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TASMANIAN SCHOOL OF BUSINESS AND ECONOMICS

Behavioural impact of marine protected areas (MPAs) in international waters

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MPAs in international waters

- MPAs are established to protect marine ecosystems by delineating regions with resource use limitations.

- Urgency of creating MPAs in international waters
  - 33% of marine fish stocks in the international waters are over-exploited (FAO, 2018)
  - less than 2% of the high seas are under protection (Brooks et al., 2020; WDPA, 2021)

- Open access resources: MPAs beyond national jurisdictions are difficult to be implemented and regulated

Fisher behaviour and the success of MPAs

- Fisher behaviour was emerging as a contextual subject of marine protection policies (Bennett, 2019)

- Understanding the fisher behaviour is important to assess:
  – 1. potential benefits; 2. changes in fishing pressure; 3. effectiveness of conservation

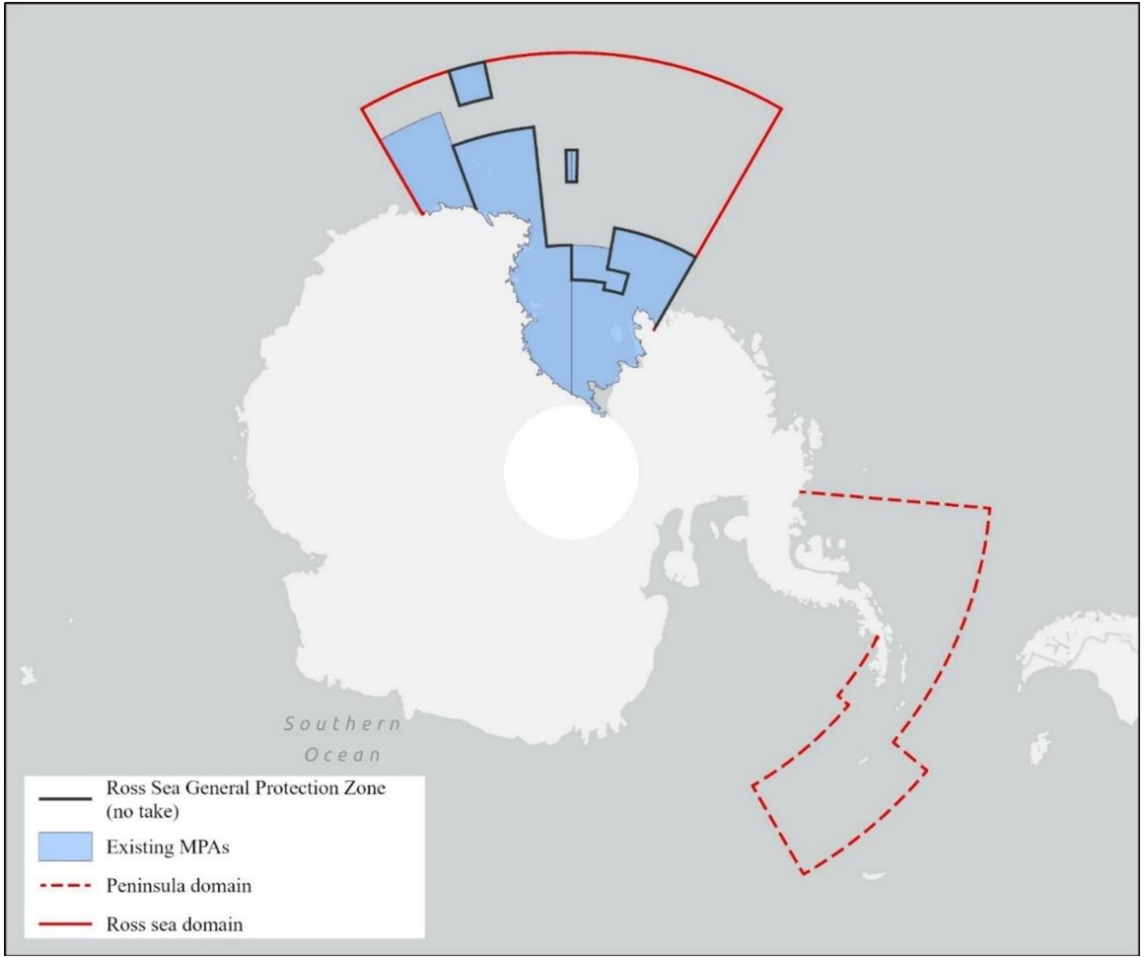
- Potential behavioural responses
  – Fishers may breach the marine conservation rules, including fishing across the borderlines
  – Fishing-the-line: fishing efforts may spill-over from MPAs to the surrounding unprotected waters and concentrate at the boundaries
  – Exploit alternative fishing grounds

Our paper

- Investigate fishers' behavioural response to a remote and large-scale MPA
- Implemented two quasi-experiments to identify the causal effects of the Ross Sea MPA on fishers' behaviours
  - Regression discontinuity (around the Ross Sea)
  - Difference-in-differences (global patterns)

Marine conservation in the Southern Ocean

- The Southern Ocean covers 10% of oceans in the world, most of which are high seas under the Antarctic Treaty
- Regulated by Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)
- Timeline of the Ross Sea MPA:
  - initially proposed by New Zealand and the United States in 2012;
  - agreed by 26 CCAMLR members in Oct 2016;
  - officially went into force from Dec 2017 to 2050



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Research questions

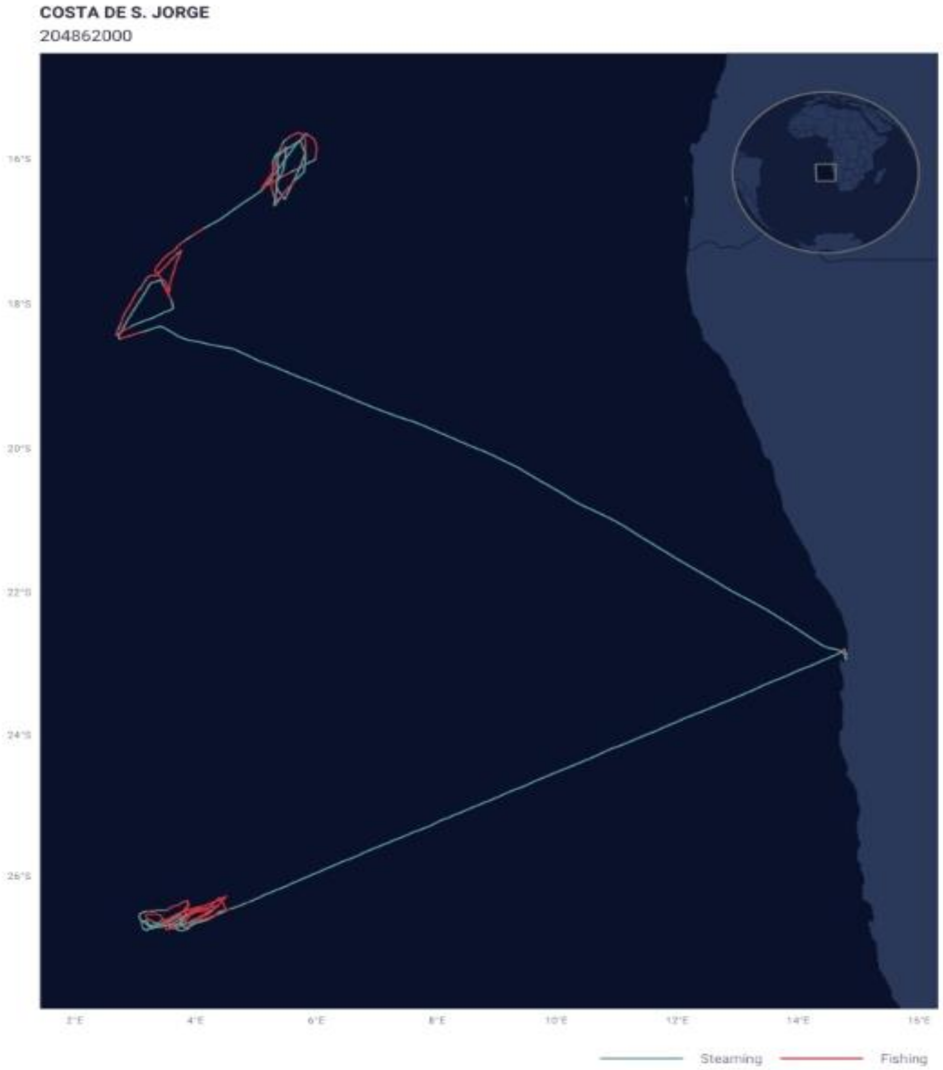
1. Was the Ross Sea MPA effective in deterring fishing efforts?

2. Did fishing efforts spill-over to the borderlines (fishing-the-lines)?

3. To what extent did MPA influence fishers' behavioural patterns?

Data

- Automatic identification system (AIS) data (Global Fishing Watch)
  - Covers from 2012-2019
  - AIS transceivers can uniquely identify a ship by its Maritime Mobile Service Identity (MMSI) code
  - AIS transceiver reports the vessel’s location to ground stations or satellites
  - Vessel-level fishing and sailing activities data binned to 0.1 degrees grids
  - Convolutional neural networks are trained to detect fishing activities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Steaming
Fishing

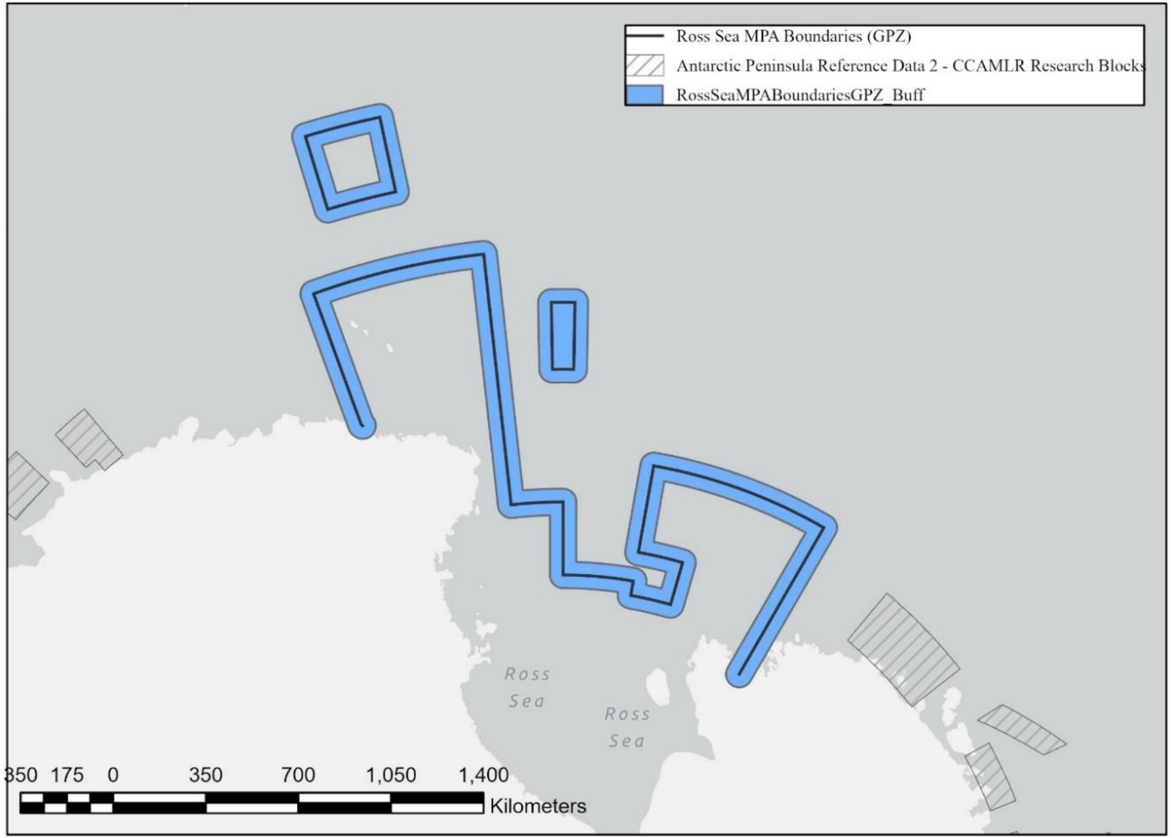
Regression Discontinuity (RD)

- Purposed to examine the fishing activities around MPA boundaries
- Use administrative boundaries to split samples into treated and control units
- The discontinuity can be measured by comparing the units just inside with outside jurisdiction
- Sample inside and outside the boundaries should not be affected by unobserved confounders

Regression Discontinuity – sample and model

- Cut-off: MPA’s no-take zone boundary
- Sample range: fishing efforts within the 50-kilometres buffer rings around the boundary
- Running variable: observations’ geodesic distance to the boundary
- Dependent variables: fishing hours
  - aggregate the fishing effort into 100 bins
- Estimation: $y_{i,p} = \alpha + \tau D_{i,p} + \beta x_{i,p} + u_{i,t}$

Regression Discontinuity – the map



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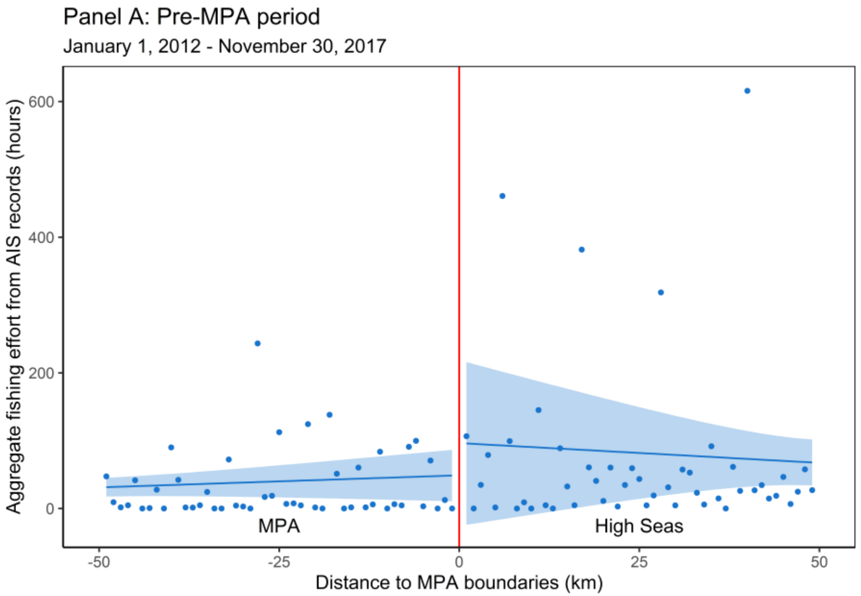
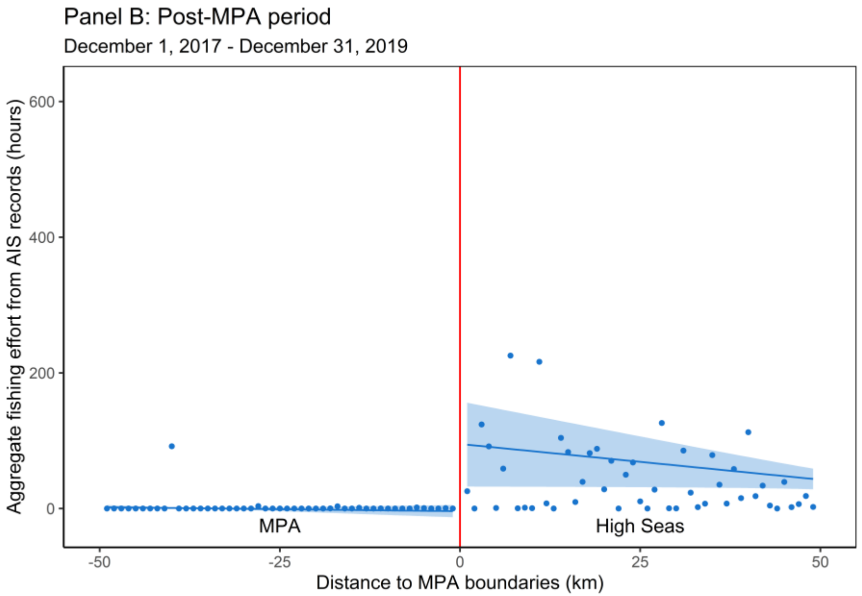
Regression Discontinuity - results





	(1) Fishing effort	(2) Fishing effort
Pre-MPA deterrence	47.525	
	(42.647)	
Post-MPA deterrence		***66.953****
		(27.306)
Observations	100	100

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Difference in differences

- Purposed to examine fisher's behavioural change due to the establishment of the Ross Sea MPA

- Ross Sea vessels (treatment group) *versus* Antarctica Peninsula vessels (control group):
  - similar administrative and fishing conditions
  - different target species

- Outcome variables: Daily time spent on fishing and sailing

- Estimation: $y_{i,t} = \beta_0 + \beta_1 D_i^{Treat} + \beta_2 D_t^{MPA} + \beta_3 D_i^{Treat} \times D_t^{MPA} + \beta_4 FEmonth + \beta_5 FEyear + \beta_6 FEvessel + \varepsilon_{i,t}$

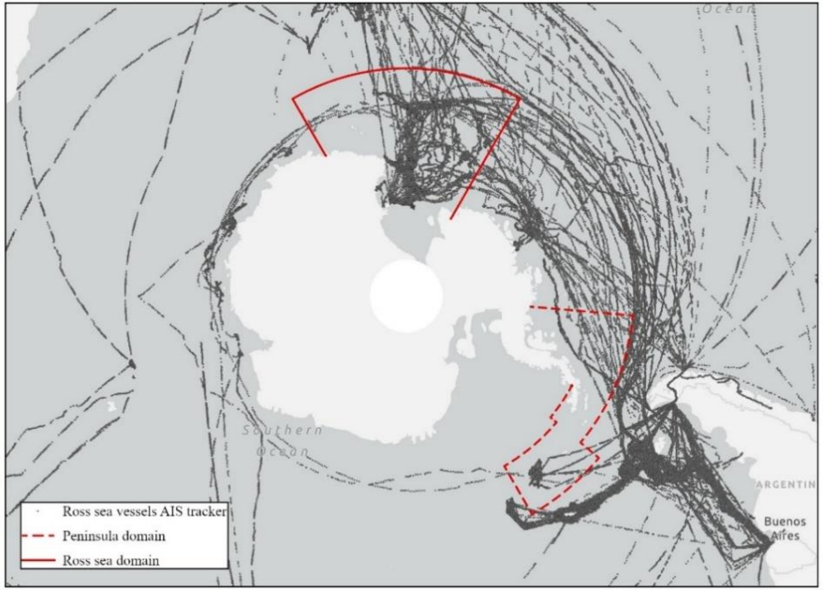

Figure a. Ross Sea vessels footprints before MPA establishment

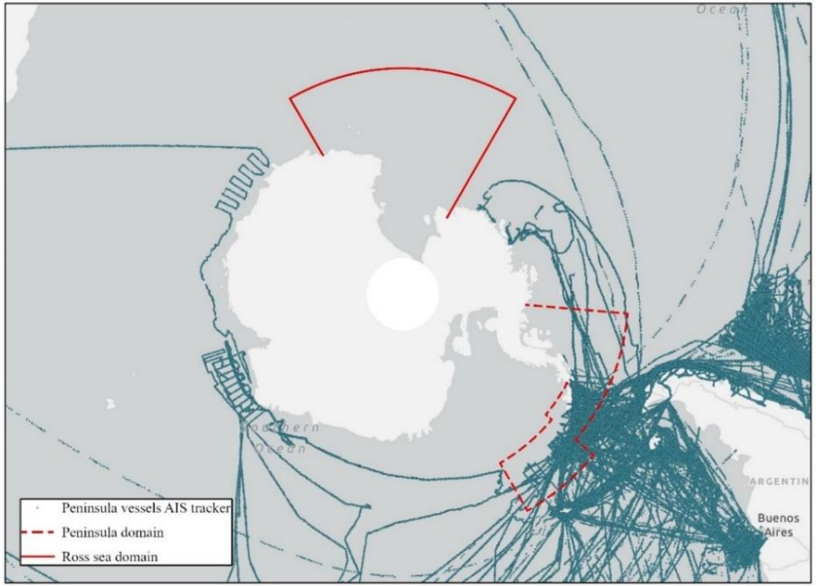

Figure b. Peninsula vessels footprints before MPA establishment

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Difference in differences - results

	Panel difference-in-difference		
Dependent variables	(1) Fishing hours	(2) Sailing hours	(3) Sailing rate (%)
Ross Sea vessels	2.615*** (0.303)	-2.846*** (0.305)	-10.835*** (1.250)
MPA	0.018 (0.344)	-0.152 (0.361)	-0.776 (1.468)
Ross Sea vessels × MPA	***-0.847****** ***(0.137)***	***0.711****** ***(0.139)***	***2.998****** ***(0.572)***
Constant	3.780*** (0.274)	19.754*** (0.279)	83.893*** (1.137)
Number of observations	90,602	90,602	90,602
Number of vessels	47	47	47
R2	0.155	0.146	0.158

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Difference in differences – sensitivity analysis

- Dynamic DiD

$$y_{i,t} = \beta_0 + \beta_k \sum_{k=T0}^{-1} period_k \times D_i^{Treat} + \beta_k \sum_{k=0}^{T1} period_k \times D_i^{Treat} + \beta_7\, FEvessel + \varepsilon_{i,t}$$

	Dynamic panel difference in differences			
Dependent variables	(1) Fishing hours	(2) Sailing hours	(3) Sailing rate %	(4) Estimated period
Ross vessel × MPA (<-2)	-0.359 (0.619)	0.243 (0.603)	1.185 (2.545)	1 Jan 2012 - 31 Dec 2014
Ross vessel × MPA (-1)	-0.216 (0.515)	0.021 (0.495)	0.618 (2.115)	1 Jan, 2015 - 31 Dec, 2015
Ross vessel × MPA (0) ***(Announcement)***	***-0.818**** ***(0.416)***	0.647 (0.391)	3.015 (1.724)	28 Oct 2016 - 30 Nov 2017
Ross vessel × MPA (1) ***(Implementation)***	***-1.357****** ***(0.369)***	***1.245****** ***(0.315)***	***5.263****** ***(1.374)***	1 Dec 2017 - 3 Nov 2018
Ross vessel × MPA (>2)	***-2.833****** ***(-0.519)***	**2.632***** **(0.459)**	***11.277****** ***(2.141)***	1 Dec 2018 - 31 Dec 2019
Constant	11.006*** (0.307)	12.682*** (0.292)	54.054*** (1.272)	

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Discussion

- The Ross Sea MPA is effective in deterring fishing activities
  - Conducting illegal fishing in Antarctic waters is easy to be detected
- No fishing-the-lines were observed
- Only one vessel exited the fishery after MPA's establishment
- However, the remained fishers spent less time on fishing due to the loss of fishing ground in the short-term
- In the long-term, they may exit or change species/gears/fishing grounds
- Due to the lack of catch data, our analysis could not address the economic impact of MPAs