

**UPDATED GLMM- STANDARDISED LOBSTER TRAP CPUE FOR
INACCESSIBLE AND GOUGH ISLANDS TAKING DATA FROM THE 2012
SEASON INTO ACCOUNT**

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ABSTRACT

The longline CPUE series for Inaccessible and Gough islands are GLMM standardised through to the 2012 season¹. Year, month, area, trap-type, soak time, depth and year-area interactions are treated as fixed effects, and year-month interactions as a random effect.

INTRODUCTION

The commercial CPUE series of a resource is often used as an index of population density and consequently to inform on population abundance when modelling the dynamics of the underlying population. It is known, however, that a number of other factors besides density may influence the recorded values of CPUE. Where sufficient data exist, General Linear Mixed Model (GLMM) standardisation is able to take some of these further effects into account, thereby producing a more reliable index of abundance. This document reports the application of a GLMM standardisation to *Jasus tristani* lobster catch per unit effort data from traps around Inaccessible and Gough Islands for the period 1997-2012. Results presented here are updated from those presented in Johnston *et al.* (2013), taking one more year's data into account (2012 season).

METHODOLOGY

Data

Raw Logsheet data

The logsheet data for the outer islands have been entered electronically into EXCEL spreadsheets. Logsheet data from the fishery are available for the Season-Years between 1997 and 2012, where a Season-Year is taken to run from September until August the following year, i.e. Season-Year 2005 refers to the period from September 2005 to August 2006.

¹ Note that 2011 refers to the split season 2011/12 for example.

The General Linear Mixed Model for the three outer islands

A GLMM which includes both fixed and random effects is used to standardise the lobster CPUE data for the three outer islands, where catches are the logsheet catches and effort is logsheet effort. (Note that this approach assumes that the logsheet data represent an unbiased sample of all of the fishery in each Season-Year.) This model allows for possible annual differences in the areal distribution of the lobsters (which is considered to be a fixed effect) and for annual differences in each month (considered as a random effect). The model is given by:

$$\ln(\text{CPUE} + \delta) = \mathbf{X}\alpha + \mathbf{Z}\beta + \varepsilon \quad (1)$$

where

α	is the unknown vector of fixed effects parameters (in this case this consists of the factors given by equation (2) below),
\mathbf{X}	is the design matrix for the fixed effects,
β	is the unknown vector of random effects parameters (which in this application consists of a year-month interaction),
\mathbf{Z}	is the design matrix for the random effects,
δ	is a small constant added to the rock lobster CPUE to allow for the occurrence of zero CPUE values (0.1 kg/trap in this case, being about 10% of the average nominal values), and
ε	is an error term assumed to be normally distributed and independent of the random effects.

This approach assumes that both the random effects and the error term have zero mean, i.e. $E(\beta)=E(\varepsilon)=0$, so that $E(\ln(\text{CPUE}+\delta)) = \mathbf{X}\alpha$. The variance-covariance matrix for the residual errors (ε) is denoted by \mathbf{R} and that for the random effects (β) by \mathbf{G} . The analyses undertaken here assume that the residual errors as well as the random effects are homoscedastic and uncorrelated, so that both \mathbf{R} and \mathbf{G} are diagonal matrices given by:

$$\mathbf{R} = \sigma_{\varepsilon}^2 \mathbf{I}$$

$$\mathbf{G} = \sigma_{\beta}^2 \mathbf{I}$$

where \mathbf{I} denotes an identity matrix. Thus, in the mixed model, the variance-covariance matrix (\mathbf{V}) for the response variable is given by:

$$\text{Cov}(\ln(\text{CPUE} + \delta)) = \mathbf{V} = \mathbf{Z}\mathbf{G}\mathbf{Z}^T + \mathbf{R},$$

where \mathbf{Z}^T denotes the transpose of the matrix \mathbf{Z} .

The sum of the factors that are considered as fixed effects (i.e. $\mathbf{X}\alpha$ in equation (1)) in the GLMM is given by the following:

$$\ln(\text{CPUE} + \delta) = \mu + \alpha_{\text{year}} + \beta_{\text{month}} + \gamma_{\text{area}} + \eta_{\text{trap-type}} + \lambda_{\text{soaktime}} + \theta_{\text{depth}} + \tau_{\text{year} \times \text{area}} \quad (2)$$

where:

μ	is the intercept,
year	is a factor with 16 levels for Gough and Inaccessible associated with the Season-Years 1997-2012,
month	is a factor with levels associated with the fishing month (1-12 for Gough, and 1-3 and 8-12 for Inaccessible),
area	is a factor with levels associated with groupings of fishing areas (Gough = 6 areas, Inaccessible = 9 areas),

<i>trap type</i>	is a factor with levels associated with the trap type (monster or beehive),
<i>soak time</i>	is a factor with 3 levels associated with the soak time period (“1”=0.0–0.49 days, “2”= 0.5–1.9 days and “3” for 2 or more days),
<i>depth</i>	is a factor with 4 levels associated with fishing depth ranges (“1” for depths < 10m, “2” for 10–39.9m, “3” for 40–89.9m, and “4” for depths ≥ 90 m), and
<i>year x area</i>	is the interaction between year and area.

In this application the CPUE has been standardised on the year 1998, month of *September*, trap type *Monster*, soak time “2”, depth category “2” and area = “1”.

For this model, because of the fixed effect interaction of area with year (which implies changing spatio-temporal distribution patterns), an index of overall abundance needs to integrate the different trends in density in each area over the size of these areas. Accordingly the standardised CPUE series is obtained from:

$$CPUE_{year} = \left[\sum_{area} \left(\exp(\mu + \alpha_{year} + \gamma_{area} + \tau_{year \times area}) - \delta \right) * A_{area} \right] / A_{total} \quad (3)$$

where

A_{area} is the surface size of the area concerned,

A_{total} is the total size of the fishing ground considered (the division by A_{total} is to keep the units and size of the standardised CPUE index comparable with those of the nominal CPUE), and

δ is taken to be 0.1 kg/trap (about 10% of the nominal average values).

Tables 1a and 1b provides the A_{area} values for Inaccessible and Gough Islands.

RESULTS

Table 2 provides standardised CPUE values derived from the updated GLMM. For comparison, the nominal CPUE values are also reported. Figure 1 compares the nominal CPUE with the updated 2013 standardised CPUE series. Figure 2 shows the month effects for each island, and Figure 3 shows the area effects for each islands.

DISCUSSION

The 2013 updated GLMM standardised CPUE series shown in Table 2 are put forward as the best upon which to base assessment of the resource and hence to provide suitable operating models which will be used to simulation test alternative OMPs for each island. The recently updated assessments of these islands (Johnston and Butterworth 2013) will thus be further updated incorporating the CPUE data reported here. This will be done before work on OMP development for these islands commences.

For Inaccessible island the CPUE trend indicates an increase over the last two seasons. Note however that the minimum legal CL was reduced from 68mm to 66mm at the start of the 2012 season. An increase in CPUE is usually expected following a reduction in minimum size, and this trend will therefor need to be carefully monitored

in the near future, to distinguish the effects of changing abundance from those of the change in minimum CL.

For Gough, the standardised CPUE values for the last three years are below the peak CPUE observed in 2009.

REFERENCES

- Edwards, C.T.T. and Glass, J.P. 2007. Reconciliation of data from the lobster fisheries on Inaccessible, Nightingale, Gough and Tristan da Cunha. Technical Report MARAM/Tristan/07/Dec/06, Ovenstone Fisheries.
- Johnston, S.J. and Butterworth, D.S. 2013. Updated 2013 rock lobster assessments for Inaccessible and Gough islands. MARAM/Tristan/2013/Sep/12.
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Table 1a: The size (km²) of each fishing area around **Inaccessible** Island.

Area	Name	Size
1	Bank	53.58
2	North point	5.88
3	Salt beach	1.10
4	East Point	10.14
5	Toms beach and Black spot	3.60
6	South Hill	3.60
7	Pyramid rock and Blinder	5.23
8	West point	5.04
9	Blendon Hall	4.32

Table 1b: The size (km²) of each fishing area around **Gough** Island.

Area	Name	Size
1	Cave Cove	6.48
2	Hawkins Bay	8.53
3	SE pt	8.01
4	SW pt	9.11
5	Gaggins pt	10.38
6	N pt	3.69

Table 2a: Standardised longline CPUE series for **Inaccessible** Island using the GLMM model detailed in the text. The number of data records for each Season-Year (N) is provided, along with the nominal CPUE series for comparison.

Season-Year	N	Nominal CPUE	Standardised CPUE (including 2012 season)
1997	238	2.986	1.774
1998	413	2.800	2.204
1999	406	3.492	2.408
2000	608	3.247	3.136
2001	584	3.362	3.057
2002	416	4.322	4.117
2003	225	6.704	5.780
2004	399	7.584	9.521
2005	435	7.010	6.851
2006	347	6.447	6.268
2007	669	4.853	4.791
2008	838	4.561	4.730
2009	1029	3.207	3.000
2010	624	2.437	2.684
2011	366	3.654	3.732
2012	534	5.172	5.578

Table 2b: Standardised longline CPUE series for **Gough** Island using the GLMM model detailed in the text. The number of data records for each Season-Year (N) is provided, along with the nominal CPUE series for comparison.

Season-Year	N	Nominal CPUE	Standardised CPUE (including 2012 season)
1997	1190	2.343	1.827
1998	1017	2.292	2.106
1999	1269	1.605	1.502
2000	1497	1.319	1.361
2001	1487	1.307	1.484
2002	1831	1.286	1.259
2003	1633	1.426	1.585
2004	951	1.894	1.643
2005	658	2.641	3.009
2005	373	4.078	4.050
2007	404	5.000	5.381
2008	398	6.044	5.825
2009	322	8.247	8.025
2010	464	6.280	5.127
2011	372	7.887	6.526
2012	605	5.746	5.718

Figure 1a: Comparative plot of the nominal and GLMM standardised longline CPUE series for **Inaccessible** Island taking into account the 2012 season's data. [Note that the minimum legal carapace size changed from 70mm to 68mm in 2003, and to 66mm in 2012.]

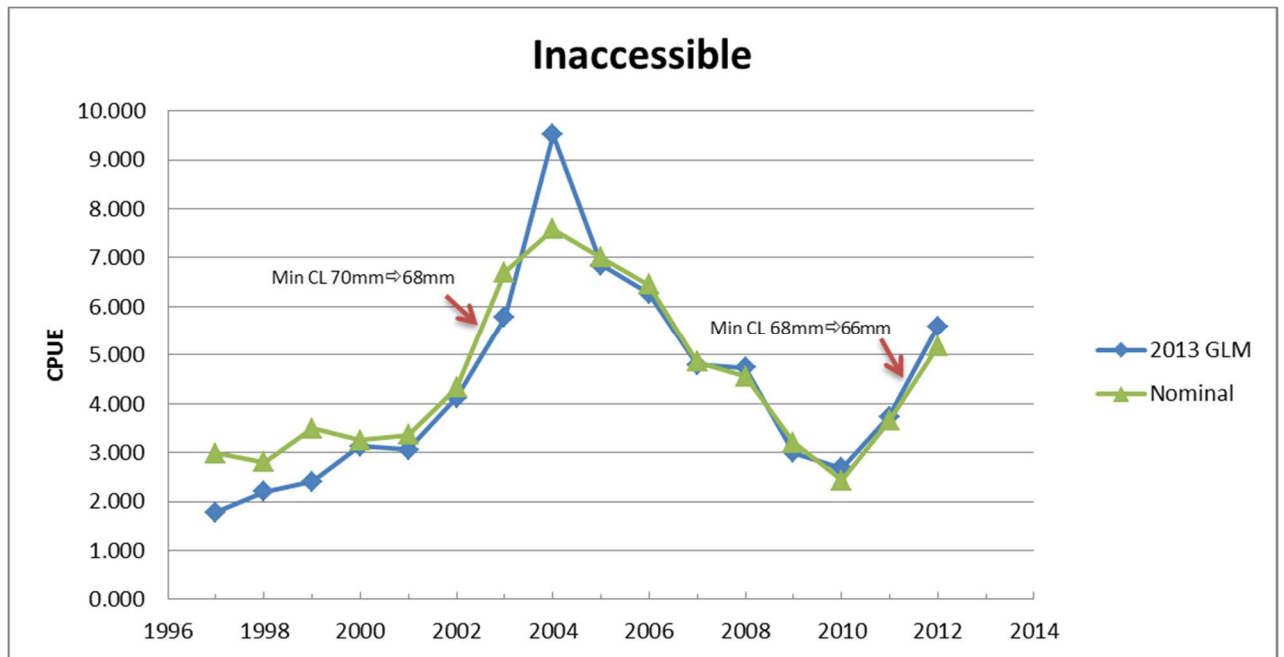


Figure 1b: Comparative plot of the nominal and GLMM standardised longline CPUE series for **Gough** Island taking into account the 2012 season's data. [Note that the minimum legal carapace size changed from 70mm to 75mm in 2003.]

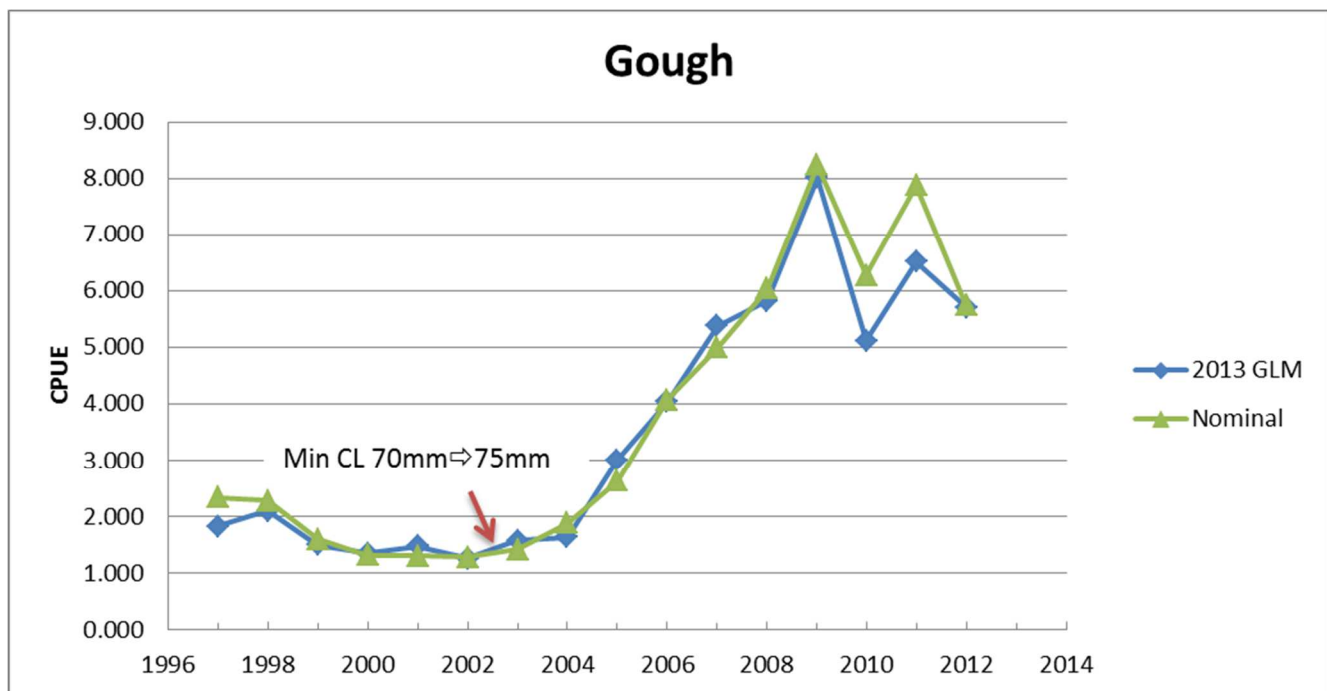


Figure 2a: GLMM month effects for **Inaccessible** Island.

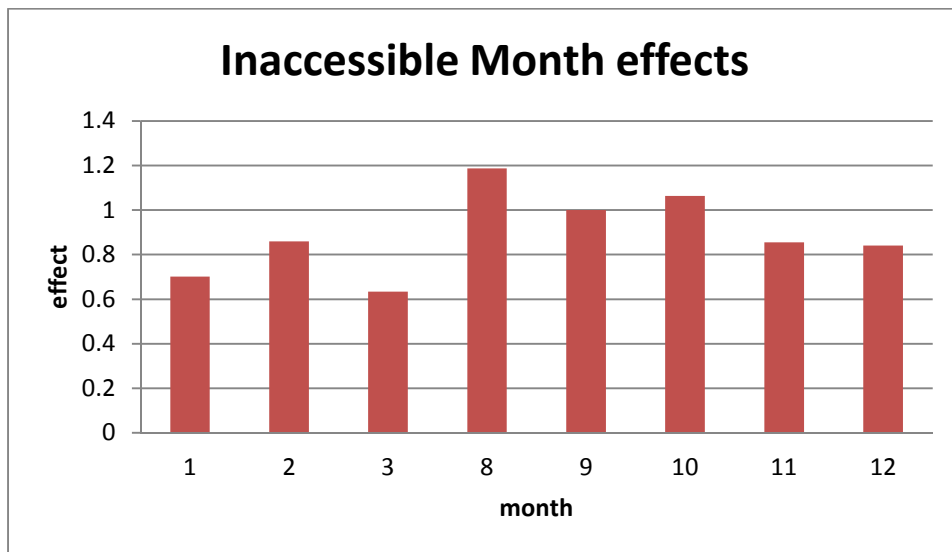


Figure 2b: GLMM month effects for **Gough** Island.

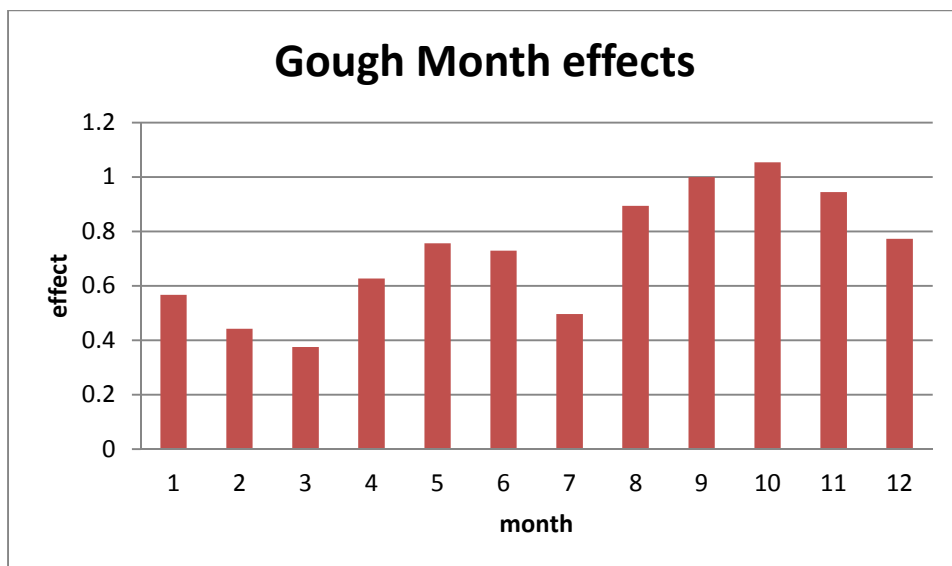


Figure 3a: GLMM area effects for **Inaccessible** Island (see Table 1a for area definitions).

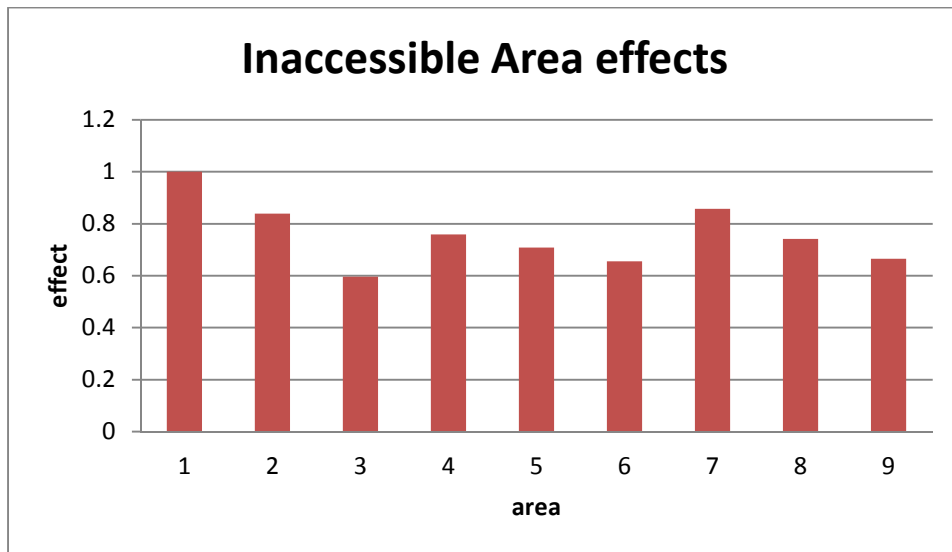


Figure 3b: GLMM area effects for **Gough** Island (see Table 1b for area definitions).

