A SPiCT ASSESSMENTS OF THE NORTH ATLANTIC SHORTFIN MAKO SHARK

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SUMMARY

The 2017 ICCAT stock assessment for north Atlantic shortfin mako shark suggested a substantial deterioration of the estimated stock status compared with the previous assessments in 2008 and 2012. The ICCAT stock assessments were based on surplus production models (ASPIC and several implementations of Bayesian surplus production models) and Stock Synthesis 3 (SS3) was also used in the 2017 assessment. In this paper, we have applied a newly developed surplus production model in continuous time that the International Council for the Exploration of the Sea (ICES) has used to provide advice on stocks where only catch and one or more indices of stock size are available.

RÉSUMÉ

L'évaluation du stock de requin-taupe bleu de l'Atlantique Nord réalisé par l'ICCAT en 2017 a suggéré une détérioration substantielle de l'état estimé du stock par rapport aux évaluations précédentes de 2008 et 2012. Les évaluations des stocks de l'ICCAT étaient basées sur des modèles de production excédentaire (ASPIC et plusieurs exécutions de modèles bayésiens de production excédentaire) et Stock Synthèse 3 (SS3) a également été utilisé dans l'évaluation de 2017. Dans ce document, nous avons appliqué un nouveau modèle de production excédentaire développé en temps continu, utilisé par le Conseil international pour l'exploration de la mer (CIEM) pour fournir un avis sur les stocks pour lesquels seules les captures et un ou plusieurs indices de la taille des stocks sont disponibles.

RESUMEN

La evaluación del stock de marrajo dientuso del Atlántico norte de ICCAT de 2017 sugería un deterioro sustancial del estado estimado del stock en comparación con las evaluaciones anteriores de 2008 y 2012. Las evaluaciones de stock de ICCAT se basaban en modelos de producción excedente (ASPIC y varias implementaciones de modelos de producción excedente bayesianos) y Stock Synthesis 3 (SS3) se utilizó también en la evaluación de 2017. En este documento, hemos aplicado un modelo de producción excedente desarrollado recientemente en tiempo continuo que ha utilizado el Consejo Internacional para la Exploración del Mar (ICES) para proporcionar asesoramiento sobre stocks para los que solo se dispone de la captura y uno o más índices del tamaño del stock.

KEYWORDS

Sharks, stock assessments, population dynamics, potential yield, exploitation.

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1. Introduction

Shortfin mako shark is a highly migratory species distributed in all of the world's oceans from 50ºN to 50ºS. They are an important by-catch in tuna longline fisheries. In the Atlantic, the Standing Committee on Research and Statistics (SCRS) of the International Commission for the Conservation of Atlantic Tuna (ICCAT) has provided cautionary advice on shortfin mako shark most recently based on stock assessments conducted in 2008, 2012 and 2017. The results of the 2017 stock assessment were considerably more pessimistic than those of the previous assessments. In this paper, we apply a new surplus production model in continuous time (SPiCT) developed and used in the ICES area.

2. Data used

Catch data were from the SS3 files used during the 2017 stock assessment. CPUE data were from the JABBA input files (Henning Winker pers. com.).

3. Stock assessment methods

Several assessment modeling approaches (Bayesian surplus production models, age-structured production modeling, catch-free age structured production models and integrated modeling (SS/)) each with several model configuration tested have been used to assess shortfin mako shark since 2008. Until 2017, most of the production models assumed observation errors. With the introduction of BSP2, JAGS and JABBA, surplus production modeling assumed both observation and process errors.

The SPiCT model is based on the generalized surplus production model also known as the Pella-Tomlinson model, where the shape of the production curve may deviate from the symmetric form (the Schaefer model). Unlike many other production models SPiCT assumes that catches as well as CPUE indices contain observation error. Process error in the surplus production function is also estimated. SPiCT uses as default some relatively weak priors on the production curve shape parameter and the ratios of observation to process error. However, it is also possible to perform a frequentist analysis without any priors (assuming data are sufficiently informative to obtain model convergence). A detailed description of the model can be found in Pedersen and Berg (2017) and the model can be run as a stand alone or on a web site (https://www.stockassessment.org/login.php).

4. Assessment results

In a first run, catches from 1950 onwards were used, as in the 2017 ICCAT assessment. This resulted in high biomass early in the time series and rapid decline even with very small catches (**Figure 1**). A similar problem occurred when the catch series started in 1986 (**Figure 2**) when the first stock size index starts, but of more concern is the highly negative surplus production at high biomasses early in the time series (**Figure 3**).

This may be an artifact of how the initial states are treated in SPiCT, and it occurs whenever the catch time-series starts before the first CPUE index. This needs further investigation, but for our purpose here, the problem can be "fixed" by omitting the catch in the first year for the run starting in 1986 and by adding a fairly strong prior on B/K in the first year for the run starting in 1950. Catches before 1950 are likely to also have been very low and it seems reasonable to assume that the biomass was approximately equal to K (carrying capacity) in 1950. The biomass ratios over time and the production curves are presented in **Figure 4** for both runs. The production curves now look more sensible.

We made a final run with indices starting in 1986, catch starting in 1987 and all priors removed. The model ran without problem (**Figure 5**).

All SPiCT runs made estimate the 2015-2016 biomass around Bmsy and fishing mortality around Fmsy. However, the reported uncertainties, especially for fishing mortalities, are considerable. The test for no auto-correlation in the residuals failed for the ESP-LL-N index, and the amount of variability between CPUE indices is high.

As is the case for several surplus production models, the absolute F and B values from SPiCT should generally not be used, and especially absolute F values should not be compared with estimates from other models since their interpretation in SPiCT is generally different from the interpretation in other models. It is only the estimates of F/Fmsy and B/Bmsy that are comparable and useful output from SPiCT in this respect.

While the trends in biomass and fishing mortality ratios do seem reasonable, the estimated stock status relative to reference points are not consistent with estimates in the accepted assessment.

We suggest that SPiCT be considered as a possible assessment tool in the next round of assessment for shortfin mako shark in the North Atlantic.

The median age at maturity for Shortfin mako shark is estimated to be 21 while the catch is mostly of immature specimens less than age 10. Therefore, the component of surplus production related to somatic growth of fish already recruited to the fishery is included in surplus production models, but the large lag effect between exploitable phase and reproductive phase is not. However, density dependence through growth and / or natural mortality in the young ages could be happening such that a production model could still provide a reasonable approximation of production. However, if density dependence occurs as a result of a stock-recruitment relationship, then the model will not be appropriate for estimating MSY reference points. But even in that case SPiCT may still provide useful estimates of biomass and F relative to historical values (rather than relative to MSY reference points) and reasonable short-term predictions.

References

Pedersen, M. W. and Berg, C. W. (2017). A stochastic surplus production model in continuous time. Fish and Fisheries, 18(2):226–243.

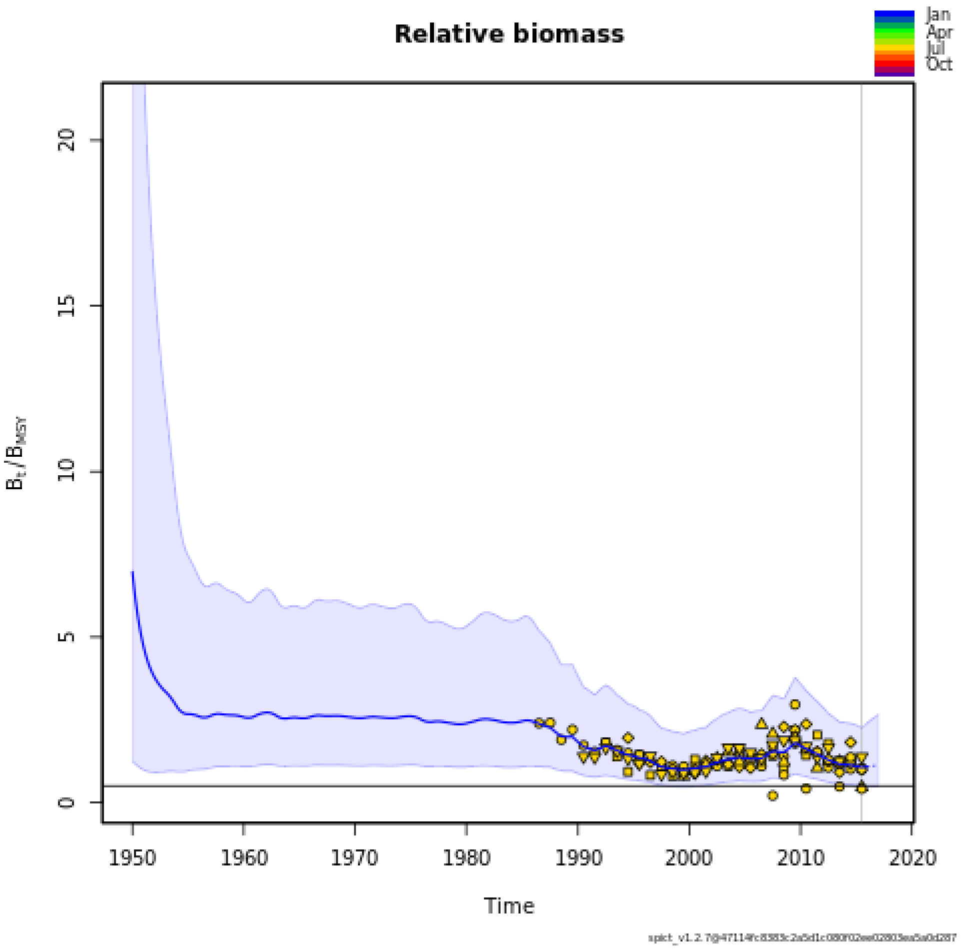

Figure 1. North Atlantic shortfin mako shark ratios of B/BMSY from SPiCT using catch starting in 1950. The symbols are the observed indices of stock sizes.

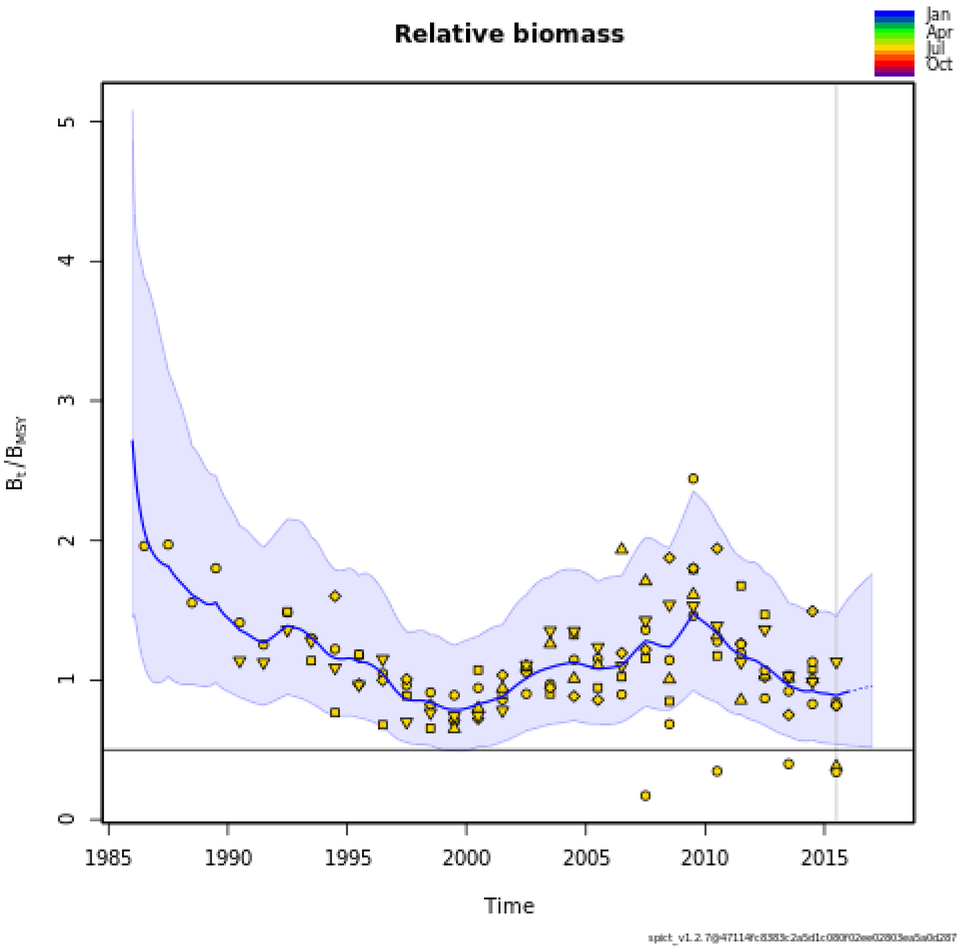

Figure 2. North Atlantic mako shark ratios of B/BMSY from SPiCT when the catch series starts in 1986. The symbols are the observed indices of stock sizes.

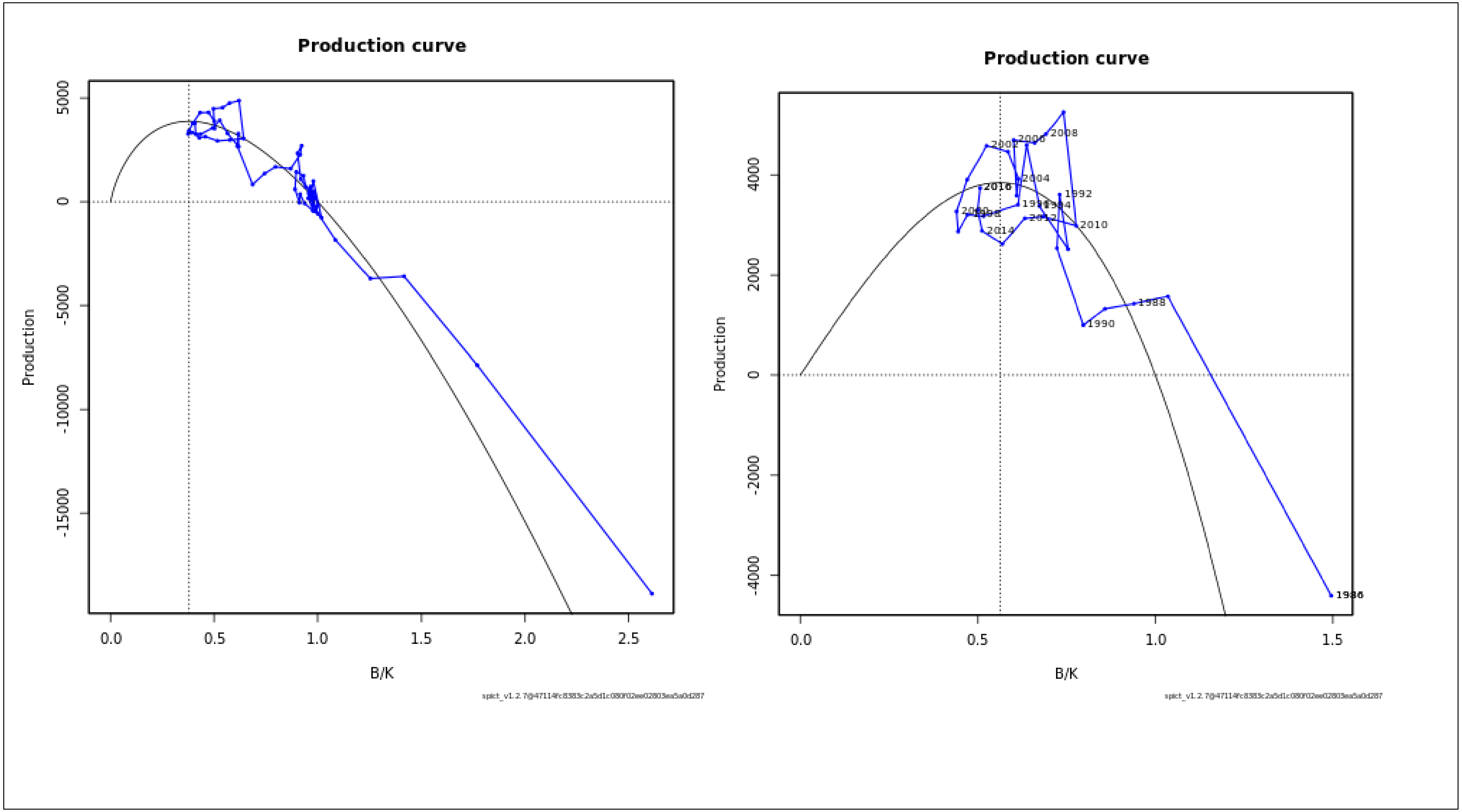

Figure 3. North Atlantic mako shark SPiCT production curves for catch starting in 1950 (left) and in 1986 (right).

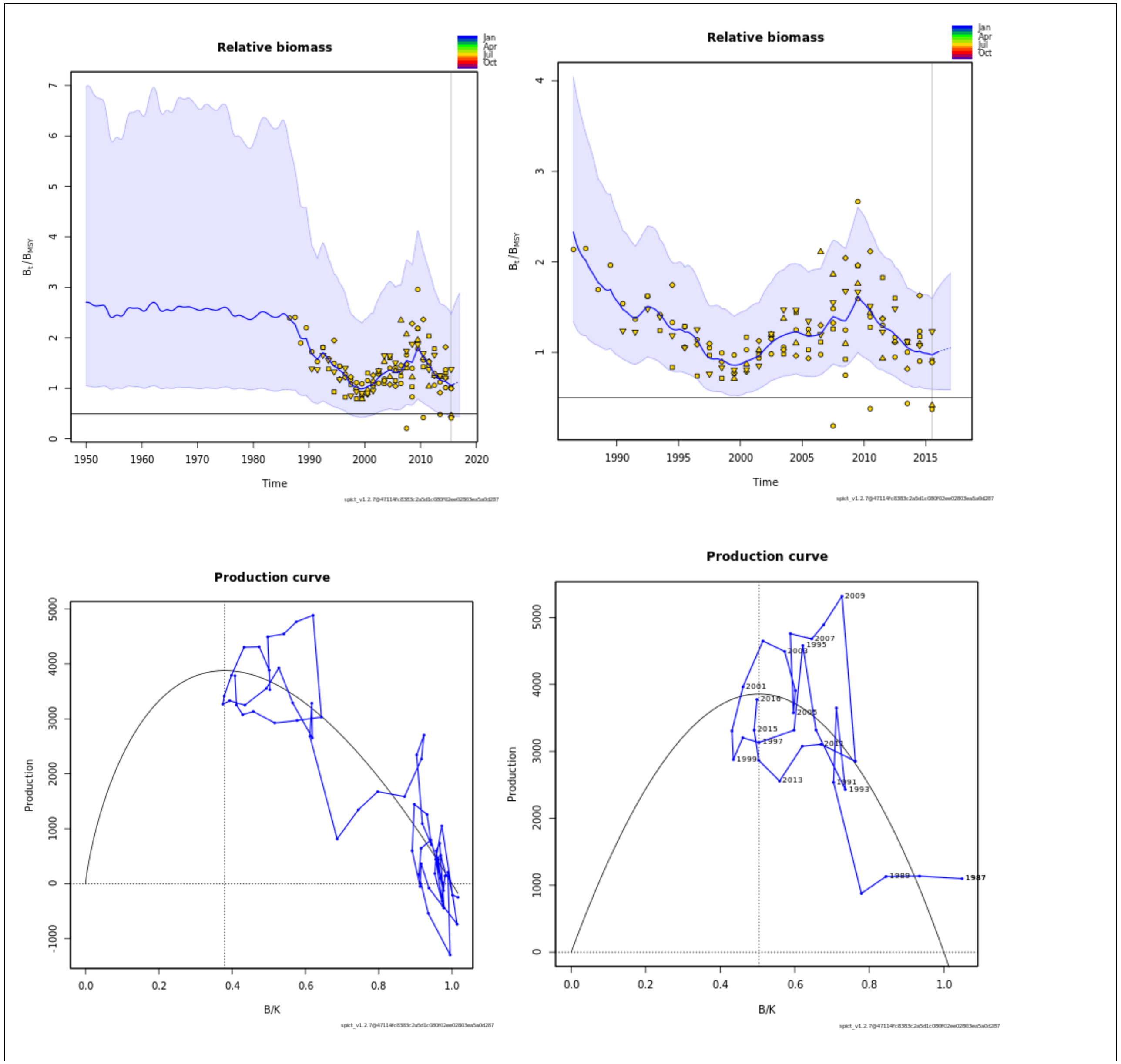

Figure 4. North Atlantic mako shark SPiCT ratios of B/BMSY (upper panels) and production curves (lower panels) when initial biomass is set equal to K with catches starting in 1950 (left panels) or when the 1986 catch is omitted in the shorter series (right panel).

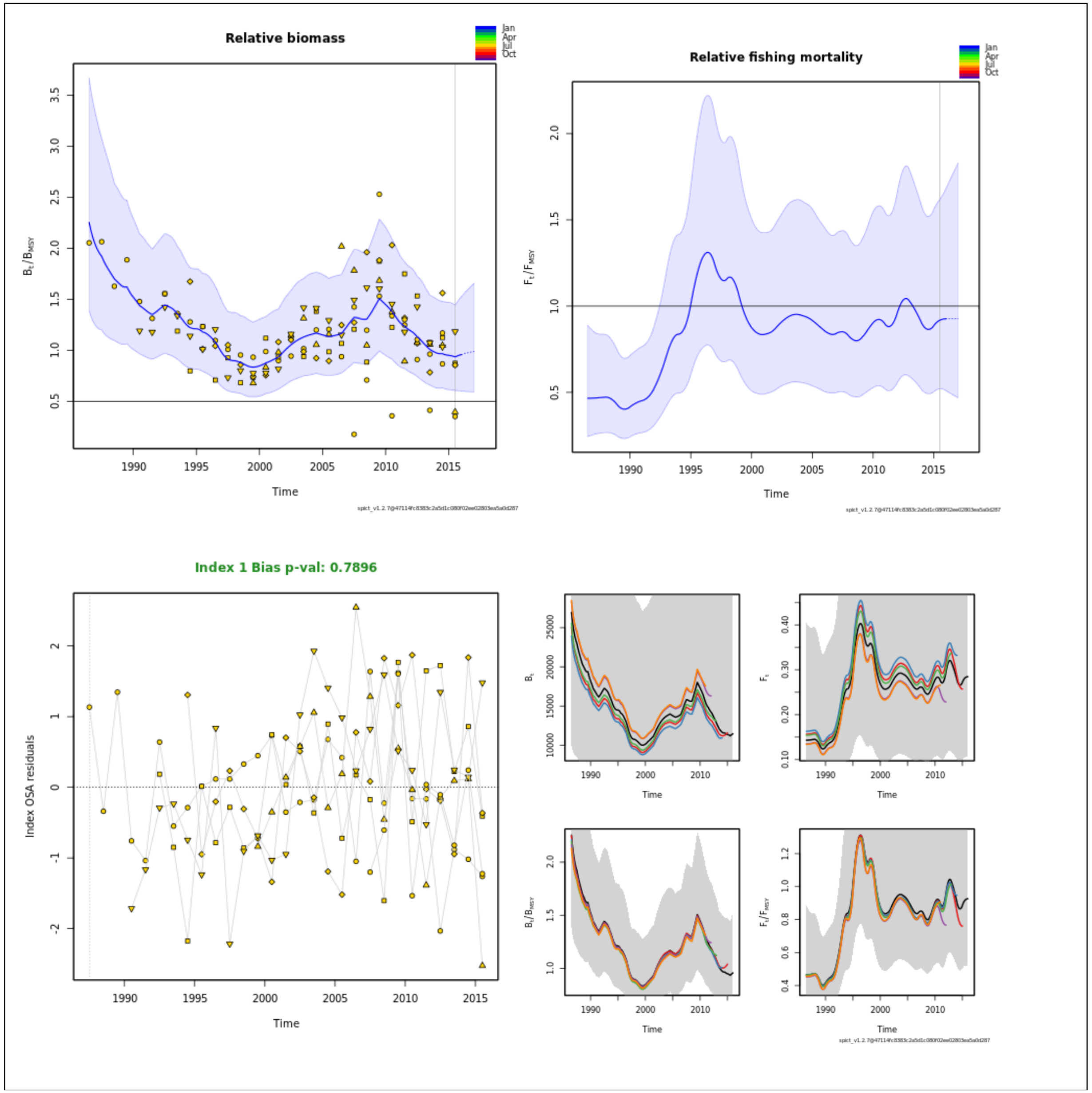

Figure 5. North Atlantic mako shark SPiCT results with CPUE starting in 1986, catch starting in 1987 and all priors removed. Upper left, ratio of Bt/BMSY, upper right ratio of F/Fmsy, lower left residuals of fits to the indices, lower right retrospective analysis.