Updated (and rescaled) Tristan GLM-standardised lobster CPUE to take account of data for the 2019 season

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APR 2020

ABSTRACT

The Powerboat CPUE series for Tristan was last updated in 2019 (MARAM/Tristan/2019/MAY/05) and took data for the 1994-2018[1] seasons into account. This GLM incorporated a method whereby the full GLM for Tristan can be rescaled to take into account the overall fishing efficiency changes as informed by the data on fishermen's names (available for the 2005-2007 and 2013-2019 seasons only). This document updates this GLM analysis by incorporating data from the most recent 2019 season. A very slight decline in the 2018 CPUE relative to 2017 is evident.

INTRODUCTION

The commercial CPUE series for 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 factors besides density may influence the values recorded for CPUE. Where sufficient data exist, General Linear Model (GLM) standardisation is able to take some of these further effects into account, thereby producing a more reliable index of density and hence abundance. This document reports the application of a number of GLM standardisations to the *Jasus tristiani* lobster catch per unit effort data from the Tristan powerboat fishery for the period 1997-2019.

METHODOLOGY

The standard powerboat CPUE database for Tristan contains information at a trip level for all seasons for the following:
  Year
  Month
  Number of traps
  Number of hoops
  Hours fished
  Total catch (in kgs)

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[1] The convention used here for split season is to use the first year, i.e. 2014 refers to the 2014/2015 season.

Note that for Tristan the "season" is assumed to start in July each year. In Johnston *et al.* (2010) a GLM was developed for which the CPUE is taken to be equal to:

$$CPUE = \frac{catch}{(number\ of\ gear)(hours\ fished)}\ \text{kg/hour/gear} \tag{1}$$

where the number of gear is:
$$number\ of\ gear = traps + 0.5 * hoopnets$$
(as suggested by James Glass pers. comm.) to allow for the different relative efficiency of the two types of gear. [Note that previous GLM analyses showed little sensitivity to alternate hoopnet calibration factors (relative to trap) to this 0.5 value.]

Table 1 summarises the variables currently available for the Tristan CPUE GLM analysis. Note that data on *area* fished are now available from 2005, and data on the fishermen's *names* (two for each trip) are available for eight seasons (2005-2007, 2013-2019). It is assumed here that both fishermen in a pair contribute fully to the catch and effort recorded for that trip (the data do not provide details at the individual level, only at the pair-level).

GLM1
The form of GLM model used in the past, and termed GLM1 here, is given by:

$$\ln(CPUE + \delta) = \mu + \alpha_{year} + \beta_{month} \tag{2}$$

where:

C	is the catch in kg,
E	is the effort in hours fished,
μ	is the intercept,
year	is a factor with 27 levels associated with the years (i.e. the Season-Years: 1994-2019),
month	is a factor with levels associated with the fishing month (1-12), and
δ	is taken to be 0.95 (used to prevent taking logs of zero).

The standardised CPUE series is obtained from:

$$CPUE_{year} = \exp\left(\mu + \alpha_{year} + \beta_{September}\right) - \delta \tag{3}$$

GLM3
GLM3 is an extension of GLM1 (as described in Johnston and Butterworth 2016) that takes area and the fishermen's names into account in the standardisation:

$$\ln(CPUE + \delta) = \mu + \alpha_{year} + \beta_{month} + \gamma_{area} + \phi_{Name} \tag{4}$$

where:

γ_{area}	is a factor with levels associated with the area fished (1-4), and
ϕ_{Name}	is the factor associated with a fisherman's name.

The standardised CPUE series (GLM3) is obtained from:

$$CPUE_{year} = \exp\left(\mu + \alpha_{year} + \beta_{September} + \gamma_{D4} + \phi_{Name12}\right) - \delta \tag{5}$$

Note that GLM3 can be run only for those years for which the fishermen's names are available, i.e. for 2005-2007 and 2013-2019.

Note the intercept in the GLMs includes 2005, September, Area D4, and fisherman number 32 (who is a fisherman who operated over each of the ten years with data on names).

Rescaling of GLM1

The approach taken here is that GLM1 continues to be the most appropriate GLM to be used as the reference case GLM for the Tristan powerboat CPUE as it takes data for the full 1994-2019 period into account. GLM3 has the advantage that it takes both the area fished and the fishermen's names (and hence their different efficiencies) into account; however this information is available for nine years only; 2005-2007 and 2013-2019. GLM3 thus has the important ability to inform on changes in the overall fishing efficiency over this period.

A reasonable way to incorporate this useful information on fishing efficiency changes, is to use GLM1 as the underlying GLM for Tristan, but to rescale the CPUE decline observed from the 2005-2019 period in line with what is estimated by GLM3 (which is able to take any fishing efficiency changes into account).

GLM1 results in a ratio $\frac{CPUE_{13-19}}{CPUE_{05-07}}$=**0.40**, where $CPUE_{05-07}$ is the average CPUE over the 2005-2007 period and $CPUE_{13-18}$ is the average CPUE over the 2013-2018 period.

GLM3 results in a ratio $\frac{CPUE_{13-19}}{CPUE_{05-07}}$=**0.45**, indicating a somewhat lesser decline in CPUE over the 2005-2019 period than GLM1 does because of a decline in the overall average of the fishermen's efficiency.

The GLM1 values are **rescaled** from 2005 to 2019 using a linear function of year as a multiplier which does not change the value for 2005 but achieves a $\frac{CPUE_{13-19}}{CPUE_{05-07}}$ ratio that equals 0.45.

RESULTS

Table 2 reports both the (unscaled) GLM1 standardised CPUE series, as well as the rescaled GLM1 series.

Figure 1 plots the standardised CPUE for GLM1 and GLM3 (where the GLM3 values are renormalized so that the average CPUE for the 2005-2007 period is identical to that for GLM1). Figure 2 plots the standardised CPUE for GLM1 and for the rescaled GLM1a. Figure 3 shows the scaling vector applied to the GLM1 standardised CPUE values to produce the rescaled GLM1 values.

Figure 4a shows the month effects estimated for GLM1 and GLM3; month effects are generally higher for August to December. Figure 4b shows the area effects estimated

by GLM3 – this shows that area effects are minimal. Figure 4c shows the "Name" effects for GLM3.

DISCUSSION

We continue to recommend that the re-scaled GLM1 series remains the more reliable CPUE series as both the full time series of data is taken into account and the new data on areas and fishing names are also incorporated. The rescaled GLM1 thus takes the fishing efficiency changes informed by these new data into account. The inclusion of the fishing efficiency changes results in a slightly less pessimistic CPUE trend over recent seasons. It is planned to use the rescaled GLM1 CPUE series presented here as input into the new OMP 2020 to recommend the TAC for the 2020/21 season. Figure 2 shows that the most recent data for the 2019 season show a slight decline since the last season.

REFERENCE LIST

Johnston, S.J., Brandao, A. and D.S. Butterworth. 2010a. GLMM- and GLM-standardised lobster CPUE from the Tristan da Cunha group of islands for the 1997-2008 period. MARAM/Tristan/2010/May/04.

S.J. Johnston and D.S. Butterworth. 2016. Rescaled Tristan GLM-standardised lobster CPUE to take account of fishing efficiency changes. MARAM/TRISTAN/2016/MAR/05.

Table 1: Table showing for which seasons different variables are available for CPUE GLM standardisation analysis. "Name" refers to the fisherman's name.

	Season	Month	Area	Name	Nominal CPUE
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005					
2006					
2007					
2008					
2009					
2010					
2011					
2012					
2013					
2014					
2015					
2016					
2017					
2018					
2019					

Table 2: Standardised powerboat CPUE series for **Tristan** Island using the original GLM1a model as well as the rescaled GLM1a which takes fisherman efficiency into account. The number of data records for each Season-Year (N) is listed, along with nominal CPUE series for comparison.

Season-Year	N	Nominal CPUE (kg/hour/gear)	GLM1 Standardised CPUE (kg/hour/gear)	Rescaled GLM1 Standardised CPUE (kg/hour/gear)
1994	1138	0.269	0.329	0.329
1995	1139	0.264	0.298	0.298
1996	1241	0.280	0.333	0.333
1997	696	0.489	0.504	0.504
1998	446	0.712	0.608	0.608
1999	338	0.961	0.786	0.786
2000	324	1.019	0.979	0.979
2001	334	1.107	1.004	1.004
2002	335	1.397	1.372	1.372
2003	382	1.684	1.567	1.567
2004	385	1.726	1.742	1.742
2005	339	2.155	2.265	2.265
2006	284	2.840	2.595	2.625
2007	310	2.365	2.117	2.116
2008	486	1.453	1.270	1.315
2009	305	1.835	1.803	1.888
2010	484	1.317	1.282	1.358
2011	376	1.321	1.237	1.326
2012	344	1.104	1.060	1.149
2013	476	0.990	0.986	1.081
2014	366	0.704	0.714	0.792
2015	343	0.833	0.861	0.966
2016	376	1.028	1.027	1.166
2017	271	1.078	1.024	1.175
2018	330	1.031	0.982	1.140
2019	321	1.039	0.972	1.141

Figure 1: Comparative plot of the GLM1 and GLM3 standardised powerboat CPUE series for **Tristan** Island. GLM3 covers the years 2005-2007 and 2013-2018 only, and takes account of fisherman efficiency. It is renormalised to the GLM1 mean for the 2005-07 period for easier comparison of trends.
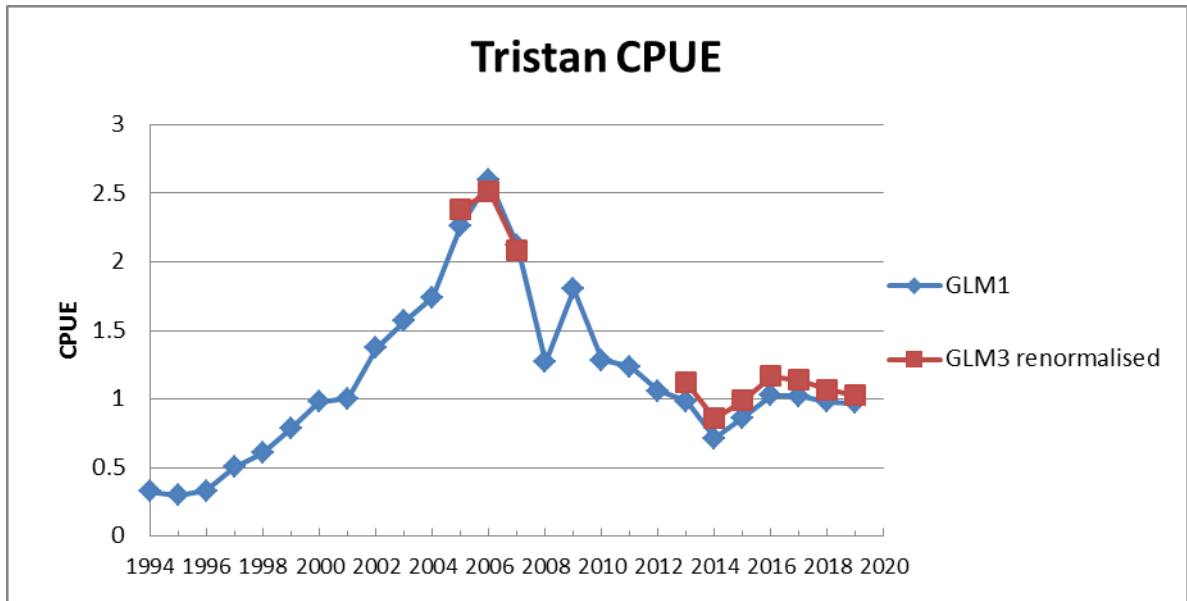

Figure 2: Comparative plot of the GLM1 and rescaled GLM1 powerboat CPUE series for **Tristan** Island. The latter includes an adjustment for changing average fisherman efficiency over time.
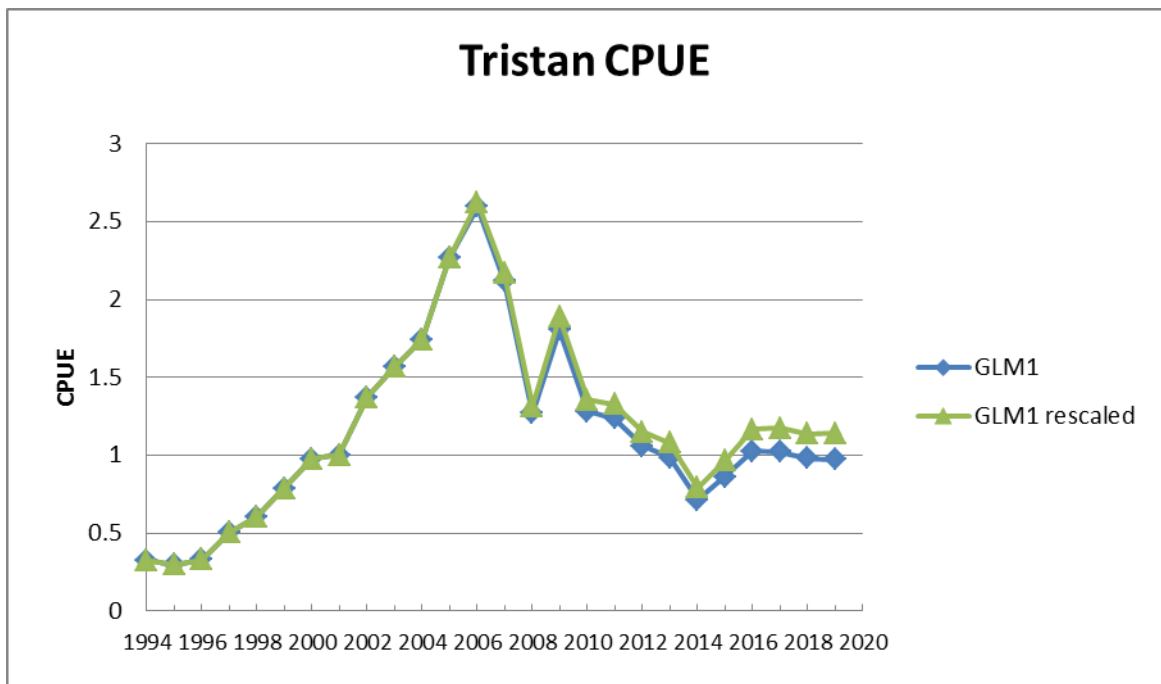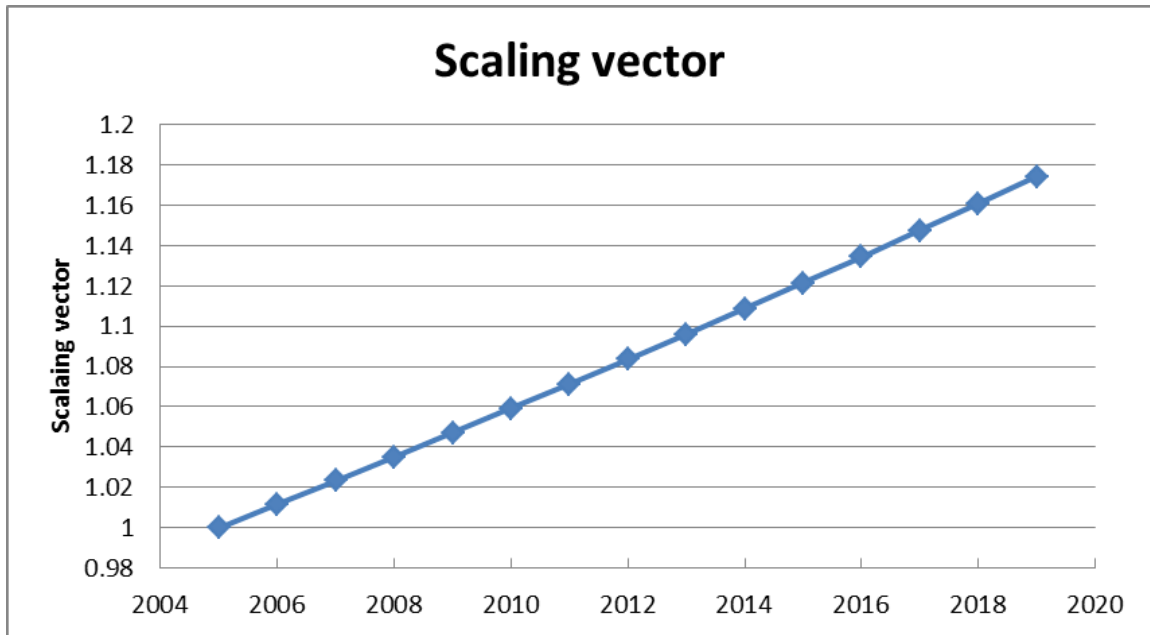
Figure 3a: The scaling vector which is applied to the GLM1 standardised CPUE values to produce the rescaled GLM1 values

Figure 3b: Comparative plot of the GLM1 and rescaled GLM1 powerboat CPUE series for **Tristan** Island. The latter includes an adjustment for changing average fisherman efficiency over time. The plot includes the current OMP 2016 CPUE target Itar (1.257) and the Ilim value of 0.90.
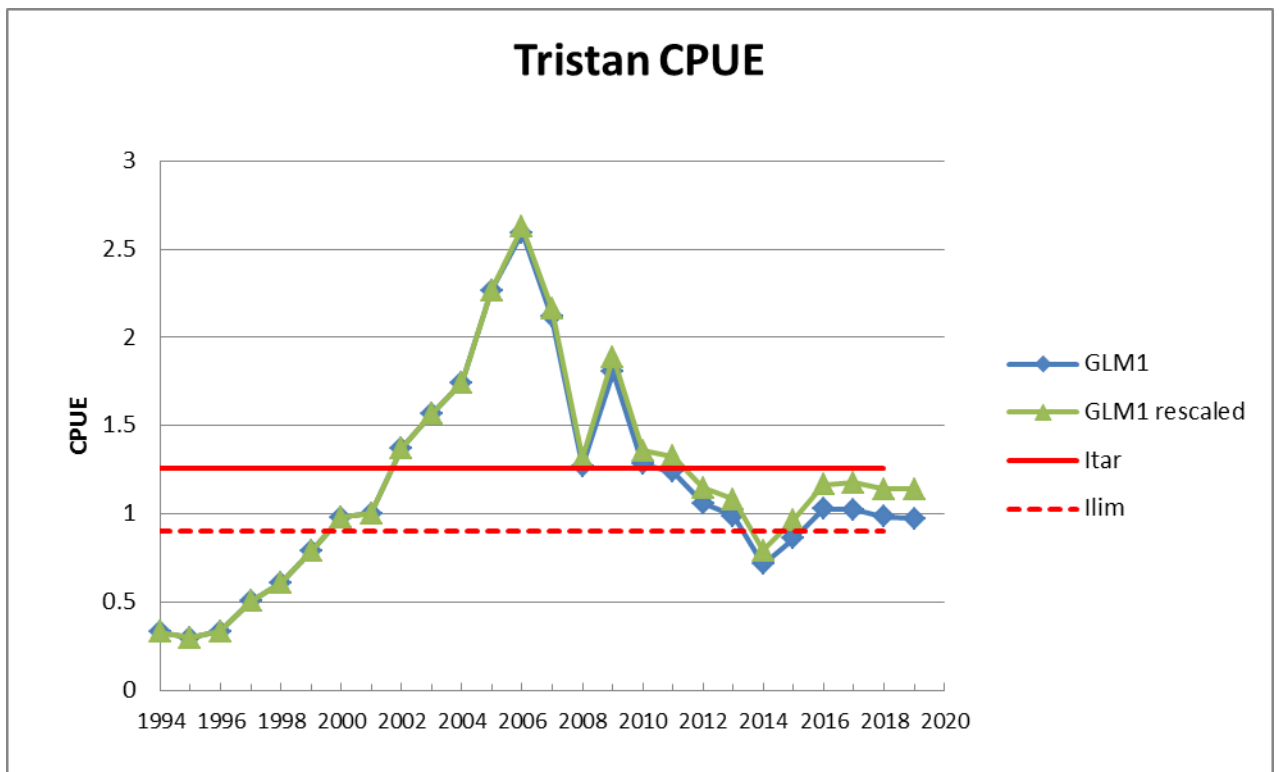
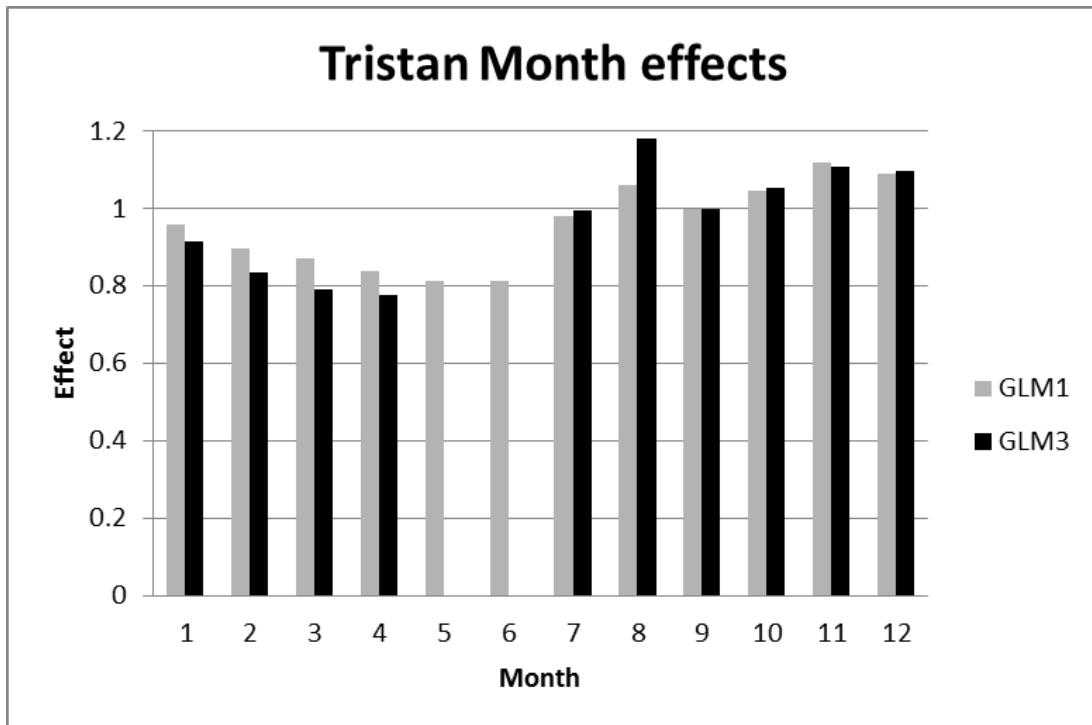Figure 4a: GLM month effects for the **Tristan** Island for both GLM1 and GLM3.

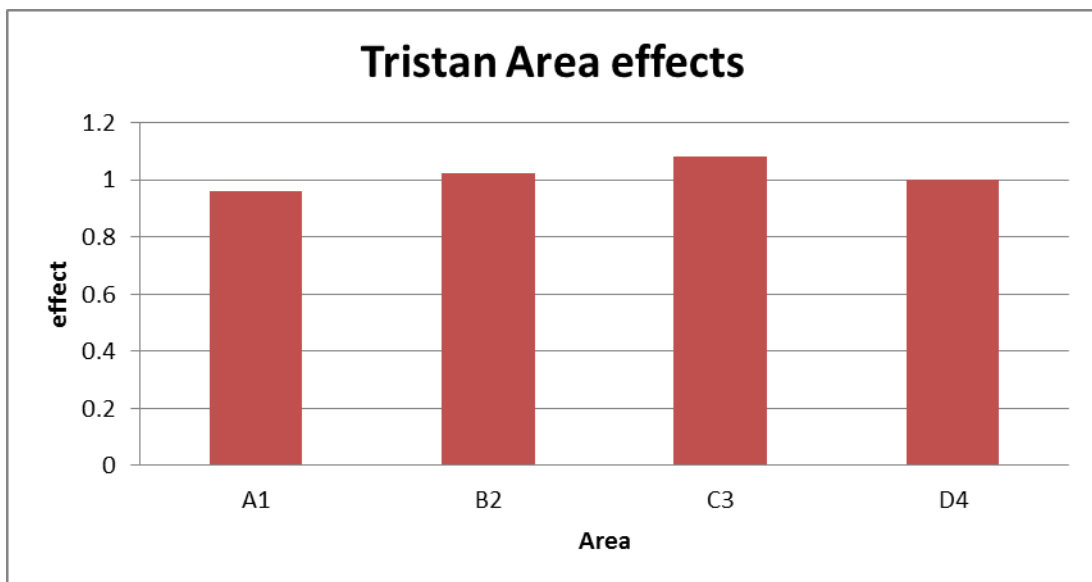Figure 4b: GLM3 area effects for the **Tristan** Island.

Figure 4c: GLM3 name (i.e. fisherman efficiency) effects for the **Tristan** Island. Names have been replaced by numerics for reasons of confidentiality.