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

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June 2008

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, are provided below.

DATA

The data upon which these assessments are based are listed in Table 1. The level of scrutiny thus far of the CPUE data differs amongst the islands, with that for Inaccessible being the most advanced.

Adjustments have been made to the CPUE series for Gough and Inaccessible compared to the values provided in Johnston and Butterworth (2008) and Johnston *et al*. (2008) respectively. 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 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 *y*, and
C_y is the catch by mass during season *y*.

The proportion of the biomass harvested each 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 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_{fin} for the proportion harvested in the last season for which there are CPUE data has been followed, as this is more readily interpreted.

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_{fin}, the minimisation is over the parameter *P* only.

For Tristan, for which the CPUE values are not comparable over the full period considered (see Table 1), the value of *q* is assumed to change from the 2003/04 to the 2004/05 season, but the same σ is assumed to apply throughout for more robust estimation.

RESULTS

Results for the estimates of sustainable yield *P* are given in Table 2. They are provided for three different choices for F_{fin}, and standard error estimates are also listed.

DISCUSSION AND MANAGEMENT IMPLICATIONS

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

F_{fin} 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_{fin} = 0.3 to be about the maximum plausible.

However, given also that this matter can be profitably further researched over the coming year, and the simplicity of the approach with consequent associated uncertainties, the particularly conservative approach advocated at this time is to consider the values in Table 2 for F_{fin} = 0.7 as a basis for setting TACs for the 2008/9 season.

Specifically then, this would suggest the following TAC changes:

Gough:	60 to not more than 89 tons
Nightingale	63 to not more than 82 tons
Inaccessible:	110 to not more than 126 tons
Tristan:	185 to not more than 186 tons

i.e. for practical purposes, the Tristan TAC is suggested to be kept unchanged for the moment.

FUTURE DEVELOPMENTS

By the time management advice is again required a year hence, encoding of data for Nightingale and Gough should have been completed. This should in turn allow analyses of the CPUE data for these two islands to be advanced to the same level as that at present for Inaccessible (Johnston *et al*., 2008). Advances on the analysis of CPUE data from Tristan should also have been made.

Overall though, these data will be limited, particularly as regards the period over which reliable data will be available, so that moving towards too great a level of further sophistication in the population modelling would not be justified. There is nevertheless a priority to develop an approach to provide insight on an appropriate value for F_{fin}

(specifically in relation to a realistic upper bound)to use in sustainable yield computations of the type above. Plans are to move to a simple age-structured model so that available (though limited) information on biological parameters for the population (growth curve, weight-at-age, etc.), together with the size-at-first-capture in the fishery, can be incorporated. This will provide insight on the extent of relative reduction of the spawning biomass as a function of F_{fin}, and so provide a basis for selecting a more realistic upper bound for that quantity.

REFERENCES

Edwards, C T T. 2007. Sources of data from the lobster fisheries on Inaccessible, Nightingale, Gough and Tristan da Cunha. MARAM document MARAM/Tristan/07/Dec/05.

Johnston, S J and Butterworth, D S. 2008. Nominal longline CPUE from Gough and Nightingale lobster fisheries. MARAM document MARAM/Tristan/08/May/02.

Johnston, S J, Brandão, A, Edwards, C T T and Butterworth, D S. 2008. Standardised longline lobster CPUE from Inaccessible island for the 1996-2005 period. MARAM document MARAM/Tristan/08/May/01.

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

Season	Gough		Nightingale		Inaccessible		Tristan	
	C	CPUE	C	CPUE	C	CPUE	C	CPUE
1996/7	104.111	-	63.474	2.09	73.306	1.35		
1997/8	79.097	1.91	52.474	1.80	62.521	0.92	112	10.6
1998/9	99.628	1.92	51.812	2.73	61.492	1.64	114	10.7
1999/0	93.647	2.03	52.623	2.78	64.176	2.30	122	26.6
2000/1	73.617	1.37	52.536	4.06	66.637	2.19	124	27.0
2001/2	90.133	1.27	57.037	3.11	70.512	2.69	127	27.6
2002/3	76.608	1.41	56.614	3.23	70.775	4.74	133	28.9
2003/4	94.868	1.54	57.472	5.95	77.283	4.95	138	35.3
2004/5	65.245	1.94	61.368	5.83	84.484	8.06	158	9.8#
2005/6	57.071	2.90	62.276	7.24	92.945	6.08	160	12.4
2006/7	56.646	4.17	62.333	8.33	103.281	-	180	19.5
2007/08							187	15.4

Sources:

Gough*:	Nominal longline CPUE – Johnston and Butterworth (2008)
Nightingale:	Nominal longline CPUE – Johnston and Butterworth (2008)
Inaccessible*:	GLMM standardised longline CPUE – Johnston *et al*. (2008)
Tristan:	Nominal catch per large powerboat day CPUE – J Glass (pers. commn).

* Adjusted for size limit change as detailed in the text.

\# From 2004/05 operating time restrictions were placed on powerboats at Tristan, so that values following are not comparable to earlier values.

Table 2: Estimates of sustainable yield *P* (in tons), with Hessian-based standard errors in parentheses from a simple age-aggregated population model fit to the CPUE data for each of the four islands of the Tristan da Cunha group. Estimates are given in relation to an assumed value of F_{fin}, which is the proportion of available abundance harvested in the final year for which a CPUE value is available.

	2007/8	F_{fin}		
	TAC	0.7	0.5	0.3
Gough	60	88.8 (4.0)	91.4 (6.1)	97.8 (11.2)
Nightingale	63	81.8 (6.8)	92.4 (9.4)	117.2 (15.7)
Inaccessible	110	126.1 (19.1)	149.3 (26.7)	203.5 (44.4)
Tristan	185	186.2 (16.1)	208.7 (22.1)	262.4 (36.2)
TOTAL	418	482.9	541.8	680.9

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 – minimum size **increased** from 70mm to 75mm
Inaccessible – 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 1 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
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
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 1: 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