Data available for input to an Age Structured Production Model of the Tristan lobster fishery.

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An age-structured production model (ASPM) is developed for the rock lobster populations at each of the four islands of the Tristan da Cunha group (Tristan, Inaccessible, Nightingale and Gough Islands).

The ASPM model is sex-disaggregated as there are substantial differences in growth rates and hence lengths at age between the sexes.

The model is fit to GLM- or GLMM-standardised longline CPUE and catch-at-length data. A catch series for each island is used. Although commercial harvesting first began in 1949, the ASPM models are run from 1990 because of considerable uncertainties regarding pre-1990 catches and related problems encountered with model-fitting when the models are initiated in 1949.

Data

Catch

The catch record in tons for each of the four islands is reported in Table 1.

CPUE

GLMM (General Linear Mixed Models) standardised CPUE series for the outer three islands for the period 1997-2008 are available (see Johnston *et al*. 2010a for details). These utilise longline CPUE data, as longlining as most of the catch made and effort expended is by longline. The catch at Tristan is taken using powerboats, and a GLM-standardised cpue for the Tristan island for the period 1997-2009 is used (Johnston *et al.* 2010b). These data are reported in Table 2.

Powerboats are used to catch a certain portion of the catch for the outer islands. Johnston (2010) provides nominal powerboat CPUE for the outer three islands. In the ASPM fitting process these data are not included in the model fitting process, but are reported for comparative purposes. These data are reported in Table 3.

Catch-at-length data

Catch-at-length data from on-board sampling of fishing operations carried out by observers are available. These data are available for Tristan, Nightingale and Inaccessible, sexes separated, all size classes (5mm intervals) from 45mm to 140mm CL. Gear is monster traps for Inaccessible and Nightingale, and nets and traps for Tristan. Data are available for 1997-2007 (excluding 1998). "Minus" groups and "plus" length groups are also created where necessary. Tables 4-7 report these distributional values. The gear used for all samples was trap and nets with 75mm mesh, but the gear used for Tristan 2006-2007 was monster trap with 50mm mesh from the vessel Edinburgh (the other Tristan samples, i.e. pre 2006, were from powerboats).

Growth assumptions

The only published information of growth of Tristan lobsters is found in Pollock and Roscoe (1977) and Pollock (1981). This information is based on tagging studies conducted in the 1970s. Size composition data from early periods were also examined to determine maximum sizes of lobsters at each island (and each sex).

To calculate length at age, parameters values for the von Bertalanffy equation are needed:

$$l_a = l_\infty\left(1 - e^{-\kappa(a-t_0)}\right)$$

Using the literature sources above, the following estimated values for l_∞ and κ are found:

The von Bertalanffy growth parameters assumed to apply for each sex and island:

	κ	l_∞ (CL mm)
Tristan Males	0.11	132.4
Tristan Females	0.06	99.8
Nightingale Males	0.066	156.5
Nightingale Females	0.06	99.8
Inaccessible Males	0.11	132.4
Inaccessible Females	0.06	99.8
Gough Males	0.066	156.5
Gough Females	0.06	99.8

We assume t_0 = 0 for males.

The growth curve parameters above are based on mature lobsters (60mm and larger). It is thought most likely that male and female lobster growth would be similar for ages prior to maturity, and that only at maturity does the growth rate slow down for females. We thus assume the female age-at-length curve to be identical to that for Tristan and Inaccessible males for ages 0-7 years. For ages 8 and above, the

l_∞ and κ values reported in Table 1 above are taken to apply, but that the t_0 parameter for females is adjusted to -15, in order to create a continuous link between the juvenile and adult portions of the growth curves.

Nightingale, Gough and Inaccessible female growth rates are assumed equal to that for Tristan females due to lack of data.

Gough males are assumed equal to Nightingale males in growth terms. There is a lack of data but it is known that sizes are slightly larger at Gough than Tristan (more like Nightingale). Inaccessible males are assumed equal to Tristan males in terms of growth again due to lack of data but in the knowledge that growth is lower at Inaccessible than at Nightingale (i.e. closer to values for Tristan).

Johnston and Butterworth (2011) describe a method for which the l_∞ values have been adjusted slightly, and growth curves modified using a "pivot" method, so that the growth increments at 85mm CL remain unchanged from the data.

Weight at length

Length (carapace length in mm) and whole weight (in g) data have been collected from Tristan and Nightingale islands for both sexes (James Glass, pers. commn). These data were collected in 1994, 2006 and 2007 from both onboard operations and factory samples. Data for a total of 655 males and 212 females are available.

A length-weight relationship of the form $W_l = \alpha l^\beta$ is estimated, where W_l is whole weight in *g*, and l is carapace length in mm. The parameter estimates are:

Males: $\alpha = 0.4789;\ \beta = 3.0244$

Females: $\alpha = 0.5907;\ \beta = 2.9449$

Figure 1 shows the data and the estimated relationship between CL (mm) and whole weight (g) for both females and females.

Minimum size limits

Until 1983 a minimum legal carapace length (CL) of 70mm was imposed at all four islands.

Then from 2003: 75mm CL Gough imposed

68mm CL Inaccessible imposed

70mm Tristan and Nightingale (i.e. unchanged).

Age at first maturity

Age-at-first maturity is set equal to 6 years. We have some idea of the **LENGTH** at first maturity for female *Jasus tristanii* from the following sources:

From Roscoe 1979 -approximately 60mm CL
From Pollock 1991 -50% maturity at 56.6mm CL Inaccessible

-50% maturity at 58.9mm CL at Nightingale

Field biologists suggest the **AGE** at first maturity would be about 6-7 years (James Glass, pers. commn). All this information is broadly compatible with the growth curves shown in Figure 1.

Season dates – i.e. split seasons

The season 1997 refers to the split season 1997/1998 i.e. only the first year of the split season will be referenced. The table below shows in detail the months that apply for each season.

Start and end months for each season.

Split season	start	end	Islands
1949-1993/94	1 May	30 April	All 4 islands
1998/99-2002/03	1 Sep	31 Aug	All 4 islands
2003/04	1 Sep	31 Jul 31 Aug	Tristan Outer islands
2004/05	1 Aug 1 Sep	31 Jul 13 Aug	Tristan Outer islands
2005/06	1 Jul 14 Aug	30 Jun 20 Aug	Tristan Outer islands
2006/07-2008/09	1 Jul 21 Aug	30 Jun 20 Aug	Tristan Outer islands

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Table 1: Historic catch time series (in MT) for all four islands.

	Tristan	**Inaccessible**	**Nightingale**	**Gough**
1990	161.431	78.781	57.295	137.099
1991	165.347	56.552	62.807	88.010
1992	137.987	71.625	60.686	99.151
1993	112.060	59.886	52.037	83.941
1994	125.230	61.586	52.366	98.192
1995	112.317	61.465	52.310	105.902
1996	119.028	73.306	63.474	104.111
1997	126.035	62.521	52.574	79.097
1998	117.258	61.492	51.812	99.628
1999	122.019	64.176	52.623	93.647
2000	124.391	66.637	52.536	73.617
2001	127.550	70.512	57.037	90.133
2002	132.550	70.775	56.614	76.608
2003	138.400	77.283	57.472	94.868
2004	157.820	84.484	61.368	65.245
2005	160.555	92.945	62.276	57.071
2006	180.000	103.281	62.333	56.646
2007	187.000	114.566	65.584	62.060
2008	180.284	114.465	72.259	67.533

Table 2: Standardised CPUE data for each island (from Johnston *et al*. 2010a and 2010b). Units are kg per trap for Inaccessible, Nightingale and Gough (longline CPUE), and kg per powerboat-day for Tristan.

	Tristan	**Inaccessible**	**Nightingale**	**Gough**
1994	0.31			
1995	0.28			
1996	0.30			
1997	0.47	1.696	0.884	1.982
1998	0.56	3.316	1.710	1.710
1999	0.74	4.378		2.112
2000	0.93	3.995	2.016	1.332
2001	0.96	6.854	2.053	1.387
2002	1.31	8.753	2.158	1.288
2003	1.50	11.869	3.831	1.461
2004	1.68	11.760	4.036	1.306
2005	2.18	6.728	3.751	2.438
2006	2.54			
2007	2.08	6.727	3.113	5.231
2008	1.24	5.455	3.073	5.455
2009	1.72			

Table 3: Nominal powerboat CPUE series for Nightingale, Inaccessible and Gough Islands The number of data records for each Season-Year (*N*) is provided, along with the nominal CPUE series for each island. The number of records for Nightingale in 2005 is so low as to suggest possible lack of representativity; this result is included here for completeness, but would better be omitted if these data are used in any quantitative analysis. (Taken from Johnston 2010.)

	Nightingale		**Inaccessible**		**Gough**	
Season-Year	*N*	**CPUE (kg/hour)**	*N*	**CPUE (kg/hour)**	*N*	**CPUE (kg/hour)**
1997	178	7.26	297	6.90	362	6.12
1998	96	7.00	253	8.43	393	6.11
1999	149	10.38	100	13.83	400	10.95
2000	128	16.72	178	14.12	414	6.84
2001	204	7.91	219	7.90	578	4.98
2002	188	14.72	153	11.16	491	4.49
2003	88	15.09	208	17.45	560	5.45
2004			41	12.77	218	4.34
2005	6	33.69			133	9.22
2006						
2007	69	30.52	124	13.10	108	11.83
2008	93	23.56	139	14.49	74	17.68

Table 4a: Inaccessible male catch-at-length data (percent of total male+female catch each year).

	1997	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
50	0.15	0.38	0.21	0.16	0.11	0.07	0.13	0.10	0.08	0.47
55	0.55	1.07	1.52	1.47	0.62	0.48	0.79	0.86	1.18	2.18
60	3.88	5.49	5.74	9.89	3.90	3.71	6.27	4.65	7.59	8.28
65	13.33	18.21	14.55	19.86	8.14	11.45	14.20	11.79	15.08	13.84
70	11.97	19.48	16.72	14.03	13.37	17.49	15.99	16.88	15.03	15.58
75	7.45	14.50	14.04	9.22	16.48	14.55	13.49	16.64	12.79	11.33
80	5.31	8.64	8.36	6.79	17.05	11.35	11.67	12.92	10.32	8.98
85	3.35	5.89	4.55	4.32	9.98	9.28	7.73	8.43	7.91	6.31
90	2.58	3.36	2.98	3.55	3.65	5.45	5.34	5.57	3.81	3.90
95	1.58	2.41	2.29	2.45	1.95	3.13	3.88	3.94	2.18	2.58
100	1.39	1.79	1.31	1.90	1.98	2.15	1.88	2.32	1.20	1.48
105	1.00	1.09	1.16	1.02	1.06	1.45	0.94	1.36	0.93	0.99
110	0.75	0.99	1.04	0.39	0.62	1.30	0.63	0.62	0.76	0.44
115	0.43	0.34	0.57	0.39	0.60	0.60	0.38	0.48	0.27	0.38
120	0.51	0.62	0.83	0.43	0.49	0.74	0.67	0.66	0.53	0.40

Table 4b: Inaccessible female catch-at-length data (percent of total male+female catch each year).

	1997	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
50	0.21	0.08	0.33	0.14	0.32	0.17	0.06	0.08	0.17	0.54
55	1.51	0.56	1.40	1.47	1.65	1.18	0.81	0.48	1.86	2.88
60	10.96	3.98	6.46	7.28	4.95	4.96	3.96	3.36	7.02	6.83
65	20.93	5.75	8.66	10.17	6.79	4.92	5.02	5.39	7.34	6.85
70	8.78	3.06	4.28	3.63	3.52	2.94	2.84	2.32	2.66	3.33
75	2.37	1.49	1.49	1.04	1.87	1.69	1.54	0.74	0.91	1.50
80	0.61	0.52	0.92	0.22	0.51	0.60	0.94	0.22	0.17	0.59
85	0.29	0.20	0.39	0.06	0.22	0.19	0.46	0.14	0.15	0.23
90	0.12	0.10	0.21	0.10	0.19	0.15	0.40	0.06	0.08	0.10

Table 5a: Nightingale male catch-at-length data (percent of total male+female catch each year).

	1997	**1998**	**1999**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
55	0.06	0.07	0.08	0.05	0.06	0.08	0.04	0.02	0.18	0.24
60	2.20	1.66	1.16	2.17	0.98	0.36	1.17	0.24	1.16	2.66
65	7.84	6.27	6.85	8.61	2.46	1.64	4.87	1.88	3.33	6.70
70	13.07	11.13	10.10	15.70	7.05	5.10	7.78	5.49	6.28	8.66
75	11.47	11.58	10.34	15.12	10.09	11.33	7.91	8.80	8.41	8.00
80	9.74	9.08	7.03	12.08	20.00	15.46	9.13	10.81	9.39	7.36
85	4.99	5.17	5.14	8.30	12.85	12.92	6.30	9.18	8.30	5.50
90	3.15	2.83	3.07	5.72	3.60	12.87	4.83	7.40	6.46	6.28
95	1.37	1.35	1.57	3.40	2.00	7.26	3.39	5.25	6.12	5.28
100	1.01	0.77	1.16	2.34	1.08	3.51	2.13	3.23	4.51	5.38
105	1.13	0.58	0.54	1.25	0.60	2.62	2.22	2.33	2.67	4.26
110	0.30	0.23	0.28	0.43	0.38	1.77	1.61	1.14	1.69	3.36
115	0.18	0.16	0.04	0.22	0.16	0.92	0.96	0.54	0.78	2.34
120	0.18	0.04	0.06	0.02	0.06	0.74	0.78	0.46	0.32	1.20
125	0.18	0.02	0.14	0.07	0.04	0.38	0.48	0.30	0.26	0.86

Table 5b: Nightingale female catch-at-length data (percent of total male+female catch each year).

	1997	**1998**	**1999**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
55	0.59	0.05	0.24	0.02	0.00	0.67	0.13	0.06	0.16	0.34
60	6.12	3.03	3.92	2.19	4.60	3.26	2.91	1.00	1.67	2.24
65	15.45	11.92	16.93	6.71	9.87	7.08	14.78	9.04	9.43	6.32
70	11.29	16.16	15.04	7.62	9.95	5.85	12.70	13.99	13.56	8.32
75	6.42	10.97	10.10	4.87	8.67	3.77	9.65	12.33	10.41	7.26
80	2.38	4.52	4.08	1.93	3.38	1.51	4.13	4.43	3.85	3.96
85	0.42	1.26	1.33	0.70	1.80	0.54	1.30	1.66	0.90	1.96
90	0.48	1.15	0.80	0.46	0.32	0.36	0.78	0.44	0.16	1.50

Table 6a: Gough male catch-at-length data (percent of total male+female catch each year).

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
60	0.26	0.28	0.35	0.58	0.34	0.02	0.27	0.67	1.38	1.06	0.64
65	0.09	1.04	1.86	2.45	1.53	0.20	1.32	1.73	3.90	2.72	2.24
70	0.69	2.35	7.93	5.41	4.13	0.98	3.15	4.60	9.66	6.23	6.32
75	1.97	3.50	10.49	9.04	8.30	2.26	6.48	8.07	11.28	6.79	8.72
80	5.62	3.87	13.99	12.07	11.31	9.33	11.05	7.07	14.44	7.89	8.53
85	8.63	4.60	11.01	11.92	12.08	19.58	12.20	5.80	13.96	6.87	7.44
90	11.12	4.36	8.51	9.59	11.32	17.08	11.68	6.07	10.88	6.07	5.89
95	11.07	4.03	6.93	5.88	9.43	10.81	8.88	5.60	5.74	6.57	5.70
100	14.68	3.78	5.19	4.06	7.14	8.15	6.73	5.00	3.40	4.87	6.34
105	10.94	3.00	3.90	2.82	4.49	5.51	4.45	3.54	1.36	4.21	6.10
110	9.36	2.09	2.04	2.25	2.45	4.67	2.19	2.74	0.52	2.74	4.59
115	6.65	1.70	1.40	1.15	1.24	3.08	1.35	2.13	0.30	1.86	2.77
120	5.32	1.14	1.34	1.07	0.80	3.10	0.71	1.40	0.22	1.10	1.46
125	6.05	1.93	1.52	1.64	1.91	5.41	0.88	0.67	0.26	1.72	1.28

Table 6b: Gough female catch-at-length data (percent of total male+female catch each year).

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
60	0.04	0.58	0.35	0.66	0.19	0.24	2.57	0.67	0.38	0.54	0.10
65	0.09	2.47	1.98	2.07	1.78	0.80	3.59	2.60	1.62	3.17	1.65
70	0.90	7.33	5.19	6.45	4.41	1.24	5.25	10.94	4.74	8.72	6.19
75	1.89	15.63	5.36	8.78	6.49	2.28	7.50	12.74	5.74	11.10	7.89
80	1.80	16.81	5.54	6.13	4.94	2.30	5.17	9.94	5.26	8.13	7.52
85	1.16	10.20	2.21	3.20	3.03	1.48	2.80	4.60	2.36	4.61	4.51
90	0.77	4.90	1.46	1.61	1.45	0.64	1.21	1.47	1.62	1.90	2.05
95	0.43	2.21	1.05	0.63	0.66	0.40	0.37	0.87	0.62	0.62	0.94
100	0.34	0.80	0.29	0.20	0.28	0.28	0.13	0.40	0.22	0.32	0.51
105	0.04	0.57	0.06	0.23	0.19	0.12	0.05	0.20	0.08	0.14	0.29
110	0.09	0.82	0.06	0.09	0.12	0.06	0.03	0.47	0.08	0.08	0.30

Table 7a: Tristan male catch-at-length data. The gear used for 1997-2005 was trap and nets with 75mm mesh, the gear used for 2006+ was monster trap with 50mm mesh (percent of total male+female catch each year).

	1997	**1998**	**2000**	**2001**	**2003**	**2004**	**2005**	**2006**	**2007**
55	0.19	0.24	0.17	0.42	0.19	0.14	0.43	0.36	0.05
60	1.27	1.39	1.14	1.10	0.67	0.61	1.24	1.34	0.05
65	5.00	3.55	3.42	4.42	3.71	3.06	2.83	3.34	0.84
70	11.40	8.03	6.10	8.30	8.70	7.15	6.22	5.96	2.13
75	15.64	8.92	8.95	11.16	13.65	11.16	8.45	8.29	4.76
80	12.03	10.31	9.52	12.89	14.55	12.18	10.37	10.75	7.19
85	9.12	7.58	6.56	12.77	15.26	12.48	9.80	11.25	10.22
90	4.88	6.72	6.78	13.82	14.03	10.56	8.27	12.73	12.60
95	2.66	2.61	4.96	10.99	12.55	8.25	5.52	12.45	14.34
100	1.27	2.00	3.36	9.06	8.51	6.19	4.07	11.39	14.93
105	0.38	0.53	1.94	4.30	4.99	3.21	2.21	8.08	14.53
110	0.19	0.12	1.25	2.10	3.14	2.19	1.97	6.64	5.75

Table 7b: Tristan female catch-at-length data. The gear used for 1997-2005 was trap and nets with 75mm mesh, the gear used for 2006+ was monster trap with 50mm mesh (percent of total male+female catch each year).

	1997	**1998**	**2000**	**2001**	**2003**	**2004**	**2005**	**2006**	**2007**
60	2.72	2.57	3.93	0.57	0.05	1.00	2.50	0.94	0.40
65	8.87	11.37	12.66	1.78	0.00	4.07	7.19	1.61	0.74
70	10.96	16.34	15.11	3.31	0.00	6.33	10.02	1.62	0.99
75	6.78	10.43	9.46	1.78	0.00	6.52	10.15	1.55	0.55
80	3.74	4.89	3.02	0.76	0.00	3.19	6.46	1.08	0.20
85	2.28	1.83	1.14	0.34	0.00	1.16	1.59	0.43	0.10
90	0.63	0.57	0.51	0.11	0.00	0.57	0.73	0.19	0.05

Figure 1: Length-weight relationships for *Jasus tristanii*. The dots show the data, and the solid curve is the model fitted to these data.