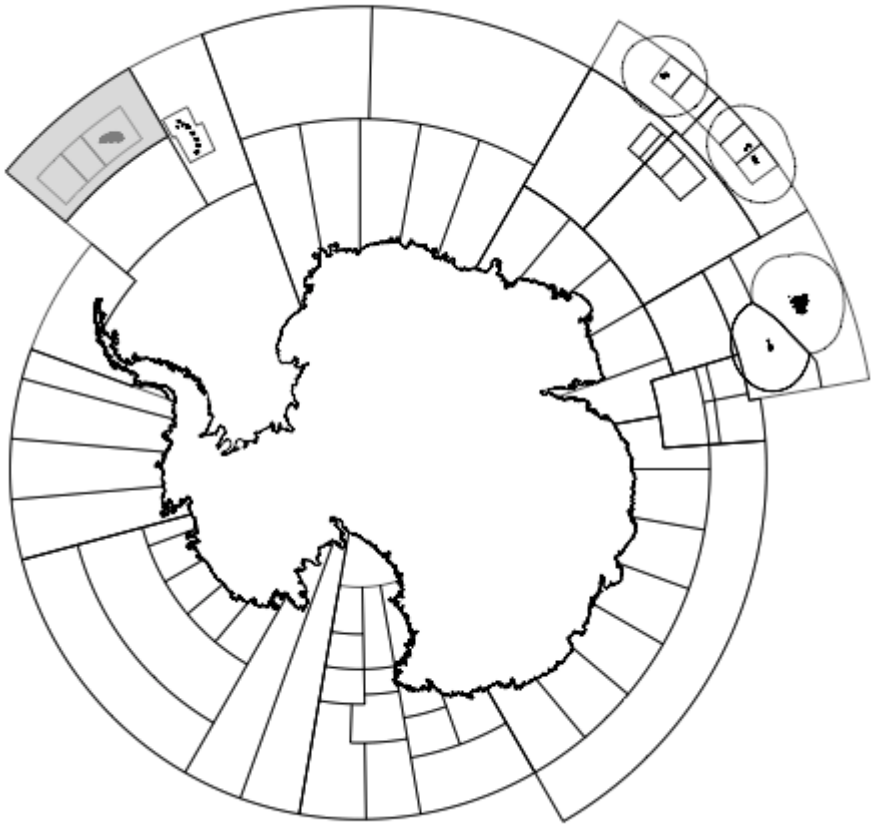
CCAMLR

Commission for the Conservation of Antarctic Marine Living Resources
Commission pour la conservation de la faune et la flore marines de l'Antarctique
Комиссия по сохранению морских живых ресурсов Антарктики
Comisión para la Conservación de los Recursos Vivos Marinos Antárticos

FISHERY REPORT

Fishery Report 2018: *Dissostichus eleginoides* South Georgia (Subarea 48.3)



The map above shows the management areas within the CAMLR Convention Area, the specific region related to this report is outlined is shaded.
Throughout this report the CCAMLR fishing season is represented by the year in which that season ended, e.g. 2015 represents the 2014/15 CCAMLR fishing season (from 1 December 2014 to 30 November 2015).

Fishery Report 2018: *Dissostichus eleginoides*
South Georgia (Subarea 48.3)

Introduction to the fishery

1. The fishery for Patagonian toothfish (*Dissostichus eleginoides*) in Subarea 48.3 began in the 1980s and expanded rapidly during the early 1990s, when considerable illegal, unreported and unregulated (IUU) catches were also taken (Table 1). The initial fishery also caused high rates of incidental bird mortality, with relatively large numbers of albatrosses and petrels attracted to the baited hooks and being caught and drowned. In response to these issues, CCAMLR introduced strict regulations designed to reduce bird by-catch. These regulations, including seasonal closures, streamer lines, line-weighting regimes and night-setting requirements, greatly reduced bird by-catch in this fishery.

2. The current toothfish fishery uses demersal longlines in which lines of baited hooks are deployed close to the sea floor at depths down to 2 250 m. Surface buoys indicate the presence of lines, and vessels typically recover lines after a soak time of 24–48 hours. Bait is usually squid, mackerel or sardines which are all sustainably sourced. The Marine Stewardship Council conditionally certified the fishery in 2004. It was recertified without conditions in 2009, 2014 and again in 2018.

3. In 2004, CCAMLR agreed to subdivide Subarea 48.3 into three Management Areas (A, B and C) (Figure 1) defined in Conservation Measure (CM) 41-02, Annex 41-02/A.

4. In 1998, the fishery was restricted to the winter months (1 May to 31 August) to minimise interactions with foraging birds during their breeding season. Since 2010, CCAMLR has applied a gradual extension to the season culminating in a season opening date for the 2015/16 and 2016/17 seasons on 16 April. These extensions were accompanied with a number of additional measures to prevent significant bird by-catch, as set out in CM 41-02.

5. In 2018, the fishery was open from 16 April to 14 September and the catch limit for *D. eleginoides* of 2 600 tonnes, which was allocated to Management Areas B and C with catch limits of 780 and 1 820 tonnes respectively, was defined in CM 41-02 (see Figure 1).

Reported catches

6. The catch series is shown in Table 1 and, with the exception of 36 tonnes in 2004 and 2 tonnes in 2007, all catches have been from within Management Areas B and C. In 2018, the total catch of *D. eleginoides* in Subarea 48.3 was 1 950 tonnes.

Table 1: Catch history for *Dissostichus eleginoides* in Subarea 48.3. (Source: fine-scale data, past reports for IUU catch.)

Season	Regulated fishery		Estimated IUU catch (tonnes)
	Catch limit (tonnes)	Reported catch (tonnes)	
1992	3500	3827	3066
1993	3350	3297	4019
1994	1300	639	4780
1995	2800	3072	1674
1996	4000	3296	0
1997	5000	3707	0
1998	3300	2837	146
1999	3500	3649	667
2000	5310	5067	1015
2001	4500	3828	196
2002	5820	5459	3
2003	7810	7485	0
2004	4420	4462	0
2005	3050	3030	23
2006	3556	3522	0
2007	3554	3527	0
2008	3920	3807	0
2009	3920	3382	0
2010	3000	2518	0
2011	3000	1732	0
2012	2600	1836	0
2013	2600	2094	0
2014	2400	2180	0
2015	2400	2195	0
2016	2750	2196	0
2017	2750	2195	0
2018	2600	1950	0

Figure 1: The location of Management Areas A, B and C in Subarea 48.3.

7. Fishing for *D. eleginoides* in Subarea 48.3 has predominantly used longlines. Occasional pot trials yielded the following catches: 66 tonnes (2001), 24 tonnes (2006) and 55 tonnes (2008). There have been no recent trials using pots. Prior to 1992, fishing focused around Shag Rocks and to the northeast of South Georgia. Since 1992, fishing effort has been distributed more widely over the South Georgia and Shag Rocks shelves and slopes.

Illegal, unreported and unregulated (IUU) fishing activity

8. There has been no reported evidence of IUU fishing activities in Subarea 48.3 between 2006 and 2018 (Table 1).

Data collection

9. Catch limits for the assessed *D. eleginoides* fisheries in Subareas 48.3 and 48.4 and Division 58.5.2 are set by CCAMLR using fully integrated assessments; more basic approaches are used for the 'data-poor' fisheries (e.g. in Subarea 48.6 and in Area 58 outside the exclusive economic zones (EEZs)). The data collection requirements are set out in the relevant conservation measures.

Biological data

10. The collection of biological data under CM 23-05 is conducted as part of the CCAMLR Scheme of International Scientific Observation (see below).

Length-frequency distribution of catches

11. The length frequencies for catches of *D. eleginoides* from 2009 to 2018 are shown in Figure 2. These length-frequency distributions of catches are unstandardised. Interannual variability shown in Figure 2 may therefore reflect differences in the fished population and changes in the fishing fleet and its behaviour, particularly the depth at which longlining occurs.

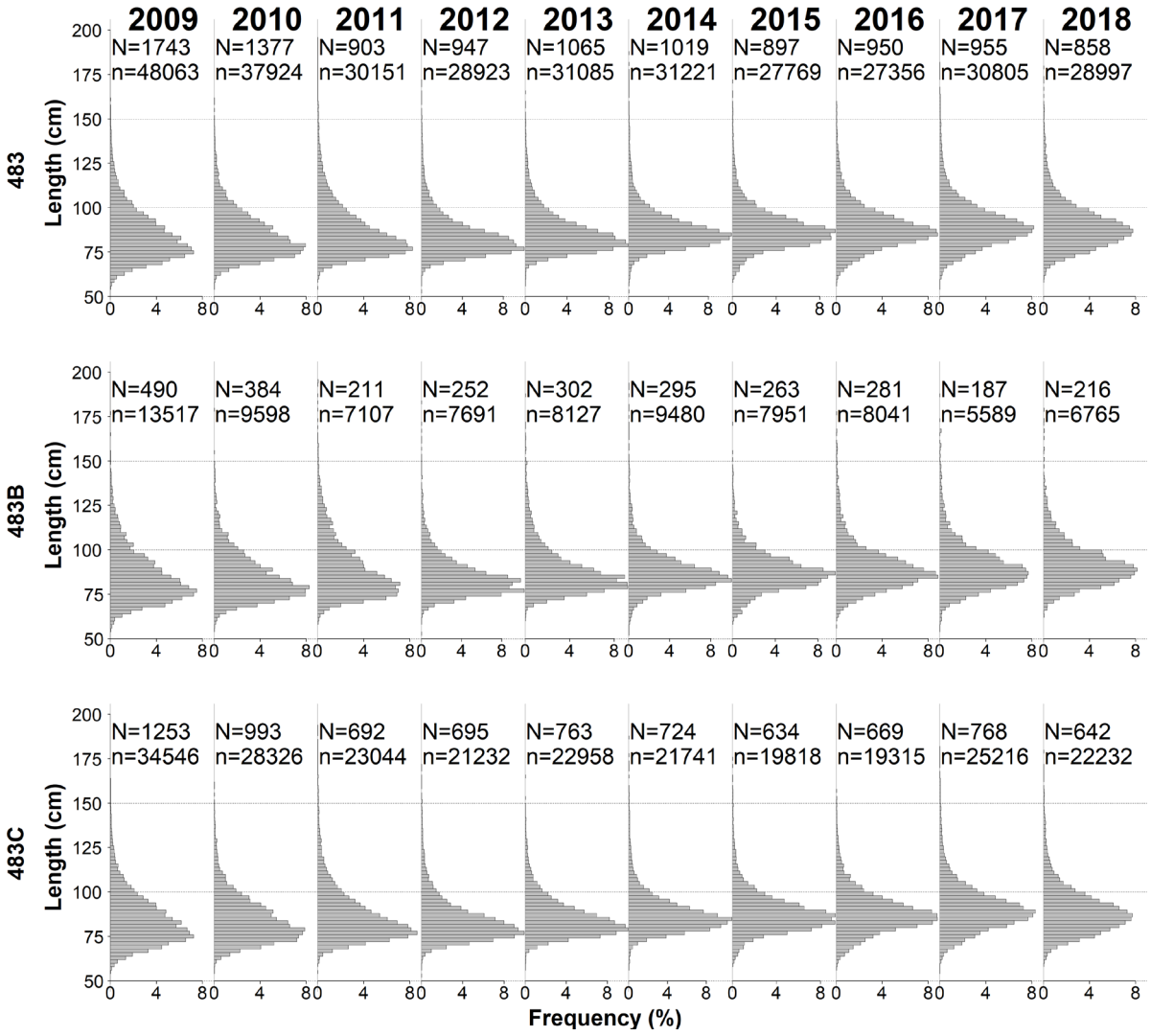


Figure 2: Length frequencies for *Dissostichus eleginoides* in Subarea 48.3 from 2009 to 2018 using observer data. The number of hauls (N) and the number of fish measured (n) in each year are given at the top of each panel. Letters to the left of the panel (B and C) refer to the management areas shown in Figure 1.

Life-history parameters

12. *Dissostichus eleginoides* is a large long-lived species belonging to the family Nototheniidae, or Antarctic cods. Toothfish show distinct depth preferences with age, with juveniles (<50 cm) living on the continental shelf and moving into deeper water (>500 m) as they reach maturity (~90 cm). Toothfish are important predators, feeding primarily on fish, cephalopods and crustaceans; they also scavenge.

Data collection

13. In January–February 2017, the UK undertook a random stratified bottom trawl survey of South Georgia and Shag Rocks (see WG-FSA-17/44). The survey is the 18th of its type (the trawl series starting in 1986) and employed the same trawl gear and survey design as previous UK surveys in Subarea 48.3 (see WG-FSA-10/38 and WG-FSA-15/26). The 2017 survey covered the whole shelf area, covering depths of 100–350 m. The primary aim of the survey was to estimate stocks of mackerel icefish (*Champsocephalus gunnari*) but juvenile *D. eleginoides* were also captured. Numbers and lengths of *D. eleginoides* provide an index of recruitment for stock assessments.

14. *Dissostichus eleginoides* were caught in 21 of the 72 hauls in the 2017 survey and were present in greatest numbers around the eastern and western ends of the Shag Rocks shelf. The total catch of toothfish was low, totalling 246 kg (63 individuals). Toothfish ranged in length from 33 to 153 cm, with evidence of a weak mode at 58–63 cm. There was evidence of a cohort of 5+ fish.

15. All toothfish vessels in Subarea 48.3 carry a CCAMLR scientific observer who collects a range of data on toothfish and common by-catch, including conversion factors, length frequencies, weights and maturity. Toothfish otoliths are collected by observers for an ageing program that provides length-at-age data for assessments. Observers also record whale occurrence at the vessel during hauling; data which is then used to model depredation rates which are included in the stock assessment. Observers work with vessels to tag toothfish and skates and collate recapture data. Tagging of *D. eleginoides* continued at a rate of 1.3 fish per tonne in 2018, with a total of 3 381 fish tagged and 614 recaptures (including within-season recaptures).

Parameter estimates

16. The biological parameters used in the stock assessment (Table 2) are taken from the scientific literature, where available. These values are derived from analyses of the biological data collected by scientific observers on board fishing vessels. Where derived values are not available (e.g. natural mortality and the steepness of the stock and recruit relationship), values have been assumed that are consistent with the values used in other toothfish assessments conducted by CCAMLR.

Table 2: Biological parameters assumed for *Dissostichus eleginoides* in Subarea 48.3.

Component	Parameter	Value	Component	Parameter	Value
Natural mortality	M	0.13	Tag-related growth retardation		0.75
VBGF	K	0.08	CASAL tag-loss rate		0.006377
VBGF	t_0	–0.7	Immediate tagging survivorship		See below
VBGF	L_∞	126	Tag probability of detection		1
Length to mass (cm to t)	A	2.54E-09			
Length to mass	B	2.8	Stock-recruit relationship steepness	H	0.75
Maturity range: 0 to full maturity		1–23	Lognormal recruitment SD		Estimated

17. Immediate tagging survivorship is applied as a length-specific tag-mortality ogive in which larger fish are assumed to experience a higher rate of mortality as a consequence of the tagging procedure than smaller fish (Table 3). Since CASAL can only apply a single tag mortality across all sizes, the correction to the tagged fish proportions at length and numbers of tagged fish must be applied externally.

Table 3: Length-specific tagging survival rates used in the assessment for *Dissostichus eleginoides* in Subarea 48.3.

	Length class (cm)						
	40	50	60	70	80	90	100 +
Proportion surviving	1.0	0.96	0.95	0.95	0.94	0.83	0.8

18. Since the length-specific tag-mortality rates are calculated externally to the assessment, the tagging mortality parameters in the CASAL input files are set to zero in all instances.

Stock assessment status

19. *Dissostichus eleginoides* in Subarea 48.3 are genetically distinct from those found on the Patagonian shelf (FAO Area 41). The stock, occurring within Management Areas A, B and C, is genetically separate from fish taken in the extreme north and west of Subarea 48.3 and the assessments consider only the stock within Management Areas A, B and C (further details of the stock assessment are provided in Appendix 1).

20. The stock of *D. eleginoides* in Subarea 48.3 was assessed using an age-structured CASAL integrated stock assessment model for both sexes combined with ages from 1 to 50, the last age being a plus group. The model was run from 1985 to 2017 and was initialised assuming an equilibrium age structure at an unfished equilibrium biomass.

21. The assessment model assumes a single-area and single-fleet fishery with separate selection patterns estimated for two distinct time periods, the first from 1985 to 1997, the second from 1998 to 2017. A fishery-independent index of abundance, derived from a first-quarter bottom trawl survey, is available for most years for the period 1987 to 2017 and an

index of catch-per-unit-effort (CPUE), determined from the commercial fishery, is also available for use in the assessment for the period 1998 to 2017. The CPUE index is corrected for cetacean depredation (i.e. CPUE is increased to account for removal of catch by sperm whales and killer whales) for the period that cetacean observations are available (2004 onwards), using a generalised linear model analysis. A similar correction is also applied to the total catch. The correction for cetacean depredation varies annually but is typically in the range of a 3% to 5% increase.

22. Double-normal selection patterns were fitted in all instances to allow for any potential reduction in selection at older ages, although in the commercial fishery, the model estimated sigmoid selection patterns.

23. The assessment model includes tag-release and tag-recapture events for which data are available from 2003. The model assumes that tagging was applied to a cohort of fish simultaneously and that tagging from each year was applied as a single tagging event. The model applies the same population processes to both the tagged and untagged components of the modelled population. In addition, tagged fish were assumed to suffer a growth retardation equal to nine months of no growth following tagging. All fish are double tagged with total tag shedding estimated at 0.0064 per year.

24. Model parameters are initially estimated by maximising the composite likelihood of the data, priors and penalties (the MPD estimates) and subsequently by estimating the Bayesian posterior distributions using Markov Chains Monte Carlo (MCMCs). Model fits were evaluated at the initial MPD by investigating fits to observations and likelihood profiles of key parameters estimated by the model, specifically B_0.

25. Likelihood profiles for B_0 from the 2017 assessment (Figure 3) showed that estimates of B_0 were most strongly influenced by the tag-release and recapture information which is included in the assessment primarily to provide an estimate of total abundance, compared to survey biomass and commercial CPUE that provide information about stock trends.

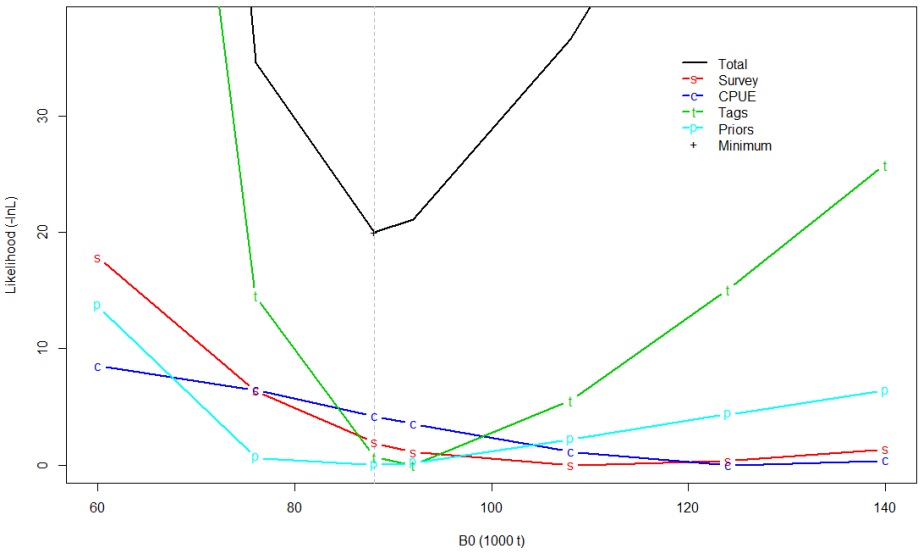


Figure 3: Likelihood profiles for values of B_0. Negative log likelihood values have been rescaled to have minimum 0 for each dataset. Vertical line indicates the overall MPD estimate of B_0. Black line indicates total likelihood, other lines indicated by symbol (t – tagging, s – survey, c – CPUE, p – priors).

26. Parameter uncertainty was estimated using MCMC analyses. The posterior distribution was sampled from 1 000 000 iterations, following an initial burn-in of 100 000 iterations, and thinned by a factor of 1 000, to achieve a final sample length of 1 000. Estimates of initial biomass levels and current biomass levels (Table 4) show that the stock remained at around 52% of B_0 in 2015.

Table 4: Median spawning biomass and 95% confidence intervals (CIs) for the initial equilibrium SSB (B_0), the current SSB ($B_{current}$) and the ratio of current to initial SSB for the 2007, 2009, 2011, 2013, 2015 and 2017 assessments.

Assessment year	B_0 (thousand tonnes)	$B_{current}$ (thousand tonnes)	$B_{current}/B_0$
2007	112 (98.7–125.0)	67.1 (52.9–79.9)	0.59 (0.54–0.64)
2009	98.5 (93.6–103.8)	60.2 (55.0–65.7)	0.61 (0.58–0.64)
2011	85.1 (78.9–92.1)	44.9 (38.9–51.9)	0.53 (0.49–0.56)
2013	85.9 (81.6–90.8)	45.4 (41.3–49.7)	0.53 (0.50–0.55)
2015	85.9 (81.6–91.3)	44.7 (41.4–48.7)	0.52 (0.50–0.54)
2017	83.2 (79.0–88.1)	42.2 (38.9–52.6)	0.51 (0.49–0.53)

27. Stochastic long-term projections conducted in accordance with the CCAMLR procedures for yield calculations (Figure 4) indicate that a constant yield of 2 600 tonnes will maintain spawning stock biomass (SSB) at 50% of B_0 over the next 35 years with 50% probability.

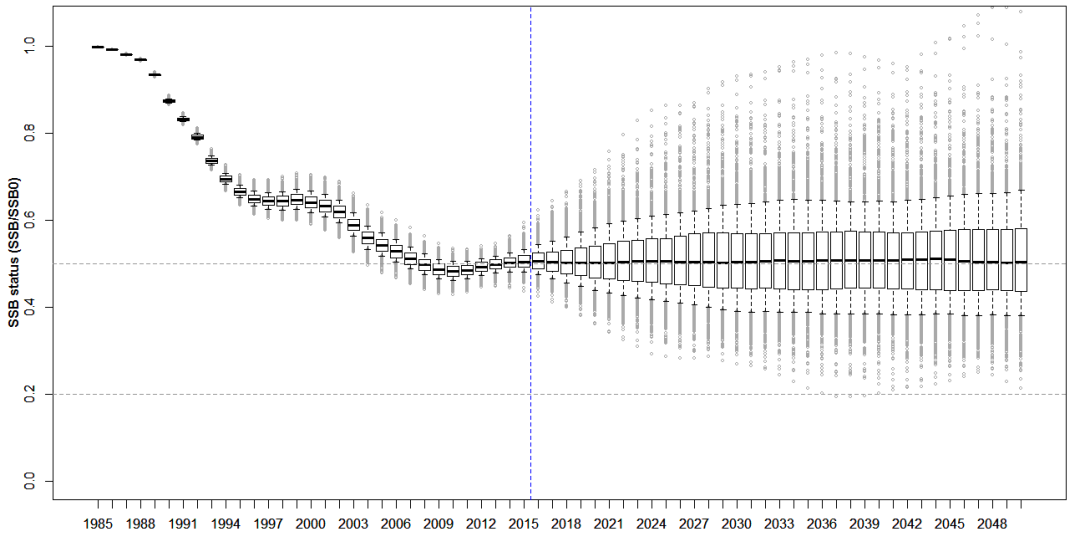


Figure 4: Estimated spawning stock biomass relative to B_0 based on a 35-year projection at a constant yield of 2 600 tonnes. Boxes show median and 25th and 75th percentiles. Whiskers extend to the 5th and 95th percentiles.

28. An Independent Stock Assessment Review for Toothfish was conducted in June 2018 (SC-CAMLR-XXXVII, Annex 5), which included Subarea 48.3. The review made suggestions for analysis of sensitivities to data and assumptions within the application of the CASAL model for all stocks and some specific to Subarea 48.3.

By-catch of fish and invertebrates

Fish by-catch

29. Annual catch limits for by-catch species groups (macrourids, skates (Rajiformes) and other species) are defined in CM 41-02. The macrourid by-catch limit is 130 tonnes and the skate by-catch limit is also 130 tonnes. If the by-catch of skates or macrourids exceeds 1 tonne in any one haul or set, then the fishing vessel must move at least 5 n miles away for a period of at least five days.

30. Catches of by-catch species groups (macrourids, skates and other species), their respective catch limits and number of skates released alive are summarised in Table 5. Both macrourid and skate catches were within the catch limits in 2018.

Table 5: Catch history for by-catch species (macrourids, skates and other species), catch limits and number of skates released alive in Subarea 48.3. Catch limits are for the whole fishery (see CM 41-02 for details). (Source: fine-scale data.)

Season	Macrourids		Skates (Rajiformes)			Other species	
	Catch limit (tonnes)	Reported catch (tonnes)	Catch limit (tonnes)	Reported catch (tonnes)	Number released	Catch limit (tonnes)	Reported catch (tonnes)
2004	221	30	221	6	-	-	4
2005	152	121	152	8	-	-	20
2006	177	136	177	7	21056	-	37
2007	177	129	177	4	9265	-	27
2008	196	161	196	12	19558	-	36
2009	196	110	196	22	23709	-	34
2010	150	70	150	7	15810	-	16
2011	150	74	150	4	12832	-	9
2012	130	54	130	2	13503	-	9
2013	130	59	130	2	14005	-	11
2014	120	61	120	3	12969	-	15
2015	120	56	120	2	10937		10
2016	138	64	138	2	14960	-	15
2017	138	54	138	3	12921	-	16
2018	130	107	130	4	21235	-	29

31. A preliminary assessment of skate populations in Subarea 48.3 using a surplus production model implemented in a Bayesian framework was presented in 2007 (WG-SAM-07/11), at which time it was considered that there were insufficient data to inform the assessment. Nevertheless, these preliminary results suggested that the by-catch limit in Subarea 48.3 for rajids would be considered sustainable.

32. A skate tagging program has been under way since 2006 in Subarea 48.3 and a preliminary assessment of skates in Subarea 48.3 using tagging data was presented in 2014 (WG-FSA-14/48). This assessment indicated a stable biomass. Using the same skate tagging programme, a stock status and population assessment of the Antarctic starry skate (*Amblyraja georgiana*) in Subarea 48.3 was presented in 2018 (WG-FSA-18/27). These results indicated that the longline fishery for toothfish does not appear to have resulted in a decline in the population of *A. georgiana* and at present has low by-catch rates of exploitation.

33. Recent genetic analysis of skates (Amblyraja spp.) (WG-FSA-18/73) suggests that skates caught as by-catch from CCAMLR subareas 48.3 and 48.4 that were identified as *A. georgiana*, *A. georgiana* sp. anon and *A. taaf* do not represent distinct, reproductively isolated species. Rather, these different morphological forms of Amblyraja appear to be interbreeding members from two geographically differentiated stocks, one occurring around South Georgia and the other around the South Sandwich Islands.

Invertebrate by-catch including VME taxa

34. There are no registered vulnerable marine ecosystems (VMEs) or VME Risk Areas in Subarea 48.3.

Incidental mortality of seabirds and marine mammals

Incidental mortality

35. A summary of bird mortality by longline in Subarea 48.3 over the past 13 seasons is presented in Table 6. The three most common species injured or killed in the fishery since 2005 were white-chinned petrel (*Procellaria aequinoctialis)*, black-browed albatross (*Thalassarche melanophrys*) and southern giant petrel (*Macronectes giganteus*).

Table 6: Number of reported birds killed in the longline fishery in Subarea 48.3.

Season	*Macronectes giganteus*	*Procellaria aequinoctialis*	*Thalassarche melanophrys*	Other
2006				
2007				
2008				
2009			1	1
2010			1	1
2011				
2012	1		1	
2013		1		
2014		77		
2015		1		
2016		30		
2017		15		
2018	2	21	1	

36. Over the last 10 years, four mammal mortalities associated with longline fishing have occurred in Subarea 48.3.

Mitigation measures

37. The requirements of CM 25-02 ‘Minimisation of the incidental mortality of birds in the course of longline fishing or longline fishing research in the Convention Area’ apply to this fishery in addition to the seasonal closure and the night-setting requirements described in CM 41-02.

38. The risk level of birds in this fishery in Subarea 48.3 is category 5 (high) (SC-CAMLR-XXX, Annex 8, paragraph 8.1).

Ecosystem implications and effects

39. There is no formal evaluation available for this fishery.

Current management advice and conservation measures

40. The limits on the exploratory fishery for *D. eleginoides* in Subarea 48.3 for the forthcoming season are defined in CM 41-02: www.ccamlr.org/measure-41-02.

Appendix 1

Stock assessment

A1. The CASAL model framework was used to create a combined-sex, single-area, three-season model fitted to tagging data, survey biomass and length structure, catch age (post 1996/97) and length structure (prior to 1997/98). Estimates of spawning stock biomass (SSB), recruitment and harvest rate from the model are shown in Figure A1. The model fit (Figure A2) is most strongly influenced by the tag-recapture data, as shown in Figure A3, to which there is a good fit. The model fits poorly to the survey length distributions shown in Figure A4.

A2. Figure A5 shows projections under a catch limit of 2 600 tonnes, which is consistent with the CCAMLR decision rule which requires the stock to be at 50% of B_0 after 35 years, with a probability of less than 10% of dropping below 20% of B_0.

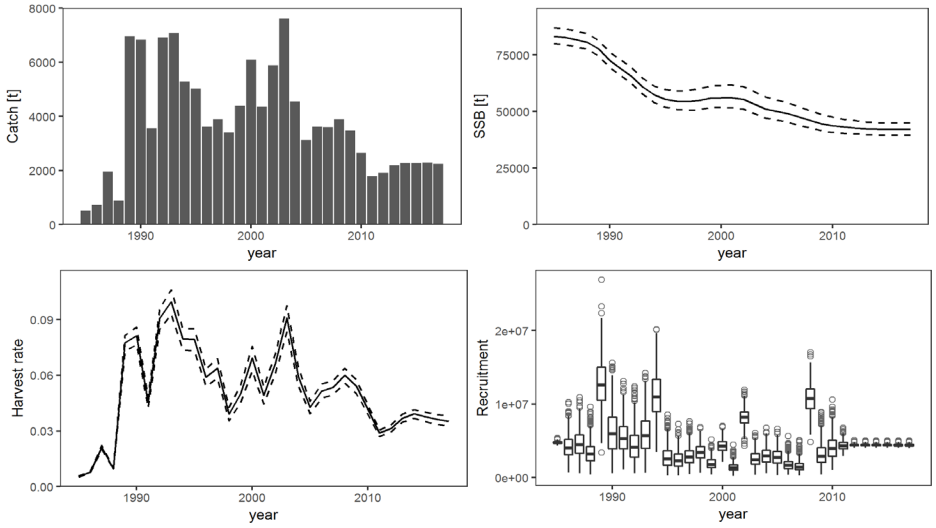


Figure A1: *Dissostichus eleginoides* in Subarea 48.3: Time series of catch, SSB, harvest rate and recruitment, with uncertainty estimated from MCMC resampling. Solid lines indicate the median value, dotted lines and the extent of whiskers indicate 10th and 90th percentiles and boxes extend from 25th to 75th percentiles.

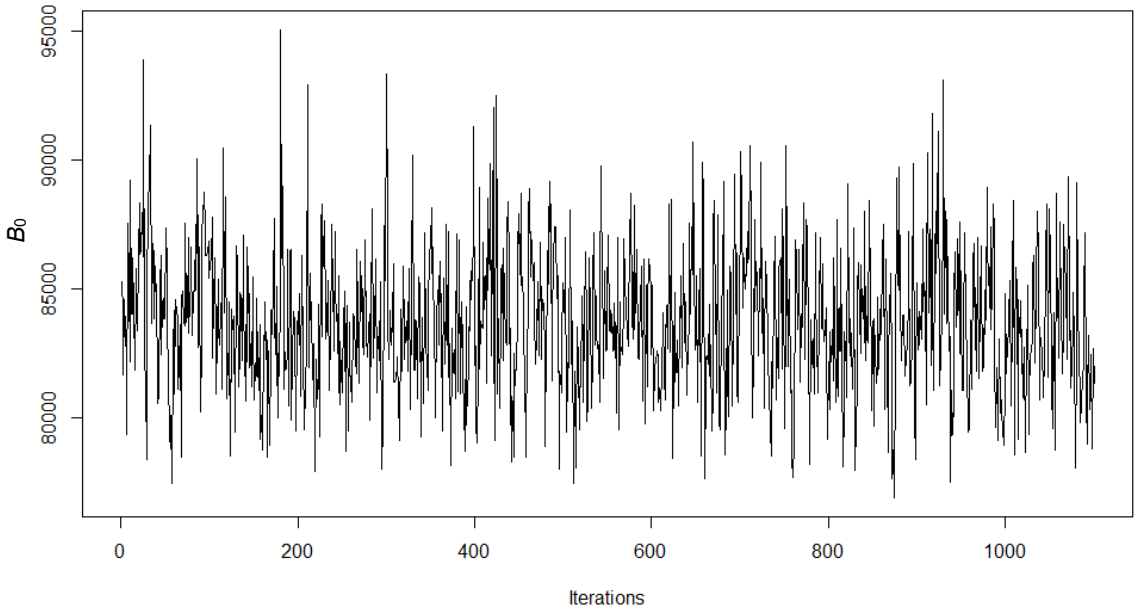


Figure A2: *Dissostichus eleginoides* in Subarea 48.3: MCMC diagnostics for B_0, showing a lack of trend in the trace.

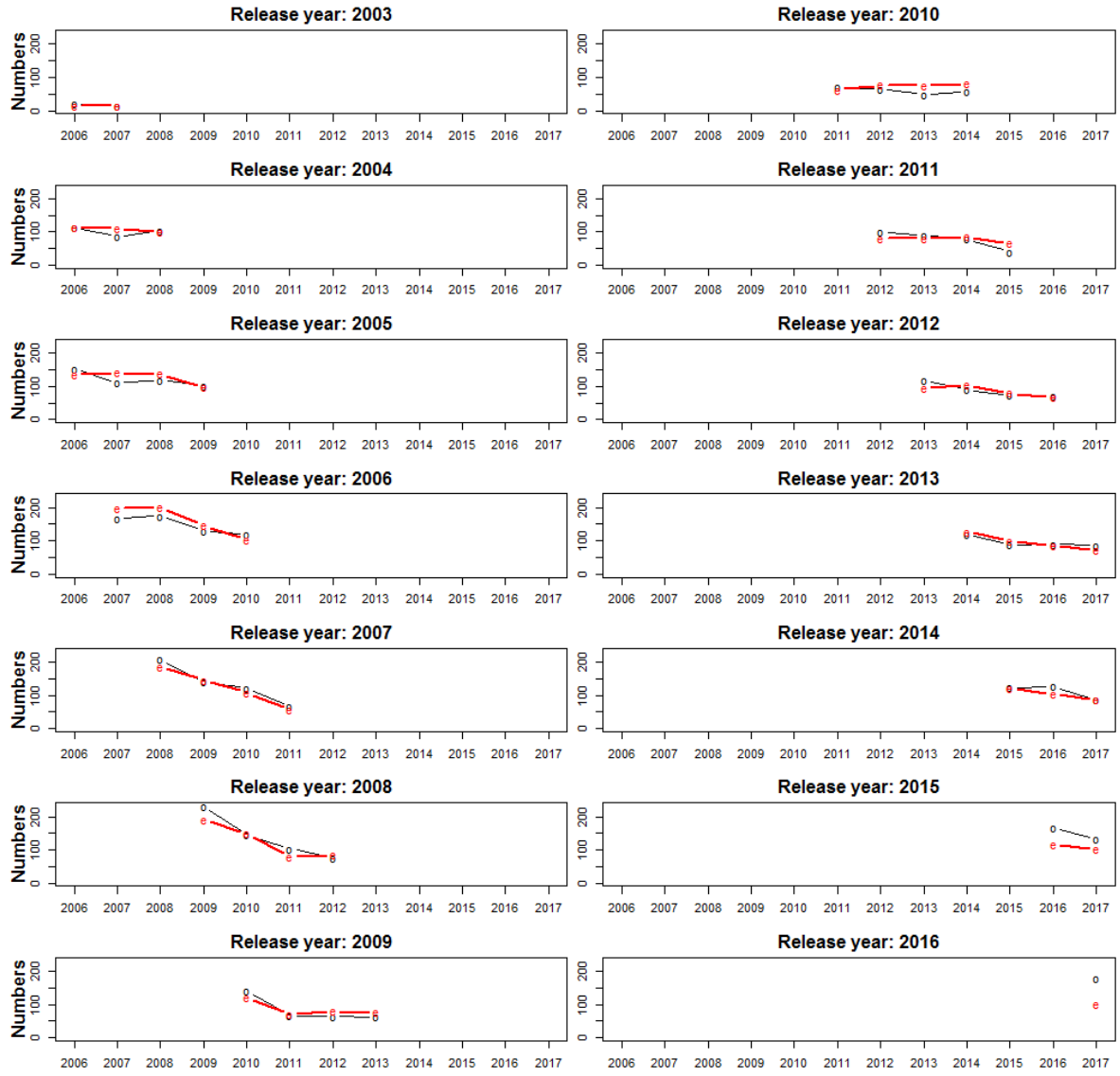


Figure A3: *Dissostichus eleginoides* in Subarea 48.3: Observed tag recaptures (black) and model fits (red) by release year.

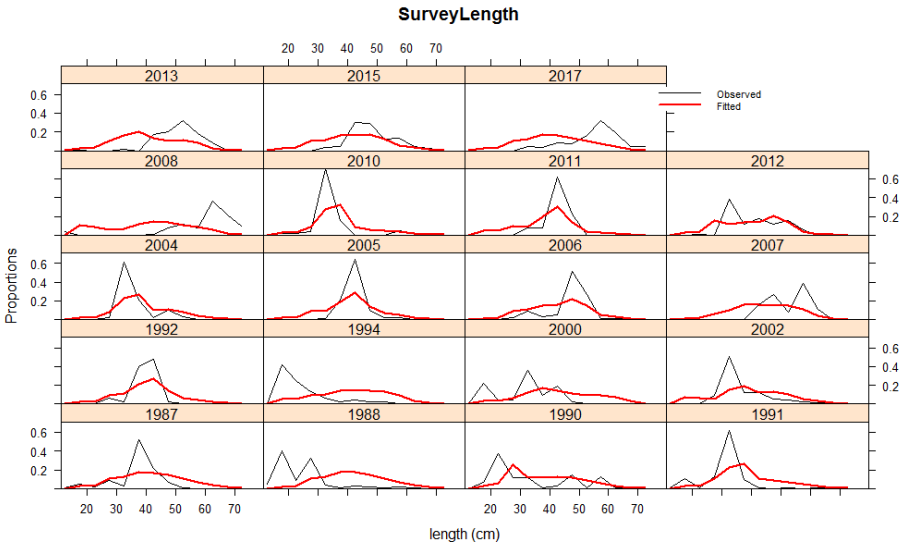


Figure A4: *Dissostichus eleginoides* in Subarea 48.3: Observed length distributions (black) and model fits (red) to survey data.

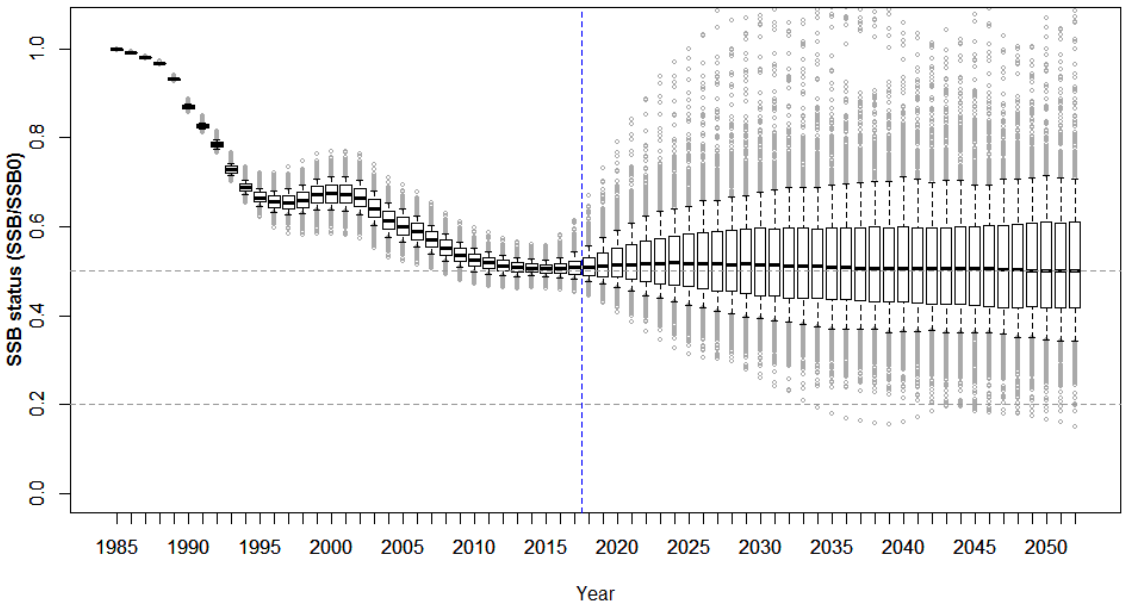


Figure A5: *Dissostichus eleginoides* in Subarea 48.3: projection of SSB relative to virgin biomass for 35 years based on a constant catch of 2 600 tonnes per year. Confidence intervals at 10% and 90% shown as dashed lines. Vertical dashed line indicates the split between model fit to past data and projection. Horizontal lines indicate 50% and 20%