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1. SUMMARY

This document updates the 2009 assessment of tiger flathead (*Neoplatycephalus richardsoni*) to provide estimates of stock status in the SESSF at the start of 2011. This assessment is performed using the stock assessment package SS v3.

The base-case assessment estimates that current spawning stock biomass is 44% of unexploited stock biomass (SSB_0). The 2011 recommended biological catch (RBC) under the 20:35:48 harvest control rule is 2,406 t and the longterm yield (assuming average recruitment in the future) is 2,513 t.

Exploration of model sensitivity showed a variation in spawning biomass of between 30% and 62% of SSB_0 .

For the base-case, SSB_{MSY} is estimated to be 30% of SSB_0 . If the standard MEY proxy multiplier of 1.2 is applied to this MSY estimate, the SSB_{MEY} estimate for the base case is 36% of SSB_0 .

2. INTRODUCTION

2.1 The Fishery

Tiger flathead have been caught commercially in the south eastern region of Australia since the development of the trawl fishery in 1915. They are endemic to Australian waters and are caught mainly on the continental shelf and upper slope waters from northern NSW to Tasmania and through Bass Strait. Historical records (e.g. Fairbridge, 1948; Allen, 1989; Klaer, 2005) show that steam trawlers caught tiger flathead from 1915 to about 1960. A Danish seine trawl fishery developed in the 1930s (Allen, 1989) and continues to the present day. Modern diesel trawling commenced in the 1970s.

2.2 Previous Assessments

Prior to 2001, the most recent quantitative assessment for tiger flathead was from the late 1980s (Allen, 1989). In that report, the assessment for tiger flathead was conducted based on catch and effort data using a surplus production model. The estimate of Maximum Sustainable Yield, MSY , for NSW and eastern Bass Strait was about 2,500 t.

Between 1989 and 2001, assessments of tiger flathead involved examination of trends in catches, catch rates, and age and length data, but no quantitative assessments were undertaken. Assessments from 1993 to 2001 can be found in the annual reports of SEFAG (the South East Fishery Assessment Group). For example, the 1993 assessment noted that tiger flathead catches from south-east Tasmanian waters contained higher proportions of larger, older fish than those from eastern Bass Strait. This suggested that tiger flathead resources off Tasmania were either more lightly fished than those in the main fishing areas, or that there was a separate stock with different population characteristics off Tasmania.

During 2001–4, data for tiger flathead were collated, summarized and presented at workshops (see Cui *et al.* (2004) for a detailed summary of these workshops and the analyses presented to them). These workshops led to revisions to the data series, the analyses of the data, and to suggestions for revisions to the data sets and research priorities. The 2004 assessment (Cui *et al.*, 2004) used 89 years (1915–2003) of data to estimate the virgin spawning stock biomass and the 2004 spawning stock biomass relative to that in 1915 and provided, for the first time, a complete picture of the dynamics of the tiger flathead fishery.

A number of changes to both the input data and some model structural changes were made and presented in the assessments developed in 2005 (Punt 2005a,b). These assessments considered tiger flathead caught off eastern Tasmania in SEF zone 30 as either separate to, or part of the same stock in zones 10 (E NSW), 20 (E Bass Strait) and 60 (Bass Strait) combined. In the scenario where E Tasmanian flathead are part of the same stock, a separate fleet was constructed to account for catches made there. Modifications to estimates of historical catches from Klaer (2005) were incorporated into catch series used in the assessments. Length-frequency data for 1945–67 and 1971–84 were obtained, and uncertainty in discard rates was estimated using a bootstrap procedure.

The intention for the 2006 assessment (Klaer, 2006a) was initially to duplicate as far as possible the assessment results from 2005 (Punt, 2005a,b) while implementing the assessment using the Stock Synthesis 2 (SS2) framework. The same assumptions were made about stock structure, i.e tiger flathead off eastern Tasmania may or may not be in the same stock as those off NSW and Victoria. Steepness was treated as an estimable parameter and annual age frequencies were added directly into the model as samples independent to length frequencies. The 2006 Shelf RAG selected the model that treated Tasmanian trawl as a separate fleet fishing the same east coast stock as the most appropriate base case.

The 2009 assessment (Klaer, 2009) moved the model from SS2 version 1.21 (June 2006) to SS3 version 3.03 (May 2009). Major changes to previous assessments were the use of age-length data to estimate growth parameters, correction to discard estimation for steam trawl, allowing selectivity change in 1985 for diesel trawl and 1978 for Danish seine, and estimation of recruitment 3 years prior to the last year (2005 for the 2009 assessment that used data to the end of 2008).

2.3 Modifications to the previous assessment

Estimation of growth parameters in the 2009 assessment was restricted to estimation of the growth CV and the K estimate. In developing the 2010 assessment it was recognized that more growth parameters should be estimated to take full advantage of the age-length data, so l_{\min} was estimated also. This change caused a substantial change in model results, suggesting that a revision of other important assumptions was also required. The primary fixed value in the flathead assessment that has a substantial effect on stock dynamics is the assumed value for natural mortality.

The natural mortality value for flathead reported by Punt *et al.* (2005) and for the "robin hood" project in Day (2006) derive from early flathead assessments that used the rate of 0.27. The value of 0.27 was the lower of the range 0.27-0.46 derived from the age structure of the lightly exploited Tasmanian fishery (Tilzey, 1998). The current value of 0.22 was chosen by Punt (2005) as the average of Hoenig estimates of 0.21 for males and 0.23 for females reported by Koopman (PIRVic, pers comm.). The only M value reported in Fishbase (www.fishbase.org) is 0.37 from a study in Marion Bay in Tasmania. A likelihood profile of M from case 7 in Klaer (2010) showed that the assessment model fit was improved by increasing values of M . However, values exceeding about 0.3 resulted in models with very different behaviour overall to the assessments of recent years, with increasingly implausible large total biomass. The revised value of M that had some support independent of the stock assessment was 0.27.

Estimation of total Danish seine discards in the period 1960 to 1978 was being estimated by the model based on little data, so the discard fraction during that period was set to be the same as for recent Danish seine where discard fraction estimates were available. Discarded catch for steam trawl and for Danish seine prior to 1960 were agreed by ShelfRAG to be set at 20% of the retained catch, which translates to a discard ratio ($\text{disc}/[\text{ret}+\text{disc}]$) of 17%.

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Table 1 Total retained catches (tonnes) of tiger flathead per fleet 1915-2010 calendar years.

Year Fleet				Year Fleet				Year Fleet						
St Trawl	D Seine	E Trawl	Tas Trawl	St Trawl	D Seine	E Trawl	Tas Trawl	St Trawl	D Seine	E Trawl	Tas Trawl			
1915	371	0	0	0	1951	583	1,625	0	0	1987	0	1,358	1,109	6
1916	373	0	0	0	1952	769	1,499	0	0	1988	0	1,177	1,263	116
1917	432	0	0	0	1953	517	2,235	0	0	1989	0	1,189	1,318	128
1918	671	0	0	0	1954	366	1,737	0	0	1990	0	591	1,425	178
1919	1,151	0	0	0	1955	211	1,932	0	0	1991	0	746	1,461	166
1920	931	0	0	0	1956	157	1,868	0	0	1992	0	1,019	1,080	170
1921	1,297	0	0	0	1957	139	1,459	0	0	1993	0	516	962	194
1922	840	0	0	0	1958	68	1,138	0	0	1994	0	626	982	178
1923	796	0	0	0	1959	32	1,467	0	0	1995	0	564	1,189	139
1924	1,356	0	0	0	1960	15	2,206	0	0	1996	0	711	1,265	114
1925	1,969	0	0	0	1961	9	1,974	0	0	1997	0	1,023	1,542	175
1926	2,167	0	0	0	1962	0	1,742	0	0	1998	0	905	1,700	186
1927	2,735	0	0	0	1963	0	3,745	0	0	1999	0	1,873	1,520	248
1928	3,277	0	0	0	1964	0	3,707	0	0	2000	0	1,286	2,006	203
1929	3,768	0	0	0	1965	0	3,322	0	0	2001	0	1,170	1,710	113
1930	3,329	0	0	0	1966	0	2,769	0	0	2002	0	1,301	1,736	235
1931	2,932	0	0	0	1967	0	2,912	0	0	2003	0	1,440	1,962	269
1932	2,642	0	0	0	1968	0	2,355	0	0	2004	0	1,410	1,667	519
1933	2,456	0	0	0	1969	0	3,289	0	0	2005	0	1,291	1,534	471
1934	2,278	0	0	0	1970	0	2,667	0	0	2006	0	1,111	1,554	353
1935	2,514	0	0	0	1971	0	1,793	286	0	2007	0	1,442	1,394	216
1936	2,712	0	0	0	1972	0	1,981	491	0	2008	0	1,466	1,731	250
1937	2,912	0	0	0	1973	0	2,397	490	0	2009	0	1,340	1,374	161
1938	2,924	0	0	0	1974	0	1,493	369	0	2010*	0	1,270	1,310	155
1939	2,185	0	0	0	1975	0	1,367	827	0					
1940	815	0	0	0	1976	0	900	712	0					
1941	403	0	0	0	1977	0	977	522	0					
1942	167	0	0	0	1978	0	836	446	0					
1943	223	0	0	0	1979	0	928	520	0					
1944	315	0	0	0	1980	0	851	609	0					
1945	953	0	0	0	1981	0	418	877	0					
1946	1,088	0	0	0	1982	0	615	930	0					
1947	884	0	0	0	1983	0	889	950	0					
1948	735	0	0	0	1984	0	890	978	0					
1949	330	0	0	0	1985	0	890	978	30					
1950	310	0	0	0	1986	0	892	1,005	26					

* 2010 catches are estimated

Table 2 Agreed tiger flathead TACs (tonnes) for 1992-2010. In 2008 the quota year changed from calendar year to 1 May – 30 April.

Year	TAC Agreed
1992	
1993	3000
1994	3500
1995	3500
1996	3500
1997	3500
1998	3500
1999	3500
2000	3500
2001	3500
2002	3500
2003	3500
2004	3500
2005	3150
2006	3000
2007	3015
2008-09	2850
2009-10	2850
2010-11	2700

Table 3 Proportion of total catch that was discarded, with sample sizes also shown.

Year	Fleet		n	E Trawl	n	Tas Trawl	n
	D Seine	n					
1992				0.0891	11		
1993				0.1019	196		
1994	0.040237	78		0.1287	269	0.08138	18
1995	0.114614	43		0.1264	131		
1996				0.1217	241		
1997				0.0307	384	0.000956	10
1998	0.053599	23		0.1179	244	0.000245	27
1999	0.013481	34		0.2008	381	0.002363	48
2000	0.072728	27		0.1142	395		
2001	0.007259	41		0.075	455		
2002	0.110041	29		0.0674	384		
2003	0.012975	112		0.0729	469	0.005699	10
2004	0.001251	39		0.0952	382		
2005	0.021237	59		0.1047	460	0.001489	16
2006	0.022935	125		0.1326	369	0.000582	59
2007	0.107291	47		0.026	103		
2008	0.03141	37		0.0208	211		
2009	0.137241	31		0.0478	191		

Table 4 Standardised catch rates from Klaer (2004b) for the steam trawl fleet.

Year	Value	CV
1919	1.618	0.31
1920	1.732	0.31
1921	1.806	0.31
1922	1.758	0.31
1923	1.646	0.31
1937	0.635	0.31
1938	0.749	0.31
1939	0.723	0.31
1940	0.611	0.31
1941	0.618	0.31
1942	0.401	0.31
1952	0.262	0.31
1953	0.208	0.31
1954	0.232	0.31
1955	0.219	0.31
1956	0.208	0.31
1957	0.169	0.31

Table 5 Unstandardised catch rates for the early Danish seine fleet.

Year	Value	CV
1950	38.7	0.33
1951	27.6	0.33
1952	31.8	0.33
1953	52.0	0.33
1954	34.4	0.33
1955	47.4	0.33
1956	46.5	0.33
1957	32.1	0.33
1958	22.5	0.33
1959	28.7	0.33
1960	43.6	0.33
1965	38.2	0.33
1966	41.5	0.33
1967	62.5	0.33
1968	61.2	0.33
1969	77.8	0.33
1970	67.1	0.33
1971	69.9	0.33
1972	114.0	0.33
1973	88.0	0.33
1974	58.1	0.33
1975	56.6	0.33
1976	41.9	0.33
1977	55.5	0.33
1978	51.9	0.33

Table 6 Standardised catch rates for the Danish seine, Eastern and Tasmanian diesel trawl fleets.

Year	Fleet		CV	E Trawl	CV	Tas Trawl	CV
	D Seine	CV					
1986*	1.0049	0.0227	0.8070	0.0165	0.9755	0.1569	
1987	1.4208	0.0227	1.0801	0.0161	0.5762	0.1871	
1988	1.5467	0.0226	1.1810	0.0158	1.0098	0.1676	
1989	1.3447	0.0229	1.1749	0.0160	0.7577	0.1606	
1990	0.8803	0.0241	1.3935	0.0168	0.7855	0.1623	
1991	1.2358	0.0242	1.3241	0.0169	0.7132	0.1585	
1992	1.3300	0.0223	1.0323	0.0176	0.6683	0.1625	
1993	0.8426	0.0230	1.0557	0.0167	0.6394	0.1540	
1994	0.7104	0.0218	0.7651	0.0161	0.6629	0.1550	
1995	0.7298	0.0233	0.8099	0.0160	0.7256	0.1552	
1996	0.6909	0.0218	0.7168	0.0158	0.6717	0.1547	
1997	0.9026	0.0215	0.7214	0.0162	0.8503	0.1531	
1998	0.7547	0.0210	0.7623	0.0162	1.0027	0.1540	
1999	1.0894	0.0215	0.9165	0.0161	1.0952	0.1543	
2000	0.7964	0.0225	1.0231	0.0155	0.8935	0.1557	
2001	0.7562	0.0226	0.9843	0.0158	0.7683	0.1530	
2002	0.8947	0.0222	1.0745	0.0158	1.4347	0.1522	
2003	0.9517	0.0220	1.0592	0.0156	1.4791	0.1515	
2004	0.9412	0.0225	0.9115	0.0158	1.9320	0.1511	
2005	0.9573	0.0229	0.7796	0.0163	1.7390	0.1516	
2006	0.9519	0.0240	0.9437	0.0168	1.3896	0.1525	
2007	1.1579	0.0239	1.1589	0.0185	1.1370	0.1539	
2008	1.0437	0.0236	1.2107	0.0179	1.0583	0.1538	
2009	1.0655	0.0240	1.1139	0.0185	1.0346	0.1553	

* CV values for 1986 were set to the average of all other years

Table 7 Standard deviation of age reading error (A Punt pers. comm. 26.08.09).

Age	sd
0.5	0.196454
1.5	0.27656
2.5	0.358881
3.5	0.443478
4.5	0.530416
5.5	0.619758
6.5	0.71157
7.5	0.805922
8.5	0.902884
9.5	1.00253
10.5	1.10493
11.5	1.21016
12.5	1.3183
13.5	1.42943
14.5	1.54364
15.5	1.661
16.5	1.78161
17.5	1.90556
18.5	2.03293
19.5	2.16383
20.5	2.29834

Table 8 Number of age-length otolith samples included in the base case assessment by fleet 1998-2009.

Year	Fleet			Total
	D Seine	E Trawl	Tas Trawl	
1998	101	209		310
1999		165	46	211
2000	191	518	56	765
2001	30	180		210
2002	558	582	146	1286
2003	102			102
2004	174	152		326
2005	603	268	11	882
2006	311	64	141	516
2007	115	302		417
2008	363	258	52	673
2009	385	473		858

Table 9 Number of retained and discard fish lengths included in the base case assessment by fleet 1945-2009.

Year Fleet				Year Fleet				
	St Trawl	D Seine	E Trawl	Tas Trawl	St Trawl	D Seine	E Trawl	Tas Trawl
1945	5,076	21,735			1980		8,757	
1946	10,916	26,475			1981		6,184	
1947	15,488	20,287			1982		5,893	
1948	11,973	20,721			1983		5,439	
1949	10,863	23,316			1984		6,702	
1950	18,057	16,640			1985		2,633	
1951	25,843	21,423			1986		12,513	
1952	32,188	28,941			1987		8,154	
1953	14,880	16,264			1988		6,274	
1954	13,167	26,263			1989		3,999	
1955	2,313	9,966			1990		1,398	
1956	343	14,878			1991		4,043	
1957	150	15,283			1992	1,442	1,004	
1958	149	17,291			1993		2,407	
1959		20,354			1994	292	156	
1960		25,334			1995	1,566	1,418	
1961		18,623			1996	3,760	2,520	
1962		20,255			1997	11,857	7,309	
1963		15,988			1998	12,271	17,252	
1964		17,882			1999	5,721	22,388	519
1965		17,861	14,310		2000	3,915	14,666	362
1966		19,101	23,222		2001	5,776	16,585	
1967		7,233	11,798		2002	3,812	13,141	5,201
1969			96		2003	2,312	10,877	649
1970			187		2004	4,427	14,104	1,520
1971			610		2005	3,974	14,946	769
1972			1,363		2006	1,805	15,795	1,323
1973			435		2007	1,028	3,870	
1974			5,590		2008	434	508	496
1975			11,684		2009	319	1,122	87
1976			14,881					
1977			20,153					
1978			16,335					
1979			12,189					

Table 10 Summary of parameters of the base case model.

Feature	Details	
Fleets	Steam trawl	Fixed discard rate of 17%
	Danish seine	Fixed discard rate of 17% to 1960, fitted thereafter
	East coast trawl	Selectivity change in 1978 from early to modern Danish
	Tasmanian trawl	Selectivity change in 1985 from early to modern diesel trawl
M	fixed	0.27
Steepness	estimated	0.62
Sigma r in	fixed	0.35
Recruitment devs	estimated	1915-2006, bias adjustment ramps 1935-60 and 2005-06
CV growth	estimated	0.096
Growth K	estimated	Female 0.180
Growth lmin	estimated	Female age 2 29.45
Growth lmax	fixed	Female 55.9

Table 11 Summary of results for the base-case and sensitivity tests.

Case	SSB0	SSB2011	SSB2011/SSB0	Steepness	SSBmsy/SSB0	RBC2011	RBClongterm
0 base case 20:35:48 <i>M</i> 0.27	21,856	9,713	0.44	0.62	0.30	2,406	2,513
1 <i>M</i> 0.2	22,809	6,848	0.30	0.79	0.25	1,101	2,274
2 <i>M</i> 0.35	25,092	15,499	0.62	0.46	0.36	3,692	2,850
3 wt x 2 length comp	21,207	9,303	0.44	0.63	0.30	2,327	2,460
4 wt x 0.5 length comp	22,051	9,884	0.45	0.63	0.30	2,444	2,543
5 wt x 2 age comp	21,693	9,207	0.42	0.62	0.30	2,268	2,492
6 wt x 0.5 age comp	22,054	10,217	0.46	0.62	0.30	2,522	2,532
7 age + length lambda 1	17,093	5,747	0.34	0.76	0.25	1,540	2,288
8 20:40:40 HCR	21,856	9,713	0.44	0.62	0.30	3,097	2,717
9 estimate <i>M</i> (0.417), <i>h</i> 0.75	26,392	23,178	0.88	0.75		10,525	5,816
10 plus onboard retained lengths	20,721	9,719	0.47	0.67	0.29	2,517	2,480

Table 12 Summary of likelihood components for the base-case and sensitivity tests. Likelihood components are unweighted, and cases 1-10 are shown as difference to the base case.

Case	Likelihood						
	TOTAL	Survey	Discard	Length comp	Age comp	Recruitment	Parm_priors
0 base case 20:35:48 <i>M</i> 0.27	10232.92	-89.66	149.00	6016.07	4185.80	-30.68	2.38
1 <i>M</i> 0.2	-24.54	6.46	0.37	-27.75	-4.45	0.83	0.00
2 <i>M</i> 0.35	18.85	-5.86	-0.86	19.45	4.60	0.81	0.70
3 wt x 2 length comp	-126.68	10.03	0.48	-173.52	24.73	11.58	-0.01
4 wt x 0.5 length comp	180.30	-6.15	0.10	213.15	-19.52	-7.26	-0.01
5 wt x 2 age comp	-5.11	0.71	1.30	34.38	-42.10	0.60	0.00
6 wt x 0.5 age comp	24.20	-0.44	-0.80	-14.98	40.64	-0.22	0.01
7 age + length lambda 1	-270.43	53.86	27.08	-369.85	-26.36	44.04	-0.03
8 20:40:40 HCR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9 estimate <i>M</i> (0.417), <i>h</i> 0.75	6.67	-0.22	-0.22	5.82	0.69	0.67	-0.07
10 plus onboard retained lengths	445.79	0.20	-0.13	444.05	-3.12	4.85	-0.05

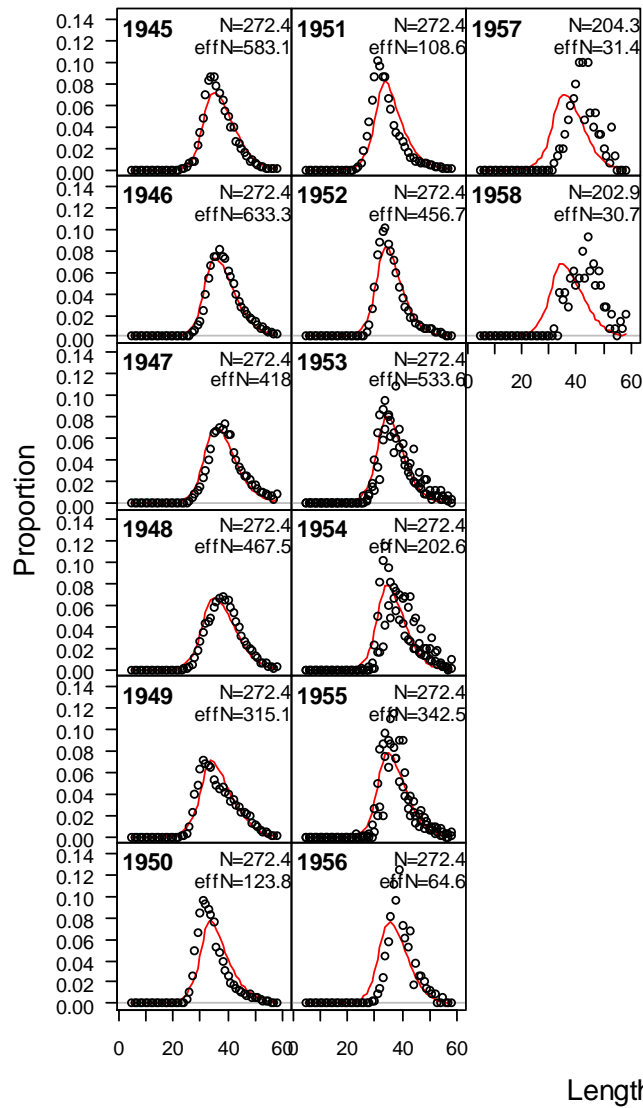
Table 13 Base-case future time trajectory of RBCs (tonnes) for the base-case assessment under the 20:35:48 and 20:40:40 harvest control rules, assuming average recruitment.

Year	RBC 20:35:48	20:40:40
2011	2,406	3,097
2012	2,462	3,069
2013	2,482	3,014
2014	2,488	2,960
2015	2,489	2,915
2016	2,489	2,881
2017	2,490	2,854
2018	2,492	2,832
2019	2,495	2,814
2020	2,497	2,799
2021	2,499	2,786
2022	2,501	2,776
2023	2,503	2,767
2024	2,504	2,759
2025	2,506	2,752
2026	2,507	2,747
2027	2,508	2,742
2028	2,508	2,738
2029	2,509	2,735
2030	2,510	2,732
2031	2,510	2,730
2032	2,510	2,728
2033	2,511	2,726
2034	2,511	2,725
2035	2,511	2,723
2036	2,512	2,722
2037	2,512	2,721
2038	2,512	2,721
2039	2,512	2,720
2040	2,512	2,719
2041	2,512	2,719
2042	2,512	2,719
2043	2,512	2,718
2044	2,512	2,718
2045	2,513	2,718
2046	2,513	2,718
2047	2,513	2,717
2048	2,513	2,717
2049	2,513	2,717

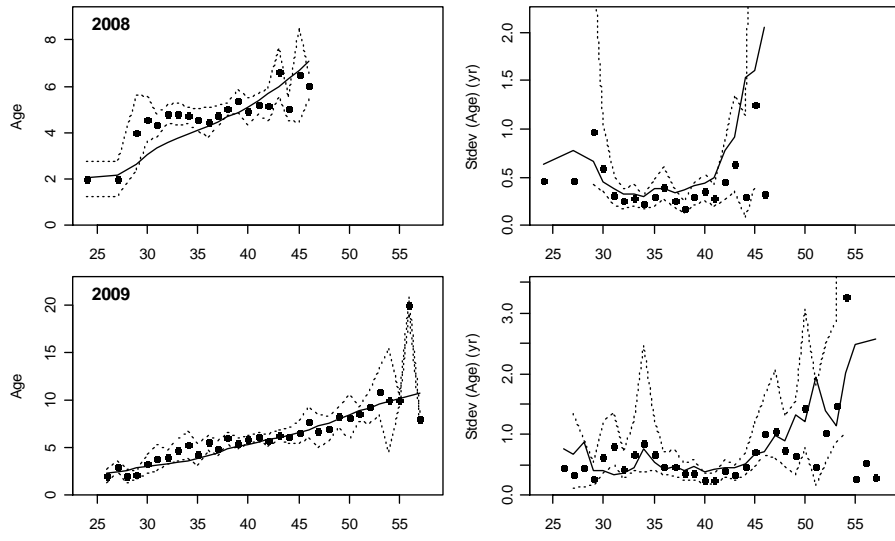
APPENDIX A: BASE-CASE FITS TO THE LENGTH COMPOSITION DATA

Retained – steam trawl

length comps, sexes combined, retained, StTrawl

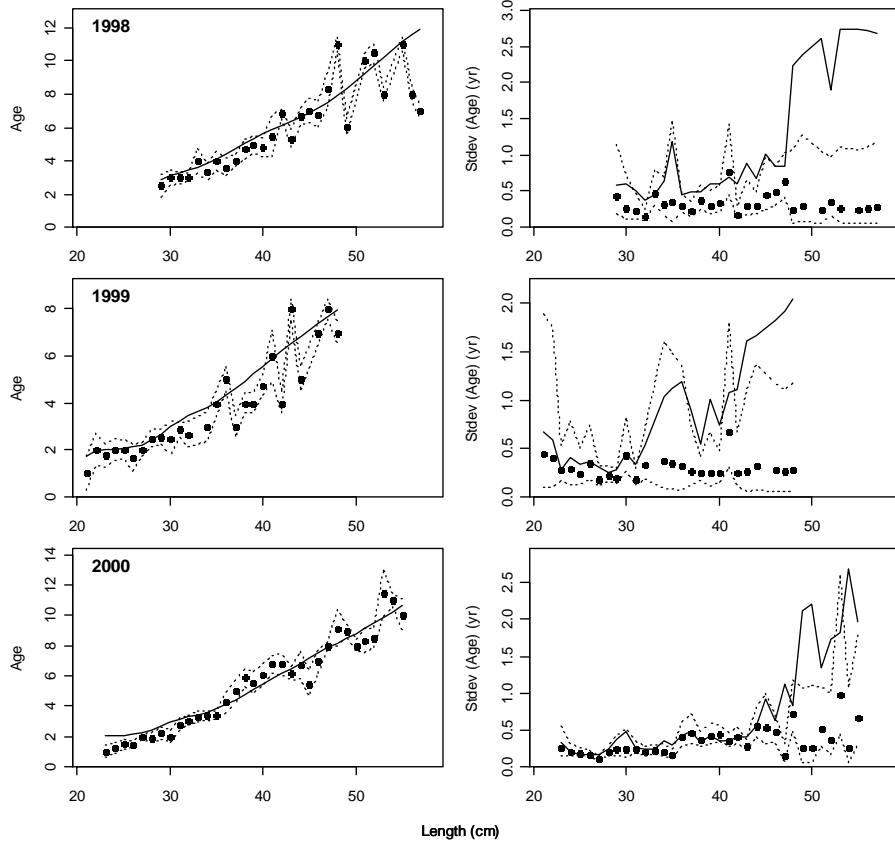


Andre's conditional AAL plot, female, retained, DSeine



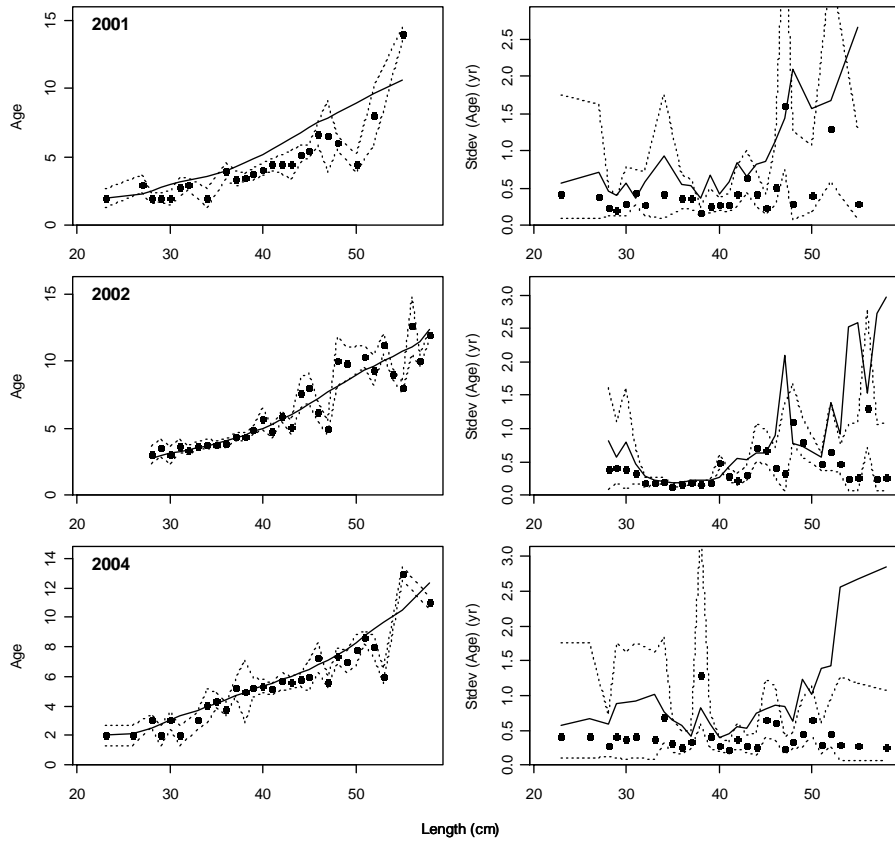
Length (cm)

Andre's conditional AAL plot, female, retained, ETrawl

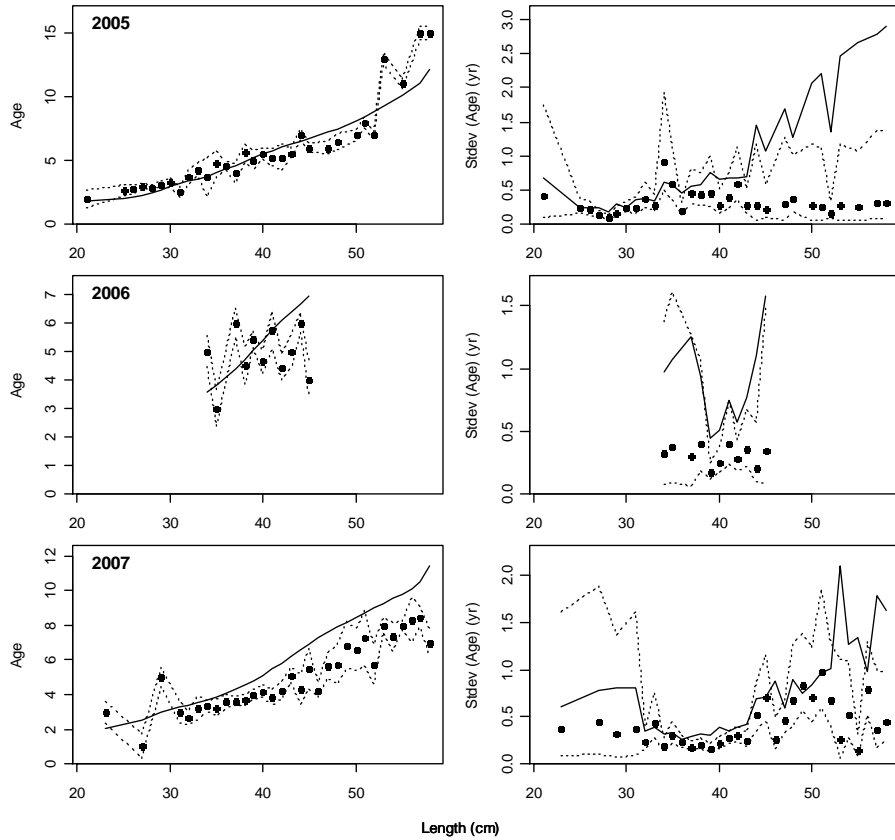


Length (cm)

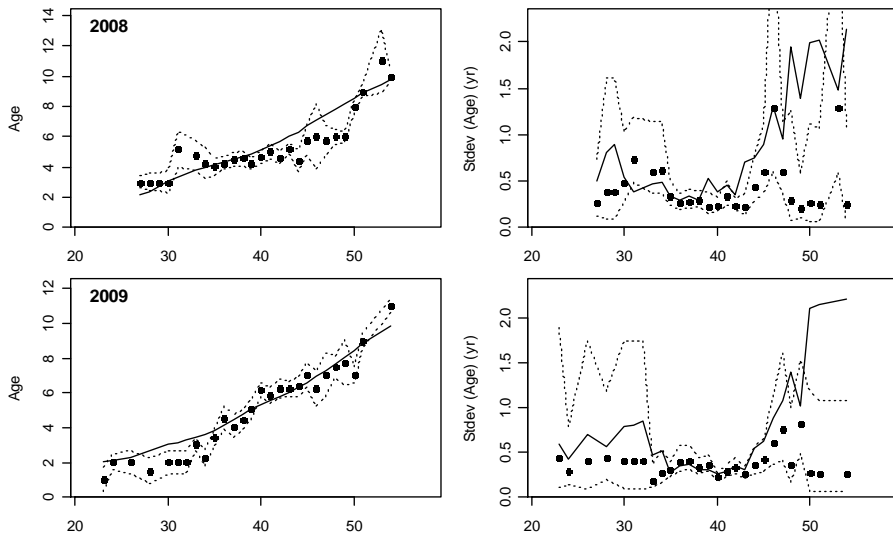
Andre's conditional AAL plot, female, retained, ETrawl



Andre's conditional AAL plot, female, retained, ETrawl

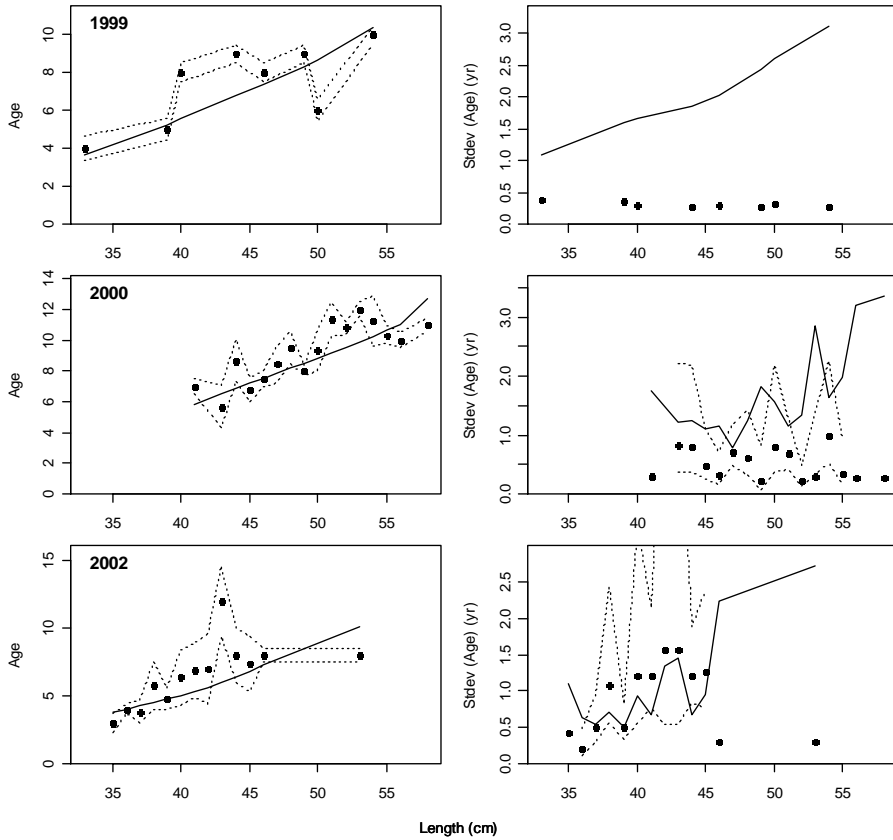


Andre's conditional AAL plot, female, retained, ETrawl



Length (cm)

Andre's conditional AAL plot, female, retained, TasTrawl



Andre's conditional AAL plot, female, retained, TasTrawl

