Data and model assumptions for an Age structured Production Model of the Tristan lobster fishery.

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An age-structured production model (ASPM) is to be developed for each of the four islands of the Tristan da Cunha group (Tristan, Inaccessible, Nightingale and Gough).

The model will be sex-disaggregated as there are substantial differences in growth rates and length at age between the sexes.

The model will be fit to CPUE and possibly catch-at-length data. A historic catch series developed for each island will be used. The model will run from 1949 when commercial harvesting first began. The resource will be assumed to be at pristine equilibrium at the start of 1949.

Model Assumptions

Natural mortality

A value of M = 0.1 yr^{-1} will be assumed for both sexes and all four islands. No direst estimates are available for *J. tristanii*. For *J.lalandii* and South African south coast rock lobster M = 0.1 is used.

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 values for l_∞ and κ result:

Table 1: 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 above growth curve parameters 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 apply, but that the t_0 parameter for females is adjusted to equal -15, in order to create a smooth 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 due to lack of data but knowing that sizes are slightly larger at Gough than Tristan (more like Nightingale). Inaccessible males are assumed equal to Tristan males in terms of growth due to lack of data but knowing that growth is lower at Inaccessible than at Nightingale (i.e. closer to values for Tristan).

Figure 1a shows the lengths at age that result using the above von Bertalannfy parameter values, and Figure 1b shows a comparative plot.

Weight at length

For *J.lalandii* from Heydorn 1969 (the two species are morphologically very similar):

Males $\qquad W_l = 0.6518 l^{2.899}$

Females $\qquad W_l = 0.5869 l^{2.972}$

where weight W is in $g,$ and carapace length l in cm.

Minimum size limits

None until 1983 when = 70mm CL (imposed at all four islands)

Then from 2003:   75mm CL Gough

                         68mm CL Inaccessible

                         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 - approximatelu 60mm CL
      From Pollock 1991   50% maturity @ 56.6mm CL Inaccessible
                                 50% maturity @ 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.

Fishing selectivity

A simple selectivity-at-length function is assumed for both sexes and all 4 islands. The function is a knife-edge function, with l_c (length at first capture) being determined after examining minimum sizes in catch-at-length samples. The value of l_c used here is 55mm CL.

Data

Catch

There are fairly good estimates of catches for all four islands from 1967 (Tristan) and 1970 (other three islands). Johnston (2009) reports on the catch data for all four islands for the period 1996+.

From Roscoe (1979) there is a plot of catches from when the fishery started (1949) to 1975. These are "total catch" for all four islands combined. There are also estimates of Gough catches from 1965-1975.

These catches are all production "tail" weights in 20lb units. Historic catch series for all four islands have been constructed using the information in Roscoe (1979) and assuming that:

- Tail weight is 30% of total weight
- The average proportion of Gough:Total catches for 1965-1975 apply to the pre-1965 period.
- The average ratio of Tristan: inaccessible: Nightingale catches for the period 1970-1980 apply to the pre-1970 period.

Table 3 and Figure 2 report these catches.

Sensitivities will need to be run to allow for the uncertainties associated with these assumptions and possibly under-reporting in the earlier years of the fishery.

CPUE

We have GLM standardised CPUE series for all four islands for the period 1997-2007 (see Johnston *et al.* 2009 for details). Table 4 lists these data. The Tristan GLM may need to be refined if further information on area fished and gear used on each trip becomes available.

Catch-at-length data

i) From pack category data: these data are for all four islands, sex combined, above mm CL only (5mm size intervals), for 2001-2008 period - see Johnston (2010) for details. Tables 5a-d report these values.

ii) Catch-at-length data from fishing operations on-board sampling made by observers are available. Data are available for Tristan, Nightingale and Inaccessible, sexes separated, all size classes (5mm intervals). Gear is monster traps for Inaccessible and Nightingale, and nets and traps for Tristan. Table 6 reports the years for which these data are available. Data for Gough will hopefully become available shortly.

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. Table 2 below shows in detail the months that apply for each season.

Table 2: 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	Tristan
		31 Aug	Outer islands
2004/05	1 Aug	31 Jul	Tristan
	1 Sep	13 Aug	Outer islands
2005/06	1 Jul	30 Jun	Tristan
	14 Aug	20 Aug	Outer islands
2006/07-2008/09	1 Jul	30 Jun	Tristan
	21 Aug	20 Aug	Outer islands

Other assumptions

Minimum age = 0

Maximum age = 20 years (plus group)

Minimum length = 1mm

Maximum length = 120mm (plus group)

Estimable parameters

K_{sp},   pristine female spawning biomass

h steepness parameter of stock recruit curve

β   parameter of length-at-age distribution

References

Heydorn .A.E.F. 1969. Notes on the biology of *Panulirus homarus* and on length/weight relationships of *Jasus lalandii*. Invest. Rep. Div. Sea. Fish. S. Afr. 69:1-27.

Johnston, S.J. 2009. Catch data for the stock assessment of lobster at the Tristan da Cunha group of islands. MARAM/TRISTAN/09/MAY/02. 3pp.

Johnston, S.J. 2010. Creating catch length frequencies for the Tristan group of islands using factory pack category data. MARAM/Tristan/10/Feb/01.

Johnston, S.J., Brandao, A. and D.S. Butterworth. 2009. GLMM- and GLM-standardised lobster CPUE from the Tristan da Cunha group of islands for the 1997-2007 period. MARAM/Tristan/09/June/03. 15pp.

Pollock, D.E. 1991. Spiny lobsters at Tristan da Cunha, South Atlantic: Inter-island variations in growth and population structure. S. Afr. J. mar. Sci. 10:1-12.

Pollock, D.E. and Roscoe, M.J. 1977. The growth at moulting of crawfish *Jasus tristanii* at Tristan da Cunha, South Atlantic. J. Cons. Int. Explor. Mer, 37(2):144-146.

Pollock, D.E. 1981. Population dynamics of rock lobster *Jasus tristanii* at the Tristan da Cunha group of islands. Fish. Bull. S. Afr. 15:49-66.

Roscoe, M.J. 1979. Biology and exploitation of the rock lobster Jasus lalandii at the Tristan da Cunha islands, South Atlantic, 1949-1976. Investl Rep. Sea Fish. Brch S. Afr. 118:1-45.

Table 3: Historic catch time series (in MT) for all four islands.

	Tristan	Inaccessible	Nightingale	Gough
1949	10.920	9.800	7.280	22.000
1950	58.240	52.267	38.827	117.333
1951	80.080	71.867	53.387	161.333
1952	196.560	176.400	131.040	396.000
1953	167.440	150.267	111.627	337.333
1954	196.560	176.400	131.040	396.000
1955	174.720	156.800	116.480	352.000
1956	218.400	196.000	145.600	440.000
1957	182.000	163.333	121.333	366.667
1958	232.960	209.067	155.307	469.333
1959	254.800	228.667	169.867	513.333
1960	258.440	231.933	172.293	520.667
1961	189.280	169.867	126.187	381.333
1962	240.240	215.600	160.160	484.000
1963	232.960	209.067	155.307	469.333
1964	160.160	143.733	106.773	322.667
1965	104.000	93.333	69.333	566.667
1966	260.000	233.333	173.333	500.000
1967	241.700	186.667	138.667	700.000
1968	145.800	105.000	78.000	533.333
1969	252.800	233.333	173.333	566.667
1970	211.900	80.000	141.000	123.000
1971	231.900	147.000	98.000	380.000
1972	206.500	116.000	49.000	190.000
1973	169.760	214.000	77.000	161.000
1974	165.845	282.000	166.000	182.000
1975	178.300	133.000	245.000	283.000
1976	148.512	224.000	182.000	64.000
1977	97.500	138.000	71.000	130.000
1978	156.580	123.000	34.000	110.000
1979	117.556	141.000	114.000	60.000
1980	114.882	74.000	113.000	113.000
1981	153.673	115.000	57.000	134.000
1982	131.770	92.000	69.000	102.000
1983	128.934	72.000	48.000	135.000
1984	117.446	77.000	80.000	105.000
1985	161.947	90.000	69.000	103.000
1986	151.325	62.000	93.000	110.000

1987	189.937	81.000	70.000	101.000
1988	163.276	72.000	77.000	123.000
1989	174.682	67.000	44.000	164.000
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 4: Standardised CPUE data for each island (from Johnston *et al.* 2009). Units are kg per trap for Inaccessible, Nightingale and Gough, and kg per powerboat-day for Tristan.

	Tristan	Inaccessible	Nightingale	Gough
1997	314	0.294	1.224	1.057
1998	469	0.649	2.223	0.975
1999	627	0.661		1.109
2000	791	0.781	2.580	0.741
2001	795	0.682	2.695	0.808
2002	853	1.210	2.807	0.713
2003	325	0.624	4.836	0.831
2004	452	2.187	5.084	0.747
2005	453	1.703	4.640	1.420
2006	541			
2007	415	1.263	3.995	2.990

Table 5a: Pack category catch length frequencies for Gough island.

Category	AAA	AA	A	B	C	D	F	G	H	J	M	KZ	K
Ave CL (mm)	162	147	138	134	126	113	104	97	91	87	81	73	66
2008	0.04	0.35	0.65	0.83	8.13	14.10	10.84	10.81	8.54	19.49	18.55	7.67	0.02
2007	0.08	0.53	0.85	0.88	9.14	16.17	8.67	4.62	8.30	20.10	20.98	9.68	0.00
2006	0.08	0.33	0.51	0.60	6.38	12.60	6.92	7.68	11.30	22.21	22.17	9.22	0.00
2005	0.02	0.20	0.22	0.24	3.86	9.20	6.75	4.55	12.40	24.70	25.03	12.79	0.02
2004	0.33	0.51	0.46	0.48	4.11	9.52	9.61	13.06	9.08	13.43	25.99	13.37	0.04
2003	0.03	0.37	0.24	0.37	5.11	10.70	9.83	11.73	10.35	14.70	20.76	14.88	0.93
2002	0.21	0.47	0.38	0.48	3.80	8.88	8.48	8.88	9.88	19.39	21.85	16.12	1.18
2001	0.16	0.48	0.44	0.58	3.61	9.82	10.73	10.68	10.80	15.52	20.95	14.52	1.71

Table 5b: Pack category catch length frequencies for Inaccessible island.

Category	AAA	AA	A	B	C	D	F	G	H	J	M	KZ	K
Ave CL (mm)	162	147	138	134	126	113	104	97	91	87	81	73	66
2008	0.06	0.20	0.17	0.18	1.58	3.59	3.27	4.50	3.65	7.97	16.24	33.56	25.03
2007	0.03	0.20	0.15	0.18	1.69	5.20	4.29	4.88	5.74	14.16	20.49	29.86	13.14
2006	0.02	0.14	0.19	0.23	1.64	4.82	3.98	4.88	6.50	15.68	21.41	28.10	12.41
2005	0.09	0.32	0.27	0.25	1.73	3.56	3.51	4.05	4.16	12.96	23.12	35.12	10.86
2004	0.34	0.69	0.48	0.37	2.49	4.42	4.40	6.65	6.16	8.39	19.68	32.21	13.71
2003	0.57	2.25	1.64	1.02	5.04	7.84	6.23	6.92	6.31	10.17	17.08	25.57	9.36
2002	0.04	0.27	0.43	0.43	3.78	7.25	4.99	6.75	5.95	10.78	18.78	34.41	6.15
2001	0.00	0.16	0.25	0.49	2.45	6.57	5.76	5.19	7.31	12.00	19.80	34.16	5.87

Table 5c: Pack category catch length frequencies for Nightingale island.

Category	AAA	AA	A	B	C	D	F	G	H	J	M	KZ	K
Ave CL (mm)	162	147	138	134	126	113	104	97	91	87	81	73	66
2008	0.00	0.05	0.14	0.22	2.56	6.85	6.13	7.36	6.61	13.30	26.06	27.42	3.30
2007	0.00	0.08	0.23	0.36	4.92	12.83	9.63	8.16	8.07	16.40	18.26	18.21	2.86
2006	0.02	0.07	0.17	0.35	4.11	10.71	5.67	8.14	10.79	18.75	19.63	19.74	1.85
2005	0.00	0.19	0.26	0.28	3.05	7.09	7.58	6.64	9.01	19.59	22.17	22.62	1.51
2004	0.02	0.12	0.12	0.21	2.36	4.97	4.82	7.74	7.37	9.21	21.98	36.13	4.95
2003	0.02	0.25	0.25	0.27	4.32	7.78	6.46	8.96	9.49	12.48	20.72	26.52	2.50
2002	0.00	0.02	0.07	0.13	1.24	3.96	4.24	5.57	5.46	11.34	26.17	38.27	3.52
2001	0.02	0.09	0.11	0.20	1.97	5.88	7.64	9.54	9.30	12.66	20.81	27.68	4.11

Table 5d: Pack category catch length frequencies for Tristan island.

Category	AAA	AA	A	B	C	D	F	G	H	J	M	KZ	K
Ave CL (mm)	162	147	138	134	126	113	104	97	91	87	81	73	66
2008	0.00	0.00	0.00	0.00	0.08	4.21	10.76	13.37	10.29	18.79	20.39	19.97	2.15
2007	0.00	0.00	0.00	0.00	0.03	3.17	12.73	15.92	16.63	20.27	17.80	12.34	1.10
2006	0.00	0.00	0.00	0.00	0.06	4.28	11.11	17.63	14.55	18.39	18.79	13.45	1.74
2005	0.00	0.00	0.00	0.00	0.09	4.45	10.32	15.22	13.00	17.25	21.97	16.02	1.69
2004	0.00	0.00	0.00	0.00	0.11	5.09	12.11	15.80	12.42	13.16	23.97	15.81	1.53
2003	0.00	0.00	0.00	0.00	0.16	6.03	14.18	18.79	13.84	11.85	18.82	15.16	1.17
2002	0.00	0.00	0.00	0.00	0.11	4.03	10.79	14.39	11.02	15.27	21.63	21.06	1.71
2001	0.00	0.00	0.00	0.00	0.09	4.55	11.89	16.83	12.17	13.03	19.78	19.46	2.21

Table 6: Years for which commercial samples of catch-size frequency data are avaialbe.

Date	Island	Sample Size
Oct 1997	Inaccessible	5898
Feb 1998	Inaccessible	1321
Sep 1999	Inaccessible	4974
Sep 2000	Inaccessible	3361
Oct 2001	Inaccessible	5095
Sep 2002	Inaccessible	3696
Oct 2003	Inaccessible	5850
Sep 2004	Inaccessible	4798
Sep 2001	Nightingale	?
Sep 2002	Nightingale	4996
Sep 2003	Nightingale	2418
Feb 2004	Nightingale	1479
Nov 2004	Nightingale	2300
Oct 2000	Tristan	1754
Oct 2001	Tristan	722
June 2004	Tristan	2103
Jan-April 2005	Tristan	2726

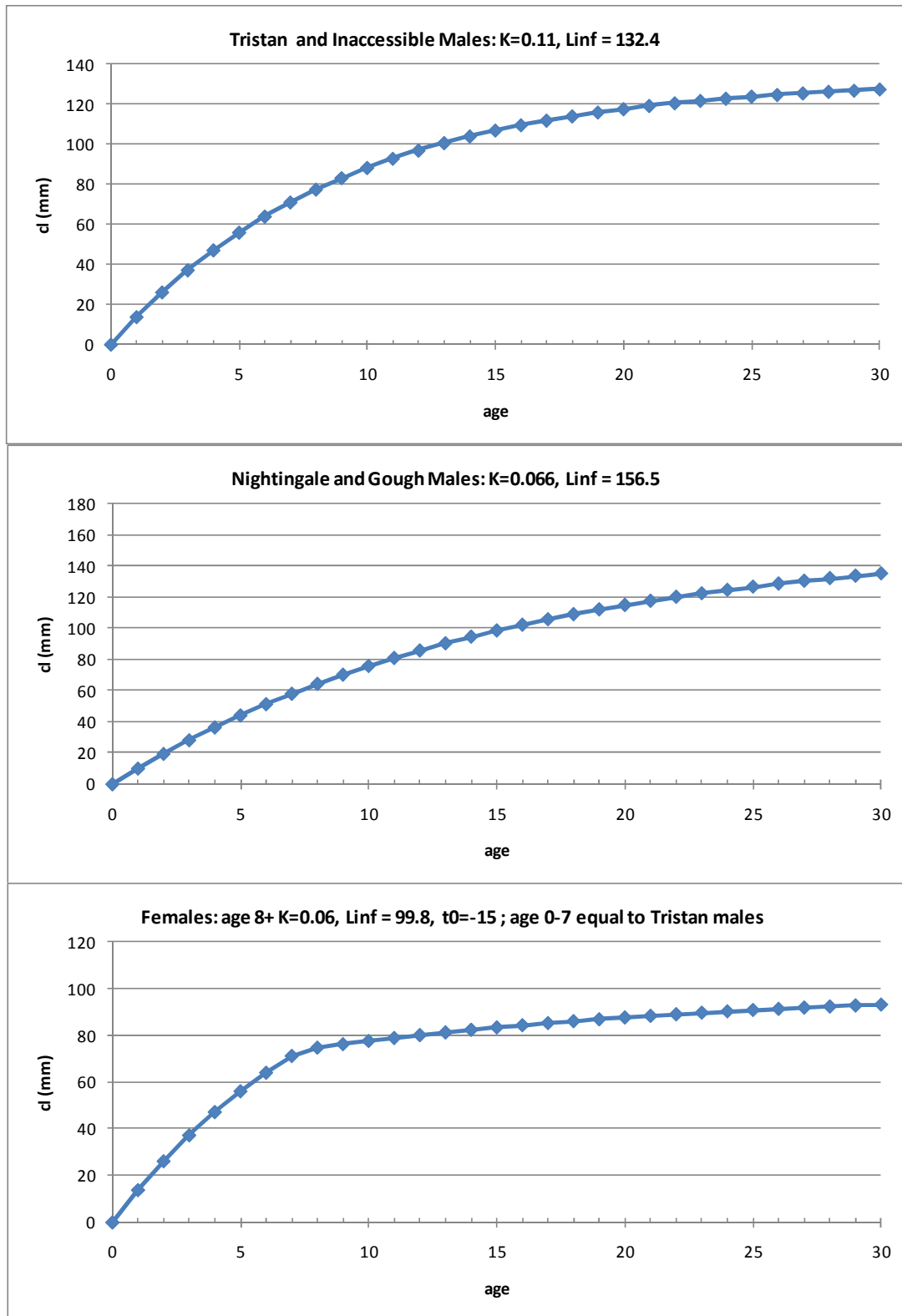Figure 1a: Length at age (CL in mm) for Tristan lobsters.

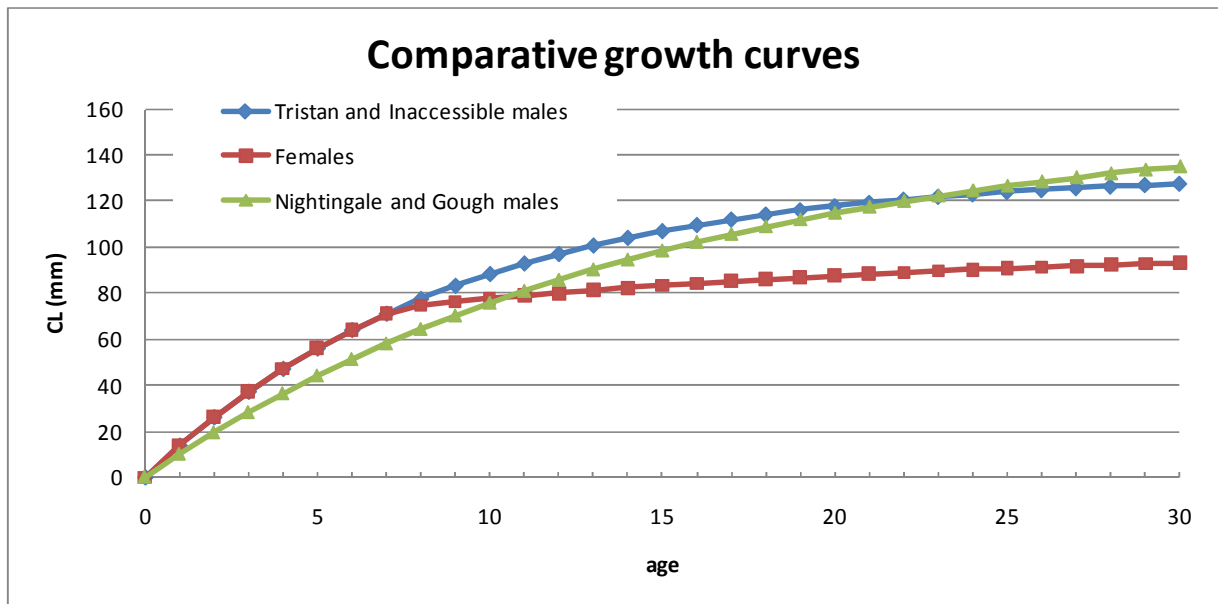Figure 1b: Comparative plot of length-at-age curves.

Comparative growth curves

Figure 2: Catch series (in MT) for all four islands.