2010 ESTIMATES OF SUSTAINABLE ROCK LOBSTER YIELD FOR THE FOUR ISLANDS OF THE TRISTAN DA CUNHA GROUP

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ABSTRACT

A simple replacement yield model is fitted to CPUE and annual catch data from 1997 for the four islands of the Tristan da Cunha group. The results suggest that the current TAC be maintained, with a slight increase (perhaps 5 tons) to the allocation to Gough, and the same decrease to the allocation to Tristan.

INTRODUCTION

The data sources upon which to assess the rock lobster resources of the islands of the Tristan da Cunha group are very limited, with original records against which to check available essentially for the last decade only (Edwards, 2007), so that it is only over this period that data can be used with some confidence. At this stage, these amount to annual catch and CPUE data only, as detailed below. This necessitates that a rather simple model be applied to estimate sustainable yield. Details of this model, and results from its application to the updated data now available, are provided below. The analyses reported thus update those provided in Johnston and Butterworth (2009).

DATA

The data upon which these assessments are based are listed in Tables 1 and 2, and consist of total catch and standardised CPUE series (Johnston 2009, Johnston *et al.* 2010). Although catch and CPUE data for the seasons 1994/95-2007/8 are available for Tristan, only the data from 1997/98 are considered here in order to render results comparable with those produced in 2009.

Adjustments have been made to the CPUE series for Gough and Inaccessible Islands compared to the values provided in Johnston *et al.* (2010). These were necessary to retain comparability of an index of abundance (biomass) over time in circumstances when the size limits were changed

at the start of the 2003/4 season, being then increased from 70 mm to 75 mm at Gough and decreased from 70 mm to 68 mm at Inaccessible. To allow for this, changes in the proportions of the catch by size class either side of this change time were examined. The average differences suggested to decrease the Inaccessible CPUE values by 2%, and to increase those for Gough by 5%, each from the 2003/4 season onwards, to better achieve comparability (see Annex).

METHODOLOGY

Given the limited data available for each island, a simple age-aggregated population model is used and fitted to the CPUE data. The assumption is made that the surplus production *P* is constant over the period considered, so that an estimate of *P* provides an estimate of the annual sustainable yield for this period.

The model is:

$$B_{y+1} = B_y + P - C_y \qquad (1)$$

where B_y is the biomass at the start of Season-Year *y*, and
C_y is the catch by mass during Season-Year *y*.

The proportion of the biomass harvested each Season-Year, F_y, is then:

$$F_y = C_y / B_y \qquad (2)$$

The estimable parameters of the model are *P* and B_{init}, where B_{init} is the biomass at the start of the first Season-Year for which CPUE data are available. However there is insufficient information content in the data to estimate two parameters, so that B_{init} has to be fixed externally. Instead though, the equivalent process of fixing F_{init} for the proportion harvested in the first season is utilised.

The model is fitted to the CPUE data for each island under the assumption that CPUE is proportional to biomass *B*, with lognormally distributed observation error:

$$CPUE_y = q\, B_y\, e^{\varepsilon_y} \qquad \varepsilon_y \text{ from } N\left(0, \sigma^2\right) \qquad (3)$$

yielding a negative log-likelihood to be minimised of:

$$-\ell n\, L = \sum_{y=init}^{fin} \left[\ell n\, \sigma + \frac{1}{2\sigma^2} \left\{ \ell n\, CPUE_y - \ell n\, q - \ell n\, B_y \right\}^2 \right] \qquad (4)$$

Closed forms for estimates of q and σ result from this formulation so that, given a value for F_{init}, the minimisation is over the parameter P only.

The initial year for the four islands is 1997/8 **.**

RESULTS

Results for the estimates of sustainable yield P are given in Table 3a. The corresponding fits of the model to the CPUE data are shown in Figure 1 and all appear broadly reasonable. They are provided for three different choices for F_{init}, and standard error estimates are also listed. Table 3b shows how results for Gough Island change if estimates of IUU catches by Andrew James (Johnston, 2009) are taken into account, while Table 4 compares current estimates of P with those from last year.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Estimates of sustainable yield P increase as F_{init} is decreased, so clearly an appropriate choice for F_{init} is crucial to the provision of sound management advice.

F_{init} cannot be greater than 1, as that would correspond to catching the complete population. Given that average catches over the last decade must have been less than sustainable levels (as CPUE has increased for all four islands), and that sustainable fishing proportions would be expected to be typically in the region of at most 10-20% for a relatively long-lived species such as rock-lobster, one might expect a value for F_{init} = 0.3 to be about the maximum plausible.

However, until this matter is further researched, and given the simplicity and uncertainties associated with the approach used, it seems best to take a more conservative approach, and as last year focus on F_{init}=0.7.

Specifically such an approach suggests the following TAC changes:

Gough	75 to not more than 88 tons (or 101 if IUU catches are factored in)
Nightingale	72 to not more than 75 tons
Inaccessible	110 to not less than 106 tons
Tristan	185 to not less than 172 tons

The substantial increase in the CPUE at Gough Island is likely in part a response of the resource to a 30MT TAC reduction in 2004. Care should be taken in interpretation of the results for Nightingale Island, as these may be influenced to some extent by the impact of a change in fishing strategy there from 2002 (see Johnston *et al.* 2009).

The main difference in RY estimates from those produced in 2009 are for Tristan. In 2009, analyses were somewhat different as the Tristan CPUE data were not comparable after 2002 when changes to the length of fishing day were made. The 2009 analyses thus fitted to two

independent CPUE series: 1997/8-2002/3 and 2003/4-2007/8. Tristan CPUE developed in 2009 were based on powerboat-day as the unit of effort. Recently however, more effort data for Tristan have become available in the form of fishing hours (as well as number of traps or hoops deployed). The Tristan 2010 CPUE thus reflects catch per hour. The updated and improved Tristan CPUE series (now represented as a single series for 1997/8-2008/9 in this assessment) results in slightly less optimistic RY estimates than those obtained in 2009. There may be some concern that for the last two Season-Years the Tristan CPUE data show a substantial drop, but 2009/10 data now available show a sharp increase again, so that these CPUE variations should be seen as more noise than signal.

Given that these recommendations are the last along interim lines, pending (it is hoped) the adoption of a management procedure approach for recommending TACs from next year, it would seem inadvisable to make major changes to the current TACs for each island. A possible approach, in line with the updated results shown above, would be to maintain the overall TAC at its present level, as well as the allocations at Nightingale and Inaccessible, but to increase the allocation to Gough by a small amount (say 5 tons), and to decrease the allocation to Tristan by the same quantity.

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Table 1: Catch (in tons) information available for assessment of the rock lobster resources at the four islands of the Tristan da Cunha group.

Season-Year	Gough	Nightingale	Inaccessible	Tristan
1997/8	79.097	52.474	62.521	126.035
1998/9	99.628	51.812	61.492	117.258
1999/0	93.647	52.623	64.176	122.019
2000/1	73.617	52.536	66.637	124.391
2001/2	90.133	57.037	70.512	127.550
2002/3	76.608	56.614	70.775	133.550
2003/4	94.868	57.472	77.283	138.400
2004/5	65.245	61.368	84.484	157.820
2005/6	57.071	62.276	92.945	160.555
2006/7	56.646	62.333	103.281	180.000
2007/8	62.060	65.584	114.566	187.000
2008/9	67.533	72.259	114.465	180.284

Table 2a: CPUE information available for assessment of the rock lobster resource at Inaccessible Island. The CPUE have been renormalized over the period considered, so that their average is 1, and the CPUE for 2003+ decreased by 2% to take account of a minimum size change.

Season-Year	2010 GLMM
1997/8	0.271
1998/9	0.530
1999/0	0.588
2000/1	0.700
2001/2	0.638
2002/3	1.095
2003/4	1.371
2004/5	1.859
2005/6	1.842
2006/7	-
2007/8	1.054
2008/9	1.054

Table 2b: CPUE information available for assessment of the rock lobster resource at Nightingale Island. The CPUE have been renormalized over the period considered so that their average is 1.

Season-Year	2010 GLMM
1997/8	0.332
1998/9	0.642
1999/0	-
2000/1	0.757
2001/2	0.771
2002/3	0.811
2003/4	1.439
2004/5	1.516
2005/6	1.409
2006/7	-
2007/8	1.169
2008/9	1.154

Table 2c: CPUE information available for assessment of the rock lobster resource at Gough Island. The CPUE have been renormalized over the period considered, so that their average is 1, and the CPUE for 2003+ increased by 5% to take a minimum size change into account.

Season	2010 GLMM
1997/8	0.823
1998/9	0.710
1999/0	0.877
2000/1	0.553
2001/2	0.576
2002/3	0.535
2003/4	0.637
2004/5	0.569
2005/6	1.063
2006/7	-
2007/8	2.280
2008/9	2.378

Table 2d: CPUE information available for assessment of the rock lobster resource at Tristan Island.

Season-Year	2010 GLM
1997/8	0.505
1998/9	0.634
1999/0	0.845
2000/1	1.073
2001/2	0.982
2002/3	1.110
2003/4	1.003
2004/5	1.273
2005/6	1.685
2006/7	2.187
2007/8	1.744
2008/9	1.046

Sources:

Gough, Nightingale and Inaccessible: GLMM standardised longline CPUE in kg/trap – Johnston *et al.* (2010)

Tristan: GLM standardised catch per large powerboat CPUE in kg/hour – Johnston *et al.* (2010)

Table 3a: Estimates of sustainable yield *P* (in tons), with Hessian-based standard errors in parentheses, from a simple age-aggregated population model fit to the 2010 GLMM or GLM CPUE data for each of the four islands of the Tristan da Cunha group. Estimates are given in relation to an assumed value for F_{init} , which is the proportion of available abundance harvested in the first Season-Year (1997/98) for which a CPUE value is available for most of the islands.

	2009/10 TAC	F_{init} 0.7	0.5	0.3
Gough	75	87.8 (4.8)	92.2 (8.1)	103.8 (15.8)
Nightingale	72	74.9 (5.3)	82.5 (7.7)	100.3 (13.3)
Inaccessible	110	105.5 (9.7)	118.3 (14.7)	149.9 (26.9)
Tristan	185	172.3 (9.1)	185.2 (12.9)	216.5 (22.3)
TOTAL	442	440.5	478.2	570.5

Table 3b: Comparison of estimates of sustainable yield *P* (in tons), with Hessian-based standard errors in parentheses from a simple age-aggregated population model fit to the 2009 GLMM CPUE data from Gough Island. Results are produced with or without taking IUU catch estimates by A. James (see Johnston 2009) into account. Estimates are given in relation to an assumed value of $F_{init} = 0.7$, which is the proportion of available abundance harvested in the first Season-Year for which a CPUE value is available for most of the islands (1997).

	2009/10 TAC	F_{init}=0.7
Gough no IUU	75	87.8 (4.8)
Gough plus IUU	75	100.5 (6.8)
Difference		12.7

Table 4: Sustainable yield (*P* in tons) statistics obtained in these analyses compared to those obtained in 2008 by Butterworth *et al.* (2008) and Johnston *et al*. (2009) in 2009 for the case $F_{init} = 0.7$.

	2008 analysis	2009 analysis	2010 analysis
Gough	88.8	86.4	87.8
Nightingale	81.8	79.0	74.9
Inaccessible	126.1	105.4	105.5
Tristan	186.2	180.0	172.3
Total	**482.9**	**450.8**	**440.5**

Figure 1a: Model fits to Gough Island CPUE for F_{init} =0.3, F_{init} =0.5 and F_{init} =0.7. In this and other Figures, on the horizontal axis the year 2002, say, refers to the Season-Year 2002/3.

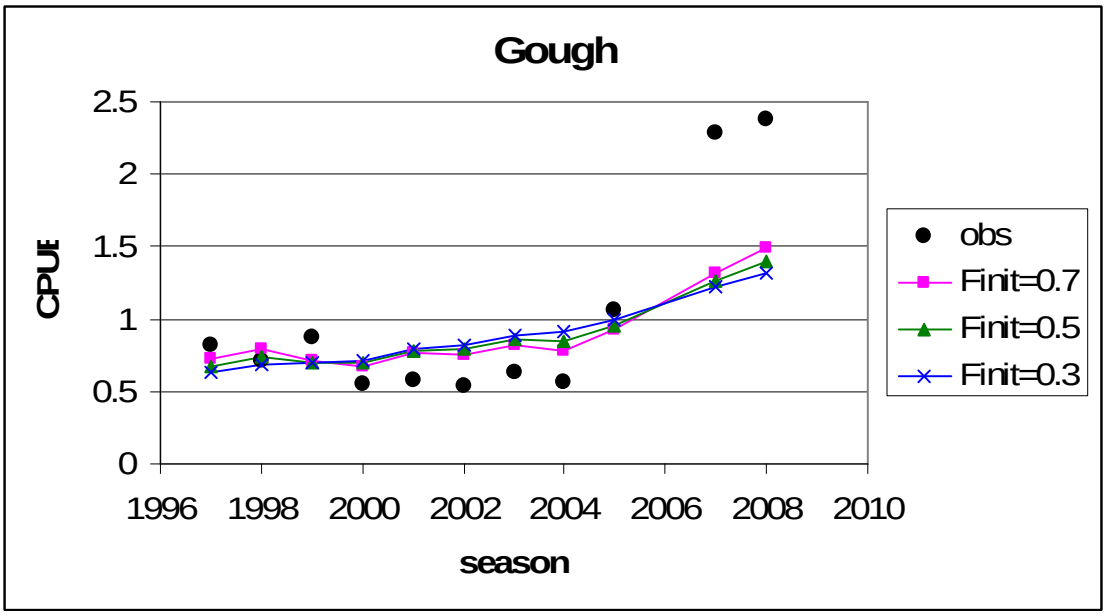


Figure 1b: Model fits to Nightingale Island CPUE for F_{init} ==0.3, F_{init} =0.5 and F_{init} =0.7.

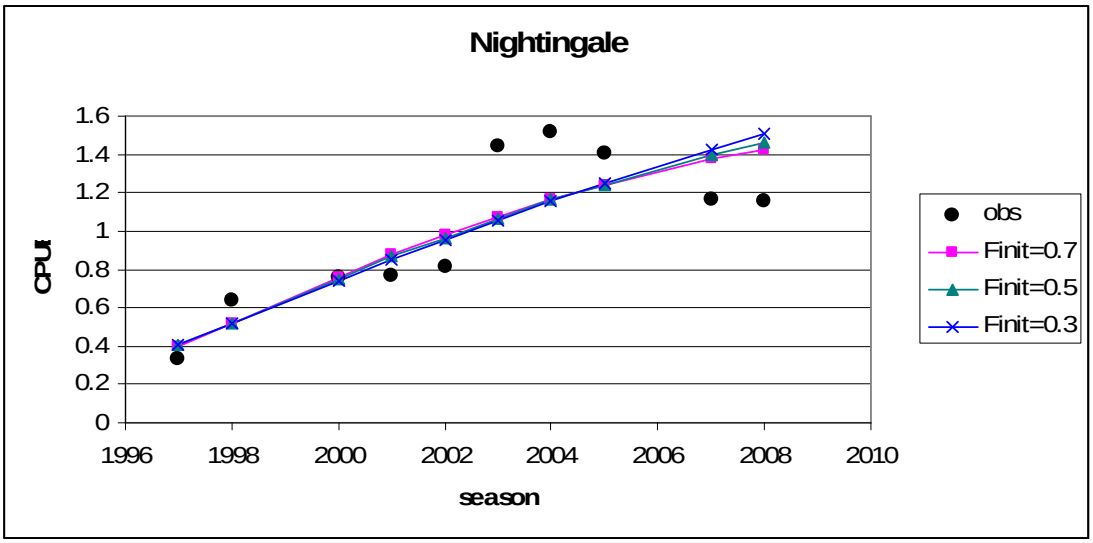


Figure 1c: Model fits to Inaccessible Island CPUE for $F_{init} = 0.3$, F_{init} =0.5 and F_{init} =0.7.

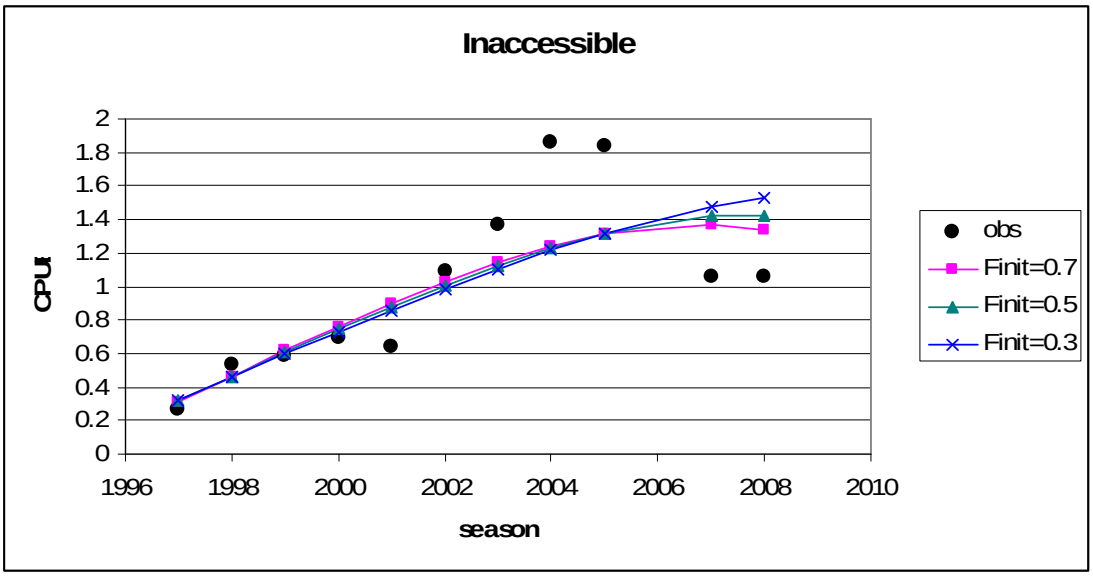
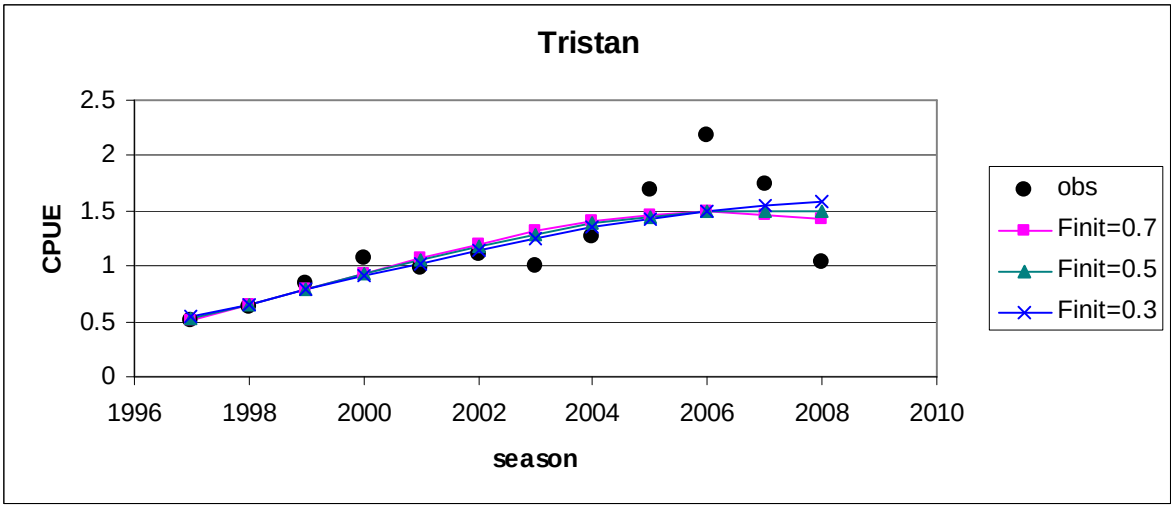


Figure 1d: Model fits to Tristan Island CPUE for $F_{init} = 0.3$, F_{init} =0.5 and F_{init} =0.7.



Annex: Method to determine effect of minimum size change on CPUE

At the start of the 2003/04 season the following minimum size changes occurred:
Gough Island – minimum size **increased** from 70mm to 75mm
Inaccessible Island– minim size **decreased** from 70mm to 68mm

Clearly these changes will have an impact on the CPUE data series for each of these islands, and a relevant CPUE scaling factor to be applied to the 2003+ CPUE needs to be calculated for both islands.

Table 1 contains information obtained from production data of both "whole" and "tail" product. It is considered (Andrew James, pers. commn) that the whole and tail grades that would be affected by the size limit adjustments are:

Gough Island:	Tails grades = M, Kz and K Whole counts = grades 72, 68, 64 and 60
Inaccessible Island:	Tails grades = Kz and K Whole counts = grades 72 and 68

Table A1 reports the proportion of the above grades as a percentage of the total production for both islands. The approach is to compare the average percentages before and after the 2003 minimum size change.

Gough Island
As expected the percentage drops in the "tails" product from around 16% to 10% (a reduction of 6%) as a result of the minimum size reduction in 2003. A smaller reduction of around 4% down to 1 % (a reduction of 3%) is seen in the "whole" product. If one takes the average over these two products, a rounded value of a 5% reduction to be applied to 2003+ CPUE to render it comparable to earlier years is obtained.

Inaccessible Island
At Inaccessible there is no clear trend in the "tails" data – and if anything, the reverse change to that expected is shown in the pre-2003 to 2003+ averages, with a decrease in the proportion of small tail grades (Kz and K) as a percentage of total product, when the minimum size was decreased in 2003. This effect expected is however seen in the "whole" production, with an increase in those grades' percentage contribution increasing from around 2% to 6% (a 4% change).

Given the anomalous result for 'tails", it was decided to treat this as a zero change, leading to a net 2% figure for adjusting the CPUE when averaging with the result for "whole" product.

Table A1: The percentage of the total production for the grades affected by minimum size change for Gough and Inaccessible Islands, for both “tails” and “whole” product.

	TAILS		WHOLE	
	Gough	Inaccessible	Gough	Inaccessible
2001	14.87	22.07	4.68	1.04
2002	16.30	26.27	2.31	2.50
2003	20.57	13.96	3.05	6.94
2004	8.43	16.90	0.10	7.25
2005	10.48	22.56	0.03	4.78
2006	5.11	21.07	0.00	6.12
2007	4.49	26.36	0.00	6.41
pre 2003	16	24	4	2
2003+	10	20	1	6
change	-6	-4	-3	4