Selection of an Asymptotic Selectivity Pattern[1]

* Kevin Piner

* NOAA Fisheries Pacific Islands Fisheries Science Center

2570 Dole Street, Honolulu HI, 96822

May-June. 2012

Disclaimer: This is a draft document and should not be cited without consent of author. The views and opinions expressed in this document reflect the author's opinion only and do not reflect the opinion of any group, agency or government.

Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), 23 May - 6 June 2012, Shimizu-ku, Shizuoka, Japan.

Document not to be cited without author's permission.

[1] PIFSC Working Paper WP-12-002
Issued 18 May 2012

Abstract

An analysis was conducted with Pacific bluefin tuna fishery data to determine which fleet (gear/area combination of catch and size composition) is most consistent with the strong assumption of an asymptotic selectivity pattern. Evidence of consistency with the asymptotic assumption is based on consistency of the model fit to the size composition data of other fleets. Both the Taiwanese longline fleet and "Japanese other" fleet showed evidence of consistency with the asymptotic selectivity pattern assumption. Given that the Taiwanese longline fleet operates only for a short duration, in a limited spatial range targeting large spawners, it is the best choice for the strong selectivity pattern assumption.

Introduction

Selectivity is a process that links fishery removals to biological composition and survey/CPUE relative abundance to the appropriate age classes. In a fully integrated model, the fit of size composition can also be influential on the population dynamics. For this reason, matching an appropriate selection process to the data is needed to accurately portray the population dynamics.

Selection patterns can be parameterized in many ways, with both parametric and non-parametric options available in Stock Synthesis (Methot 2011). Parametric selectivity patterns generally follow one of two functional forms:

a. Asymptotic. Strong assumption. Asymptotic forms imply that the fishery sees all fish greater than a certain size in proportion to their occurrence in the population. Provides stability to a model by implying (along with M, growth and observed size frequency) an upper bound to population size.
b. Domed. Weak assumption. Allowing a fishery pattern to have a domed shape provides better fit via a less informative model structure. Descending limb confounded with estimates of M and maximum size. Weak assumptions may lead to model instability and unrealistic scaling.

The assumptions of selectivity pattern shape can have a large influence on model results. Considerable attention should be paid to the choice of those assumptions. This paper describes the results of a systematic search for the fishery size composition that is most consistent with an asymptotic selectivity pattern assumption.

Material and Methods

The model and data used for this analysis (with changes described below) were distributed to the Pacific Bluefin Tuna Working Group on April 27, 2012. A new base model for this paper was created with the following changes:

Data file

1) Weight composition observations (fleets 7 and 13) re-binned by combining the last 14 size bins into 7 bins (combined 2 adjacent bins) to remove negative allocation error in original file.

CTL file

1) Convert all selectivity patterns to parametric functional forms.
2) Set all lambdas>1 =1.
3) Specify fleet 11 (EPO size composition) lambda=0.1.
4) Allow time varying process to fleet 1 (JPLL size composition) via a selectivity block defined as 1994-2011 to be consistent with how CPUE is treated.

To determine which fishery size composition is most consistent with an asymptotic selectivity assumption, each fishery size composition likelihood component was systematically assigned a logistic (asymptotic) selectivity pattern with a lambda=100 given to its contribution to the total negative log likelihood. This forced the model to fit that fishery's observed size composition with the assumed asymptotic selectivity assumption. All other fisheries were given a double normal (allowed to be domed shaped) selectivity pattern parameterization with lambda=1 assigned to the contribution of their size composition. The negative log likelihood for each fleet's size composition was recorded for each run (Table 1). The fleet with observed size composition that is most consistent with asymptotic selectivity pattern assumption should show the best fit from the other size composition likelihood components.

Results

Results indicate that the Taiwanese longline fleet and the "Japanese other" fleet are the most consistent with the asymptotic selectivity pattern assumption (Table 1). Size compositions for all other fleets are fit best (indicated by 0 in table 1) if either one of these two fisheries is assumed to be the asymptotic selectivity pattern.

Discussion

The assumption of at least one fleet modeled with an asymptotic selectivity pattern is standard in fisheries modeling, but it is an influential assumption. In the case of Pacific bluefin tuna, the most internally consistent choice is either the TWLL fleet or the JPN other fleet. It was surprising that the Japanese longline fleet (F1) did not have much support as the asymptotic selectivity pattern fleet. It is likely that the aggregation of size samples from areas and season that did not target the largest bluefin was the cause.

This paper did not consider the Eastern Pacific Ocean (EPO) fleets (F11 purse seine and F12 sport) and down-weighted their contribution to the total likelihood. This is because it has been well described that juvenile bluefin move to the EPO and return (Bayliff 1994) and that the proportion that make this migration influences both CPUE catchability and selectivity parameter estimates (Piner et al. 2011). It is beyond the scope of this paper to determine the best way to deal with this issue, and so these fleets were down-weighted in the analysis.

The results of this paper are applicable to this generalized model. Significant changes in model structure (such as time varying selectivity patterns, growth, etc.) could alter these results. In a similar analysis, Piner et al. (2012) showed that changes in the assumptions about growth of striped marlin caused small changes in the choice of the fleet most consistent with an asymptotic selectivity pattern. Pacific bluefin tuna growth is much better known (Shimose et al. 2009) and this small effect is less of a concern. There is benefit to conducting such analyses before fine tuning the models as the fine tuning (e.g. changing inputted weightings) will strengthen the support for the original model's assumptions. Conducting this type of analysis with basic model structure and natural weights avoids those issues.

Although it may be that no fleet operates with a true asymptotic selectivity pattern, the TWLL is the best choice if such a strong assumption is needed. Based on first principles, the TWLL fleet is the most obvious choice as it operates during a short season and in a limited area on the spawning aggregations of the largest fish (Lee and Hsu 2008). Although there is evidence that the JPN other fleet also is consistent with the asymptotic selectivity pattern assumption, this fleet is not a small, directed operation targeting only the largest fish. Given agreement on the known characteristics of the TWLL fleet and the results of this work, the TWLL fleet appears to be the best choice for the strong assumption of asymptotic fishery selection pattern.

References

Bayliff, W.H. (1994). A review of the biology and fisheries for northern bluefin tuna, Thunnus thynnus, in the Pacific Ocean. FAO Fish. Tech. Paper. 336:244-295.

Lee, H.H., and C.C. Hsu (2008). Abundance index for longline fishery targeting spawning Pacific bluefin tuna Thunnus orientalis in south-western North Pacific Ocean. Fisheries Science. 74:1336-1338.

Methot, R.D. Jr. (2011). User manual for stock synthesis, Model Version 3.20, 165 p.

Piner, K., H.H. Lee, I., Taylor, A. Aires-da-Silva, and S. Teo (2011). Introduction of a spatially structured model of Pacific bluefin tuna. ISC/11-1/PBFWG/06

Piner, K., H.H. Lee, I. Taylor, G. DiNardo. (2011). Preliminary striped marlin stock assessment. ISC/11-2/BillWG/01

Shimose, T., T. Tanabe, K.S. Chen, C.C. Hsu. (2009) Age determination and growth of Pacific bluefin tuna, Thunnus orientalis, off Japan and Taiwan. Fish. Res. 100:134-139.

Table 1. The degradation in model fit (negative log likelihood – best fit) for each size composition included in the model. Columns depict the size composition forced to fit an asymptotic selectivity pattern assumption. Rows contain the degraded fit for each likelihood component across models. Missing cells correspond to the model run (column) where the observed composition negative log likelihood was forced to fit asymptotic assumption (row) with an emphasis of 100. A value of 0 indicates best fit across models.

Likelihood component	F1 JLL	F2 SPelPS	F3 Tuna PSJS	F4 Tuna PSPO	F5 Jpn Troll	F6 Jpn PL	F7 Jpn Set Net NOJ Weight	F8 Jpn Set Net NOJ Length	F9 Jpn Set NetOAJ Length	F10 TWLL.0	F13 Jpn other
F1		1169.5	265.5	225.3	2450.9	2031.8	915.0	112.5	260.1	0.0	19.9
F2	30.9		4.2	186.6	354.5	277.5	129.3	132.2	90.2	0.0	38.6
F3	214.6	1559.8		134.2	1110.3	2979.6	343.1	41.4	102.9	128.3	0.0
F4	285.9	320.8	135.0		236.6	546.0	233.9	145.3	300.2	0.0	82.0
F5	188.0	299.6	136.4	96.3		151.0	170.9	181.4	6.9	0.0	33.5
F6	149.9	300.3	71.0	12.8	355.6		277.8	194.0	225.4	0.0	19.7
F7	29.2	151.0	70.2	68.2	677.8	158.5		49.0	51.6	23.9	0.0
F8	12.0	59.4	57.9	41.7	182.8	203.2	67.4		54.4	0.0	7.7
F9	55.7	311.2	365.9	222.5	989.9	298.6	0.0	130.0		23.7	44.7
F10	314.2	796.6	213.9	90.4	1167.8	1336.0	1216.9	105.0	1211.8		0.0
F11*	709.2	1250.3	850.5	224.5	259.1	323.3	241.7	272.5	208.7	114.9	0.0
F12*	185.7	265.0	327.0	155.6	149.1	297.4	48.8	56.9	69.5	16.8	0.0
F13	0.0	268.8	111.8	36.4	322.8	186.0	38.0	1.8	44.2	1.8	
Sum	2175.3	6752.4	2609.3	1494.4	8257.1	8788.9	3682.7	1422.1	2626.0	309.4	246.0

*this denotes the EPO fleets which received a low weight in the model and were not themselves evaluated as potential candidates for the asymptotic selectivity pattern assumption. Negative log-likelihood values do not include multiplication of lambda values.