Hot spots in the ice: importance of polynyas for marine ecosystems
(Final year of project)

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Kristen Krumhardt, Laura Landrum, Zephyr Sylvester, Marika Holland, Stephanie Jenouvrier, Sara Labrousse, Alice Eparvier, Michelle LaRue, Bilgecan Sen, Christian Che-Castaldo, Cassandra Brooks
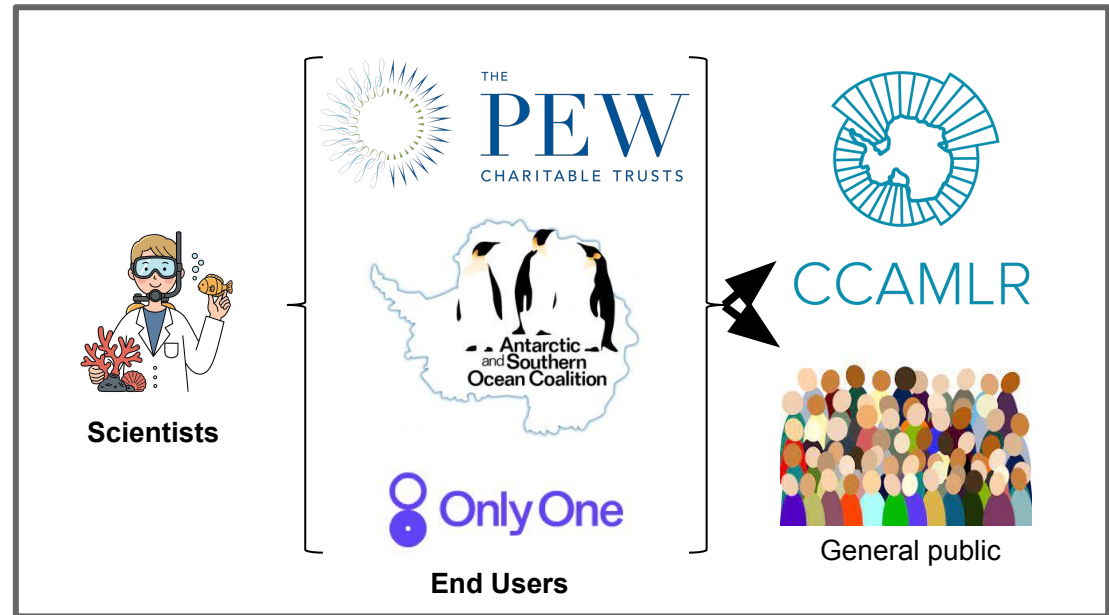
Photo: John Weller

Antarctic Conservation

- The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is the multi-national body which manages the Southern Ocean

- Process:

  - Consensus based decisions

  - Decisions must be grounded in the "best available science"

  - Science <u>must</u> go through working groups and national delegations in closed meetings

Science-Policy-Public Interface

Scientists

End Users

General public

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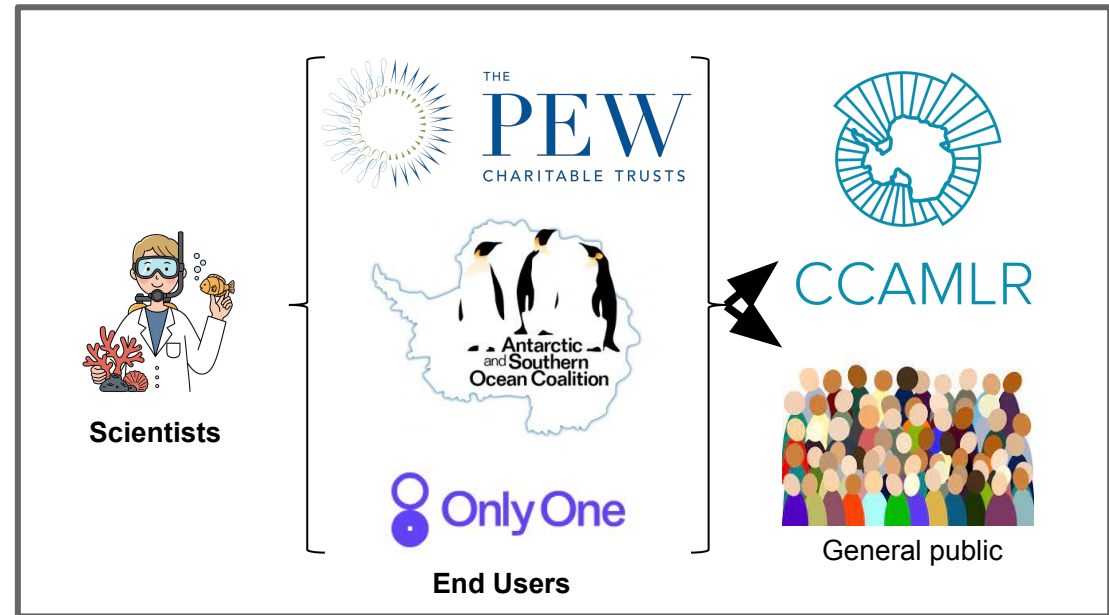 - Science <u>must</u> go through working groups and national delegations in closed meetings

Science-Policy-Public Interface

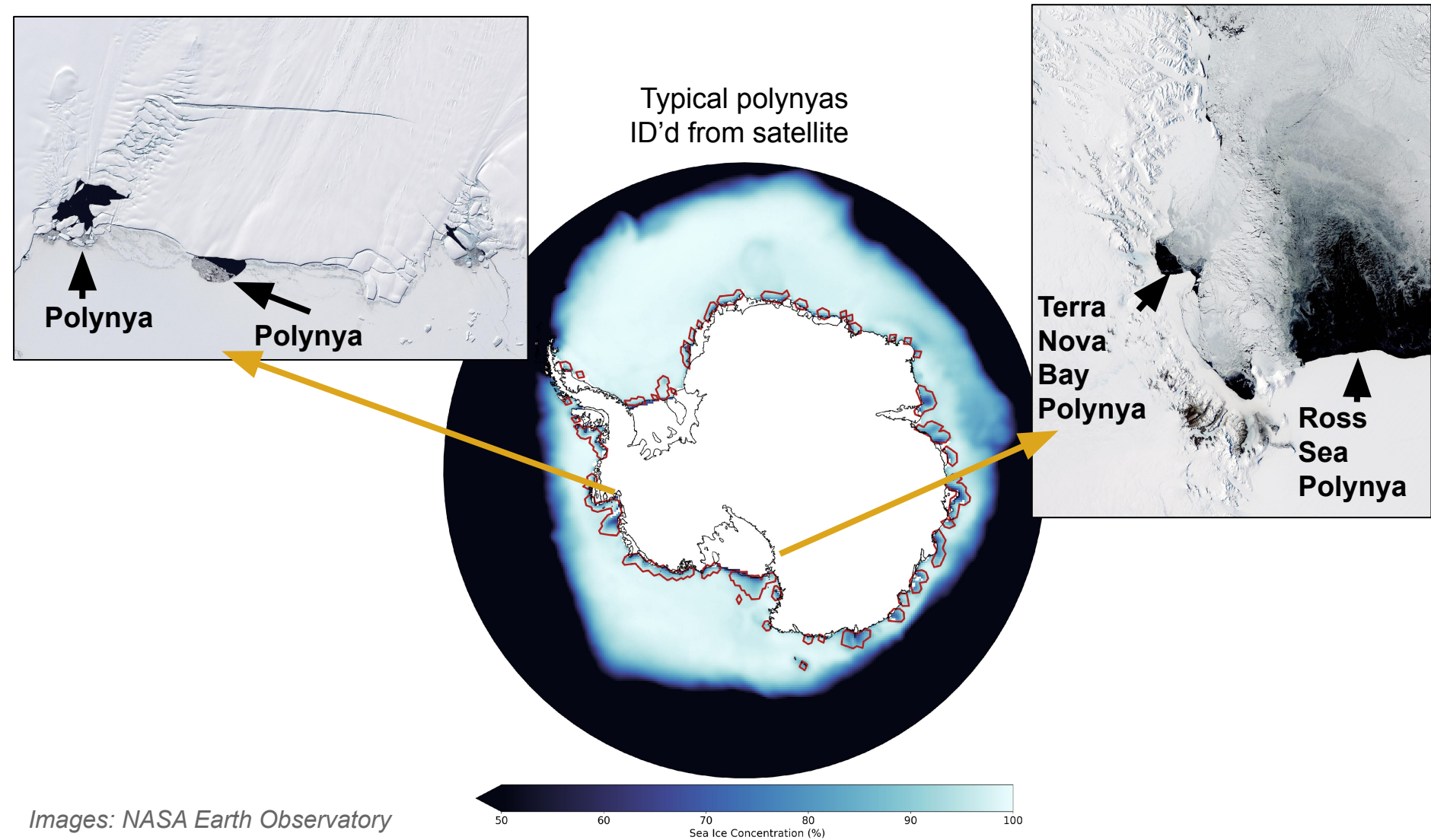Scientists

End Users

General public

End-user goals:
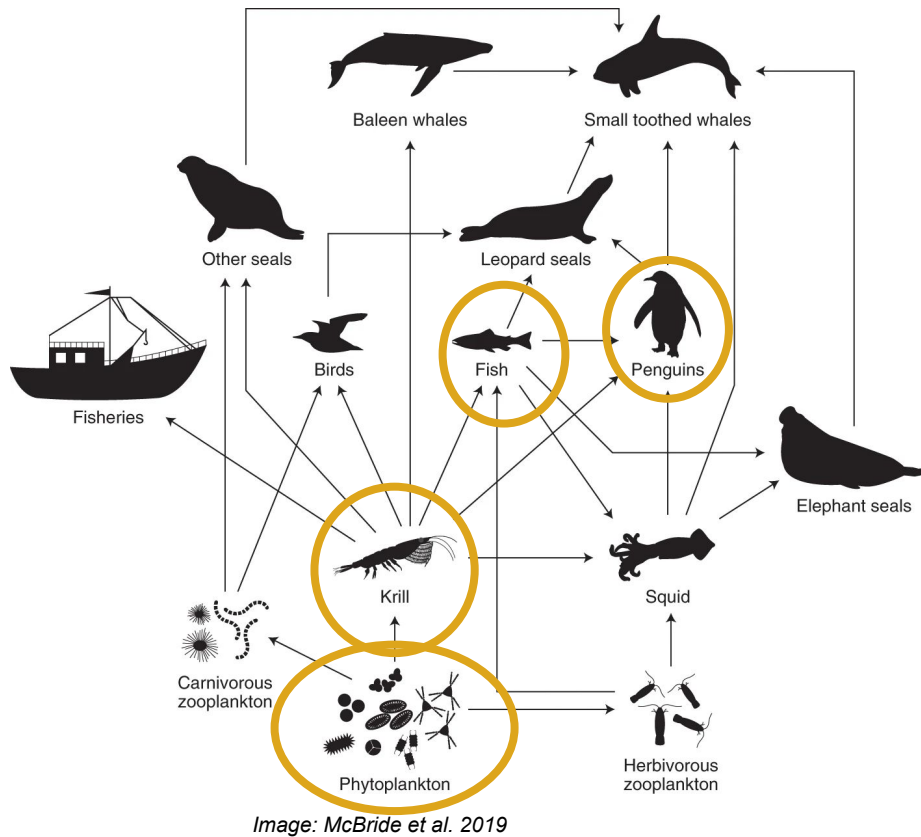- Contribute "best available science"
- Engage the public
- Influence Member States

End-user tool:
- 3 audiences – policymakers (CCAMLR), the General Public, Scientists
- Flexible, engaging, compelling
- Web-based

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How important are polynyas for the Antarctic ecosystem?

Polynya

Polynya

Typical polynyas
ID'd from satellite

Terra
Nova
Bay
Polynya

Ross
Sea
Polynya

Sea Ice Concentration (%)

50   60   70   80   90   100

Images: NASA Earth Observatory

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Science Goal: Creating an Antarctic Ecosystem Value (AEV) Index

Image: McBride et al. 2019

- Create spatial maps of **Antarctic Ecosystem Value** for management regions to support conservation <u>in present and future</u>.

- Include species at multiple trophic levels.

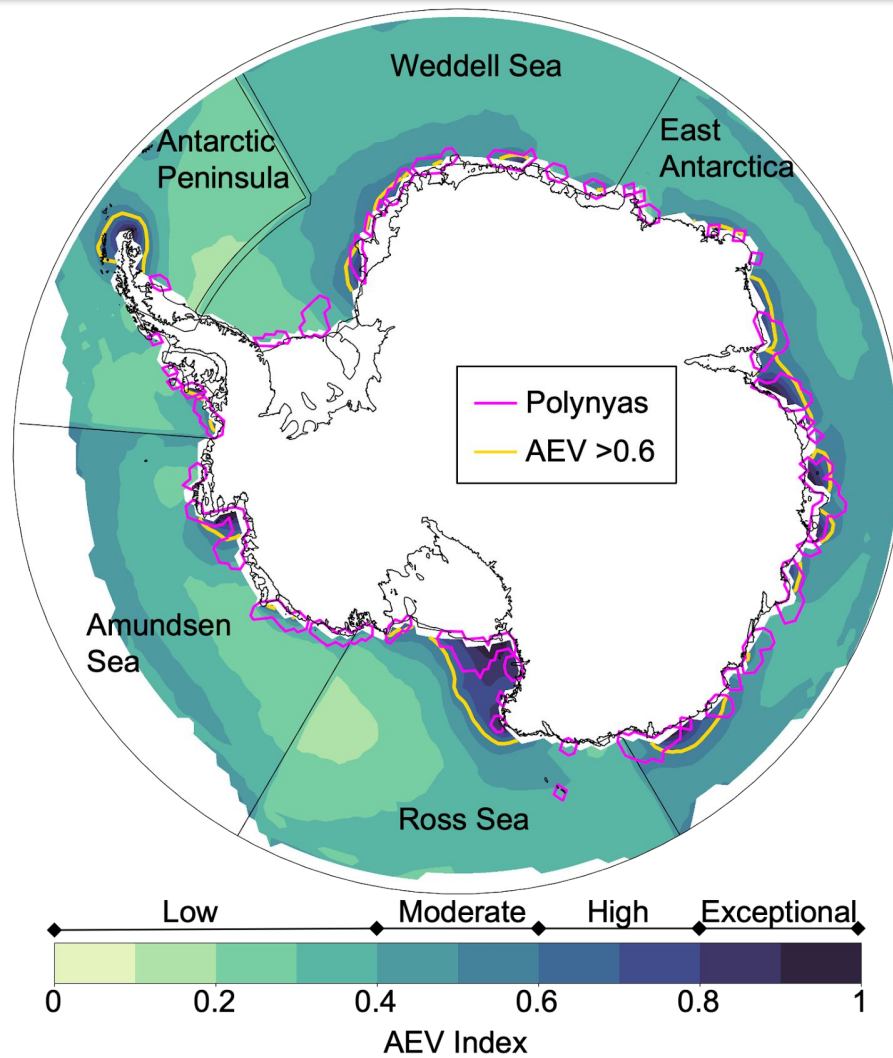- Use Earth System Model data, biological models, satellite data.

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$$AEV_{ij} = \frac{\left(\dfrac{NPP_{ij}}{NPP_{max\_hemi}} + \dfrac{KGP_{ij}}{KGP_{max\_hemi}} + \dfrac{FD_{ij}}{FD_{max\_hemi}} + \dfrac{EP_{ij}}{EP_{max\_hemi}} + \dfrac{AP_{ij}}{AP_{max\_hemi}}\right)}{EI_{max\_region}}$$
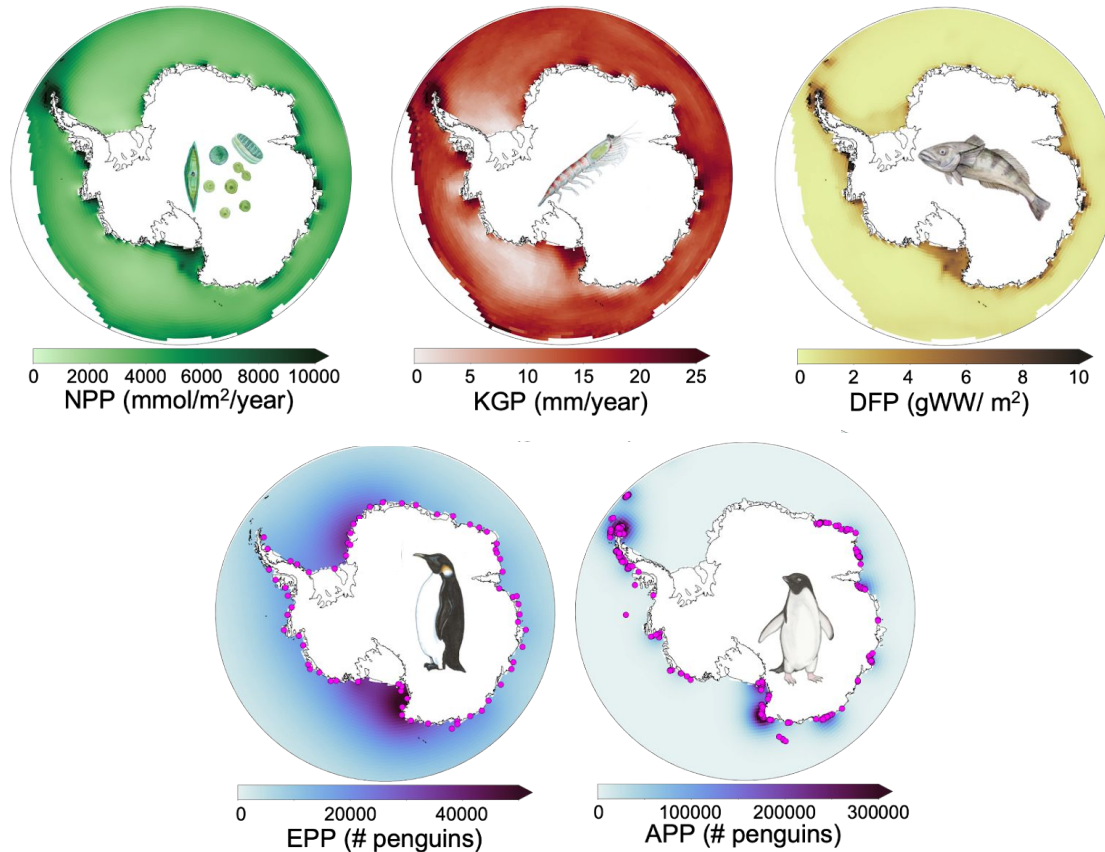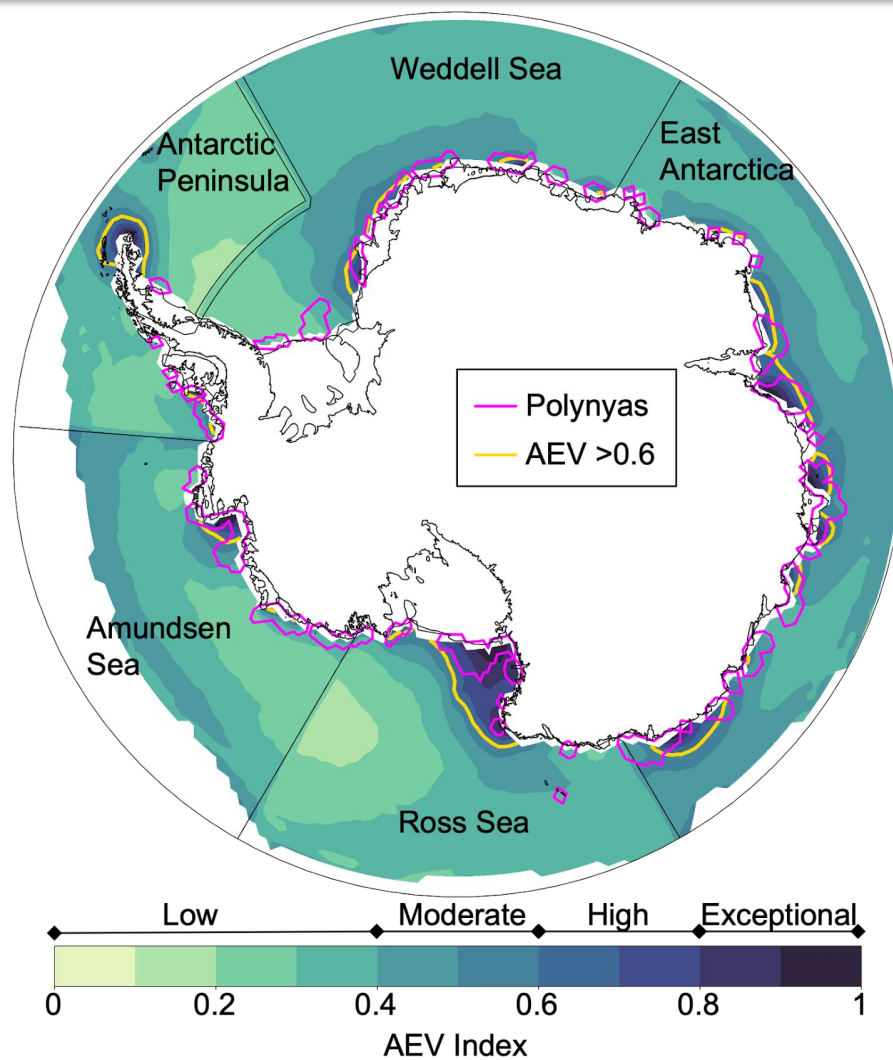
DuVivier et al.
(in revision – Nat. Comm.)

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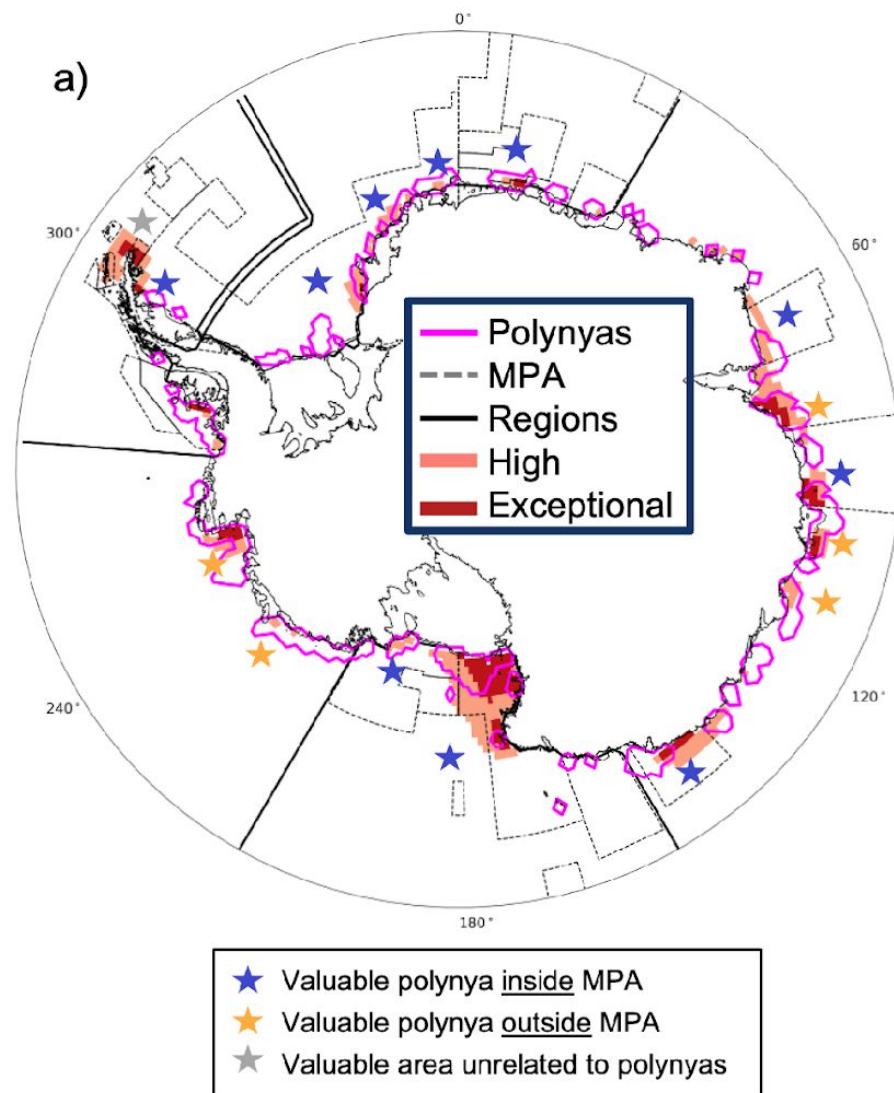
Present Day AEV Index

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(in revision – Nat. Comm.)

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Present Day AEV Index

DuVivier et al.
(in revision – Nat. Comm.)

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Future AEV Index

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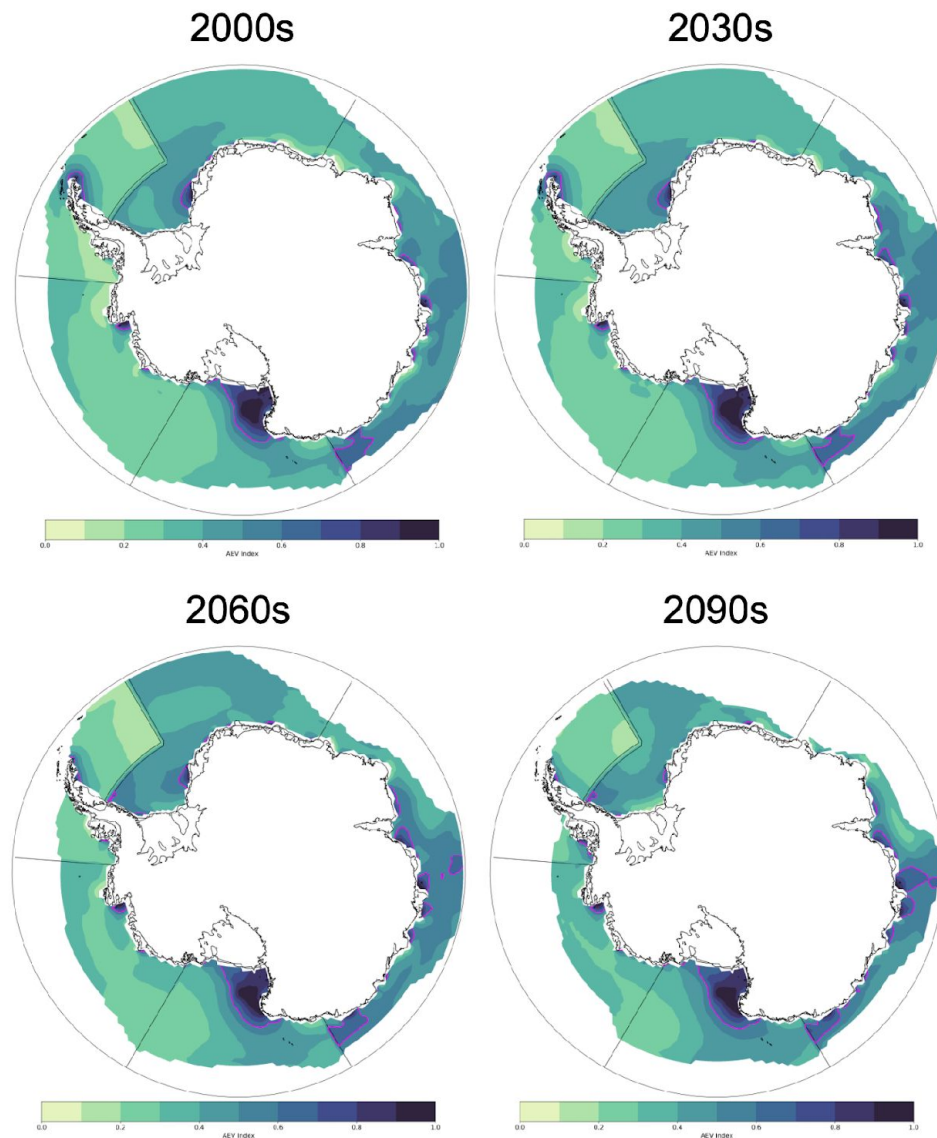
Maps directed at policy-maker and scientist audience needs.

Maps directed at general public and policy-maker audience needs with links to scientific data.

Upcoming Milestones

- Summer 2025
  - OnlyOne finalizing web-tool
  - ShinyApp tool updates
  - Complete science manuscripts
    - 2 in review, 4 in prep
  - CCAMLR Working Group on Ecosystem Monitoring and Management Meeting
    - 2 project attendees, 1 white paper

- September 2025 ☐ NASA project officially ends

- October 2025
  - Annual CCAMLR meeting
    - Web tool launch/training
    - 2 project attendees, 1 white paper

Photo: John Weller

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Thanks for your attention! Questions?
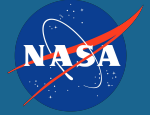
Thanks to the entire science team!

Thanks to NASA for funding!

Alice DuVivier

Laura Landrum

Marika Holland

Kristen Krumhardt

Michelle LaRue

Cassandra Brooks

Zephyr Sylvester

Cara Nissen

Stephanie Jenouvrier

Bilgecan Sen

+ Alice Eparvier

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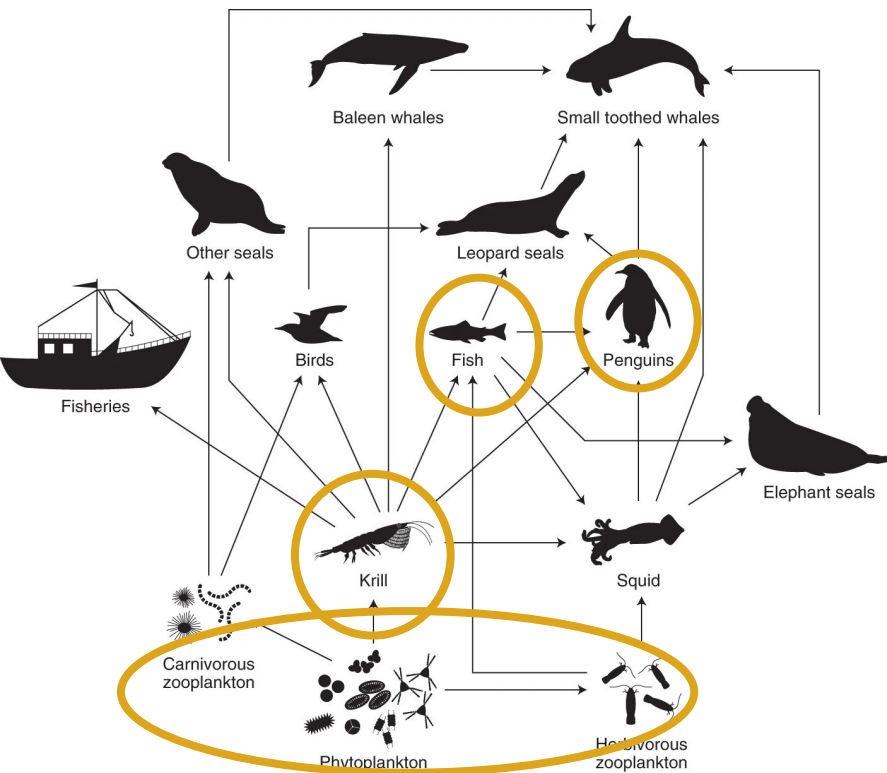# Extra slides

How important are polynyas for the Antarctic ecosystem?

Image: McBride et al. 2019

Image: NASA Earth Observatory

duvivier@ucar.edu
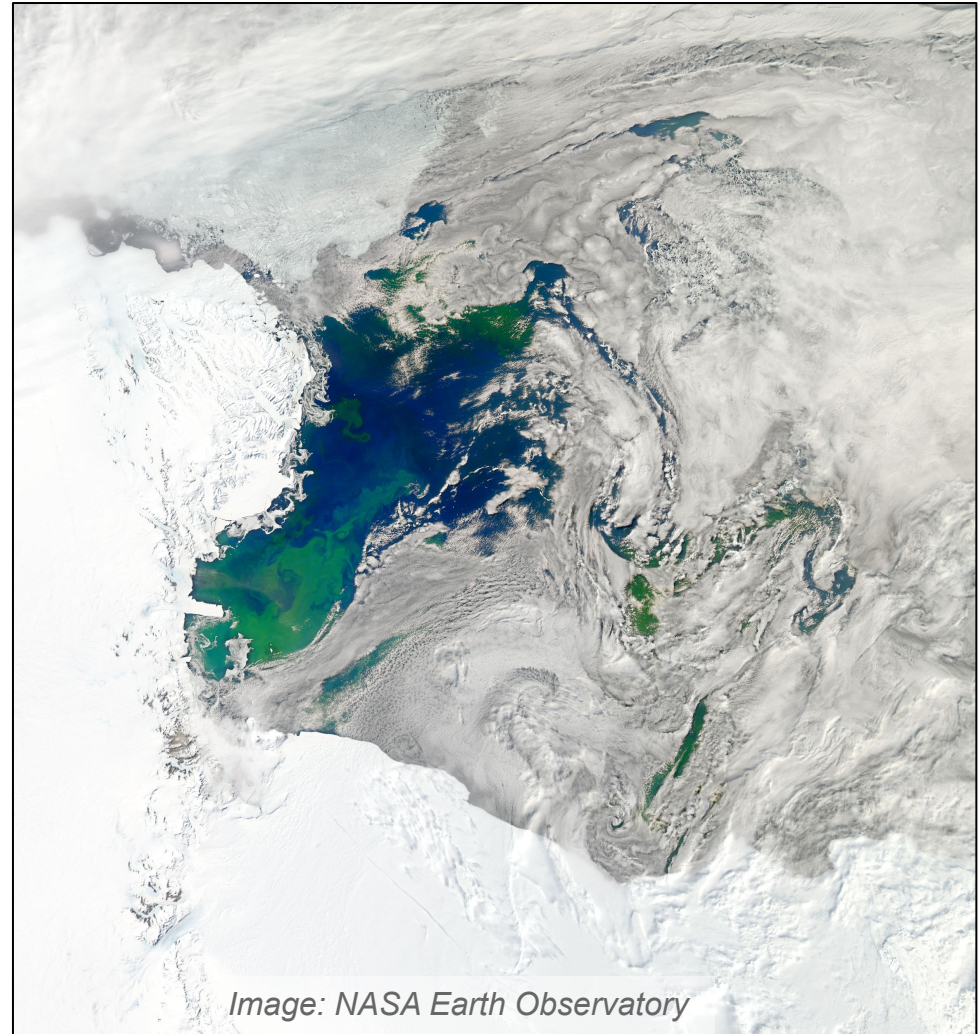
How important are polynyas for the Antarctic ecosystem?

Polynya: Area bounded by land or sea ice that has lower sea ice concentration than surrounding region

Terra Nova Bay Polynya

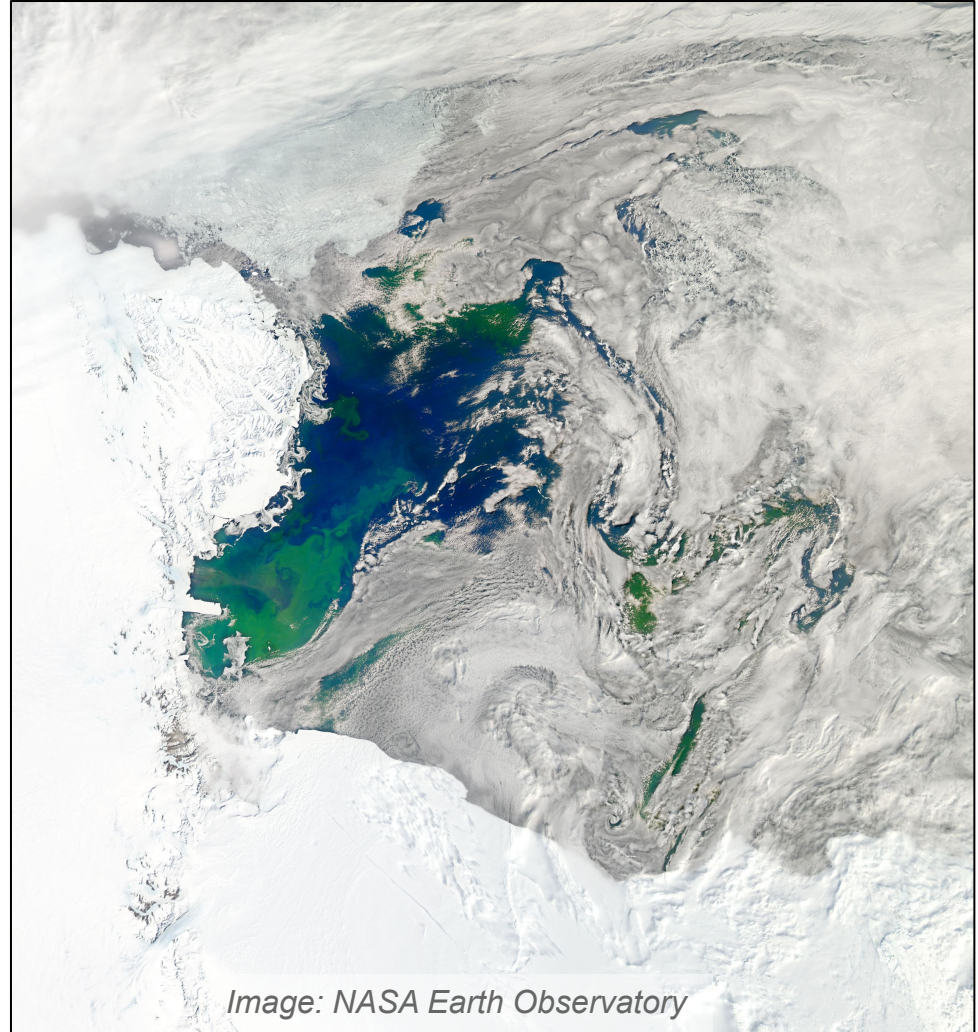Ross Sea Polynya
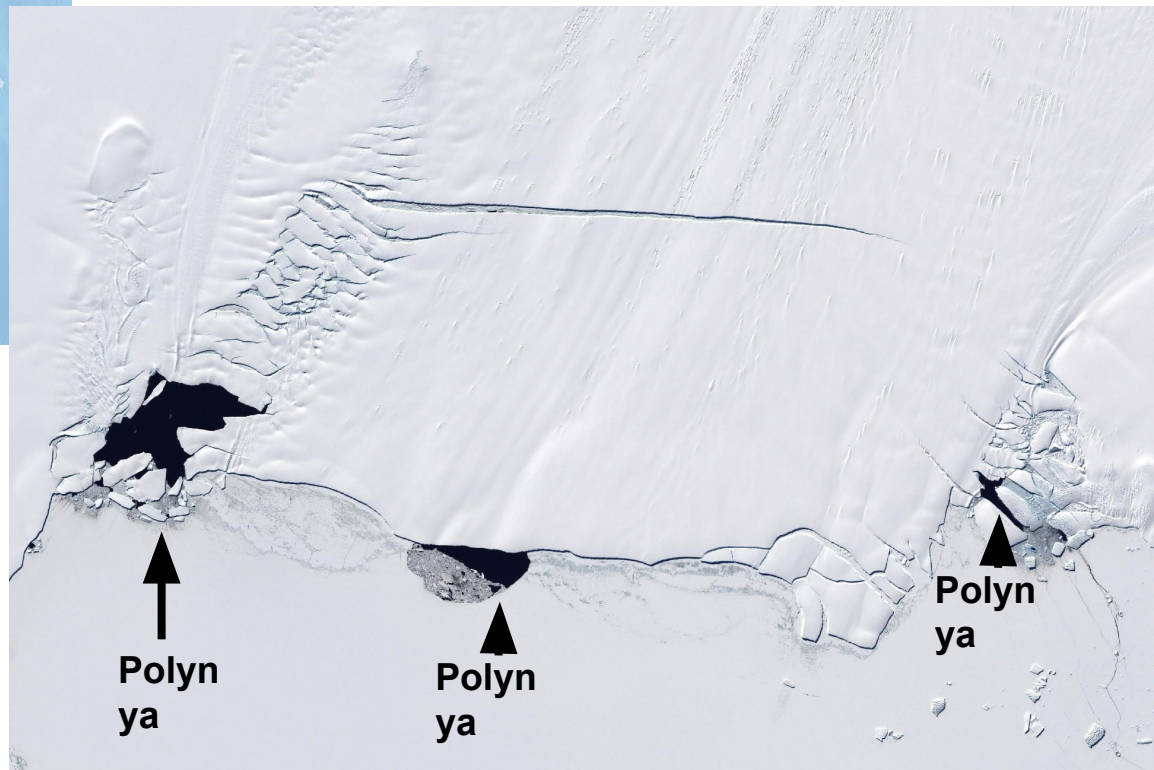
*Image: NASA Earth Observatory*

Image: NASA Earth Observatory

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Polynyas

Images: NASA Earth Observatory

Polyn ya

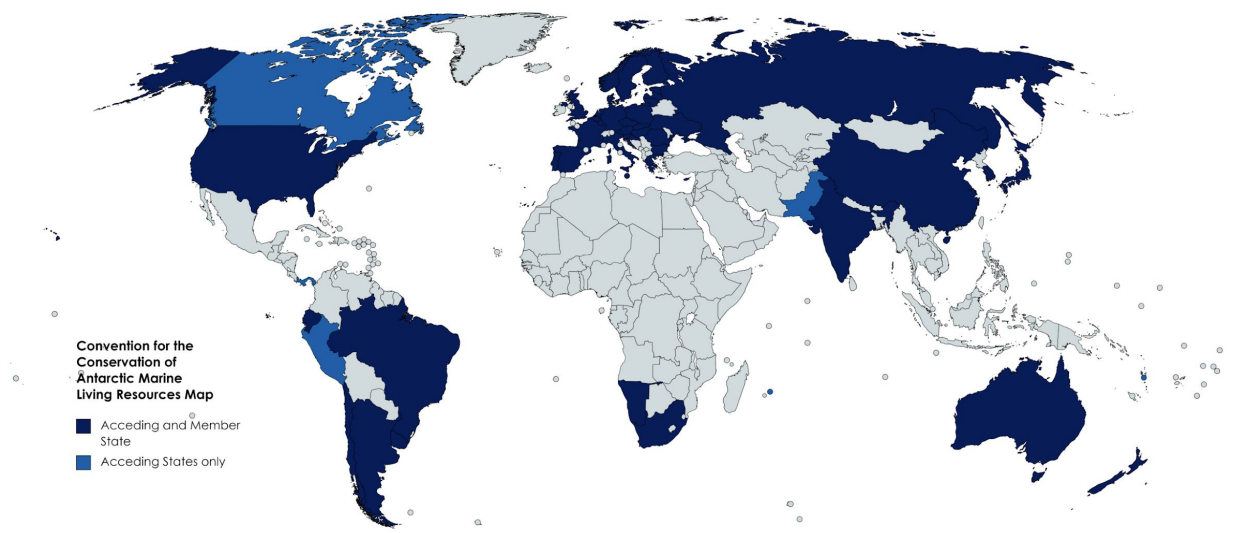Polyn ya

Polyn ya

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Antarctic Conservation:

- The Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is the multi-national body which manages the Southern Ocean.

- According to CCAMLR's legal Convention, management decisions must be grounded in the "best available science"

- To CCAMLR, the "best available science" is defined as the science that comes through its Scientific Committee and Working Groups

- CCAMLR meetings can only be attended by Member State delegates and officially invited observers to CCAMLR.

- Our end-user goals:

  - Contribute "best available science"

  - Engage the public

  - Influence Member States
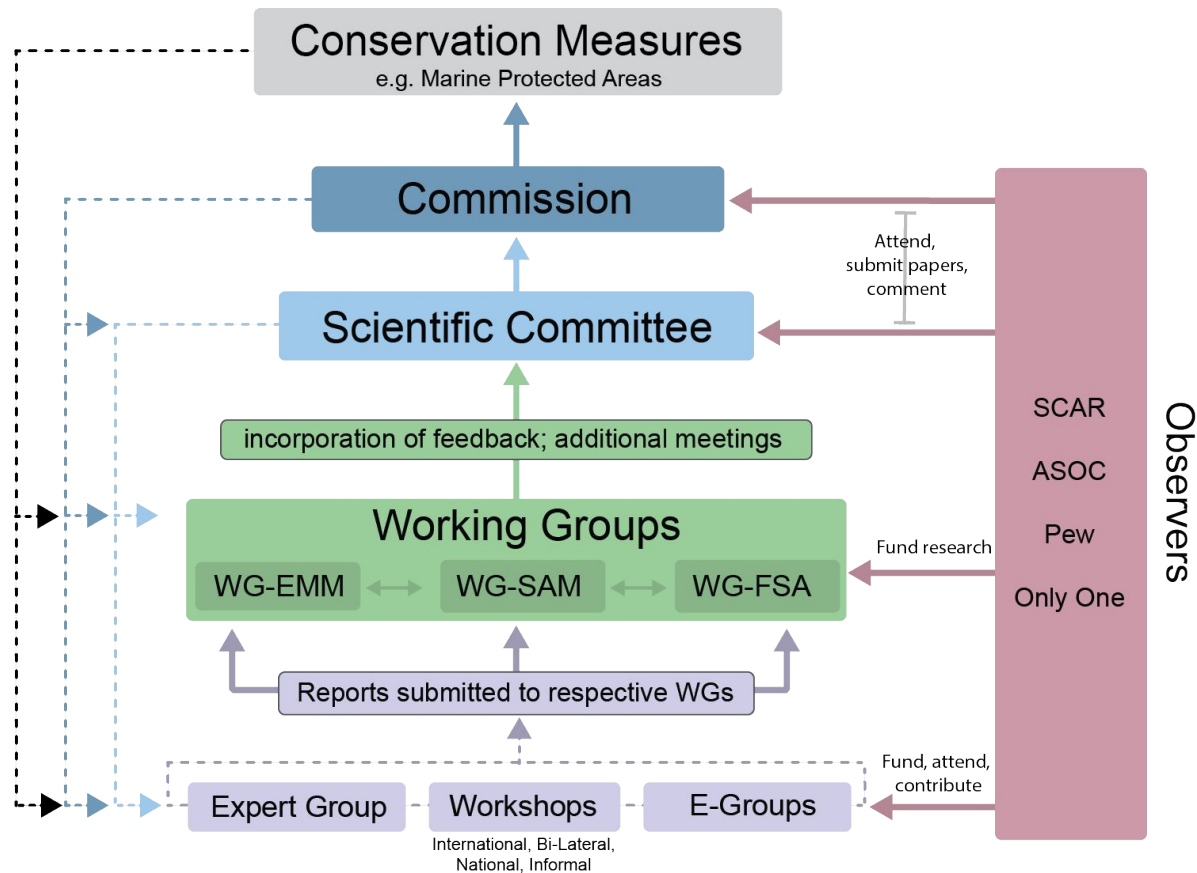
White papers must be submitted through National delegations to Working Groups. Contributing these papers is a significant step towards contributing to the "best available science".

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End User Needs

From Wikipedia

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- Adopting any policy (e.g., an MPA) requires unanimous consensus by members of CCAMLR.

- The Antarctic conservation decision-making process is unique and challenging because it is fundamentally political.

- Global geopolitics (e.g., the war in Ukraine) can be major barriers to decision-making

CCAMLR annual meeting plenary (invitation only; Hobart, AU)

Building to consensus for the Ross Sea MPA

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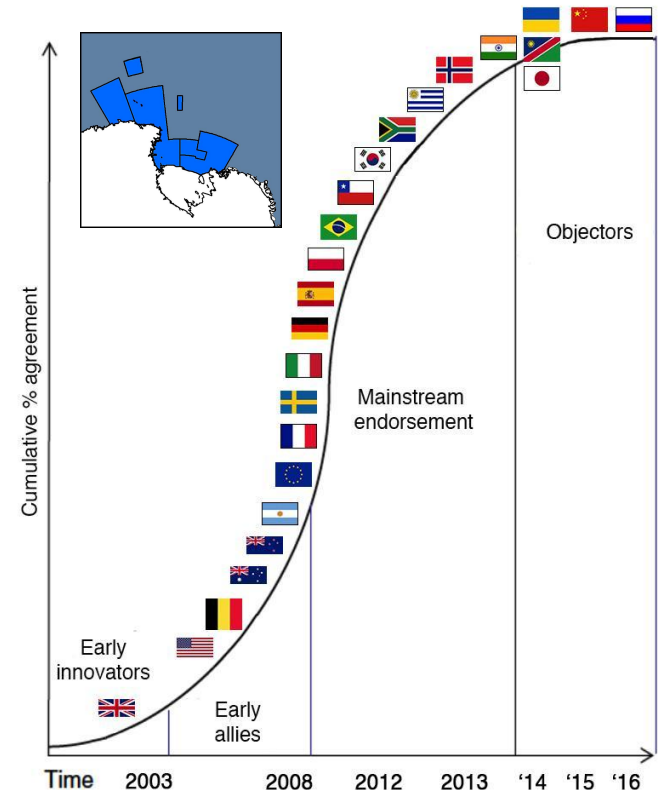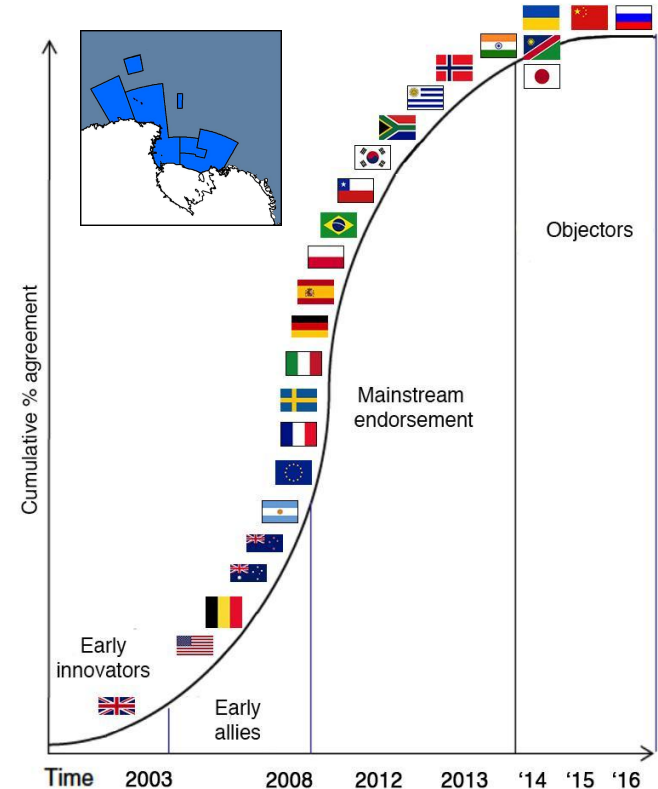
- Ross Sea region MPA adopted in 2016
  - 14 years of scientific discussion & input
  - 12 years of public engagement
  - 5 years of CCAMLR diplomatic negotiations

Building to consensus for the Ross Sea MPA
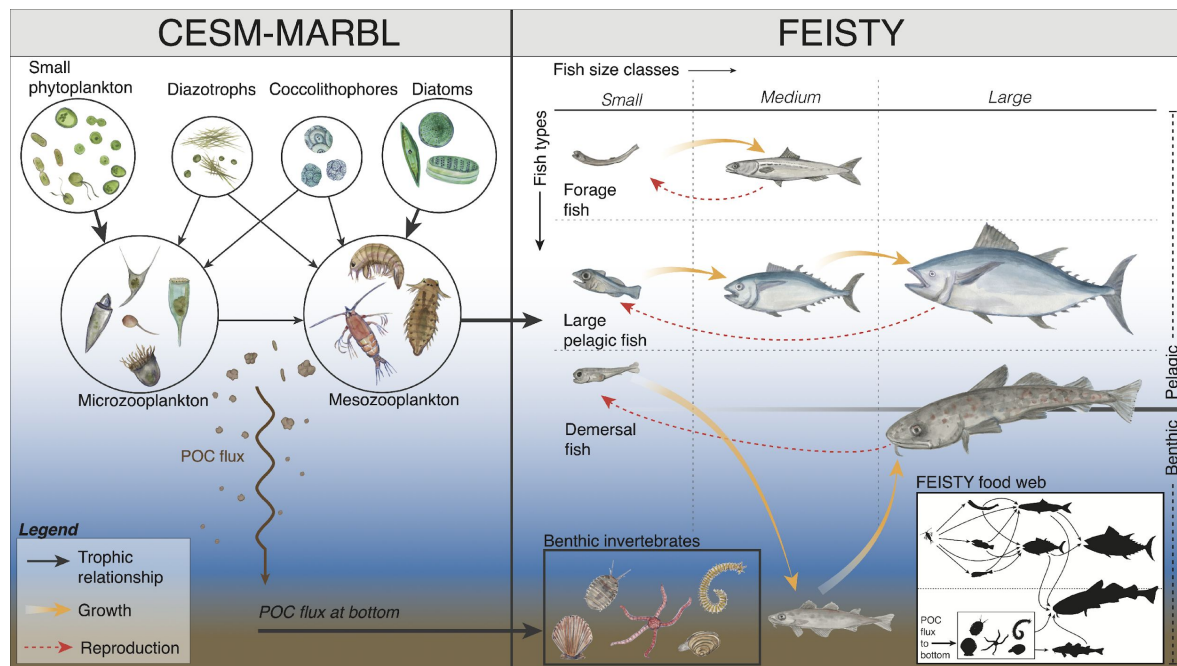

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Using the CESM2 Large Ensemble to project future physical and ecosystem changes

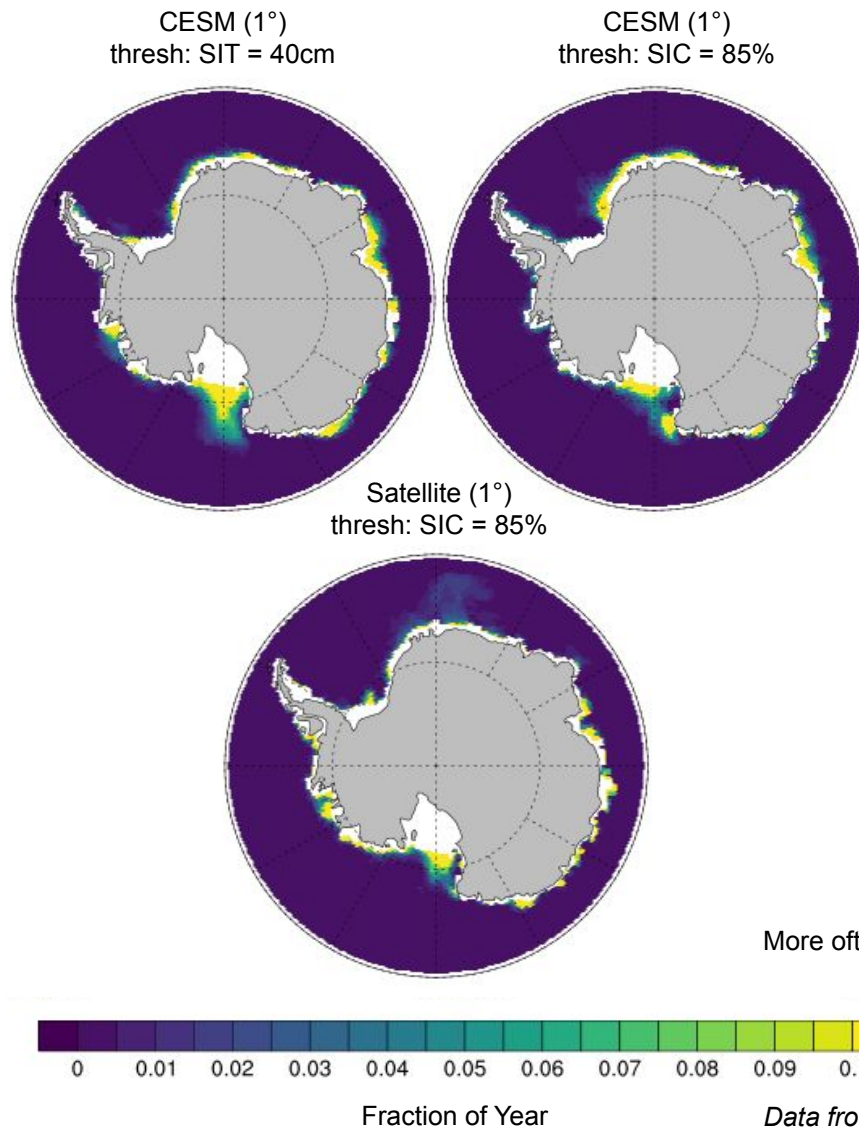## Community Earth System Model (CESM2)
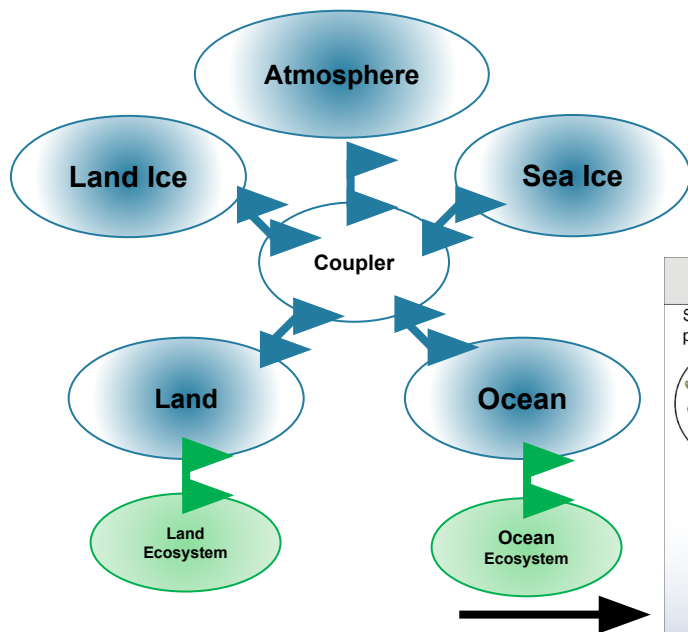
CESM2 Large Ensemble (CESM2-LE)
- 50 simulations from 1850-2100 (focusing on 1950-2100)
- Capture range of internal climate variability for a given forcing scenario

Offline Model
Uses CESM data

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Identifying polynyas is not trivial!

CESM (1°)
thresh: SIT = 40cm

CESM (1°)
thresh: SIC = 85%

Satellite (1°)
thresh: SIC = 85%

We developed a polynya ID tool that is reproducible, verifiable, and applicable to both satellite and model gridded data using sea ice concentration (SIC) or sea ice thickness (SIT).

More often identified as "polynya"

0   0.01   0.02   0.03   0.04   0.05   0.06   0.07   0.08   0.09   0.1

Fraction of Year

Data from Landrum et al. (in prep)

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Scientists and End Users co-developed content for web tool

Frames from 4+ hours of interviews with Dr. Laura Landrum, Dr. Marika Holland, Dr. Stephanie Jenouvrier, and Dr. Kristen Krumhardt.

These interviews and others will provide the backbone of narrative to populate the website with explanatory media and other outreach products to expand the reach of the stories.

- May 2025
  - End user meeting: feedback, strategy discussion
- Summer 2025
  - OnlyOne finalizing tool
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Photo: John Weller