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SC8-DW09

Progress report on NZ's exploratory fishery for toothfish

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Interim research report from the New Zealand bottom longline research carried out in the SPRFMO area 2019 and 2020

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Abstract

In 2019 the Commission of the South Pacific Regional Fisheries Management Organisation (SPRFMO) approved a proposal by New Zealand to extend its previous (2016, 2017) exploratory bottom longline fishing for toothfish for the 2019 to 2021 period (CMM-14a-2019). One of the authorised New Zealand vessels, *San Aspiring*, undertook the research programme for toothfish in the SPRFMO Convention Area during September-October 2019 and February-March 2020. Preliminary analysis of the information collected reinforced previous research results showing localised high catch rates of Antarctic toothfish in the southern SPRFMO Convention Area, similar in magnitude to catch rates in the north region of Convention for the Conservation Of Marine Living Resources (CCAMLR) Subareas 88.1 and 88.2. The toothfish catch was almost entirely Antarctic toothfish, other than four Patagonian toothfish (*Dissostichus eleginoides*). Also consistent with previous records was a high proportion of males to females.

Fish were in poor body condition compared with fish from the continental slope as assessed using both Fulton's condition factor (SCI) and a modified Fulton's condition factor (SCF) using somatic weight to account for large differences in body weight due to gonad maturation over a season (Dutil et al. 1995, Hansson et al 2017). Fenaughty et al (2018) reported a similar result from this area and considered this to be consistent with a spawning event prior to the late-winter sampling in 2016 and 2017. Body condition was slightly better in 2017 when sampling occurred about 5 weeks later than in 2016. The 2020 results indicate that Antarctic toothfish somatic condition was still poor during summer and in fact either almost identical using a traditional Fulton's condition factor or marginally worse using the somatic variation, than that observed during the (hypothesised) post-spawning period. These Antarctic toothfish body length and mass relationships indicating physical condition, sex ratio, and gonad condition are consistent with previous observations from the northern Ross Sea region in CCAMLR Subareas 88.1 and 88.2 (Fenaughty 2006, Fenaughty et al. 2008, Parker & Marriott 2012, Stevens et al. 2016, Parker et al 2014, 2019, 2020). As this is one of the few areas accessible to fishing during the winter period it may be an important source of information to improve our knowledge on Antarctic toothfish spawning.

All information so far indicates that Antarctic toothfish also spawn north of 60° south latitude suggesting that Antarctic toothfish spawning may extend over a wider geographic area than initially hypothesised from CCAMLR stock distribution studies.

Similar to results previously reported from the 2016 and 2017 research (Fenaughty et al. 2018), catch rates were similar in magnitude to those observed on some of the northern features of CCAMLR Subareas 88.1 and 88.2 and generally higher than the average from the CCAMLR Ross Sea fishery (CCAMLR Subareas 88.1 and 88.2) further south on the 'slope' area.

Introduction

Antarctic and Patagonian toothfish (*Dissostichus mawsoni* and *Dissostichus eleginoides*) have circumpolar distributions and can move over large distances (CCAMLR Secretariat 2016). The observed distribution of Antarctic toothfish in the SPRFMO Convention Area immediately north of the CCAMLR Convention Area is consistent with current stock hypotheses for Antarctic toothfish in Area 88 (Parker et al. 2014, Hanchet et al. 2008 and 2015).

New Zealand presented a proposal to the third meeting of the SPRFMO Scientific Committee in 2015 (MPI 2015, SC03-DW-01) for a 2-year exploratory fishery for Patagonian toothfish and Antarctic toothfish utilising the bottom longlining fishing method (autoline variant). The research was designed to cover key gaps in our knowledge of the distribution and life cycle of Antarctic toothfish in the South Pacific Ocean and Ross Sea to underpin understanding and management of those stocks. Following an assessment by the Scientific Committee this proposal was deemed acceptable under Article 22 (then CMM2.03, and subsequently CMM 03- 2017) and the Bottom Fishery Impact Assessment Standard. The Compliance and Technical Committee and Commission considered the proposal in early 2016 and the Commission approved a 2-year exploratory fishery with a retained catch limit of 30 tonnes of *Dissostichus* spp. (both species combined) for each of the two years (CMM-14-2016). Under a memorandum of

As part of this research, two exploratory fishing voyages were completed, the first in August 2016 (Fenaughty & Cryer 2016, SC-04-DW-02), the second in August/September 2017. Detailed results from both voyages were presented to SC-06 as part of the proposal for a continuation of the exploratory fishery (SC-06-DW-03-rev2). Results indicated that catch-rates in the SPRFMO exploratory fishery were higher than those typically recorded from much of the adjoining CCAMLR Convention Area. Most fish caught were large Antarctic toothfish and in relatively poor post-spawning condition a spawning ground. Only two Patagonian toothfish were caught and fish bycatch was less than 1% of the total catch by weight in both years (161 kg for both years). Invertebrate bycatch was less than 1 kg in total for both years.

In 2019, the SPRFMO Commission approved the continuation of the New Zealand exploratory fishing for toothfish under CMM-14a-2019, starting in 2019, This exploratory fishery in SPRFMO complements the exploratory fishing research carried out by New Zealand in 2016 and 2019 (Parker et al 2019, Parker et al. 2020) in the northern region of CCAMLR Subareas 88.1 and 88.2 which is immediately south of the SPRFMO fishing area.

In this context SPRFMO and CCAMLR signed an arrangement in 2019 to facilitate, where appropriate, co-operation between the two organisations; particularly with respect to stocks and species which are within the competence and/or mutual interest of both organisations.

The conditions for operation of this second research approval are covered under CMM-14a-2019. Paragraph 6 of the measure states: '*The first exploratory trip each year may occur any time in 2019, 2020, and 2021, with a maximum of four trips each year, with some of the trips between August and October each year to characterise post-spawning dynamics. The remainder of the trips between March and October will provide additional information on spawning dynamics, distribution, and movement patterns.*

Review of results is covered under Paragraph 7. '*The Scientific Committee will review results each year at its annual meeting and advise the Commission on progress, including whether any stock indicators show sustainability concerns and what, if any, additional measures might be required to restrict the likely bycatch of deepwater sharks or other non-target species.'*

This report summarises key interim results from 2019 and 2020 activities in this fishery. A more comprehensive final report will be prepared following the third year of the research for submission to Scientific Committee.

Methods

The 2019 and 2020 SPRFMO research surveys were carried out by the authorised New Zealand vessel San *Aspiring* during the spring (September-October) of 2019 and the late summer of 2020 (February-March). A key objective of the project is to fish (as feasible) similar locations before and after the assumed spawning period to explore spatial seasonal trends (Figure 1).

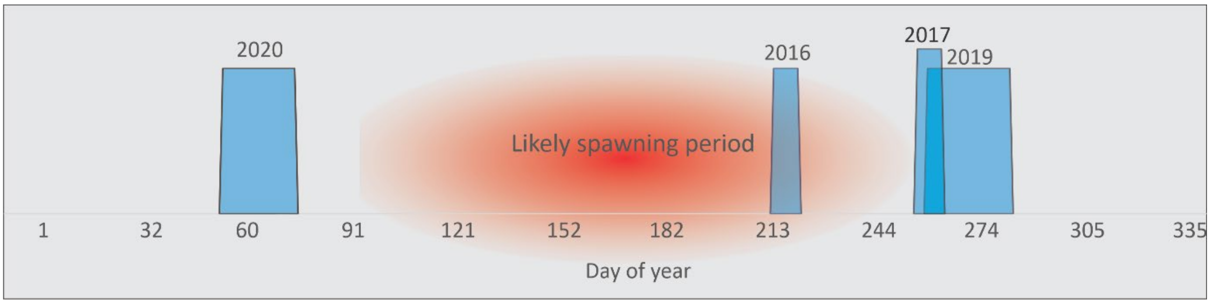

Figure 1. Annual seasonal timings of the four research periods 2016, 2017, 2019, and 2020 referenced to the likely spawning period for Antarctic toothfish Dissostichus mawsoni. The labelled blue boxes identify the time period for each of the four research trips made to date.

The approved research design (CMM-14a-2019) currently restricts sampling to four fishing Blocks close to the southern border of the SPRFMO Convention Area shown in blue in Figure 2. The vessel uses the bottom longline method employing an autoline system with integrated weight line to minimise seabird interactions. This is the identical fishing gear configuration as used for fishing operations and research fishing within CCAMLR and allows comparability with CCAMLR research.

Table 1. Station summary for the 2019 and 2020 toothfish research. There was a total of 35 sets made in 2019 and 32 sets in 2020. Start and end dates referred to the beginning and end of all recorded fishing operations. TOA is the code for Antarctic toothfish. Catch rate is in kg per 1000 hooks hauled.

Fishing Year	Fishing Block	Number of sets	Start date	End date	TOA catch	No of fish	Number of hooks set	Average Soak Time	TOA Catch rate	Mean TOA fish weight
2019	L	10	7/10/2019	11/10/2019	452.58	14	31709	12.24	14.27	31.5
	N	12	25/09/2019	5/10/2019	36048.77	1265	41803	12.29	862.35	27.7
	O	13	16/09/2019	23/09/2019	0	0	50617	11.69	0.00	0
2020	L	10	23/02/2020	27/02/2020	2978.34	115	29138	12.30	102.21	25.7
	N	12	28/02/2020	7/03/2020	37980.93	1399	42421	12.65	895.33	26.5
	O	10	11/03/2020	15/03/2020	0	0	26567	11.56	0.00	0

Results

Toothfish catch

Table 1 summarises the timing and effort of research sets made in the three fishing Blocks (L, N, and O) surveyed during 2019 and 2020. Overall, a total of 67 sets were made during the two years for a total catch of Antarctic toothfish of 77.5 tonnes. The average soak-time (the duration over which the baited hooks were allowed to passively fish) was 12.1 hours which is consistent with CCAMLR toothfish research projects such as the New Zealand winter toothfish research and the annual shelf (pre-recruit) surveys.

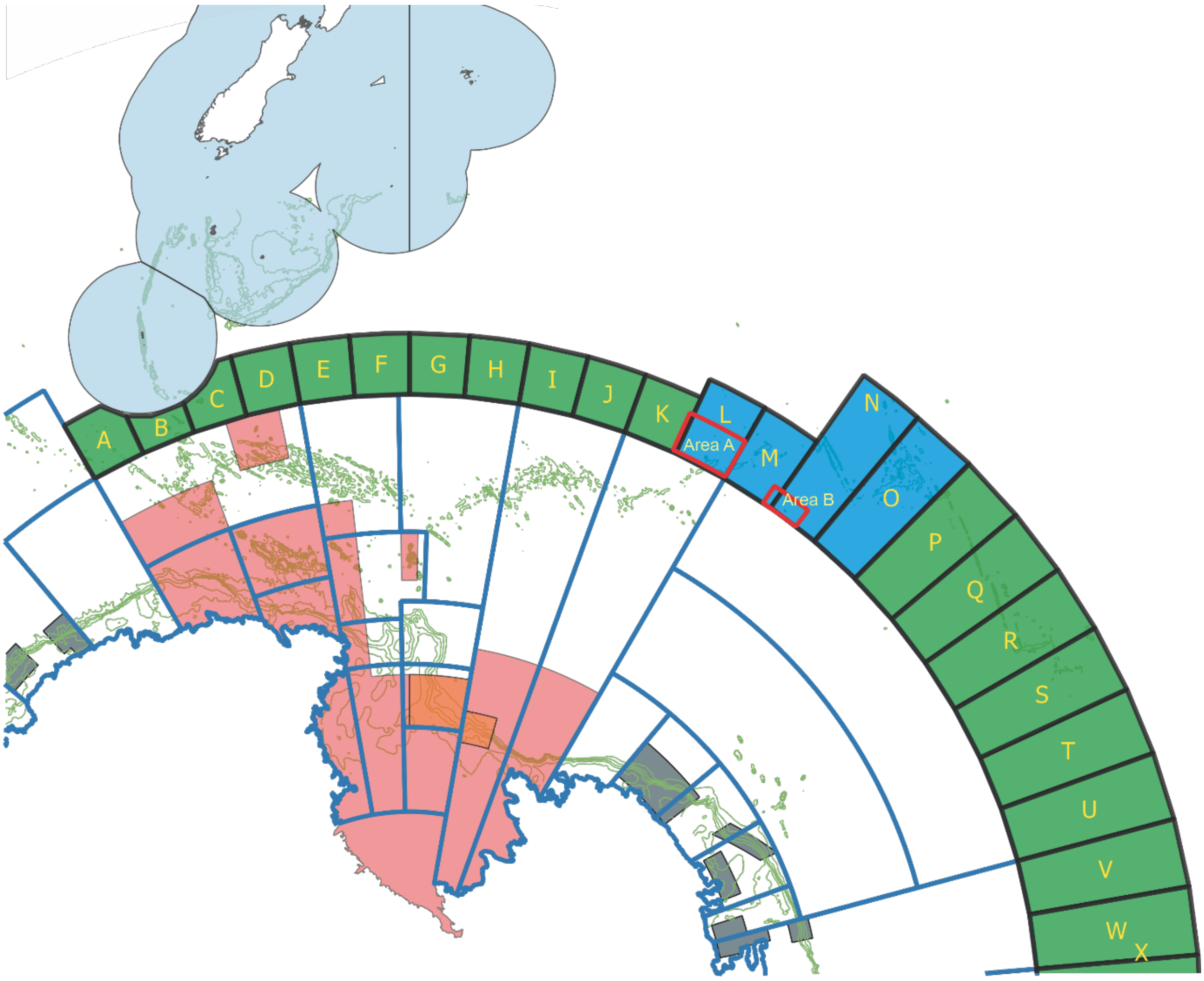

Figure 2. 2019 and 2020 research areas available for fishing coloured blue as defined by CMM-14a-2019. The red boxes (Area A and Area B) show previous research areas from 2016 and 2017.

Bycatch

Bycatch (Table 2) was about 8% of the total catch by weight in 2019 and 4.4% in 2020 and comprised mostly Macrourids (grenadiers or rattails). Macrourids are generally recorded under a collective category by the vessel for reporting, however these were further identified by the scientific observers as caml rattail, Whitson's grenadier, bigeye grenadier, ridge scaled rattail and cosmopolitan rattail for both years. In 2019, bigeye grenadier was found to dominate the species group north of 57°S latitude, while caml grenadier and Whitson's grenadier were mainly found south of 56°S latitude. Two cosmopolitan rattails and one ridge scaled rattail were caught In Fishing Block O.

Other bycatch taxa included Muraenolepids, blue antimora, and Patagonian toothfish (4 individuals). All *Etmopterus* were identified by observers as blue-eyed lantern shark *Etmopterus viator.*

Table 2. Catch and proportions by species for the 2019 and 2020 research sets. Data are from the vessel reported catches.

Common name	**Taxonomic name**	**2019**		**2020**		**Grand Total**
		Weight (kg)	% total	Weight (kg)	% total	Weight (kg)
Antarctic Toothfish	*Dissostichus mawsoni*	36,501.4	87.53%	40,959.3	91.33%	77,460.6
Grenadiers	*Macrourus* spp	1,244.2	2.98%	939.4	2.09%	2,183.6
Blue Antimora	*Antomora rostrata*	1,284.1	3.08%	386.9	0.86%	1,671.0
Morid cods	*Moridae*	553.8	1.33%	15.3	0.03%	569.1
Giant lepidion	*Lepidion* sp.	0.0	0.00%	400.5	0.89%	400.5
Patagonian toothfish	*Dissostichus eleginoides*	80.1	0.19%	65.4	0.15%	145.6
Lantern shark	*Etmopterus* spp	14.7	0.04%	34.0	0.08%	48.7
Brittle stars	*Ophiuroidea*	2.9	0.01%	15.7	0.04%	18.6
Moray cods	*Muraenolepis* spp	0.0	0.00%	9.5	0.02%	9.5
Catsharks	*Scyliorhinus* spp	2.7	0.01%	0.0	0.00%	2.7
Cutthroat eels	*Synaphobranchidae*	0.6	0.00%	0.8	0.00%	1.4
		41,703.48		**44,846.73**		**82,511.21**

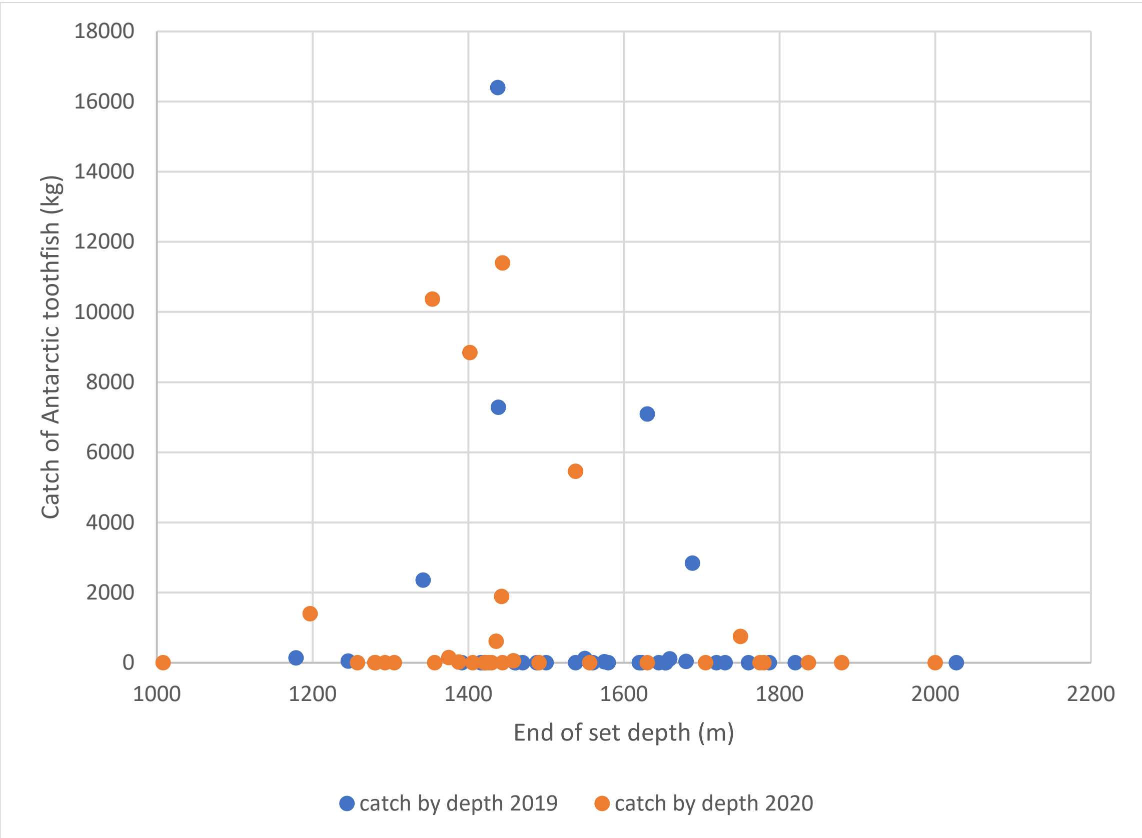

Figure 3. Retained catch per set of toothfish in relation to fishing depth during New Zealand's exploratory fishing in the SPRFMO Area in 2016 and 2017. Additional fish were tagged and released at a rate of three fish per tonne of catch retained.

Figure 3 shows the relationship between depth of fishing (equivalent to bottom depth) and catch for the 2019 and 2020 research. The figure highlights a relatively high proportion of lines with no *Dissostichus* caught. This research is deliberately designed to spread effort widely through the research area fishing in a range of depths which exceeded 2000 m at times consequently resulting in variable catches (and at times nil catch) of *Dissostichus* spp. This effect is also reflected in the higher bycatch levels seen in Table 2 when compared with the CCAMLR target fishery immediately south in which bycatch is typically about 5% of the overall catch.

Biological data were collected from *Dissostichus* spp. and bycatch species from each set (Table 3). Antarctic toothfish were sampled for length, weight, sex, gonad stage and gonad weight. Otoliths were subsampled from the overall sample. The four Patagonian toothfish caught were also sampled for full biological data and otoliths. Biological data were collected from some key bycatch species. As toothfish ageing is a priority focus, bycatch species were not sampled for otoliths.

Table 3. Biological measurements recorded for 2019 and 2020 research.

Fishing season	Common name	Taxonomic name	Species Code	Total Length	Snout-Anus Length	Standard Length (cm)	Weight (kg)	Sex	Stage	Fish Maturity Stage	Gonad Weight (g)	Otolith(s) collected	Stomach fullness
2019	Abyssal grenadier	Coryphaenoides armatus	CKH	2	2	0	2	2	0	0	0	2	0
	Caml rattail	*Macrourus caml*	QMC	134	135	0	135	135	135	135	135	135	0
	Lantern sharks	*Etmpoterus spp*	SHL	43	0	0	43	43	0	0	0	43	0
	Antarctic Toothfish	*Dissostichus mawsoni*	TOA	473	0	0	473	473	473	473	473	473	52
	Bigeye grenadier	*Macrourus holotrachys*	MCH	217	218	0	218	218	209	209	209	218	0
	Patagonian Toothfish	*Dissostichus eleginoides*	TOP	3	0	0	3	3	2	2	2	3	0
	Ridge scaled rattail	*Macrourus carinatus*	MCC	1	1	0	1	1	1	1	1	1	0
	Whitson's rattail	*Macrourus whitsoni*	WGR	21	21	0	21	21	21	21	21	21	0
	Sharks, skates and rays	*Elasmobranchii*	SKX	3	0	0	3	3	0	0	3	3	0
	Total 2019			**897**	**377**	**0**	**899**	**899**	**841**	**841**	**841**	**899**	**52**
2020	Abyssal grenadier	*Coryphaenoides armatus*	CKH	4	4	0	4	4	4	4	4	4	0
	Caml rattail	*Macrourus caml*	QMC	104	104	0	104	104	104	104	104	104	0
	Lantern sharks	*Etmpoterus spp*	SHL	72	72	0	0	72	0	0	0	72	0
	Antarctic Toothfish	*Dissostichus mawsoni*	TOA	510	1	0	509	510	510	510	510	510	63
	Bigeye grenadier	*Macrourus holotrachys*	MCH	193	193	0	193	193	193	193	193	193	0
	Patagonian Toothfish	*Dissostichus eleginoides*	TOP	1	1	0	0	1	1	1	1	1	0
	Ridge scaled rattail	*Macrourus carinatus*	MCC	4	4	0	4	4	4	4	4	4	0
	Whitson's rattail	*Macrourus whitsoni*	WGR	43	43	0	43	43	43	43	43	43	0
	Unidentified bony fish	*Osteichthyes spp*	MZZ	7	7	0	0	7	6	0	0	7	0
	Total 2020			**938**	**429**	**0**	**857**	**938**	**865**	**859**	**859**	**938**	**63**
	Grand total			**1835**	**806**	**0**	**1756**	**1837**	**1706**	**1700**	**1700**	**1837**	**115**

Toothfish biology

Antarctic toothfish total lengths ranged from 108 to 189 cm (Figure 4). Only about 1.5% of the catch-weighted samples (and raw data) for both years was composed by fish shorter than 120 cm total length, indicating a distribution of almost entirely reproductively mature toothfish. Reinforcing previous data from 2016 and 2017 research, the length distribution of males was slightly smaller than females, consistent with records from the northern areas of the Ross Sea region to the south-west. The sex ratio was skewed to males at 60.3% in 2019 and 64.2% in 2020 of the catch-weighted sample, again replicating previous analyses from this area in 2016 and 2017 and observations from the northern hills area of CCAMLR Subarea 88.1. Figure 4 shows the scaled (weighted by the overall number of fish caught for each line) length information collected from the *San Aspiring* research within SPRFMO during 2019 and 2020.

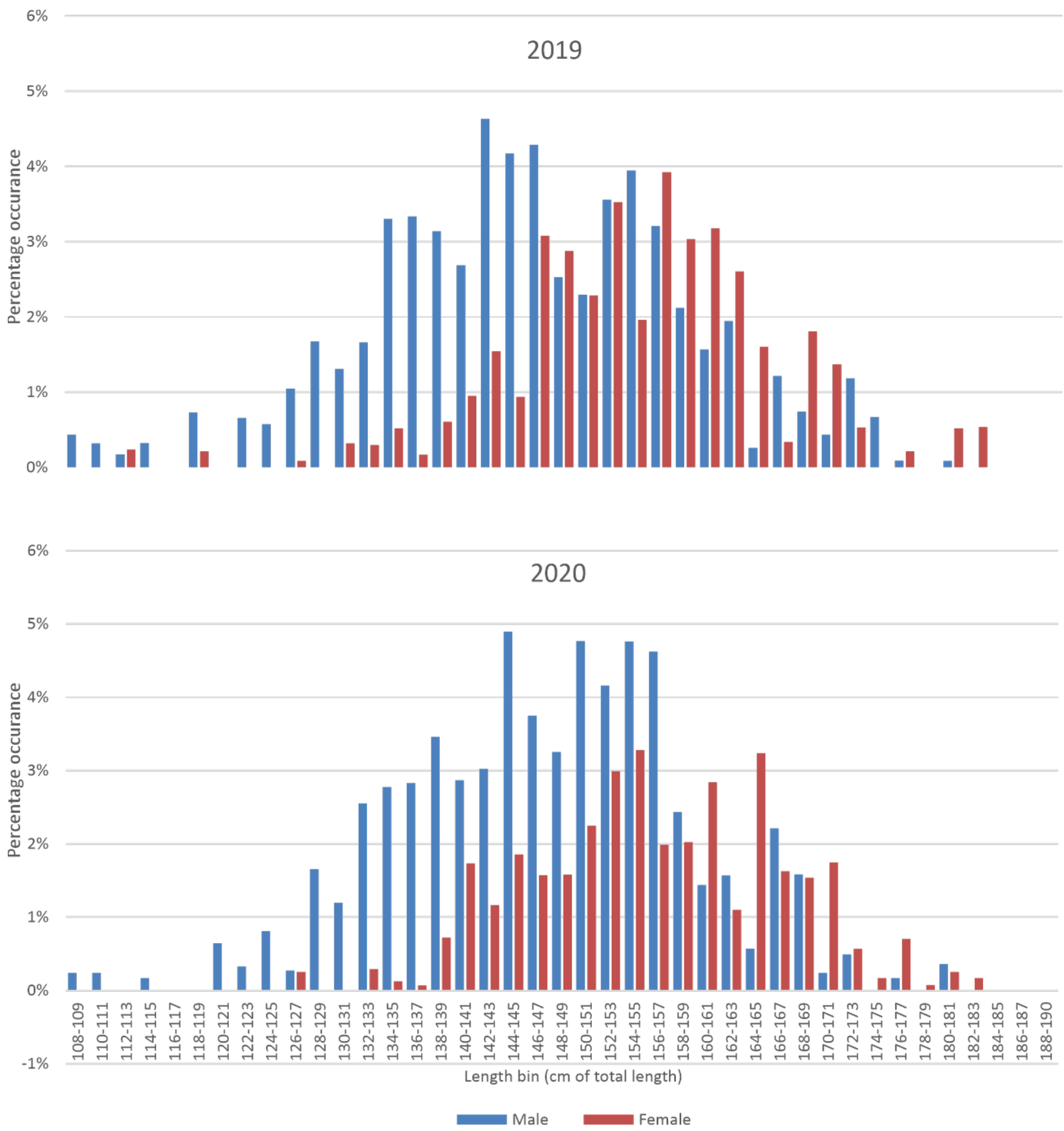

Figure 4. Antarctic toothfish Dissostichus mawsoni scaled length frequency by sex for 2019 and 2020 research. Total scaled sample 1279 fish 2019 and 1511 fish 2020.

The 2020 sample was collected in late summer, reflecting a pre-spawning population, and was compared with the 2019 sample from late spring, a post spawning population. However, the relative size range, overall sex ratio and general length distributions were similar across the two periods.

Gonadosomatic Indices (GSI, gonad mass as a proportion of the total body mass) for Antarctic toothfish (Figure 5) showed that both males and females caught during the 2020 February-March period are in a phase of reproductive development progressing toward spawning, with most males and females showing ripening gonads. This contrasted with the 2019 data from September-October, showing mainly reproductively mature and reproductively spent fish for females and a range from resting to reproductively spent gonads for males. In summary, the 2020 data was consistent with a pre-spawning phase and the 2019 data indicated a late spawning to post spawning phase, thus identifying a spawning period between June and August (Figure 1).

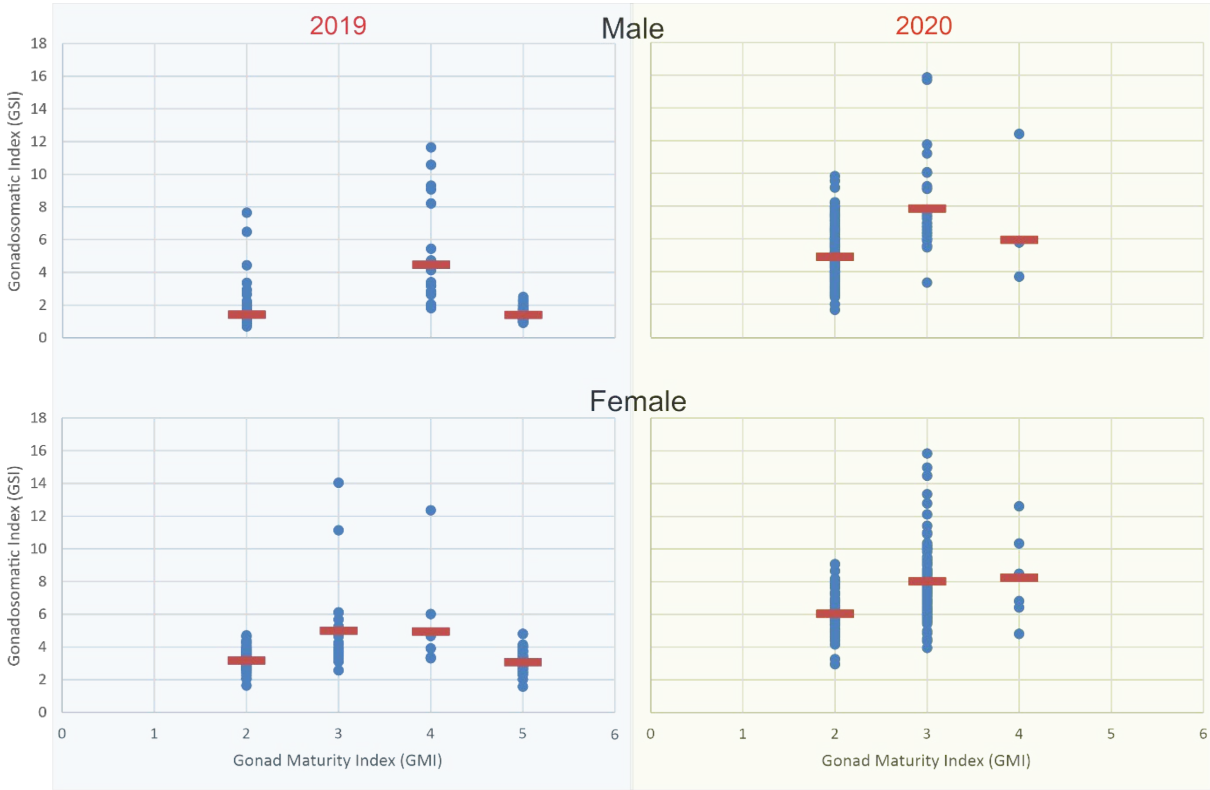

Figure 5. GSI (gonadosomatic indices) plotted by sex and fishing year. Red bars indicate the mean value by recorded gonad maturity index.

Although many of the Antarctic toothfish sampled were recorded as stage 2 (resting or recovering), the calculated GSI weights indicate that most, if not all, of these fish were recovering from spawning in both seasons.

A related metric, Fulton's condition factor or Condition Index (CI) is often used to define general fish body condition; traditionally based on the relationship between the fish length and total body weight for fish species that that grow isometrically. This relationship has been calculated and shown in Figure 6. A modified somatic condition factor (SCF) was also calculated by subtracting the recorded gonad weight from each fish to approximate the somatic weight[1]. This is premised on the recorded data from the Antarctic toothfish biological record showing very few sampled fish with any stomach contents, and assumes that liver mass remains relatively constant and is a smaller contributor to body mass. The data are summarised in Figure 6 and indicate that the pre-spawning fish in 2020 have a marginally worse (SCF) than, or almost identical (CI), body condition to the post-spawning fish from 2019.

The condition of Antarctic toothfish from the biological samples collected in the SPRFMO area over all four seasons generally reflects the 'poor' condition of spawning Antarctic toothfish typically seen in other areas such as the northern Ross Sea 'hills' and the South Sandwich Islands. However, in those other areas we have established a loose inverse relationship between spawning condition and condition factor. In the Ross Sea this is postulated to be an effect caused by a migration of well-conditioned mature fish that had been feeding in the southern slope area moving northward into an area of low food abundance for spawning.

However, this result is consistent with, and supports findings from the 2019 winter survey. Parker et al 2020 reported that sex-specific condition factors were lower than those observed in the summer or pre-spawning winter periods, and much lower than those observed on the Ross Sea slope during the summer fishery.

One possibility is that this more northern SPRFMO spawning cohort is not substantially supported by migration from the south or alternatively, that any migration from more southern regions takes place later in the year during autumn and early winter. Additional sampling pre-and post-spawning in this area may provide more information to further inform these observations. The collection of liver weights during biological sampling may assist in this work.

[1] SCF Somatic body mass here is calculated as the recorded fish weight less the weight of the gonads. Toothfish in general have large gonads at spawning – in females this can be up to 25% of body mass. For this reason, to remove any bias with time in this calculation a separate analysis based on the somatic body weight (i.e. the body weight less weight of reproductive tissue).

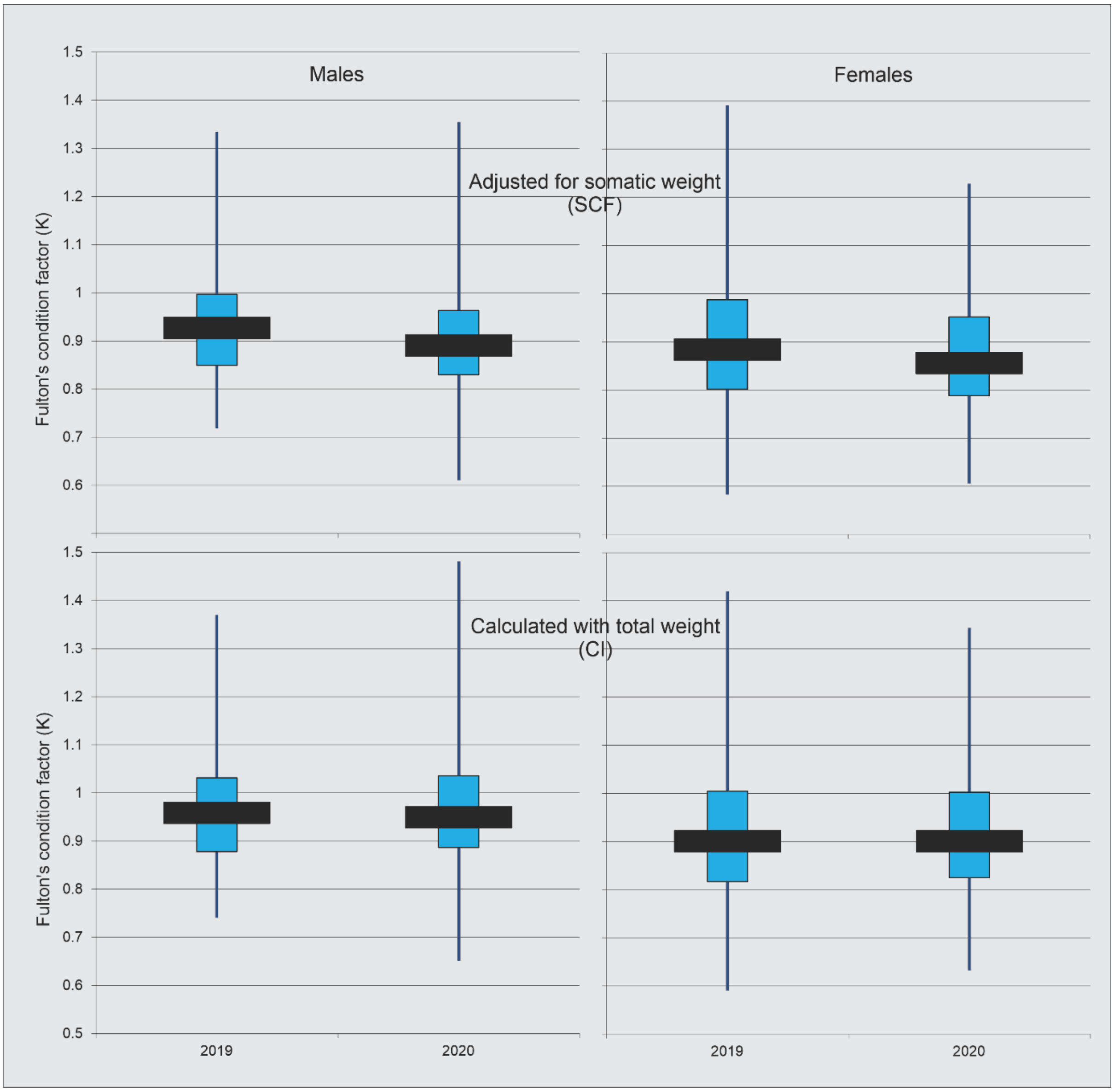

Figure 6. Fulton's condition factor (Condition Index (CI) and modified somatic condition factor (SCF)) plotted by sampling year and by sex

This relative lack of body condition for both sexes is also evident in Figure 7 which shows the length weight relationships by sex for the 2019 and 2020 research. Also noticeable is the generally larger cohort of females in the pre-spawning period from 2020 in comparison to the post spawning sample in 2019.

For the purposes of contrast, Figure 8 compares length weight regression trendlines for samples collected by Sanford vessels from the Ross Sea region (CCAMLR subarea 88.1, data as used by Fenaughty et al. 2008). Fenaughty et al. (2018) also showed that pre-spawning Antarctic toothfish sampled from the South Sandwich Islands show a similar trend to that seen in Subarea 88.1 north, and that these trends are consistent over time.

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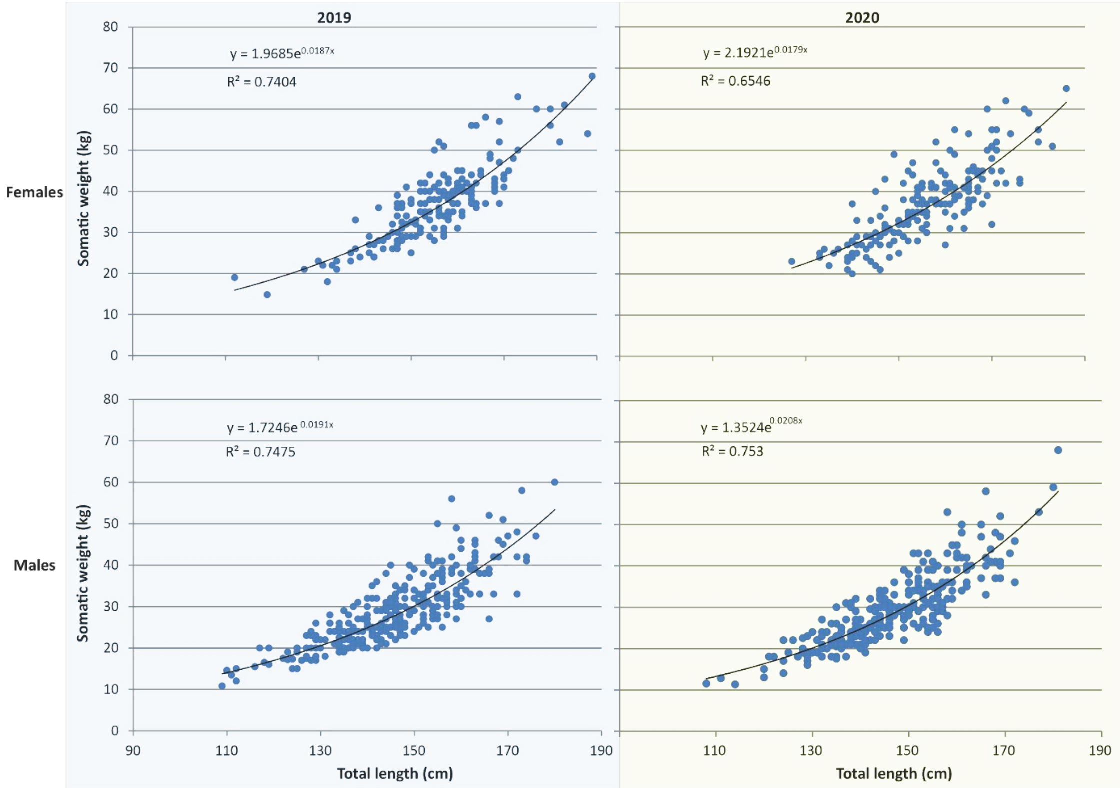

Figure 7. Length weight relationship of male and female Antarctic toothfish sampled during the SPRFMO exploratory toothfish fishery in 2019 and 2020.

Table 4. Length-weight regression coefficients calculated from records taken from Sanford research sets in Subarea 88. (Ross Sea) north and south of 70 degrees S between 2001 and 2006 and from SPRMO Research for 2016 and 2017 combined, 2019 and 2020. The weight is in grams and total length in centimetres. The standard equation is W=aLb

Sex	Area	Season	*a*	*b*	N	R^2
All	88.1 North	2001-2006	0.0176	2.9045	13 073	0.78
	88.1 South	2001-2006	0.0046	3.2068	40 657	0.96
	SPRFMO	2016-17	0.0180	2.8540	565	0.77
	SPRFMO	2019	0.0147	2.9079	473	0.78
	SPRFMO	2020	0.0075	3.0405	509	0.75
Male	88.1 North	2001-2006	0.0326	2.7708	6 547	0.73
	88.1 South	2001-2006	0.0048	3.1979	16 247	0.96
	SPRFMO	2016-17	0.0357	2.7123	365	0.76
	SPRFMO	2019	0.0346	2.7315	293	0.75
	SPRFMO	2020	0.0085	3.0136	282	0.75
Female	88.1	2001-2006	0.0188	2.8474	6 496	0.80
	88.1 South	2001-2006	0.0043	3.2178	24 092	0.97
	SPRFMO	2016-17	0.0177	2.8637	200	0.73
	SPRFMO	2019	0.0208	2.8611	179	0.75
	SPRFMO	2020	0.0270	27942	183	0.66

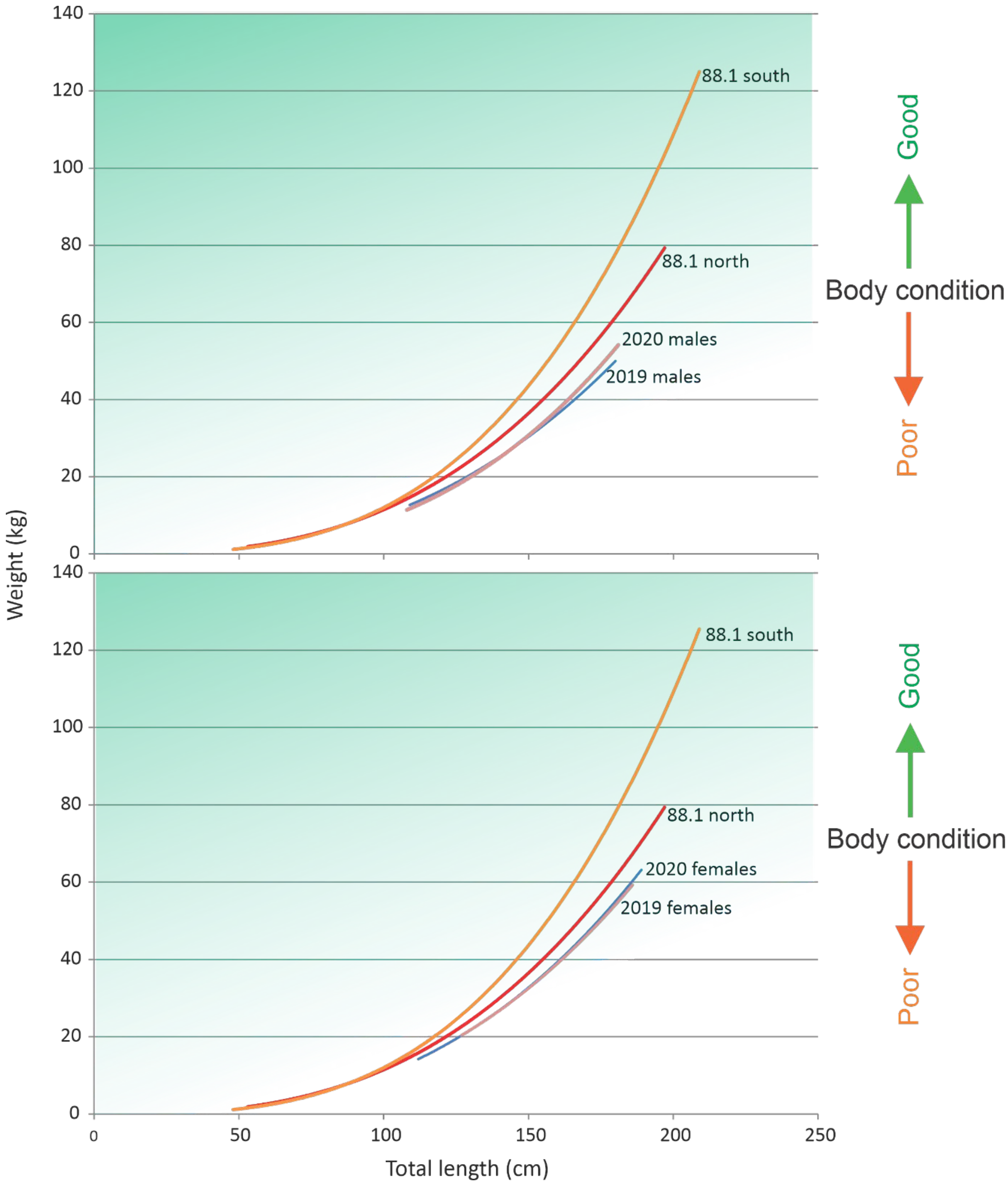

Figure 8. Length weight regression trendlines (power) from CCAMLR 88.1 data 2001 to 2006 (data from Fenaughty et al 2008) with the 2019 in 2020 SPRFMO data plotted for comparison. The data used to produce these plots are summarised in Table 4.

The 2016-17 records from SPRFMO research indicated that the Antarctic toothfish sampled during the post spawning period were in poorer condition than seen in either 88.1 north or in the South Sandwich Islands pre-spawning sample.

Figure 8 shows the trendline from the Southern area of 88.1 (labelled 88.1 S. in the figure). This is an area thought to support a large population of mature Antarctic toothfish feeding in an area of relatively high productivity, potentially in preparation for spawning. The better condition of these fish is clear in Figure 8: for any given length fish of the Subarea 88.1 south area are heavier than the ones of the Subarea 88.1 north and the exploratory fishery area. What is also evident is that the fish sampled from the SPRFMO area (both pre-spawning and post-spawning) are in a poorer condition than even those seen in other spawning fisheries such as the Subarea 88.1 north and the South Sandwich Islands fishery.

Otoliths

During 2019 and 2020, 983 otolith pairs have been collected for ageing. This is in addition to the 460 previously taken during the 2016 and 2017 research. This ageing will be incorporated in the overall New Zealand research assessment on Antarctic toothfish which incorporates both the SPRFMO and CCAMLR areas.

Interactions with marine mammals, seabirds, reptiles, or other species of concern

Seabirds

All line setting was carried out after nautical dusk with no deck lighting and with a tori line deployed. The vessel uses integrated weighted main line (50 grams per metre). A bird exclusion device is permanently deployed to protect the immediate area of water near the hauling position. Offal, used bait and bycatch is minced and then discharged on the opposite side to the haul room only when no setting or hauling is taking place. Sump grates are used to prevent the accidental discharge of offal from the factory floor.

The scientific observer carries out a minimum of one bird observation period during all daylight hauls. The numbers of birds seen varied depending on location and time spent in an area. Most birds were observed circling the vessel or sitting on the water astern of the vessel. The most commonly seen bird species were Cape and Antarctic petrels, black browed albatross, grey petrel, and blue petrel. Also present were giant petrel, wandering albatross, light mantled sooty albatross, sooty shearwaters and Antarctic fulmar. Less commonly recorded were white chinned petrels, Salvin's albatross, Westland petrel, Buller's albatross and grey headed albatross.

One blue petrel was found alive on deck and released unharmed in 2019. There were no seabird interactions in 2020.

Marine mammals, turtles, or other species of concern

No marine mammals were observed in 2019. One small pod of pilot whales was seen in 2020 while the vessel was not carrying out fishing operations. No other marine mammals were observed in 2020.

Tagging

Toothfish are required to be tagged at a rate of 3 fish per tonne of green weight catch retained (approximately 1 in each 10 fish captured). In both seasons the required rate was met.

CMM-14a-2019 par b) requires that: *A minimum tagging rate of three fish of each Dissostichus species per greenweight (live weight) tonne shall be implemented. The rules applied by CCAMLR in the immediately adjacent 88.1 A and B North region, where tagged fish were released starting in early 2015, shall be applied (CM 41-01 Annex C). These rules require a minimum overlap statistic (a comparison between the observed length frequency from vessel biological information and the size composition of fish returned alive with tags, see CCAMLR's calculator) of at least 60% once 30 or more Dissostichus of a species have been successfully released with tags.*

In both seasons the required rate and overlap statistic was met. These are shown by year in Figure 9. Over the four years of the exploratory fishery to date, 308 Antarctic toothfish have been tagged and released.

Tagging was carried out by crew members trained in both the use of tagging and equipment and in the recording of data with oversight by the scientific observer. To ensure that fish to be tagged were randomly selected by size, the haul room crew were periodically instructed (prior to the fish coming on board) to tag the next suitable[2] fish caught. The fish was then carefully removed from the water using a net, placed on a mat on the haul room floor and assessed for condition. If suitable, the hook was removed, the fish was then measured for total length and two white CCAMLR t-bar tags inserted

[2] Conforming to the suitability requirements specified in the CCAMLR Toothfish and Skate tagging instructions - https://www.ccamlr.org/en/system/files/Toothfish%20and%20Skate%20Tagging%20Instructions.pdf

(one tag either side of the anterior part of the second dorsal fin) following the CCAMLR tagging protocol. Once the tag data had been accurately recorded the fish was released back into the water.

In 2019 one Antarctic toothfish tagged during the trip was recaptured the following day. In 2020 there were five recoveries; four had been tagged by *San Aspiring* the previous year and one was tagged in the Ross sea (88.1 K) in 2005, having grown from 73cm to 143cm.

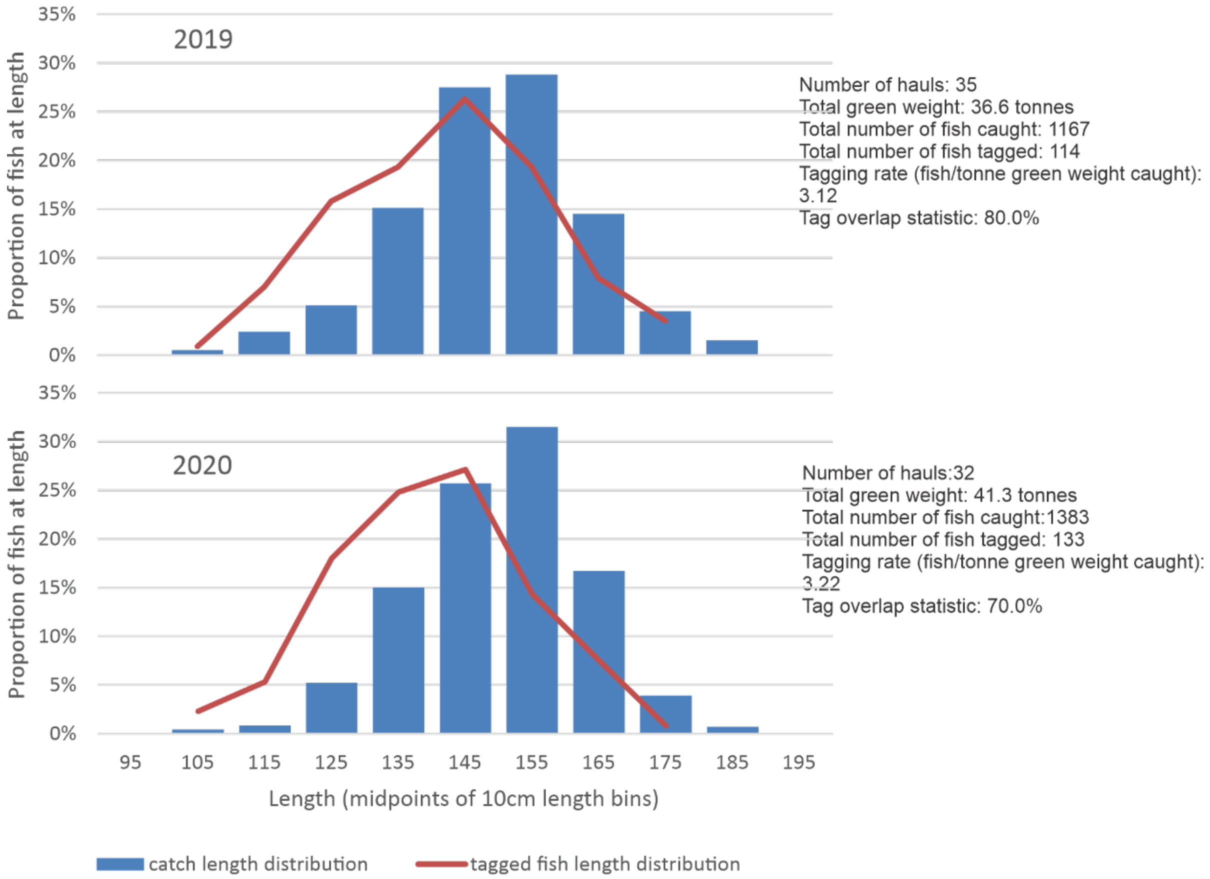

Figure 9. Tagging size overlap statistic for Antarctic toothfish from the SPRFMO exploratory toothfish fishery in 2019 (top) and 2020 (bottom). Weights given are retained weights.

Benthic interactions and potential interactions with VMEs

Following the CCAMLR benthic sampling protocol[3] for bottom longline, lines are divided into numbered segments of 1200 m (equivalent to one magazine of 857 hooks). Any benthos found on a segment are placed by the crew into a 10-litre bucket marked with that segment's number. Benthic species are then identified to taxa level by the observer and weighed to the nearest 10 grams.

[3] This protocol is consistent with SPRFMO CMM 02-2020 Conservation and Management Measure on Standards for the Collection, Reporting, Verification and Exchange of Data, section H and provides comparability with CCAMLR reports from bottom longline fishing.

Most benthic material was found north of 57°S in strata O and N, with precious or red (*Corallium*) corals (CLL) the most frequently observed taxon in 2019 and in 2020, Table 5.

Table 5. Observer identified and recorded benthic species from required benthic sampling protocols.

		Stratum L			Stratum N			Stratum O		
Species		Segments where present	Quantity	Weight	Segments where present	Quantity	Weight	Segments where present	Quantity	Weight
2019										
BPD	Lamp shells							1.7%	2	0.02
CLL	Precious corals				14.6%	8	1.07	40.7%	38	19.38
DDI	Cup corals							1.7%	1	0.03
ECH	Basket stars				12.5%	8	0.9			
CRN	Sea lilies							5.1%	12	1.08
GLS	Glass sponge	9.4%	3	0.16	4.2%	2	0.19	8.5%	6	0.24
ISI	Bamboo coral							5.1%	3	1.85
ONG	Sponges	3.1%	1	0.41				1.7%	1	0.01
PAB	Bubblegum coral							1.7%	1	0.36
PRI	Sea fans				2.1%	1	0.02	1.7%	1	0.02
SOC	Soft corals				2.1%	1	0.01	3.4%	3	0.06
THO	Bottlebrush coral							1.7%	1	0.01
Trip Total 2019										**25.82**
2020										
ANT	Anemone				2.0%	1	0.02			
HDR	Hydroid				2.0%	1	0.02	3.2%	1	0.02
CLL	Precious coral	8.8%	3	0.95	12.0%	8	0.45	25.8%	11	3.45
STP	Cup coral				2.0%	1	0.02			
COR	Hydrocoral									
GOR	Basket star				12.0%	11	0.93			
COR	Hydrocoral				4.0%	2	0.04	3.2%	1	0.08
CRN	Sea lily	2.9%	1	0.03				6.5%	2	0.18
COZ	Bryozoa	5.9%	2	0.02						
GLS	Glass sponge	38.2%	17	2.27	2.0%	1	0.03	9.7%	3	0.14
ISI	Bamboo coral							16.1%	5	1.04
PAB	Bubblegum coral				2.0%	1	0.1			
PRI	Sea fans							12.9%	4	0.93
THO	Bottlebrush coral				2.0%	1	0.02			
ZAH	Zoanthid				2.0%	2	0.03			
CHR	Golden coral	2.9%	1	0.04				3.2%	1	0.02
Trip Total 2020										**10.81**

Summary of key interim results

- Relatively high catch rates of Antarctic toothfish in Strata L and N. Catch rates are similar to those found in two assumed spawning areas in the northern regions of CCAMLR subareas 88.1 and 88.2.

- The toothfish catch was almost entirely of Antarctic toothfish. Four Patagonian toothfish were taken, three large specimens in the NE sector of research Block O in 2019 and a small specimen in the south of RB L.

- Antarctic toothfish sex ratios were skewed, with males dominating in both years. Males were 60.3% of the total sample in 2019 and 64.2% in 2020.

- Fish had poor body condition and low GSI, as observed during previous years. While the presumption for this result from the 2016, 2017 and 2019 data was that this was a consequence of a spawning event shortly before the exploratory fishing was carried out; the 2020 sample collected during late summer, and presumably pre-spawning, also showed similar poor body condition.

- So far 983 otolith pairs have been collected for aging from 2019 and 2020 – from 355 female and 628 male Antarctic toothfish.

- 308 Antarctic toothfish have been tagged since 2016 and five previously tagged fish recovered after at least one season. One of these had come from the Ross Sea slope area and had been at liberty for 15 years.

- Antarctic toothfish size is almost entirely representative of adult fish and is consistent with this being a spawning area for Antarctic toothfish.

- There have been no seabird interactions as a result of fishing and only common and widely distributed seabird species have been recorded attending the vessel. One passing pod of pilot whales was observed while the vessel was not fishing.

- There has been little benthic bycatch, well short of CCAMLR and SPRFMO notification thresholds.

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Appendix 1: Reproductive summary

The following describes the CCAMLR staging that is applied in assessing the fish caught within SPRFMO.

Females

Maturity stage Description

F1. Immature Ovary small, firm, no eggs visible to the naked eye.

F2. Maturing virgin or resting Ovary more extended, firm, small oocytes visible, giving ovary a grainy appearance.

F3. Developing Ovary large, starting to swell the body cavity, colour varies according to species, contains oocytes of two sizes.

F4. Gravid Ovary large, filling or swelling the body cavity, when opened large ova spill out.

F5. Spent Ovary shrunken, flaccid, contains a few residual eggs and many small ova.

Males

Maturity stage Description

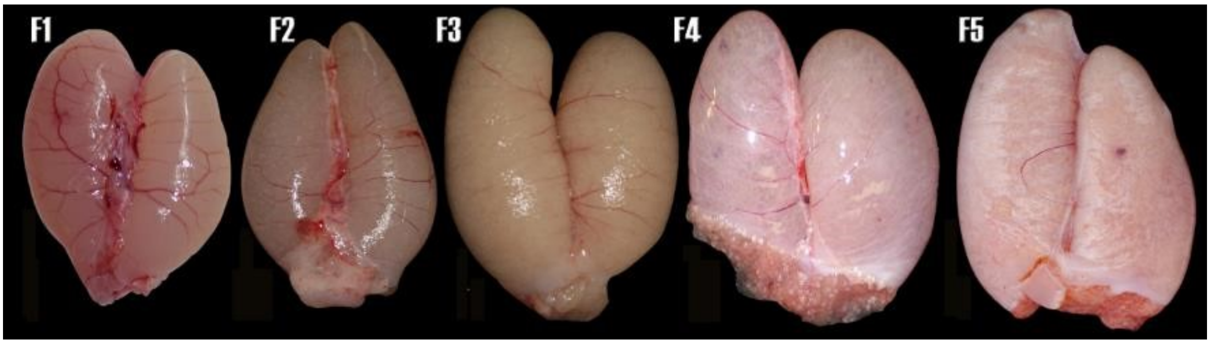
M1. Immature Testis small, translucent, whitish, long, thin strips lying close to the vertebral column.

M2. Developing or resting Testis white, flat, convoluted, easily visible to the naked eye, about 1/4 length of the body cavity.

M3. Developed Testis large, white and convoluted, no milt produced when pressed or cut.

M4. Ripe Testis large, opalescent white, drops of milt produced when pressed or cut.

M5. Spent Testis shrunk, flabby, dirty white in colour.



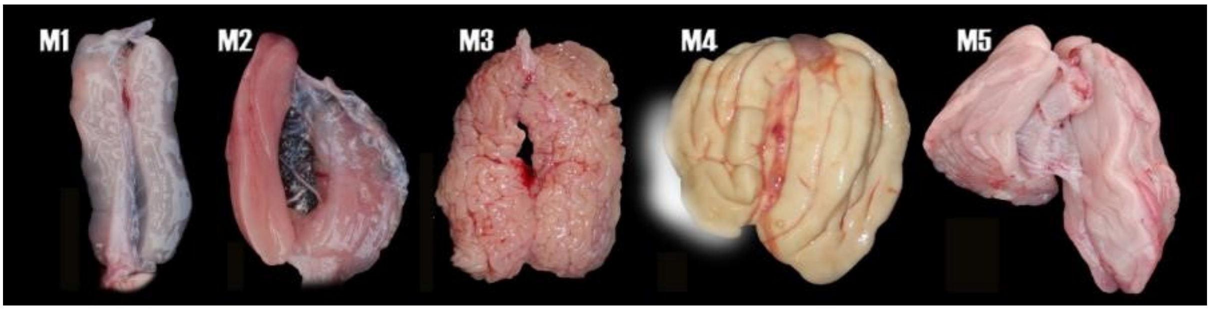


Table 6. Reproductive information collected in 2019 by San Aspiring, see in conjunction with Figure 5.

Stage	**Description males**	**Males**	**Males % of sample**	**Description females**	**Females**	**Females % of sample**
2	Developing or resting Testis white, flat, convoluted, easily visible to the naked eye, about 1/4 length of the body cavity	182	62.1%	Maturing virgin or resting. Ovary more extended, firm, small oocytes visible, giving ovary a grainy appearance.	89	49.9%
3	Developed - Testis large, white and convoluted, no milt produced when pressed or cut.		0.0%	Developing - Ovary large, starting to swell the body cavity, colour varies according to species, contains oocytes of two sizes	26	14.4%
4	Ripe - Testis large, opalescent white, drops of milt produced when pressed or cut	21	7.2%	Gravid Ovary large, filling or swelling the body cavity, when opened large ova spill out.	7	3.8%
5	Spent -Testis shrunk, flabby, dirty white in colour	90	30.7%	Spent Ovary shrunken, flaccid, contains a few residual eggs and many small ova.	58	32.2%
Grand Total		**293**			**180**	

Table 7. Reproductive information collected in 2020 by San Aspiring

Stage	Description males	Males	Males % of sample	Description females	Females	Females % of sample
2	Developing or resting Testis white, flat, convoluted, easily visible to the naked eye, about 1/4 length of the body cavity	274	81.8%	Maturing virgin or resting. Ovary more extended, firm, small oocytes visible, giving ovary a grainy appearance.	62	35.6%
3	Developed - Testis large, white and convoluted, no milt produced when pressed or cut.	54	16.1%	Developing - Ovary large, starting to swell the body cavity, colour varies according to species, contains oocytes of two sizes	106	60.9%
4	Ripe - Testis large, opalescent white, drops of milt produced when pressed or cut	7	2.1%	Gravid Ovary large, filling or swelling the body cavity, when opened large ova spill out.	6	3.4%
5	Spent -Testis shrunk, flabby, dirty white in colour	0	0.0%	Spent Ovary shrunken, flaccid, contains a few residual eggs and many small ova.	0	0.0%
Grand Total		**335**			**174**	