

**Updated (and rescaled) Tristan Island GLM-standardised *Jasus tristani* lobster
CPUE to take account of data for the 2020 season**

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SUMMARY

The Powerboat CPUE series for Tristan Island was last updated in 2020 (MARAM/Tristan/2020/MAY/08) and took data for the 1994-2019¹ seasons into account. The GLM standardisation incorporated a method whereby the full GLM time series for Tristan Island could 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 2013-2020 seasons only). This document updates this GLM analysis by incorporating data from the most recent 2020 season. A substantial increase in the 2020 CPUE relative to 2019 is evident.

KEY WORDS: *Jasus tristani*, rock lobster, GLM-standardised CPUE

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 tristani* lobster catch per unit effort data from the Tristan Island powerboat fishery for the period 1997-2020.

METHODOLOGY

The standard powerboat CPUE database for Tristan Island 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)

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 standardisation was developed for which the CPUE is taken to be equal to:

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

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 efficiencies 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 Island CPUE GLM analysis. Note that data on *area* fished are now available from 2005, and data for the fishermen’s *names* (two for each trip) are available for eleven seasons (2005-2007, 2013-2020). 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 standardisation model used in the past, and termed GLM1 here, is given by:

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

where:

| | |
|----------|--|
| C | is the catch in kg, |
| E | is the effort in hours fished, |
| μ | is the intercept, |
| $year$ | is a factor with 28 levels associated with the years (i.e. the Season-Years: 1994-2020), |
| $month$ | 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:

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

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:

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

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:

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

Note that GLM3 can be run only for those years for which the fishermen's names are available, i.e. for 2005-2007 and 2013-2020.

Note the intercept in the GLMs includes 2005, September, Area D4 and fisherman number 2 (who is a fisherman who operated over each of the eleven 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 Island powerboat CPUE as it takes data for the full 1994-2020 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 eleven years only; 2005-2007 and 2013-2020. 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 Island, but to rescale the CPUE decline observed from the 2005-2020 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 $\frac{CPUE_{13-20}}{CPUE_{05-07}}=0.42$, where $CPUE_{05-07}$ is the average CPUE over the 2005-2007 period and $CPUE_{13-20}$ is the average CPUE over the 2013-2020 period.

GLM3 results in a ratio $\frac{CPUE_{13-20}}{CPUE_{05-07}}=0.47$, indicating a somewhat lesser decline in CPUE over the 2005-2020 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 2020 using a linear function of year as a multiplier which does not change the value for 2005 but achieves a $\frac{CPUE_{13-20}}{CPUE_{05-07}}$ ratio that equals 0.47. Note that this function is linear for 2005-2019 and then assumes no further changes in fishing efficiency from 2019+.

RESULTS

Table 2 reports both the (unscaled) GLM1 standardised CPUE series for Tristan Island, 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 both as the full time series of data is taken into account and as 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 to indicate a slightly more optimistic CPUE trend over recent seasons. Figure

2 shows that the most recent data for the 2020 season show a substantial increase of about 30% since the 2019 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 for Tristan Island. "Name" refers to the fisherman's name.

| | Season | Month | Area | Name | Nominal CPUE |
|------|--------|-------|------|------|--------------|
| 1997 | | | | | |
| 1998 | | | | | |
| 1999 | | | | | |
| 2000 | | | | | |
| 2001 | | | | | |
| 2002 | | | | | |
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| 2015 | | | | | |
| 2016 | | | | | |
| 2017 | | | | | |
| 2018 | | | | | |
| 2019 | | | | | |
| 2020 | | | | | |

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 | 0.328 | 0.328 |
| 1995 | 1139 | 0.264 | 0.297 | 0.297 |
| 1996 | 1241 | 0.280 | 0.332 | 0.332 |
| 1997 | 696 | 0.489 | 0.502 | 0.502 |
| 1998 | 446 | 0.712 | 0.604 | 0.604 |
| 1999 | 338 | 0.961 | 0.781 | 0.781 |
| 2000 | 324 | 1.019 | 0.977 | 0.977 |
| 2001 | 334 | 1.107 | 0.998 | 0.998 |
| 2002 | 335 | 1.397 | 1.371 | 1.371 |
| 2003 | 382 | 1.684 | 1.564 | 1.564 |
| 2004 | 385 | 1.726 | 1.742 | 1.742 |
| 2005 | 339 | 2.155 | 2.266 | 2.266 |
| 2006 | 284 | 2.840 | 2.589 | 2.615 |
| 2007 | 310 | 2.365 | 2.111 | 2.154 |
| 2008 | 486 | 1.453 | 1.266 | 1.305 |
| 2009 | 305 | 1.835 | 1.803 | 1.878 |
| 2010 | 484 | 1.317 | 1.281 | 1.348 |
| 2011 | 376 | 1.321 | 1.235 | 1.313 |
| 2012 | 344 | 1.104 | 1.058 | 1.136 |
| 2013 | 476 | 0.990 | 0.985 | 1.068 |
| 2014 | 366 | 0.704 | 0.713 | 0.782 |
| 2015 | 343 | 0.833 | 0.861 | 0.953 |
| 2016 | 376 | 1.028 | 1.027 | 1.148 |
| 2017 | 271 | 1.078 | 1.023 | 1.155 |
| 2018 | 330 | 1.031 | 0.982 | 1.121 |
| 2019 | 321 | 1.039 | 0.969 | 1.117 |
| 2020 | 141 | 1.260 | 1.261 | 1.454 |

Figure 1: Comparative plot of the GLM1 and GLM3 standardised powerboat CPUE series for **Tristan** Island. GLM3 covers the years 2005-2007 and 2013-2020 only, and takes account of fisherman efficiency. It is renormalised to the GLM1 mean for the 2005-07 period for easier comparison of trends.

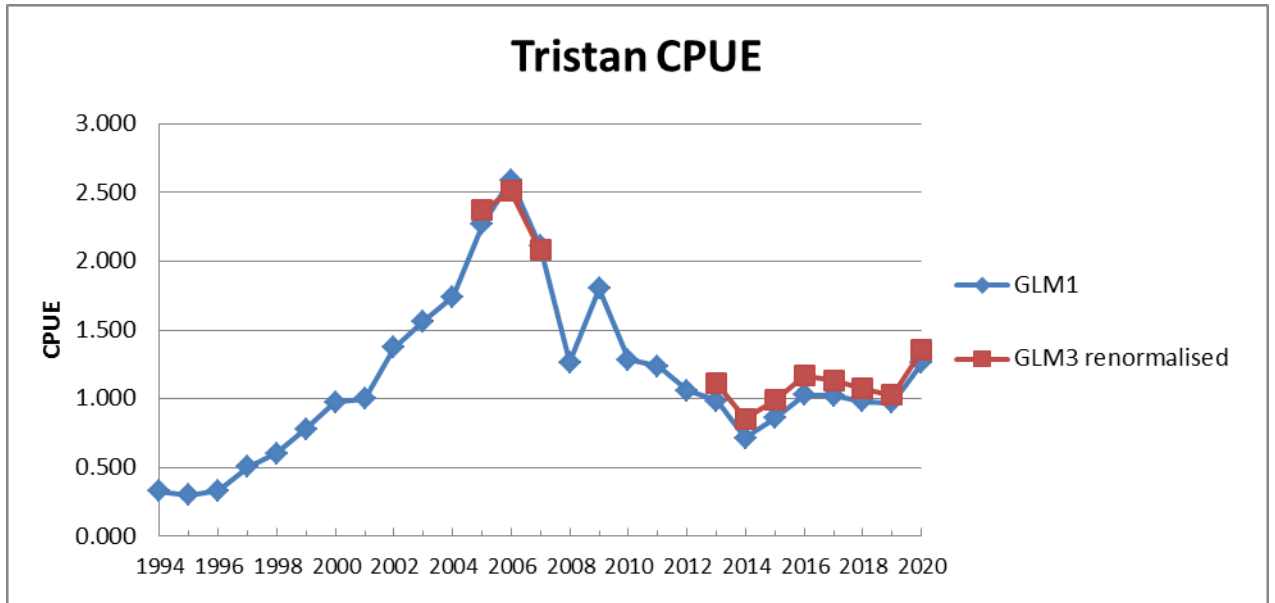


Figure 2: Comparative plot of the GLM1 and the rescaled GLM1 powerboat CPUE series for **Tristan** Island, along with the Nominal CPUE series.

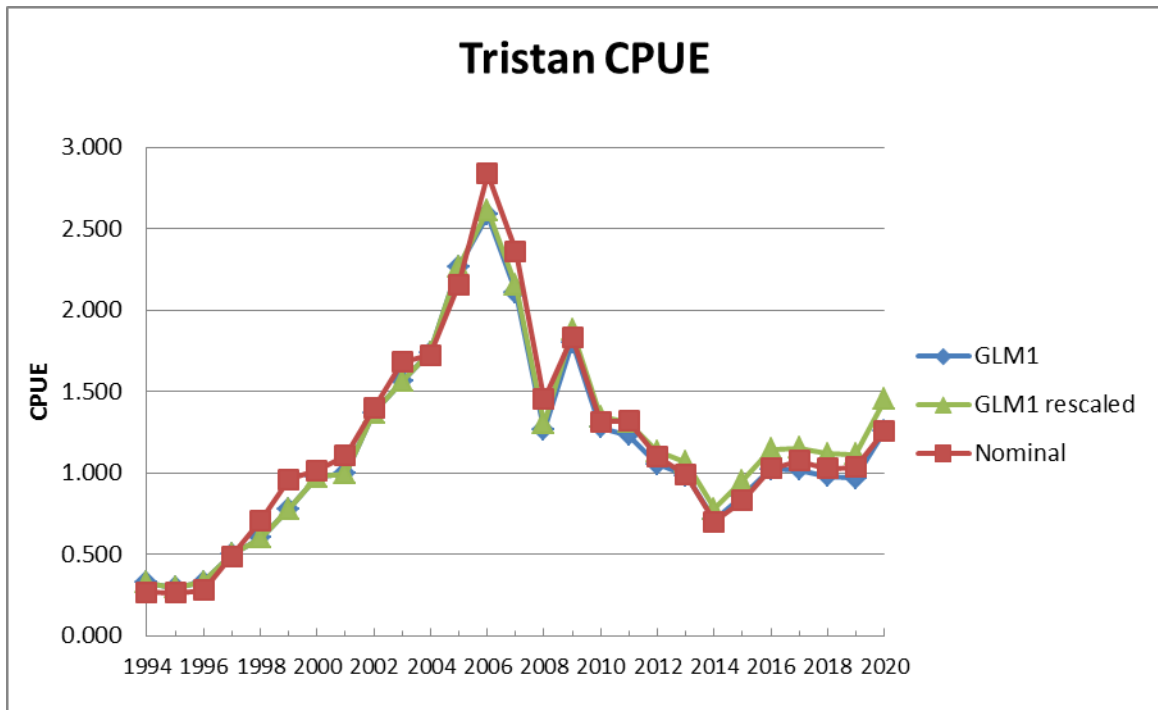


Figure 3a: The scaling vector which is applied to the GLM1 standardised CPUE values to produce the rescaled GLM1 values for **Tristan** Island.

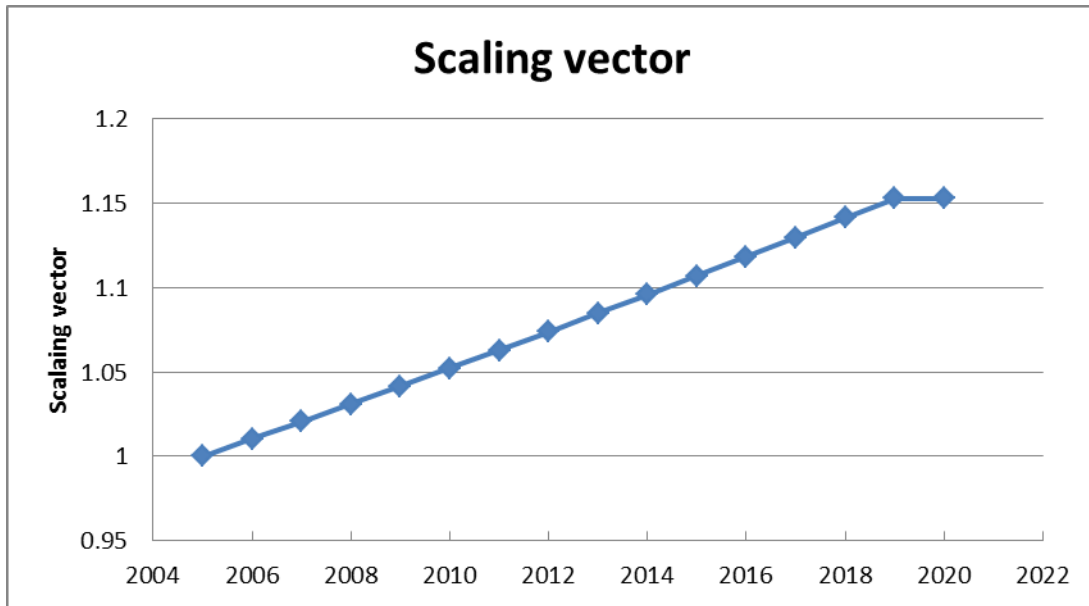


Figure 3b: Rescaled GLM1 powerboat CPUE series for **Tristan** Island which includes an adjustment for the changing average fisherman efficiency over time. The plot includes the current OMP 2020 CPUE target $J_{tar}=1.0$ and $J_{lim} = 0.70$ (these are equivalent to the previous I_{tar} and the I_{lim} values 1.287 and 0.90 respectively).

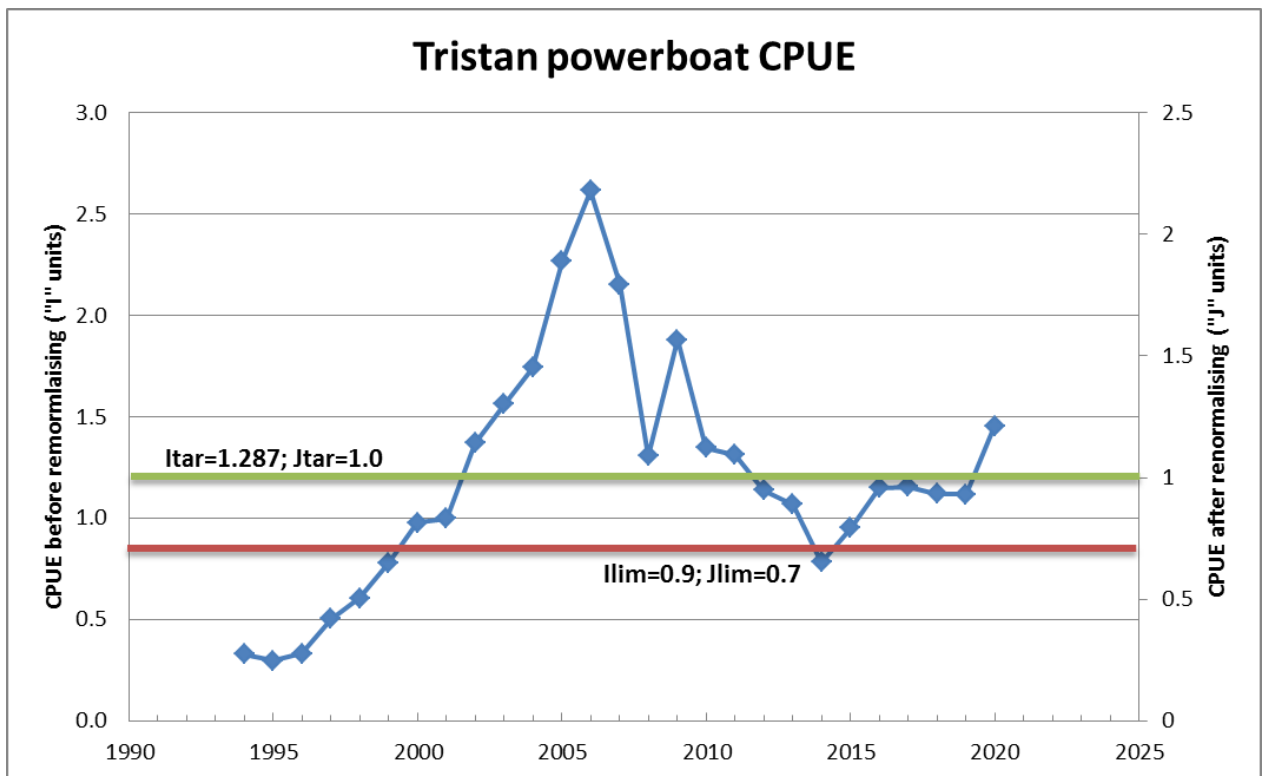


Figure 4a: GLM month effects for the **Tristan** Island for both GLM1 and GLM3.

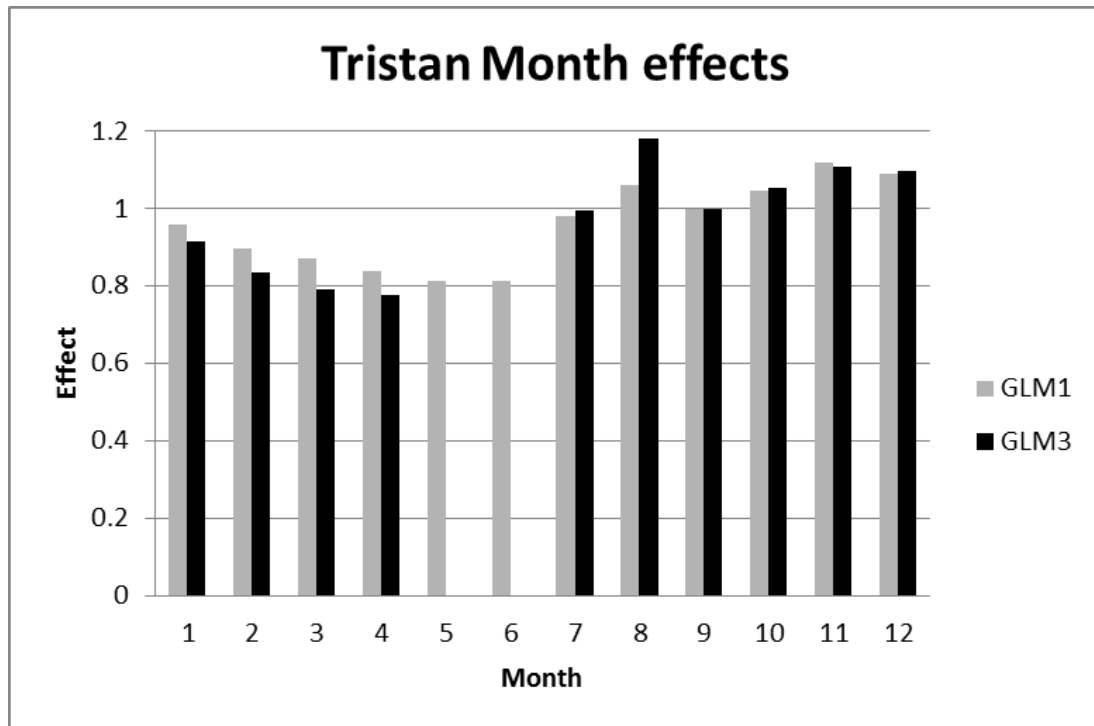


Figure 4b: GLM3 area effects for the **Tristan** Island.

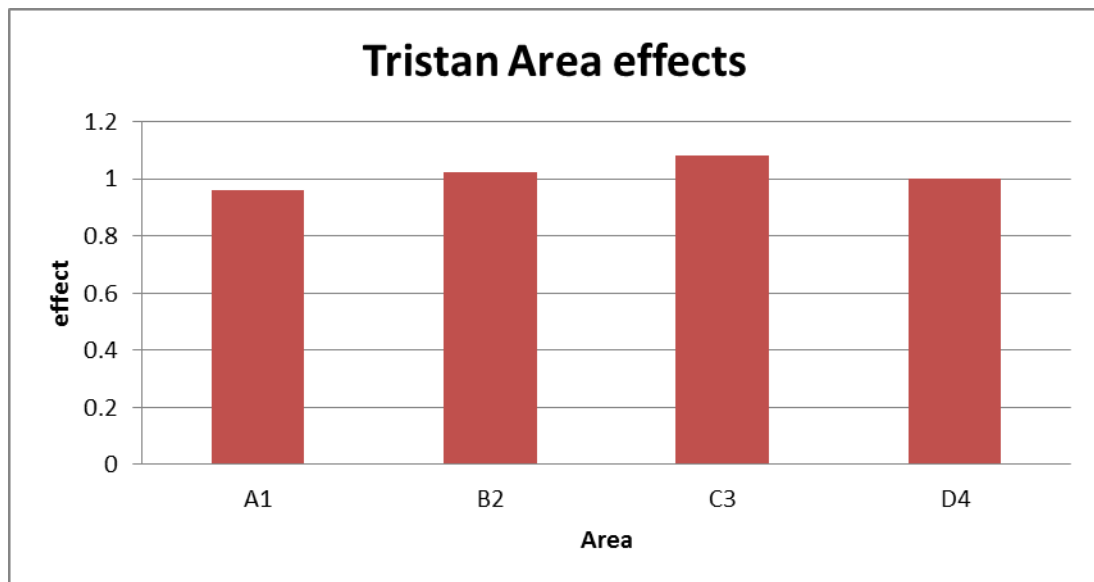


Figure 4c: GLM3 name (i.e. fisherman efficiency) effects for the **Tristan** Island. Names have been replaced by numerics for reasons of confidentiality.

