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SCAR Group

ICED

Person
Responsible:

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Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) Oct 2021-Sep 2022 Report

Summary

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Summary of activities up to September 2022 and any other important matters

ICED is a regional programme of IMBeR (Integrated Marine Biosphere Research) and the Scientific Committee on Oceanic Research (SCOR) and is a SCAR Co-Sponsored programme. ICED is a multidisciplinary programme examining the response of Southern Ocean ecosystems to natural and anthropogenic change and feedbacks to the Earth System. ICED's coordinated circumpolar analyses unite a range of stakeholders to understand interactions between climate and ecosystem dynamics and generate scenarios and projections of the impacts of future change to support sustainable governance in this globally important ocean. Key outputs this year have addressed our three Research Challenges (1) Understanding and quantify the state and variability of Southern Ocean ecosystems, (2) Improving scenarios and projections of future Southern Ocean ecosystems at multiple scales, and (3) Informing conservation and sustainable management of Southern Ocean ecosystems. We promote and address these challenges by identifying and undertaking high-priority research, delivering workshops, conference sessions and stakeholder-engagement activities.

Highlights 2021-22

Research Challenge (RC) I: Understanding and quantify the state and variability of Southern Ocean ecosystems

ICED has continued to develop whole ecosystem level understanding of the structure and functioning of Southern Ocean ecosystems, their variability and response to change across a range of spatial and temporal scales. Work has focused on detailed analyses of key species from phytoplankton to higher predators, and the structure of food webs. Studies continue to examine physical, biogeochemical, and biological interactions and the effects of past and recent variability and change, such as ocean warming, sea ice change and ocean acidification, and pollutants including plastics. Work in these areas is pivotal to guiding and informing our work under RC II and III. The outputs under RC I over the past year address all three Research Objectives. These include:

- **ICED-MEASO:** The Marine Ecosystem Assessment of the Southern Ocean ([MEASO](#)) has produced a series of papers on key species and drivers to support scenarios, projections and governance in a [MEASO Special Issue](#), with several more in review. The collection of papers involves >200 authors from 19 countries, including many ICED scientists as lead and co-authors. This initiative, developed in response to the need to undertake a comprehensive marine ecosystem assessment of the Southern Ocean in support of raising global awareness of the impact of change on these unique ecosystems, understanding their role in Earth System processes and feedbacks, and underpinning policy decisions at the global and Southern Ocean scales. Many of these papers were directed at quantifying the state and variables of Southern Ocean ecosystems. A summary of this work was presented at the UNFCCC COP26 in Nov 2021 and the UN Ocean Conference 2022 (see details given under RC III), the Antarctic Treaty Consultative Meeting 2022, the 1st SKAG Annual Meeting Mar 2022, and will also be presented at the 2022 SCAR Open Science Conference, Aug 22, and the Challenger Symposium, Sep 2022. A synthesis paper for policy makers is also in development.
- **ICED multi-year campaign on sea ice ecosystems:** ICED has continued work to campaign and plan for a focus on sea ice ecosystems, including a multi-year, multidisciplinary field work effort. We look forward to working with SCAR to progress this initiative, following their endorsement of the initiative during SCAR Ex Com in 2021.
- **New EU Horizon 2020 programme, PolarRES:** ICED and a range of international scientists, led by Norway, have been awarded a new EU Horizon2020 programme, ‘Polar Regions in the Earth System: the Role of Local and Regional Polar Processes in Changing the Polar Climate and the Global Climate System’ ([PolarRES, 2021-2026](#)). This project started in September 2021. PolarRES is a multi-partner project, and a member of the EU Polar Cluster and will link closely with those throughout. Using understanding and data on the abundance and distribution of key species in the Southern (and Arctic) Ocean, we will generate future projections of their dynamics using outputs from high resolution physical models of the polar regions. This will input to RC’s II and III.
- **New Natural Environment Research Council Long Term Science (LTSM) project, BIOPOLE:** ICED scientists are part of a new 5 yr project ‘Biogeochemical processes and ecosystem function in changing polar systems and their global impacts’ ([BIOPOLE, 2022-2027](#)). BIOPOLE will address a fundamental aspect of the Earth System – how nutrients in polar waters drive the global carbon cycle and primary productivity. Contribution to GC I includes the way in which polar ecosystems (particularly zooplankton) process nutrients, and the way in which

these nutrients are supplied to the rest of the world's oceans. SCAR is a key stakeholder in this programme.

- **Joint research interests with other programmes and initiatives:** ICED continues to work with other key programmes and initiatives to outline future collaborations/links to improve understanding of the state and variability of Southern Ocean ecosystems, including with CCAMLR and IWC (see RC III) and SCAR's new Scientific Research Programmes [Ant-ICON](#) and [AntClim^{now}](#) (see RC III). ICED also gave a presentation to SCARs EG-EGBAMM at the 2022 SCAR Business on the outcomes of MEASO, and specific outputs relating to this group.
- **United Nation's Decade of Ocean Science for Sustainable Development (2021-2030), Southern Ocean Action Plan:** Together with SCAR, the SOOS, BIODIVERSITY AQ, IAATO, EPB and a range of Task Force members, ICED has developed a [Southern Ocean Action Plan](#) to be considered as an official programme of the UN Decade of the Ocean, in support of a range of societal outcomes for the Southern Ocean. A major contribution of ICED under the decade will be the multi-year sea ice campaign (see above), as well as the continuation of MEASO and key activities to support governance. Activities will address all three RC's. Activities this year have included:
 - 2nd Southern Ocean Regional Workshop, 20-22 Sep 2021, online, <https://www.sodecade.org/resources/>
 - Southern Ocean Decade Update Webinar on the Action Plan development, Dec 2021 <https://www.sodecade.org/2021/11/23/southern-ocean-un-decade-update-webinar/>
 - UN Decade Lab on Working Group 2: A Healthy and Resilient Ocean, Online, 9-11 March, 2022 <https://www.oceandecade-conference.com/en/a-healthy-and-resilient-ocean.html>
 - Town Hall, AGU Oceans 2022 Conference to raise awareness of Action Plan
 - Launch of the Southern Ocean Action Plan, online, 12 Apr 2022 <https://www.sodecade.org/resources/>
 - UN Oceans Conference, 2022, Virtual Side Event, From the Southern Ocean to the Arctic – a Call to Action via the UN Ocean Decade, 27th June, (<https://www.youtube.com/watch?v=UoqDN7izxHw>) [From the Southern Ocean to the Arctic – a Call to Action via the UN Ocean Decade](#)
- **IMBeR's West Pacific Symposium online, 2021:** In Nov 2021 ICED teamed up with another IMBeR regional programme, CLIOTOP- Climate Impacts on Top Predators, to develop a joint session at the West Pacific Symposium on "Changing West Pacific Ocean: Science and Sustainability". Our session 'Connectivity of the West Pacific and Southern Ocean: the Importance of Oceanic Top Predators' was organised and co-chaired by a range of ICED and CLIOTOP scientists, with a focus on ECR leadership, with support by mid and established researchers in both regional programmes. This approach has been central to ICED in recent years.
- **American Geophysical Union Oceans conference, online 2022.** In March 2022, ICED and SKAG scientists involved in the ICED Krill modelling workshop 2021 convened a joint ICED-SKAG session 'HL09 The role of Southern Ocean ecology in the Earth system: integrating across scales, disciplines, and methods'.

RC II: Improving scenarios and projections of future Southern Ocean ecosystems at multiple scales

ICED has continued its model development in support of creating a suite of models of physical dynamics (ocean circulation and climate), biogeochemical cycles, and biological dynamics (life histories, population dynamics, food web structure) within a hierarchical framework of models of different spatial, temporal and trophic resolution. The ultimate aim of these activities is to advance end-to-end ecosystem modelling approaches that integrate physical, chemical and biological processes and generate projections of Southern Ocean ecosystems. We have used our understanding of the drivers and impacts of climate change (under RC I) in the Southern Ocean to further our work on developing scenarios of key drivers and projections of ecological change. The outputs under GC II over the past year address all three Research Objectives. These include:

- See **ICED-MEASO** special issue above, which includes outputs on scenarios and projections.
- See **UN Decade of Ocean Research for Sustainable Development** above, which includes a focus on scenarios and projections.
- **Joint research interests with other programmes and initiatives:** ICED continues to work with other key programmes and initiatives to outline future collaborations/links to improve scenarios and projections of Southern Ocean ecosystems, including with CCAMLR, IWC and SCAR's new Scientific Research Programmes [Ant-ICON](#) and [AntClim^{now}](#) (see RC III)
- **ICED scenarios and projection:** ICED continues to develop work on projections. Further work on developing projections continues with CCAMLR and SCAR, including the SCAR Krill Action Group (SKAG) [Workshop on evaluating change in Antarctic krill populations](#) in April 2021 and the ICED Antarctic krill modelling Workshop in May 2021:
- **ICED krill modelling workshop 2021:** ICED (Murphy, Hofmann, Johnston, Thorpe, Corney), and SCAR (Brookes) scientists and B. Meyer from the SCAR Krill Action Group (SKAG) and ICED ECRs (D. Veytia, A. Bahl, Z. Sylvester, D. Bahlburg) organised a virtual [ICED Antarctic krill Modelling Workshop](#) in May 2021. See Report at <https://doi.org/10.5281/zenodo.6780069> . This workshop successfully united the research community (particularly Early Career Researchers, ECRs) engaged in modelling Antarctic krill and its application to understanding their ecology, links and feedbacks with Southern Ocean and Earth System processes, and input to conservation and management options.
 - Since this workshop was held, the ECRs involved in leading it have been developing two community papers (with the support of ICED mid-career and established researchers) to progress krill modelling, led a joint ICED-SKAG session at AGU Oceans 2022 (See RCI), submitted a paper on the outcomes to CCAMLR WG-EMM 2021, and summarised results at the 1st SKAG Annual Meeting in March 2022.

RC III: Informing conservation and sustainable management of Southern Ocean ecosystems

ICED has worked with a range of stakeholders to ensure the science under RC I and II is relevant to, accessible to, and incorporated into adaptation, mitigation and sustainable management and conservation procedures, by improving communications, facilitating knowledge-exchange and enhancing understanding between science, policy, and society. Key outputs include:

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- **Antarctic Treaty System:** ICED is continuing its work with the Antarctic Treaty Commission via SCAR, within which ICED is a 'Co-Sponsored Programme,' and with a number of Antarctic Treaty agreements including the Committee for Environmental Protection (CEP) and CCAMLR. ICED is also continuing to work with other international environmental treaties and organisations, conservation groups, and international committees, including the International Whaling Committee (IWC). In April 2022 the Southern Ocean Task Force (of which ICED is part of, see above) submitted a paper on the UN Decade of Ocean research Southern Ocean Action Plan (led by SCAR) to the 2022 Antarctic Treaty Consultative meeting.
- **Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR):** Over the past year, the CCAMLR Working Groups, Scientific Committee and Commission meetings all took place virtually (for the second year running), and as such the agendas were more constrained than in previous years. Key topics included krill management strategies and climate change. ICED scientists continue to have an important role taking the inter-sessional science forward in these areas, including through topical E-groups. A summary paper based on the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) in support of ongoing climate change discussions within CCAMLR, was submitted to the CCAMLR Working Groups (WG-EMM and WG-FSA, July 2021), (Cavanagh et al. 2021: CCAMLR WG-EMM 2021/P07) which acknowledges the significant contributions by ICED in this area. The paper encourages CCAMLR to integrate climate change considerations in advice across its agenda. This builds on contributions and work undertaken by ICED to date, and there will be an important role for ICED as this work progresses within CCAMLR. This is reflected in recommendations that CCAMLR continues to actively engage with ICED and SCAR in this regard. Preparations are now underway for the 2022 CCAMLR meetings. The focus will be on krill management strategies with important contributions from ICED scientists and activities listed above, while also keeping climate change and other topics on the agenda. ICED scientists have also contributed to a number of papers submitted to CCAMLR (through their national delegations) in support of conservation and management.
- **International Whaling Commission (IWC):** ICED scientists have continued to work with the IWC. This included participating in the International Whaling Commission (IWC) Climate Change Workshop, Nov-Dec 2021. The purpose of the workshop was to review the latest information about the implications of climate change for cetacean species to help define and develop the role of the IWC in helping to address this issue. The workshop also considered how the IWC could best interact with other international bodies (including ICED) that are also seeking to address climate change. ICED scientists contributed to a presentation: "Understanding the impacts of climate change on Southern Ocean ecosystems – synergies between CCAMLR and IWC", highlighting common issues between both IWC and CCAMLR, together with the role of international science programmes (including ICED), in understanding and addressing climate change, as well as other cross-cutting issues. The workshop report is currently (April 2022) being presented at the IWC Scientific Committee for endorsement.
- **SCAR:** Over the past year ICED has also contributed to the development of SCAR's next generation of scientific research programmes [Ant-ICON](#) and [AntClim^{now}](#), ensuring that they utilize the outputs of the ICED programme to avoid duplication of effort across the Southern Ocean and wider community, and encourage collaborations in areas of mutual interest across our research challenges. We have also engaged closely with SKAG (through our Krill Modelling initiatives) and SCAR and SOOS through ICED-MEASO and the Southern Ocean Action Plan under the UN Decade of the Ocean.

- **IMBeR:**
 - **IMBIZO 6: Buoyant Solutions for Ocean Sustainability conference, October 2021:** ICED scientists co-organised and participated in this event, including presenting at the workshop on ocean governance and climate adaptation and integrating human dimensions in decadal-scale prediction systems.
 - **Transdisciplinary Research:** ICED scientists had a lead role in a study in which IMBeR was used as a case study to understand the contribution of interdisciplinary global research networks to solving complex socio-ecological challenges (van Putten et al, 2021).
- **Input to UNFCCC Conference Of the Parties 2021 (COP26):**
 - The work of ICED-MEASO was featured in the **COP26 Conference MEASO** (see above) event at the Cryosphere Pavilion in the Blue Zone, Nov 2021, Glasgow, UK. ICED scientists presented on the key outcomes of MEASO and took part in a discussion panel. The session reported the scientific outcomes from this internationally coordinated assessment of the Southern Ocean ecosystem, which has been developed over the last three years.
 - **Input to the UN Ocean Conference 2022: The Southern Ocean Task Force united with Arctic equivalent at the UN Oceans Conference, 2022,** to deliver a Virtual Side Event, From the Southern Ocean to the Arctic – a Call to Action via the UN Ocean Decade, 27th June, (<https://www.youtube.com/watch?v=UoqDN7izxHw>) [From the Southern Ocean to the Arctic – a Call to Action via the UN Ocean Decade](#)
- **Conservation Groups:**
 - **Cambridge Conservation Initiative:** ICED scientists continue to co-lead a science-policy initiative between the British Antarctic Survey and the Cambridge Conservation Initiative based in Cambridge, UK.
 - **Climate Change and Southern Ocean Resilience Expert Working Group:** ICED scientists continue to engage in the Climate Change and Southern Ocean Resilience Expert Working Group to inform global policymakers on the importance of Southern Ocean management in the context of climate change, and critical actions that could be taken by CCAMLR.
- **IPCC:** ICED scientists contributed to IPCC AR6 via their MEASO papers. ICED scientist Andrew Constable was also instrumental in the development of the IPCC's Working Group 2 report on the Polar Regions.

Education and Outreach

See direct ICED input to the UNFCCC Conference Of the Parties 2021 (COP26), the IPCCs AR6, the UN Ocean Conference 2022, and the UN Decade of Ocean Science for Sustainable Development 2021-2030 detailed above

2022 - Xavier, J. C., Cherel, Y., Golikov, A., Queirós, J., Perales-Raya, C. & Rosas-Luis, R. (2021). Cephalopod International Advisory Council workshop "The role of cephalopods as predators and prey: the relevance of cephalopod beaks in ecological studies". Sesimbra, Portugal (2-8 April)

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2021- Corsi, I., Manno, C. & Xavier, J. C. (2021). Unravelling the occurrence and impact of multiple stressors of natural and anthropogenic origin pollutants in Polar Regions. SETAC Conference Seville 3-6 May (online)

2021 - Guímaro, H., Menezes, G. A & Xavier, J. C. (2021). Webinar on information about SCAR Fellowships in Portuguese (online) (involving APES Portugal, APECS Brazil and SCAR)

Publications

Publication	Activity
ICED/IMBeR activity papers	
All ICED-MEASO Special Issue Papers see details here: https://www.frontiersin.org/research-topics/10606/marine-ecosystem-assessment-for-the-southern-ocean-meeting-the-challenge-for-conserving-earth-ecosys	Regional programme activity
Janssen, A.R., R. Badhe, N.C. Bransome, P. Bricher, R. Cavanagh, T. de Bruin, P. Elshout, S. Grant, E. Griffin, E. Grilly, S.F. Henley, E.E. Hofmann, N.M. Johnston, D. Karentz, R. Kent, A. Lynnes, T. Martin, P. Miloslavich, E. Murphy, J.E. Nolan, E. Sikes, M. Sparrow, M. Tacoma, M.J.M. Williams, J.A. Arata, J. Bowman, S. Corney, S.C.Y. Lau, C. Manno, R. Mohan, H. Nielsen, M.A. van Leeuwe, C. Waller, J.C. Xavier and A.P. Van de Putte. 2022. Southern Ocean Action Plan (2021-2030) in support of the United Nations Decade of Ocean Science for Sustainable Development. DOI: 10.5281/zenodo.6412191	Regional programme activity
van Putten, Ingrid, Kelly, Rachel, Cavanagh, Rachel D., Murphy, Eugene J., Breckwoldt, Annette, Brodie, Stephanie, Cvitanovic, Christopher, Dickey-Collas, Mark, Maddison, Lisa, Melbourne-Thomas, Jess, Arrizabalaga, Haritz, Azetsu-Scott, Kumiko, Beckley, Lynnath E., Bellerby, Richard, Constable, Andrew J., Cowie, Greg, Evans, Karen, Glaser, Marion, Hall, Julie, Hobday, Alistair J., Johnston, Nadine M., Llopiz, Joel K., Mueter, Franz, Muller-Karger, Frank E., Weng, Kevin C., Wolf-Gladrow, Dieter and Xavier, José C. (June 2021). A Decade of Incorporating Social Sciences in the Integrated Marine Biosphere Research Project (IMBeR): Much Done, Much to Do? <i>Frontiers in Marine Science</i> 8. doi: 10.3389/fmars.2021.662350.	IMBeR activity
Clarke P, Cubaynes H, Stockin K, Olavarria C, de Vos A, Fretwell P, Jackson J, 2021. <i>Frontiers in Marine Science</i> , Cetacean Strandings From Space: Challenges and Opportunities of Very High Resolution Satellites for the Remote Monitoring of Cetacean Mass Strandings. 10.3389/fmars.2021.650735	Publications involving ICED scientists
Collins, M, Hollyman P, Clark J, Soeffker M, Yates O, Phillips R 2021. Mitigating the impact of longline fisheries on seabirds: Lessons learned from the South Georgia Patagonian toothfish fishery (CCAMLR Subarea 48.3). <i>Marine Policy</i> , 10.1016/j.marpol.2021.104618	

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<p>López-López L, Genner M, Tarling G, Saunders R, O’Gorman E., 2021. Ecological Networks in the Scotia Sea: Structural Changes Across Latitude and Depth. 10.1007/s10021-021-00665-1</p>	
<p>Gutt J, Isla E, Xavier JC, Adams BJ, Ahn I-Y, Cheng C-HC, Colesie C, Cummings VJ, di Prisco G, Griffiths H, Hawes I, Hogg I, McIntyre T, Meiners KM, Pearce DA, Peck L, Piepenburg D, Reisinger RR, Saba GK, Schloss IR, Signori CN, Smith CR, Vacchi M, Verde C, Wall DH (2021) Antarctic ecosystems in transition – life between stresses and opportunities. Biological Reviews 96:798-821. doi:10.1111/brv.12679</p>	
<p>Jones DC, Ceia FR, Murphy E, Delord K, Furness RW, Verdy A, Mazloff M, Phillips RA, Sagar PM, Sallée J B, Schreiber B, Thompson DR, Torres LG, Underwood PJ, Weimerskirch H, Xavier JC (2021) Untangling local and remote influences in two major petrel habitats in the oligotrophic Southern Ocean. Global Change Biology. doi:10.1111/gcb.15839</p>	
<p>Seco J, Aparício S, Brierley AS, Bustamante P, Ceia FR, Coelho JP, Philips RA, Saunders RA, Fielding S, Gregory S, Matias R, Pardal MA, Pereira E, Stowasser G, Tarling GA, Xavier JC (2021) Mercury Biomagnification in a Southern Ocean food web. Environmental Pollution:116620. doi:10.1016/j.envpol.2021.116620</p>	
<p>Devi Veytia, Sophie Bestley, So Kawaguchi, Klaus M.Meiners, Eugene J.Murphy, Alexander D. Fraser, Kazuya Kusahara, Noriaki Kimura, Stuart Corney. 2021 Overwinter sea-ice characteristics important for Antarctic krill recruitment in the southwest Atlantic. https://doi.org/10.1016/j.ecolind.2021.107934</p>	
<p>Relevance to policy</p>	
<p>2021- Spain, Bulgaria, Belgium, Brazil, Chile, Portugal and United Kingdom. Review of information related to Education & Outreach available through the Antarctic Treaty Secretariat webpage. ATCM XLIII/WP49 (José Xavier was the coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2</p>	
<p>2021- Bulgaria, Belgium, Brazil, Chile, Portugal, Spain and United Kingdom. Fourth report of the Intersessional Contact Group on Education and Outreach. ATCM XLIII/WP15 (José Xavier was the coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2</p>	
<p>021- Portugal and Bulgaria. Using treated wastewater for hydroponic cultivation of vegetables in the Antarctic. ATCM XLIII/IP34 (José Xavier was the coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2</p>	
<p>2021 - Portugal and Spain. Celebrating Magellan and Elcano. ATCM XLIII/IP33 (José Xavier was the coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2</p>	
<p>2021- Portugal, Belgium, Bulgaria and United Kingdom. Education and outreach by the Antarctic Treaty Parties under the ATCM framework: a review. ATCM XLIII/IP32 (José Xavier was the</p>	

coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2	
2021 - Portugal, Canada, New Zealand, South Africa and the United Kingdom. Breeding of seabirds insensitive to shifting ocean temperatures. ATCM XLIII/IP31 (José Xavier was the coordinating-contributor from Portugal). ISBN (complete work): 978-987-4024-99-2	

Future Plans

RC I:

- ICED multi-year campaign on sea ice ecosystems: ICED will continue to develop a plan for a focus on sea ice ecosystems, including a multi-year, multidisciplinary field work effort with SCAR as a contribution to the UN Decade of the Ocean.
- **ICED-MEASO outputs**
 - o Publication of remaining papers on status, changes, and futures for the MEASO assessment in the Frontiers special issue
 - o Summary of MEASO for policy maker's document
 - o Summary paper on the major outcomes of MEASO in a high-profile peer reviewed journal (e.g., Nature)
 - o Presentation of outcomes of MEASO at SCAR OSC 2022
 - o Presentation of outcomes of MEASO at the Challenger Society's Challenger 150 Conference, Session T10, London, UK, 6-8 Sep 2022 and the ICES-PICES 'Effects of Climate Change on the World's Ocean' conference, Bergen, Norway, 17-23 April 2023
- **Southern Ocean Decade:**
 - o Await results of submission of Southern Ocean Action plan to the UN Decade of Ocean Science for Sustainable Development to become an endorsed programme
- **PolarRES** annual General Assembly Meeting 2022, Bergen Norway
- **BIOPOLE** Annual Meeting Feb 2023, UK
- **Develop further understanding** of the role of biology and ecosystem processes in biogeochemical cycling and on primary and secondary production (though research projects such as BIOPOLE)

RC I & II

- **Outputs from the ICED Krill Modelling Workshop**, May 2022: ECR led Papers on;
 - o 1 - Overwintering and recruitment in sea ice environments (led by Alexis Bahl and Dominic Bahlburg)
 - o 2- Modelling sea ice –krill recruitment (led by Zephyr Sylvester and Devi Veytia)
- **Develop stronger links** to the physical scientists engaged in heat and carbon research. This will facilitate the inclusion of ecological feedback processes in their models, and the uptake of their model outputs (particularly on the 3D nature

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of oceanic processes, variability in small scale processes such as storm events, MLD and eddies, and horizontal and sub-mesoscale structure) to examine the influence of physics and biogeochemistry on zooplankton (and other key species) in the Southern Ocean and their subsequent role in carbon and heat cycling. Initiatives such as the BIOPOLE project (of which SCAR and ICED are key stakeholders) will provide access to relevant individuals and research groups.

RC III

- **Antarctic Treaty System:**
 - o Input to 2022 Working Group and Scientific Committee meetings of CCAMLR, as well as inter-sessional activities related to key CCAMLR topics including climate change and krill management.
 - o Input to the 2022 Antarctic Treaty Consultative meetings and meetings of the Committee for Environmental Protection (CEP), via ICED's input to SCAR
- **International Whaling Commission:** Input to 2022 meetings of the IWC, as well as inter-sessional activities.
- **Develop stronger links** with social scientists and economists with respect to supporting conservation and management decision making