Retrospective analysis of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity, including stochastic projections

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ABSTRACT

For stochastic future recruitment and for annual catch levels of 375 tonnes to 775 tonnes, in increments of 100 tonnes, the median of the spawning biomass estimates for the Base case model drops initially, but returns to its current level within a decade, while the exploitable biomass continues to increase. However the retrospective analysis gives rise to a concern: the 2013 assessment suggested a continuing increase in spawning biomass under a 575 tonne TAC, whereas the update of this assessment to 2016 shows an initial decline that returns to its present level only some 10 years later. Hence it is suggested that until either improved values of standardised trotline CPUE become evident, or an OMP is introduced, the TAC should not be increased above its present value of 575 tonnes. Lowering the tag-reporting rate results in a slightly more pessimistic view of resource status.

INTRODUCTION

A retrospective analysis of the Prince Edward Islands (PEI) toothfish resource is conducted for the Base case model presented by Brandão and Butterworth (2017). This is done in order to investigate if there are any systematic patterns which would indicate an inconsistency in the data that would explain the difference in the status of the resource estimated in Brandão and Butterworth (2016) and in Brandão and Butterworth (2017). This paper also reports on projections that take into account stochasticity in future recruitment under future annual constant catches of 575 t (the present TAC) as well as 100 and 200 t above and below this value. Stochastic projections are also shown for each of the retrospective analysis. As no 2017 data were available for the most recent assessment, when performing the retrospective analysis, the Base case model of Brandão and Butterworth (2017) actually represents the retrospective analysis for 2016. The one difference between results reported here and those of (Brandão and Butterworth (2017) is that in this paper the estimated catch for 2017 of 225 t (Deon Durholtz, pers. comm.) was used instead of the TAC value of 575 t.

A sensitivity to the Base case model of Brandão and Butterworth (2017) is also rerun that assumes a tag-reporting rate of 0.8 instead of 1.

RESULTS AND DISCUSSION

Table 1 shows the results for the Base case in which the tag-recapture rate is set to 0.8. For comparison, the results reported for the Base case model (with a tag-recapture rate of 1.0) in Brandão and Butterworth (2017) are repeated here. The effect of a lowering the tag-recapture rate is a slightly lower status of the resource.

Figures 1a-b shows the median spawning biomass depletion together with twenty year projections assuming future stochastic recruitment under constant future annual catches of 375 t to 775 t in increments of 100 t for the Base case model and for retrospective models from 2013. Projections assume that in future all catches are from the trotline fishery, as has been the case since 2014, and that there are no illegal removals. As the pot fishery has not been operational since 2005, the projections assume no pot fishery. Figure 1a shows these results separately for each model, while Figure 1b shows the results separately for each assumed future annual catch. Figure 2 shows the above projections for the **Base case** (2016) model together with their 90% probability envelopes as well as the lower 10^{th} percentile for each of the assumed annual catches. Median, 5^{th} and 95^{th} percentiles for spawning biomass depletion for the **Base case** model under several future annual catches for the current year (2017) and every 5^{th} year thereafter are given in Table 2.

Figure 3 shows retrospective median spawning biomass depletion and median spawning biomass projections assuming stochastic future recruitment and under future annual catches of 575 t for the **Base case** model and three **retrospective analyses** (with the 90% envelopes for the 2013 retrospective model), including historical trajectories as well, enlarged over a recent period.

Figures 4 shows the model fits by the **Base case** model and the three **retrospective analyses** to the longline and the trotline GLM-standardised CPUE data.

CONCLUSIONS

For all scenarios under all future catch levels considered the median of the spawning biomass estimates drops initially, but returns to its current level inside a decade. The retrospective analysis shows a slight drop in the status of the resource with the inclusion of extra data after 2014, with minimal difference in the near future with the addition of the 2016 data, but a lower depletion in the long run (Figure 1a and Figure 4). The retrospective analyses show a slight improvement in fitting the initial high CPUE data for longlines as more data becomes available, while the fits to the trotline CPUE data reflects a slight drop in the trend with the most recent years data (Figure 3).

Last year, although some higher catches also showed a spawning biomass decrease, the TAC was maintained at 575 t because of concerns about negative trends in the most recent GLM-standardised longline followed by trotline CPUE indices. This last trend continues given data from a further year. An accompanying concern is the retrospective pattern in the estimated spawning biomass trend: the 2013 assessment suggested a continuing increase in spawning biomass under a 575 tonne TAC, whereas the update of this assessment to 2016 shows an initial decline that returns to its present level only some 10 years later. Hence it is suggested that until either improved values of standardised trotline CPUE become evident, or an OMP is introduced, the TAC should not be increased above its present value of 575 tonnes.

References

Brandão, A. and Butterworth, D.S. 2016. Updated assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity to include data from 1997 to 2016. DAFF Branch Fisheries document: FISHERIES/2016/OCT/SWG-DEM/69.

Brandão, A. and Butterworth, D.S. 2017. Assessment of the toothfish (*Dissostichus eleginoides*) resource in the Prince Edward Islands vicinity to include data from 1997 to 2016. DAFF Branch Fisheries document: FISHERIES/2017/SEP/SWG-DEM/27.

Table 1. Estimates for a Base case model with three fleets (longline, trotline and pot) that assumes different commercial selectivities for the three gears, and also a change in selectivity for the longliners between 2002 and 2003, when fitted to the CPUE and catch-at-length data for toothfish from the Prince Edward Islands EEZ. Results for a sensitivity that sets the tag-reporting rate to 0.8 instead of 1.0 are also shown. The estimates shown are for the pre-exploitation toothfish spawning biomass (K_{sp}), the current spawning stock depletion (B_{sp}^{2018}) in terms of both K_{sp} and $MSYL_{sp}$, and the (longline) exploitable biomass ($B_{\exp}^{2018}$) at the beginning of the year 2018 (assuming the same selectivity as for 2017). Estimates of parameters pertinent to fitting the catch-at-length information are also shown, together with contributions to the (negative of the) log-likelihood. Numbers in brackets represent CVs. The details of the basic model are given in Brandão and Butterworth (2017).

Parameter estimates		**Model**	
		Base case (tag-reporting rate 1.0)	**Base case (tag-reporting rate 0.8)**
K_{sp} (tonnes)		28 711 (0.108)	25 686 (0.106)
$MSYL_{sp}$ (Longline)/K_{sp}		0.244	0.244
B_{sp}^{2018}/K_{sp}		0.408 (0.096)	0.371 (0.100)
B_{sp}^{1997}/K_{sp}		1.337 (0.099)	1.371 (0.102)
$B_{sp}^{2018}/MSYL_{sp}$(Longline)		1.677	1.523
$B_{\exp}^{2018}$ (tonnes)	Longline	10 202 (0.148)	8 441 (0.153)
	Pot	15 347 (0.125)	12 506 (0.130)
	Trotline	11 949 (0.134)	9 728 (0.138)
σ_{CPUE}	Longline	0.370	0.354
	Trotline	0.221	0.220
σ_R		0.500††	0.500††
a_{50}^{97-02} (yr)		6.499	6.499
δ^{97-02} (yr^{-1})		0.020	0.020
ω^{97-02} (yr^{-1})		0.057	0.055
a_{50}^{03-17} (yr)	Longline	6.424	6.423
	Pot	8.582	8.580
	Trotline	7.263	7.267
δ^{03-17} (yr^{-1})	Longline	0.131	0.131
	Pot	0.872	0.873
	Trotline	0.273	0.273
ω^{03-17} (yr^{-1})	Longline	0.074	0.074
	Pot	0.000	0.000
	Trotline	0.037	0.037
β		0.116 (0.019)	0.116 (0.003)
σ_{len}	Longline	0.042	0.042
	Pot	0.035	0.035
	Trotline	0.038	0.037

†† Input value.

Table 1 cont. Estimates for a **Base case** model with three fleets (longline, trotline and pot) that assumes different commercial selectivities for the three gears, and also a change in selectivity for the longliners between 2002 and 2003, when fitted to the CPUE and catch-at-length data for toothfish from the Prince Edward Islands EEZ. Results for a **sensitivity** that sets the tag-reporting rate to 0.8 instead of 1.0 are also shown. The estimates shown are for the pre-exploitation toothfish spawning biomass (K_{sp}), the current spawning stock depletion (B_{sp}^{2018}) in terms of both K_{sp} and $MSYL_{sp}$, and the (longline) exploitable biomass ($B_{\exp}^{2018}$) at the beginning of the year 2018 (assuming the same selectivity as for 2017). Estimates of parameters pertinent to fitting the catch-at-length information are also shown, together with contributions to the (negative of the) log-likelihood. Numbers in brackets represent CVs. The details of the basic model are given in Brandão and Butterworth (2017).

Parameter estimates		Model	
		Base case (tag-reporting rate 1.0)	Base case (tag-reporting rate 0.8)
-ln L: Length		-880.0	-882.4
-ln L: CPUE		-17.48	-18.30
-ln L: Recruitment		9.813	14.51
-ln L: Tagging		178.0	178.2
-ln L: Total		-709.6	-708.1
MSY (tonnes)	Longline	1 271†	1 448†
	Pot	1 271	1 137
	Trotline	1 209	1 081

† Based upon the average of the two selectivity functions estimated.

Table 2. Median, 5th and 95th percentiles for spawning biomass depletion for the **Base case** model assuming stochastic future recruitment and under future annual catches of 375 to 775 tonnes in increments of 100 tonnes for the current year (2017) and every 5th year thereafter.

		Current (2017)	2022	2027	2032	2037
Future catch of 375 t	**5th percentile**	0.440	0.395	0.419	0.479	0.603
	Median		0.398	0.555	0.842	1.167
	95th percentile		0.401	0.935	2.578	3.252
Future catch of 475 t	**5th percentile**	0.440	0.386	0.400	0.451	0.569
	Median		0.389	0.532	0.811	1.124
	95th percentile		0.394	0.910	2.543	3.201
Future catch of 575 t	**5th percentile**	0.440	0.377	0.381	0.421	0.534
	Median		0.381	0.509	0.779	1.080
	95th percentile		0.387	0.885	2.509	3.149
Future catch of 675 t	**5th percentile**	0.440	0.368	0.361	0.392	0.500
	Median		0.373	0.488	0.748	1.037
	95th percentile		0.380	0.861	2.474	3.103
Future catch of 775 t	**5th percentile**	0.440	0.359	0.339	0.363	0.465
	Median		0.365	0.469	0.716	0.993
	95th percentile		0.373	0.838	2.439	3.057

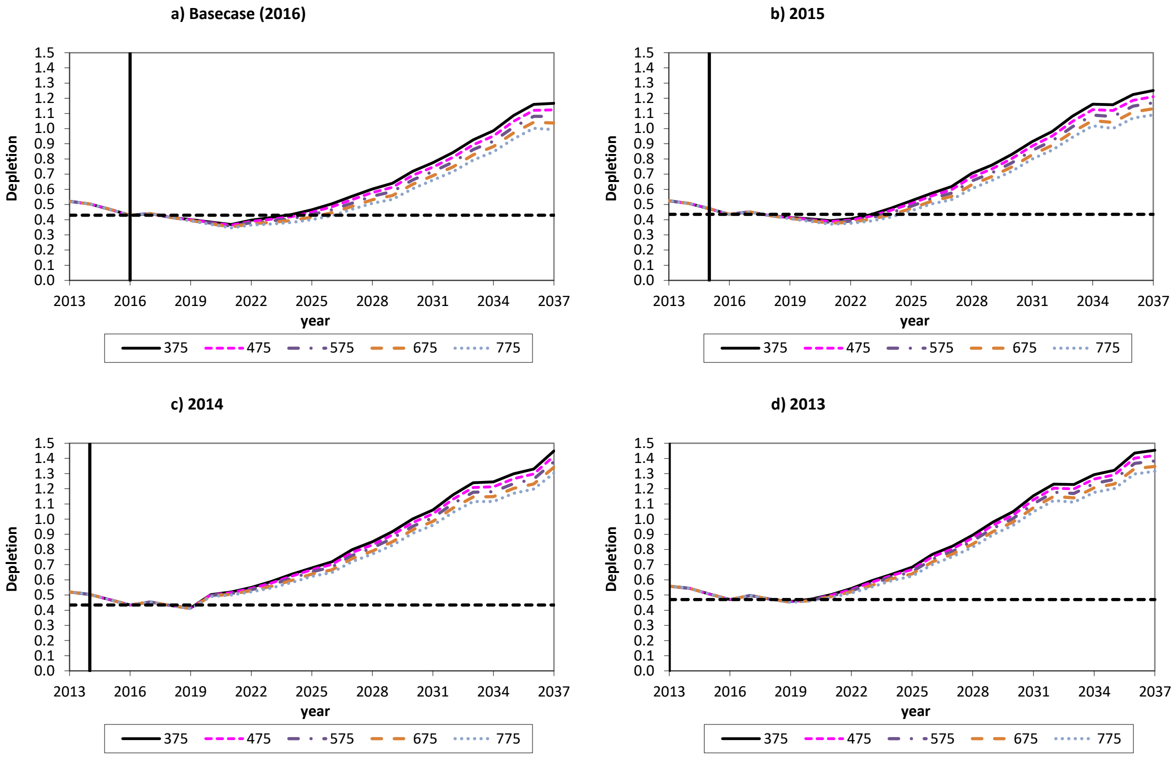


Figure 1 (a). Median spawning biomass depletion projections (shown after the vertical line) assuming stochastic future recruitment and under future annual catches of 375 to 775 tonnes in increments of 100 tonnes (assumed to be all from trotlines as is the case for catches taken since 2014) for the **Base case (2016)** (a) and three **retrospective analyses**. The dashed horizontal lines show the current depletion value for each of the retrospective analysis.

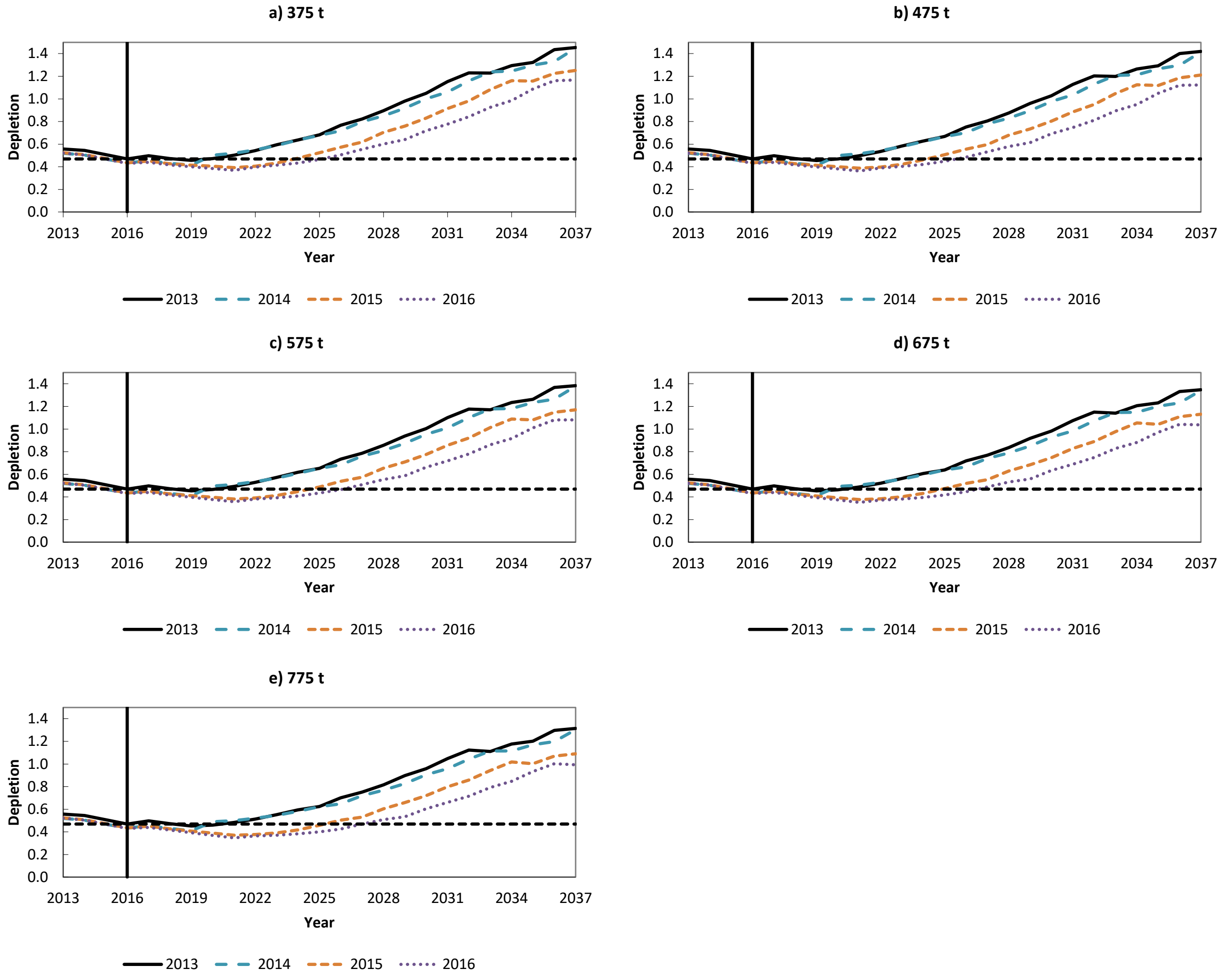


Figure 1 (b). Median spawning biomass depletion projections as for Figure 1 (a) but with the **retrospective analyses** shown in the same plot for each of the future annual catches assumed. The vertical lines represent the **Base case** current year (i.e. 2016) and the dashed horizontal lines show the current depletion value for the Base case.

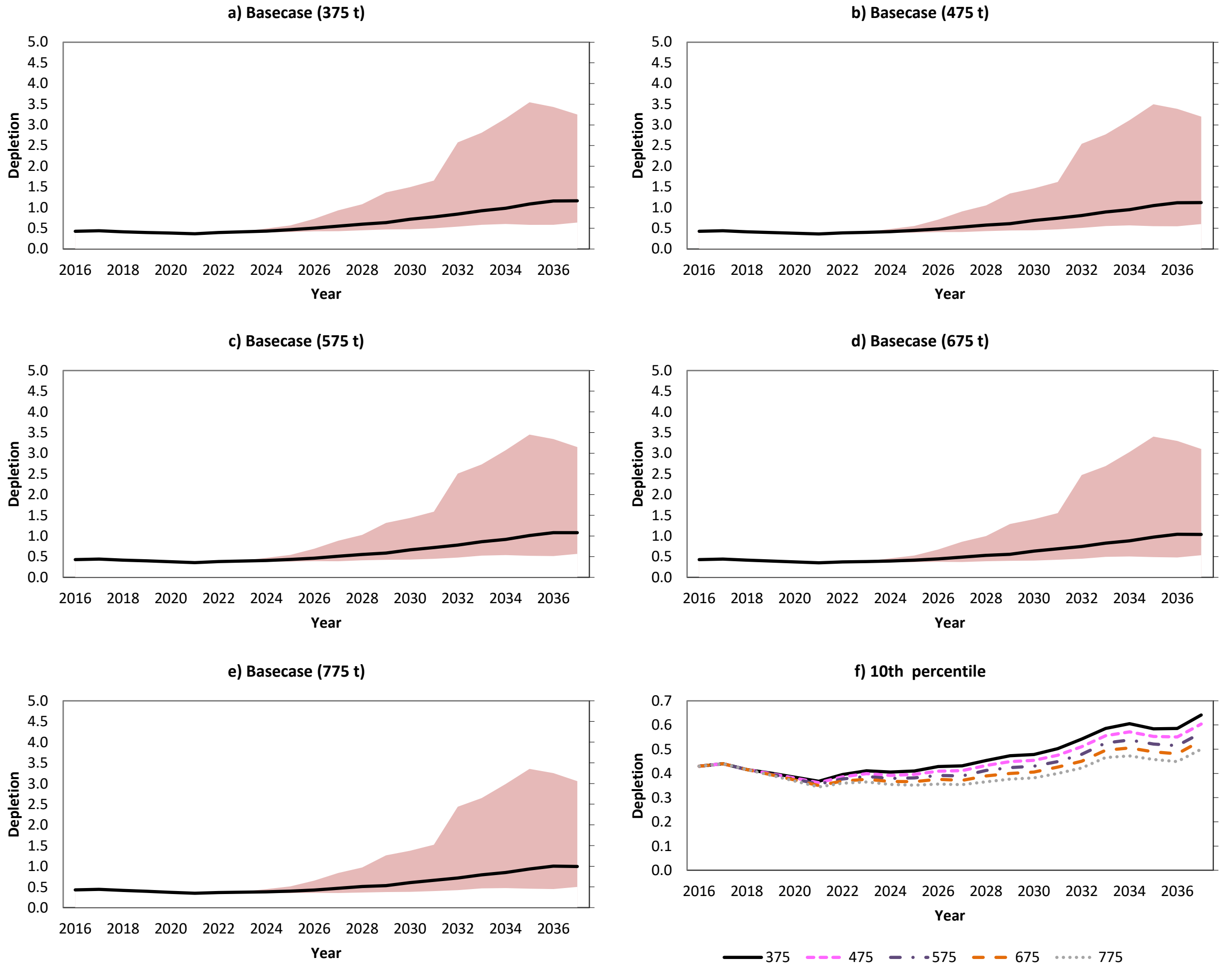
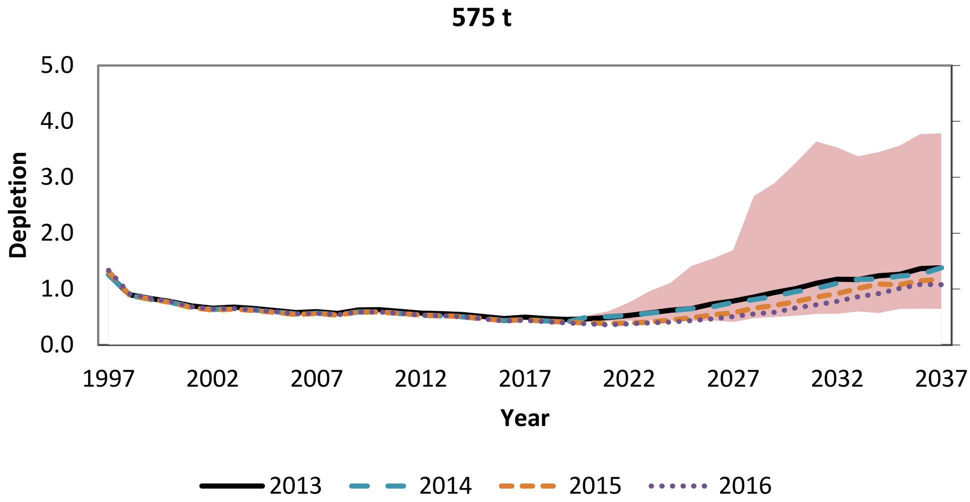
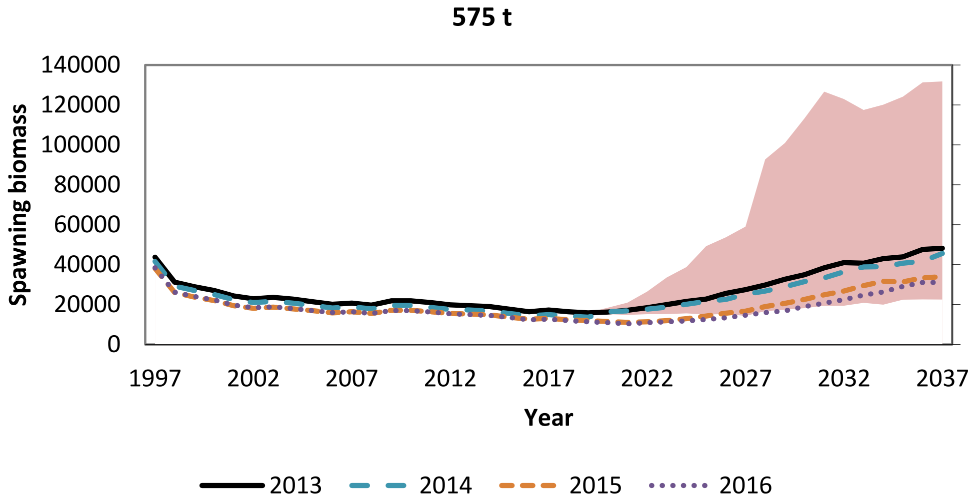


Figure 2. Median spawning biomass depletion projections assuming stochastic future recruitment and under future annual catches of 575 (a) to 775 (e) in increments of 100 t (assumed to be all from trotlines as is the case for catches taken since 2014) for the **Base case** (2016) model together with their 90% envelopes. The plot on the bottom right hand corner shows the lower 10^{th} percentiles for each future annual catch.





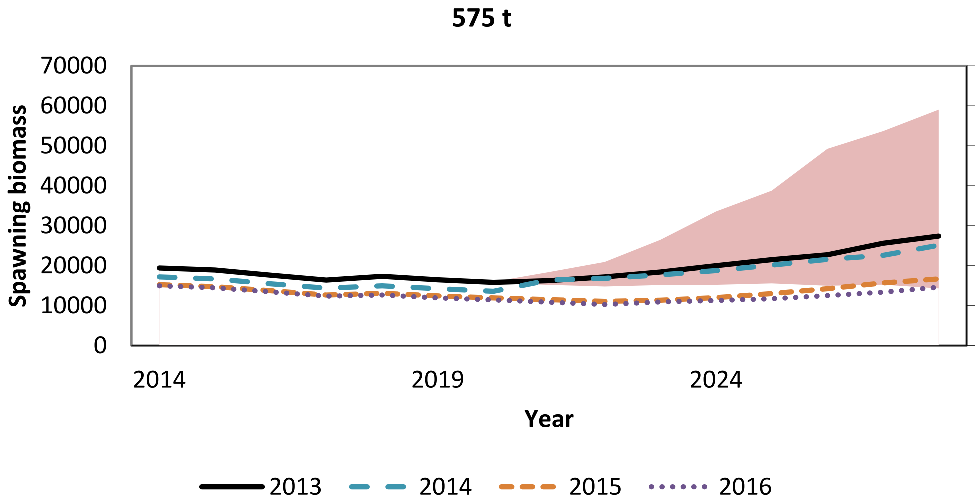


Figure 3. Retrospective median spawning biomass depletion projections (top) assuming stochastic future recruitment and under future annual catches of 575 t (assumed to be all from trotlines as is the case for catches taken since 2014) including historical trajectories and similarly for spawning biomass (middle). The median spawning biomass over a recent period is given in the bottom plot for a better definition. The 90% envelopes shown are for the 2013 **retrospective** model.

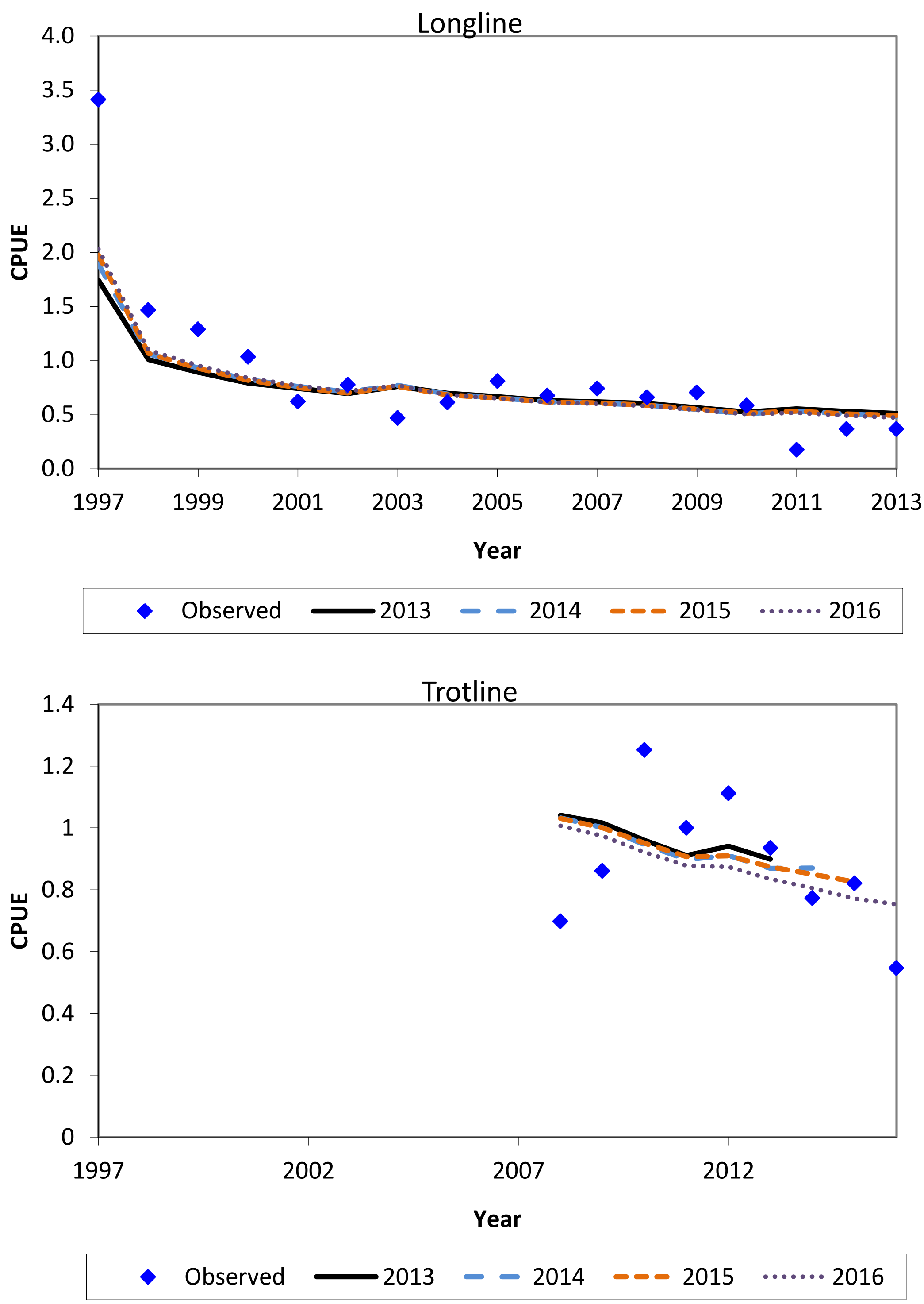


Figure 4. GLM-standardised CPUE indices and predicted values for the **Base case** and the three **retrospective analyses** for the **longline** fishery (top) and the **trotline** fishery (bottom).