Legault, C.M. 2009. Report of the Retrospective Working Group, January 14-16, 2008, Woods Hole, Massachusetts CRD 09-01.

Legault C.M., Alade L., Gross W.E., Stone H.H. 2013. Stock Assessment of Georges Bank Yellowtail Flounder for 2013. TRAC working paper.

Lux F.E. and Nichy F.E. 1969. Growth of yellowtail flounder, *Limanda ferruginea* on three New England fishing grounds. Res. Bull. int. Commn NW Atlant. Fish., 6:7-25.

Table 1: Mean BHZ estimates from the scallop survey for selected periods, compared to corresponding VPA mortality estimates

Period	L_c	Mean Cl2 BHZ	Mean Op BHZ	Mean BHZ	Mean VPA Z (2-4)
1999-2003	20	0.30	0.61	0.37	
1999-2003	25	0.32	0.54	0.37	
1999-2003	30	0.53	0.99	0.64	0.76
2010-2012	20	0.35	0.39	0.38	
2010-2012	25	0.50	0.53	0.53	
2010-2012	30	0.91	0.92	0.92	0.49 (0.59 retro-adj)

Figure 1: Whole-stock BHZ from the trawl and scallop surveys, compared to VPA estimated total mortality.

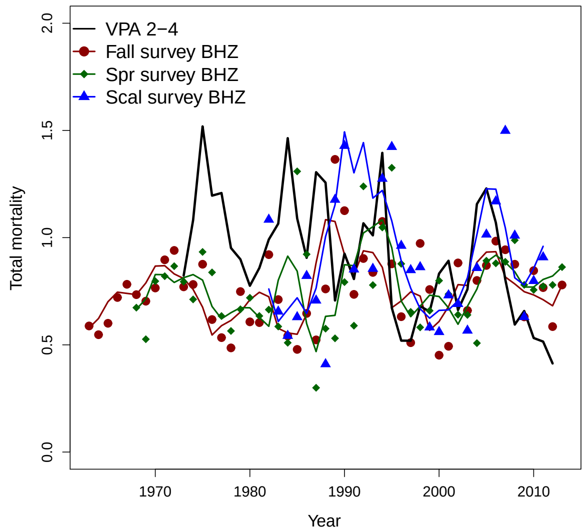

Figure 2: Closed Area II-S and Open BHZ from scallop survey

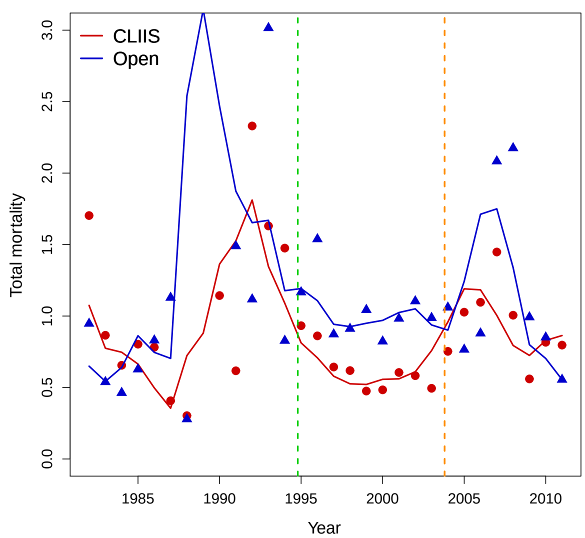

Figure 3: Mean length-at-age for Georges Bank yellowtail flounder from the NEFSC trawl surveys