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Sea ice characterisation of the proposed Ross Sea region Marine Protected Area Special Research Zone

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Summary

Paper CAMLR-XXXIV/29 proposes an MPA for the Ross Sea region that includes a Special Research Zone (SRZ) along with three other General Protection Areas. This paper presents an analysis of sea ice within and surrounding the boundaries of the proposed SRZ over the past 16 years, the impact it has had on the fishery in the area during that time, and potential influences sea ice might impose on achieving the objectives of the proposed SRZ in the future. Based on historic satellite-derived sea ice coverage data, the upper shelf and slope areas within the SRZ (fishable depths) were accessible to fishing in about half of the fishing seasons. Over the past 16 seasons, the SRZ was accessible to fishing in January in 8 seasons, open later (mostly after the fishery closed) and never completely cleared in 4 seasons, and remained severely constrained by sea ice in the remaining 4 seasons. However, some catch was still removed from the area in constraining ice years (2010 and 2013). The main influence of sea ice on achieving the proposed objectives of the SRZ pertains to the deployment and subsequent recovery of tagged fish to examine movements and estimate exploitation rate within the SRZ.

1. Introduction

CAMLR-XXXIV/29 proposes an MPA for the Ross Sea region that includes a Special Research Zone (SRZ) along with three other General Protection Areas (Figure 1). In 2013, the Scientific Committee agreed on the importance of research fishing in the SRZ (SC-CAMLR-XXXII paragraph 3.76 (iv)(b)). The configuration of the SRZ as outlined could provide areas with contrasting exploitation rates to compare the effects of fishing between areas of the slope remaining open to fishing, areas of the slope that are lightly fished (SRZ), and the areas of the slope that will be closed to fishing.

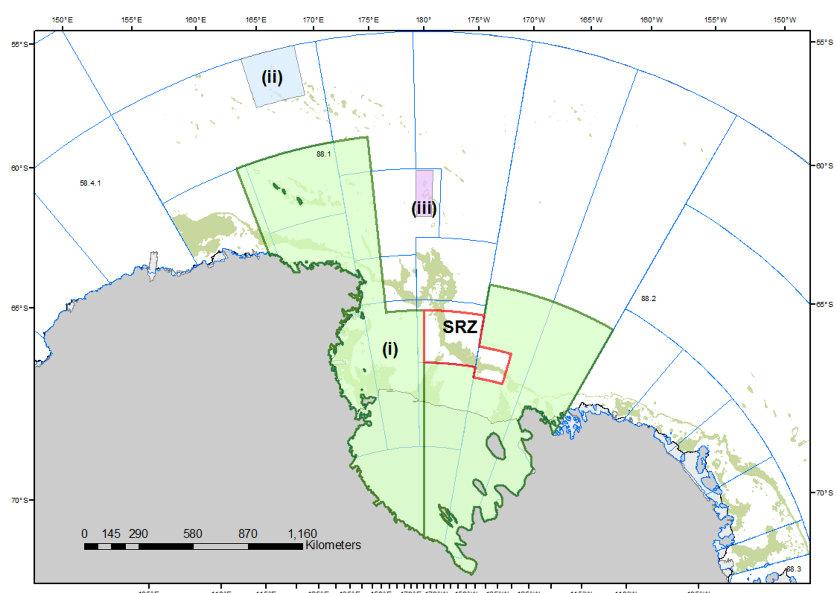


Figure 1: Proposed Ross Sea Region Marine Protected Area, including the boundaries of the General Protection Zone, composed of areas (i), (ii), and (iii), and a Special Research Zone (SRZ). Shaded bathymetry indicates fishable depths 600–1800 m.

Proposed structured fishing within the expanded SRZ would be designed to: maintain the integrity and continuity of the toothfish tagging programme; ensure contrasting local exploitation rates between lighter and more heavily fished locations to better understand the ecosystem effects of fishing and climate change; and better understand toothfish distribution and movements with potential implications for stock assessment (CAMLR-XXXIV/29). The purpose of this paper is to present an analysis of sea ice within and surrounding the SRZ over the past 16 years, the impact it has had on the fishery in the area during that time, and potential influences sea ice might have on achieving the objectives of the SRZ in the future.

2. Sea ice conditions

Two summaries of the historical ice coverage of the area included in the SRZ have been completed (Fenaughty & Parker 2015, Parker et al. 2014). Fenaughty & Parker (2015) summarized the impact of sea ice on fishing operations in a number of focus fishery areas throughout the Ross Sea region. The main slope areas included in the SRZ were polygons G and I (Table 1). These two polygons were ranked as the most constrained by the seasonal pattern in sea ice over the 16 year period analysed. Note that polygon I does not include the portion of the SRZ occurring in Subarea 88.2A.

The seasonal period with the best access to the SRZ based on Fenaughty & Parker (2015) is February. On average only half of each area was fishable during January, and less than 20% in either December or in March.

A detailed summary of the proposed fishable area within the SRZ area shows a similar annual pattern of ice retreat and advance, with some years never allowing fishery access, some for a short period, and some where access was feasible during the fishery (Figure 2). In the past 16 years, 8 years showed a pattern of retreating ice during December and open water within the SRZ in January, supporting the conclusions of Fenaughty & Parker (2015) that access is typically very constrained during December (Table 1). Of the other 8 seasons, four showed intermediate ice coverage (20–40%) that would constrain navigation and fishing activity in some areas, termed here as “marginal” ice coverage . These marginal years were likely accessible only during February. The other four seasons showed a variable pattern remaining near 60% ice cover throughout the season. At this level of ice coverage, even navigation through the area would be difficult for fishing vessels.

These patterns are illustrated by animations showing a year with three generalized levels of access to the SRZ (good, marginal, and poor, Figure 3). Access within the defined SRZ could be further constrained by the condition of the ice bridge regulating access into the Ross Sea polynya (Figure 3), and is not taken into account in the ice analysis of the SRZ itself.

Despite constraints imposed by sea ice in some years on the SRZ area, the fishery has still been able to operate in the area. In 2010, 2013, and 2015, despite bad or marginal ice conditions, the fishery was able to catch 244 tonnes, 654 tonnes, and 272 tonnes respectively in SSRU K (Table 2). This may reflect greater motivation more recently to access the area once the high catch rates became more common knowledge among vessels, or other factors such as inaccessibility of other preferred fishing grounds.

Table 1: The average percentage of area by month that fishing polygons have been fishable 1999–2015. The annual column shows the average of values from all six months for that polygon. Source: Fenaughty & Parker (2015).

Polygon	Dec	Jan	Feb	Mar	Apr	May	Annual
G (north)	20.1	52.9	58.5	23.5	0.0	0.0	25.8
I (south)	19.2	50.8	59.1	6.4	0.0	0.7	22.7

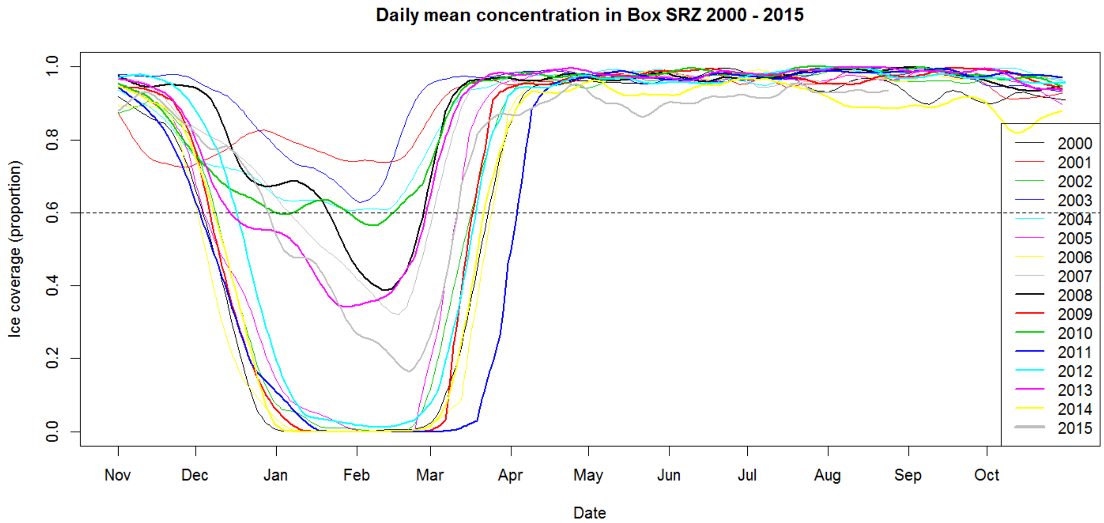
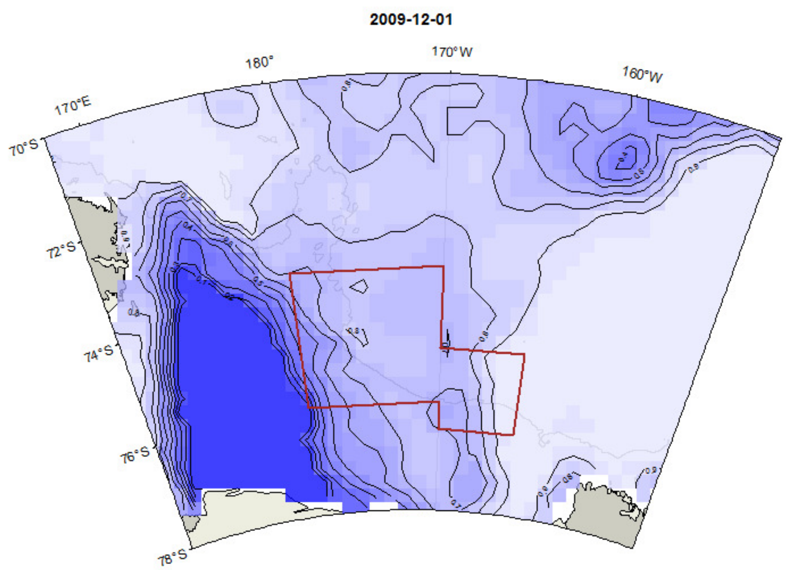


Figure 2: Daily mean sea ice concentration within the fishing footprint of the SRZ from November through April for fishing years 2000–2015. A threshold of 60% sea ice concentration was considered to be the maximum level of navigable sea ice observed for fishing vessels in the Ross Sea, though fishing typically occurred in areas with less than 15% ice coverage (see Parker et al . 2014). Note that very few locations have been fished in the portion of the SRZ in SSRU 88.2A, and therefore this figure does not index that area (see Figure 4)



Click 2014 animation: good ice conditions in SRZ
Click 2008 animation: marginal ice conditions in SRZ
Click 2010 animation: poor ice conditions in SRZ

Figure 3: Animation of the daily sea ice concentration in the SRZ (red polygon) for the 20th of December through the 1st of April in fishing years 2014, 2008, 2010, representing good, marginal, and poor access to the SRZ). Dates are embedded at the top of the animation. Sea ice concentrations from open water (0, blue) to 1 (100% ice coverage, semi-transparent white). Solid white indicates missing data or permanent ice clipped from satellite images. Each pixel shows the value for that cell for the period shown and the mean value for all pixels within the red polygon is shown in the box at the bottom of the image. Sea ice concentration contour lines every 0.10. SSRU boundaries and the 1000 m depth contour are visible in the background of the image. HTML controls allow the animation to be paused, reversed, advanced, or sped up.

Table 2: Details of the number of vessels fishing and resulting catch in SSRU 88.1K, the subjective sea ice condition for 88.1K, and the number of vessels fishing and resulting catch for the Ross Sea fishery from 2000–2015 seasons.

Year	Vessels fishing in 88.1K	Catch (t) in 88.1K	88.1K sea ice	Total # vessels in Ross Sea	Total Ross Sea catch (t)
2000	3	183	Good	3	752
2001			Bad	7	623
2002	1	121	Good	2	1 367
2003			Bad	9	1 795
2004	1	<0.5	Bad	21	2 190
2005	9	709	Good	10	3 217
2006	6	590	Good	13	2 968
2007			Marginal	15	3 091
2008	4	60	Marginal	16	2 259
2009	6	861	Good	13	2 448
2010	5	244	Bad	14	2 869
2011	6	644	Good	15	2 850
2012	10	1 570	Good	16	3 214
2013	17	654	Marginal	18	3 186
2014	8	771	Good	20	2 924
2015	9	272	Marginal	14	2 834

Note the table includes the following quarantined catches:

2011	1	0		1	45
2013	1	151		1	157
2014	1	86		1	109
2015	1	171		1	304

3. Potential effect of sea ice on achieving SRZ objectives

The effects of sea ice on the distribution of fishing effort may influence the likelihood of achieving the proposed objectives for structured fishing within the SRZ.

3.1 Objective 1: Integrity of tagging programme

If sea ice prevents fishery effort in the SRZ then both deployments of tagged fish and the potential for recapture of tagged fish in the following year(s) are impacted. The presence of tagged fish in an area where recovery effort cannot occur creates a bias in the mark-recapture estimator. The scale of that bias depends on the numbers of tagged fish that can be recaptured and the pattern of fishing effort (Mormede et al. 2014). The direction and extent of the bias under different management scenarios (including two MPA scenarios) was examined by Mormede et al. (2015), but the exact level of bias would depend on the final nature of tagging rates and catches etc. This is already the case as the fishery in SSRU 88.1K is variable among seasons (Table 2), however increasing the tagging rate in this area could increase the inter-annual bias created in that area. As the eastern portion of the SRZ can be more constrained by sea ice conditions (Figure 4), release of tagged fish and recovery effort in subsequent years in this area would require multiple years of favourable ice conditions, and may be sporadic compared with areas further west.

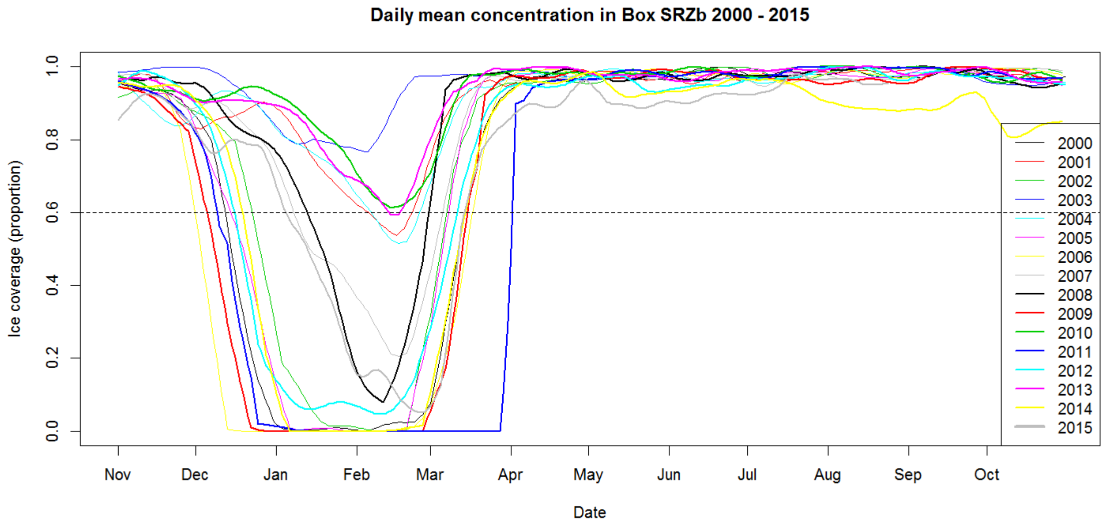


Figure 4: Daily mean sea ice concentration within the portion of the proposed SRZ occurring in SSRU 88.2A from November through April for fishing years 2000–2015.

3.2 Objective 2: Relative exploitation rates and effects of climate change

Although some fishing in the SRZ was carried out in nine of the last ten years, it is unlikely that full access will be available every year, and therefore it is likely that the catch allocation for the SRZ in some years would not be caught. While this would act to increase the contrast in exploitation between the slope and the SRZ, it will also tend to reduce the numbers of tags available for recapture within the SRZ (due to movement and natural mortality occurring in unfished years). Because tag recaptures are necessary to estimate exploitation rates, this in turn will influence the precision of exploitation rate estimates possible within the SRZ. Furthermore, the longer the time at liberty, the more the calculated exploitation rates are confounded with migration parameters.

Monitoring the trends in environmental variables as correlates to changes in climate will be important data for the MPA monitoring programme. Where possible, stationary, long-term observation stations would be needed to record physical and chemical variables through time. Some examples would be temperature, current speed and direction, and turbidity. Remotely sensed data on sea ice distribution, thickness, and movement patterns, along with primary productivity, wind, surface temperature, and cloud cover can be collected from existing platforms (e.g. see http://www.soos.aq). Ship-based environmental monitoring of environmental variables (e.g. via CTD), secondary productivity and time-series of observations of benthic communities can also be monitored for change. Fisheries observations can be used to monitor location-specific toothfish diet, age composition, and movement patterns. In addition, bycatch composition and distribution can be monitored in each area from fishing vessel platforms.

The effects of climate change are likely to be undetectable in short time scales and therefore sampling should occur periodically and intensively to precisely characterise areas of interest with respect to the biological and physical variables to be monitored. Additional research would be needed to recommend the appropriate frequency, intensity, locations for each of the environmental variables of interest.

Sea ice conditions are likely to have strong influences on environmental variables, but will also influence the ability for vessels to reach areas in order to make ship-based measurements, making long-term, sub-surface moorings a better choice for continuous data collection for some variables. Sea ice will also prevent some remotely sensed variables such as chlorophyll from being observed.

Objective 3: Toothfish distribution and movement

One potential method to document and monitor movement patterns of fish from within the SRZ is to tag and release fish with pop-off satellite transmitters (PSATs). This tag design does not rely on the fishery for recovery and therefore the location of the fish at a specified deployment time can be documented provided that the tag floats to the surface free of ice. This constraint on the use of PSATs may be severely limiting in and around the SRZ, but tagged fish moving west into the polynya would have less of a risk associated with sea ice interference. Alternatively, archival tags that record fine-scale depth, temperature, acceleration, light, and magnetic field are available but designed to be recovered by the fishery. Initial research to deploy PSATs within SSRU 88.1K is currently underway by the USA (Jones 2015).

4. References

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