GLM-standardised lobster vessel CPUE at Tristan

S.J. Johnston and D.S. Butterworth.

MARAM
Department of Mathematics and Applied Mathematics
University of Cape Town
Rondebosch, 7701

Summary

A GLM method is described which is used to standardise the vessel CPUE data at Tristan. The vessel CPUE provides a more optimistic indication of stock status than the powerboat CPUE for the last three seasons. The 2018-2019 vessel GLM 2020 values are slightly above the Jtar target CPUE value, whereas the 2018-2019 powerboat GLM values are slightly below.

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 at least some of these further factors into account, thereby producing a more reliable index of density and hence abundance. This document reports the application of a GLM standardisation to the *Jasus tristiani* lobster catch per unit effort data from the fishery by vessels (as distinct from powerboats) (i.e. from the *Edinburgh/Geo Searcher*) for the period 2007-2019 (see Figures 1a and b). Previously only a nominal vessel CPUE series has been generated, where each CPUE record is set equal to the corresponding daily catch.

At present, a GLM is used to standardise the catch and effort data from the powerboats, which take the bulk of the catch limit for Tristan. The vessel operated by Ovenstones (initially the *Edinburgh*, which was replaced by the *Geo Searcher* in 2017) is used predominantly to “mop up” any portion of the catch limit still uncaught near the end of the season.

Note that the vessel CPUE is used in both the assessment of the Tristan rock lobster fishery as well as input into the newly developed Tristan OMP.

METHOD

A similar GLM analysis to that applied to the outer islands longline CPUE data is used here. One problem is that “area” data are available only for 2012, 2014-2019. To be able to provide a standardised series for the full period, the approach involves obtaining a GLM_area series that takes area into account (for 2012, 2014-2019), as well as a GLM_no area series for the full set of 2007-2019 seasons which omits the area data.

The form of the **GLM_area** model for the vessel is as follows:

$$\ln(CPUE+\delta) = \mu + \alpha_{year} + \beta_{month} + \gamma_{area} + \lambda_{soaktime} + \theta_{depth} + \pi_{sequential\ day} \qquad (1)$$

where

μ	is the intercept,
year	is a factor with 6 levels Season-Years 2012, 2014-2019 (excluding 2016),
month	is a factor with 6 levels associated with the fishing month (2, 3, 4, 5,11 and 12),
area	is a factor with 10 levels associated with fishing areas (Areas B-K),
soak time	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),
depth	is a factor with 4 levels associated with fishing depth ranges ("1" for depths < 50m, "2" for 50–74m, "3" for 75–99m, and "4" for depths >100m),
sequential day	is a factor with 14 levels associated with the trip length,
CPUE	is the retained catch per trap, and
δ	is taken to be 0.1 kg/trap (about 10% of the average CPUE value).

In this application the CPUE has been standardised on the year 2012, month of *February*, soak time "2", depth category "2" , sequential day 2, and area = "B".

The standardised CPUE series is then obtained from:

$$CPUE_{year} = \exp(\mu + \alpha_{year})\text{-}\delta \qquad (2)$$

The form of the **GLM_no area** model for the vessel is as follows:

$$\ln(CPUE + \delta) = \mu + \alpha_{year} + \beta_{month} + \lambda_{soaktime} + \theta_{depth} + \pi_{sequential\ day} \qquad (3)$$

i.e. identical to above except that the *area* covariate is omited and *year* is a factor with 12 levels (2007-2019 excluding 2016).

The standardised CPUE series is then again obtained from:

$$CPUE_{year} = \exp(\mu + \alpha_{year})\text{-}\delta \qquad (4)$$

Final GLM output

The approach taken here is that GLM_area is the most appropriate GLM to be used as the reference case GLM for the vessel CPUE at Tristan as it takes area into account. Whilst at present the GLM-area series is very similar to that obtained from GLM_no area approach, this may well change in the future. This area information however is available for six years only: 2012 and 2014-2019 (excluding 2016 for which no vessel-based fishing took place). GLM-no area series, however, has the advantage that whilst it does not incorporate area information, it does cover the full range of years from 2007-2019 (12 years given the exclusion of 2016).

A reasonable method of combining the information from both GLMs is to use the GLM_area values from 2012 onwards, but incorporate the pre-2012 GLM_no area values by re-scaling them so that the 2012 GLM_no area value is equal to the 2012 GLM_area value. Note that this method of "rescaling" and combining information from two different GLMs is similar to that developed for the Tristan powerboat CPUE data where information of the fishermen names is limited to more recent years only (Johnston and Butterworth 2019). This combination is referenced as the final standardised 2020 vessel GLM CPUE series

RESULTS

The vessel catch at Tristan has ranged from 10-50mt since 2007. This has amounted to between 10-30% of the annual TAC set for Tristan (Figures 1a and b). The vessel catches are therefore an important component of this fishery.

Figure 2a compares the new GLM standardised vessel CPUE (for GLM_area and GLM_no area) with the original nominal CPUE series. Figure 2b plots the final standardised 2020 vessel GLM series (GLM 2020, obtained using the combination method described above), along with the nominal and powerboat GLM series. Here all series are renomalised to their 2010-2012 averages. The current values of the target CPUE (Jtar) and the limit CPUE (Jlim) used in the OMP for Tristan are also indicated. The 2020 GLM and the nominal series show similar trends. The vessel CPUE provides a somewhat more optimistic indication of stock status than the powerboat CPUE for the last three seasons. The 2018-2019 vessel GLM 2020 values slightly above above the Jtar value, whereas the 2018-2019 powerboat GLM values are slightly below. Table 1 reports the nominal and GLM values pre- and post-normalisation.

Figure 3 shows the values of covariate factor estimates for the GLM-area analysis. Of particular interest is that area "B" provides about 40% greater catch rates than the other areas, and that there is a strong decline in catch rates with increasing depth. The "sequential days" factors show little variation.

CONLCUSION

It is recommended that the vessel CPUE data is analysed annually using the GLM approach described above.

Reference

Johnston, S.J. and Butterworth, D.S. 2019. Updated (and rescaled) Tristan GLM-standardised lobster CPUE to take account of data for the 2019 season. MARAM document MARAM/TRISTAN/2020/MAY/08.

Table 1: Standardised vessel CPUE series for Tristan Island using the GLM models detailed in the text. The number of data records for each Season (*N*) is provided, along with the nominal CPUE series for comparison. A data record represents data for a line of 20 traps. The last column provides Final GLM 2020 values re-normalised values to their 2010-2012 average.

Season	*N*	**Nominal vessel CPUE kg/day**	**Standardised vessel CPUE kg/day GLM_no area**	**Standardised vessel CPUE kg/day GLM_area**	**Final 2020 vessel GLM kg/day**	**Renormalised Final 2020 vessel GLM kg/day**
2007	55	1.773	2.144	-	2.692	2.144
2008	46	1.951	1.877	-	2.357	1.877
2009	220	1.514	1.498	-	1.881	1.498
2010	72	0.811	1.158	-	1.454	1.158
2011	135	0.989	0.986	-	1.238	0.986
2012	135	1.200	0.856	1.080	1.075	0.856
2013	148	0.654	0.497	-	0.624	0.497
2014	434	1.038	0.934	1.160	1.160	0.924
2015	337	0.638	0.612	0.760	0.760	0.605
2016	-	-	-	-	-	-
2017	38	1.865	1.882	2.280	2.280	1.815
2018	142	0.681	1.162	1.317	1.317	1.049
2019	209	1.184	1.120	1.344	1.340	1.080

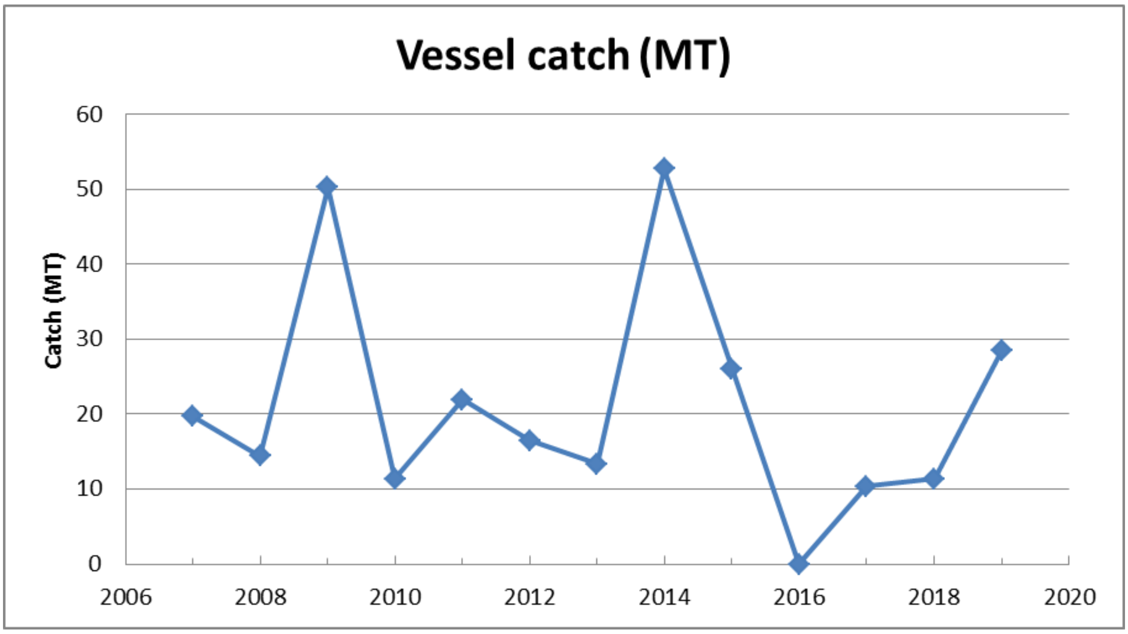

Figure 1a: The catch (MT) taken by the vessel since 2007.

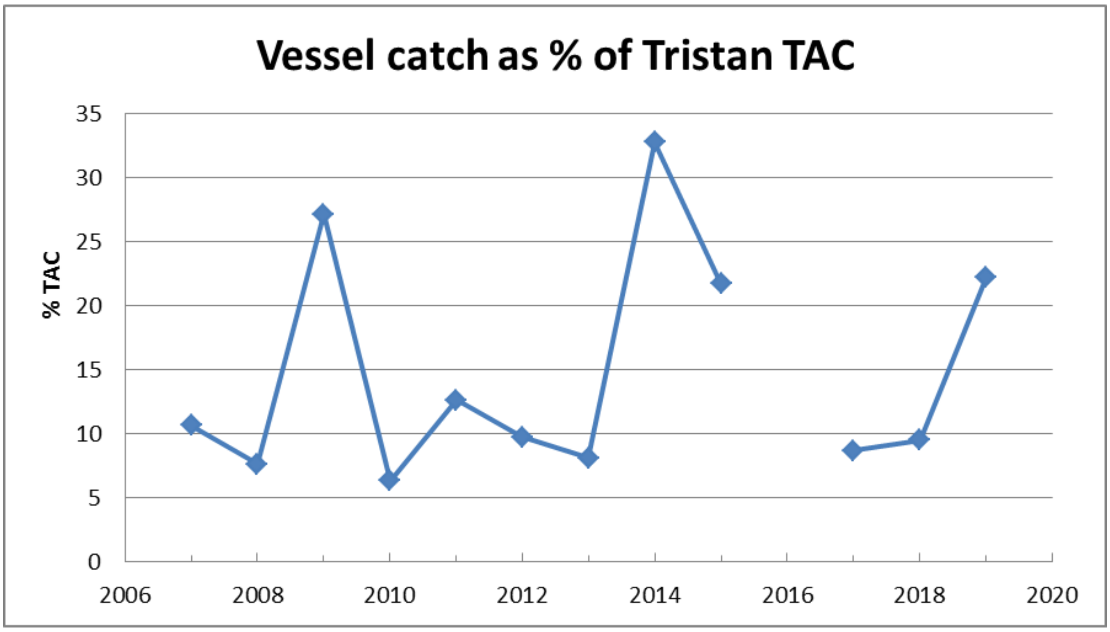

Figure 1b: The vessel catch as a percentage of the total Tristan TAC.

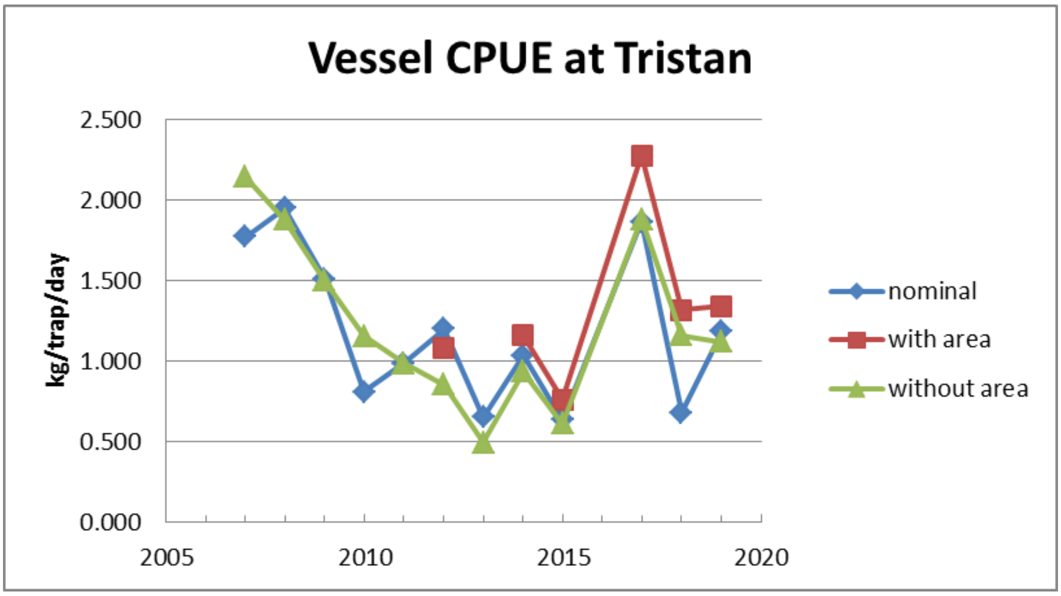

Figure 2a: The standardised vessel 2020 GLM_area and GLM_no area CPUE series plotted together with the original nominal series. These series have not been renormalised.

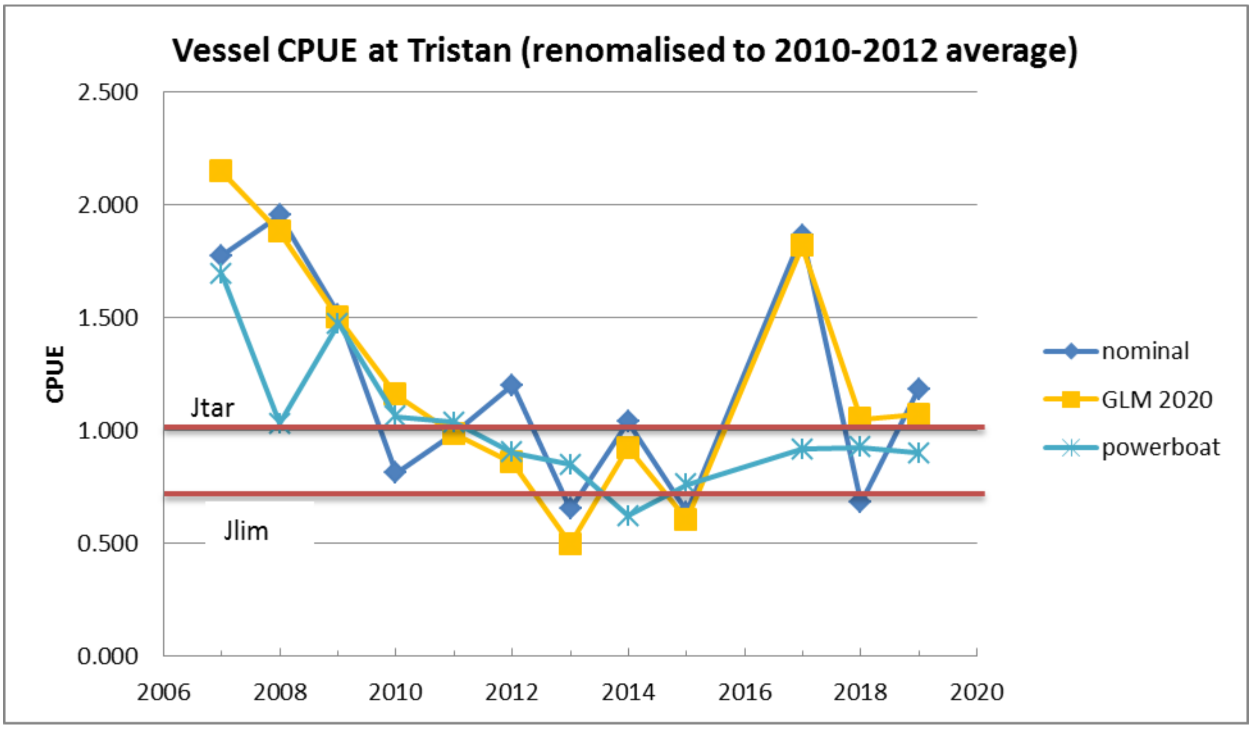

Figure 2b: The final standardised 2020 vessel GLM CPUE series (GLM 2020) plotted with the original nominal series as well as the powerboat GLM series. All series have been renormalized to their average 2010-2012 values. The plot also indicates the current target CPUE level (Jtar) and the lower Jlim value.

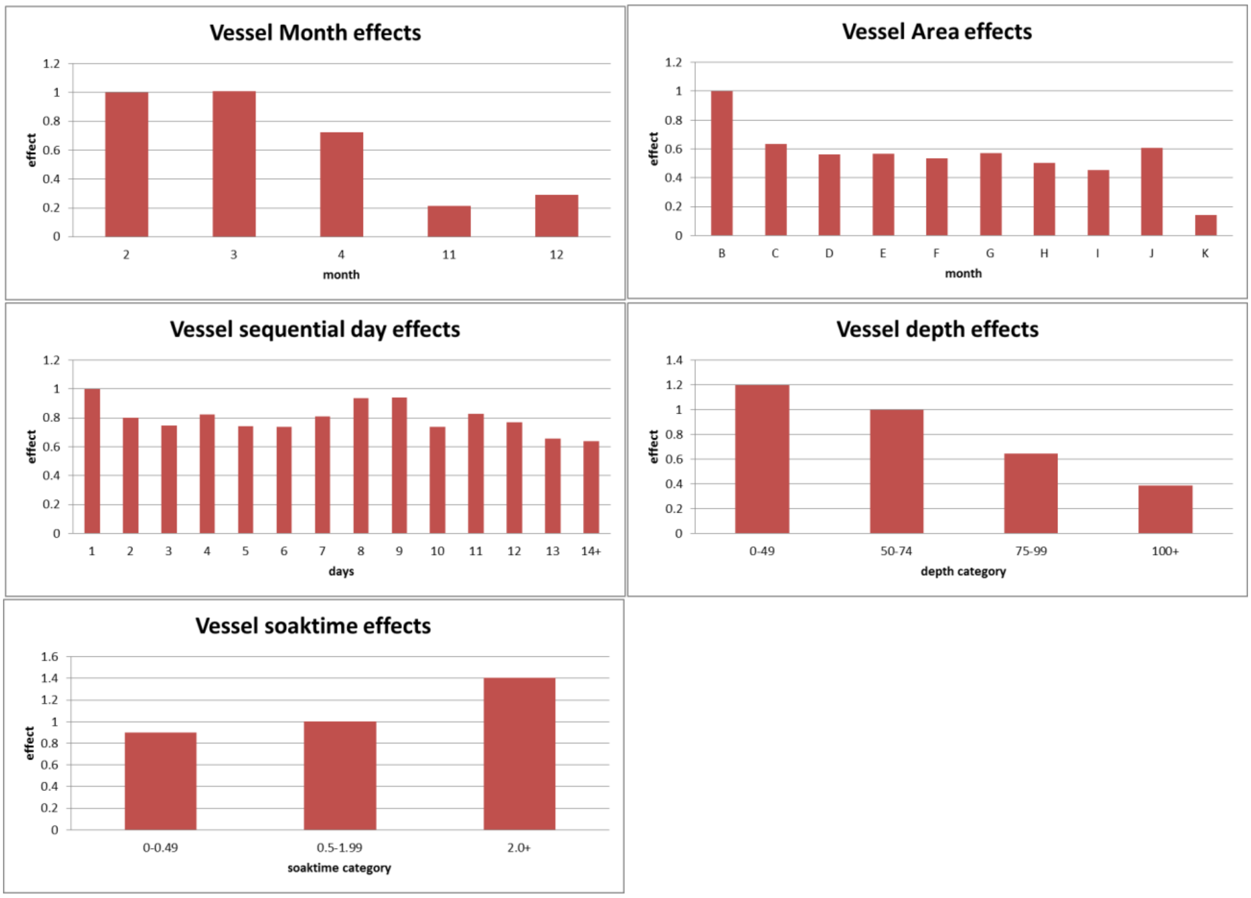

Figure 3: The covariate factor estimates for the vessel-related GLM_area analysis.