SCOR Working Group Proposal 2023

Fine-scale near-surface stratification in the Polar Oceans (FINESS)

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Summary/Abstract (247 of 250 words)
Summer sea-ice and snow melt in the Arctic can result in persistent, thin (< 1 m) meltwater layers under and around ice floes, with observations, albeit limited, going back to Nansen's Fram expedition in 1893. Similar layers have also been observed in the Antarctic sea-ice zone (e.g., Zemmelink et al., 2005), but they show much greater variability in duration and extent. In addition, increased freshwater release into the polar regions from glacial melt and riverine input can impact the coastal environments of Greenland, the Siberian Arctic, and Antarctica. The importance of such layers for many aspects of the Arctic system have recently been highlighted with interdisciplinary observations in pack- and landfast sea-ice. Yet historically, such observations are poorly described in the literature and measurements are challenging without disturbing the stratification. In particular, the current lack of representation of such thin meltwater layers in global and regional models is a significant limitation in understanding the climate system.

This working group will synthesize the most important impacts of fine-scale salinity stratification in polar regions, and how they influence globally-relevant processes associated with exchange of gases, aerosols and energy across the water-ice-air interface. We will use existing observations to evaluate our current knowledge on physical, biological and chemical processes and facilitate recommendations on future observations, sampling and parameterizations in global climate models. We will build and strengthen existing cross-cutting relationships in this field through regular online meetings, and a series of workshops discussing new observations and relationships with existing datasets.

Scientific Background and Rationale (1244 of 1250 words)

The ocean is typically characterized by a surface mixed layer due to wind forcing at the ocean surface and overturning that arises from buoyant warm water rising up from depth. The mixed layer is sensitive to seasonal atmospheric variability, whereas longer-term trends tend to dominate below. Dynamics within the mixed layer are important for driving upper ocean primary productivity and the exchanges between the atmosphere and the deep ocean, such as carbon sequestration (Cai et al., 2010, Moreau et al., 2019). Yet, superimposed on top of these, can be very fine (order of decimeters) layers of less dense, usually relatively fresh, water (Fig. 1a). In the polar regions, they encompass sea-ice, snow and glacial melt, and river runoff (Perovich et al., 2021; Haumann et al., 2016), and lead to some of the shallowest mixed layer depths in the Arctic. These freshwater lenses, or meltwater layers, have been most commonly observed in the Arctic and impact atmosphere-ocean fluxes, ice-ocean fluxes, ice mass balance, biological activity and community structure, and gas exchange between the upper and deep oceans (Fig. 1b; Smith et al., 2023; Crews et al., 2022). Comparable freshwater lenses can be also found in the Antarctic, and even globally, where freshwater lenses in equatorial regions associated with precipitation or river runoff are shorter lived, but impact air-sea exchange and the local hydrological cycle (Shackelford et al., 2022; Iyer & Drushka, 2021). Here we propose to focus on meltwater layers in polar oceans, but some similarities in the processes and impacts may also be applicable to such features in temperate and equatorial regions.

Due to their small scale, these features are rarely detected by standard sampling methods on ships (such as the CTD rosette) or even with most autonomous platforms which typically begin profiling at least 5 m under the surface of the ocean (e.g. Ice Tethered Profiler). However, some observational datasets indicate that this phenomenon is long-lasting in seasonally ice-covered oceans (e.g., Eicken, 1994), with occasional variations due to mixing processes, but they can be found on a large spatial range. More recently, satellite observations allow us to track these freshwater lenses (Supply et al., 2022) in the open ocean. However, satellite monitoring is still problematic under sea-ice and close to the sea-ice edge, limiting large-scale tracking in polar oceans. Crucially, global climate models are unable to explicitly represent these layers, especially due to the vertical resolution of the surface ocean layer (typically 5-10 m) and do not yet have other parameterizations representing these features, significantly affecting our ability to predict changes to a rapidly changing system. Such features can be represented in 1D models, where parameterizations can be more easily tested. Parameterizations of these lenses are likely to have applications for global ocean and climate processes (e.g., Iyer & Drushka, 2021, Zeppenfeld et al., 2019). It will also help better constrain the freshwater budget of the Arctic, a key element for improving models as the Arctic is the main source of freshwater for the global ocean (Solomon et al., 2021). It is also applicable to the Antarctic, which could potentially play a larger role in the freshwater budget of the global ocean with the ongoing melting of ice sheets (Paolo et al., 2015).

A better understanding of the dynamics of these freshwater lenses and of their parameterization in models is needed. This working group will focus on small-scale polar stratification, where regional features have global consequences. This effort has already started in the Arctic using observations from the MOSAiC expedition (2019-2020) that targeted these layers through many observational methods over the spring – summer – autumn transitions. These observations were summarized in a recently submitted manuscript (Smith, M., et al., currently under review): *Thin and transient meltwater layers and false bottoms in the Arctic sea-ice pack - a review of observations and recent insights on a historically overlooked feature,* which highlights limitations in the existing understanding of the Arctic meltwater layer in the Central Arctic Ocean (Figure 1). Despite substantial differences in geography, the Antarctic ice zone is subject to similar shallow mixed-layers from sea-ice and glacial meltwaters, increasing volumes of which as a result of climate change will affect Southern Ocean mixing and turnover (Bronselaer et al., 2020; Li et al., 2023; Swart et al., in review), and biological productivity (Kim & Kim, 2021, Moreau *et al.* 2019).

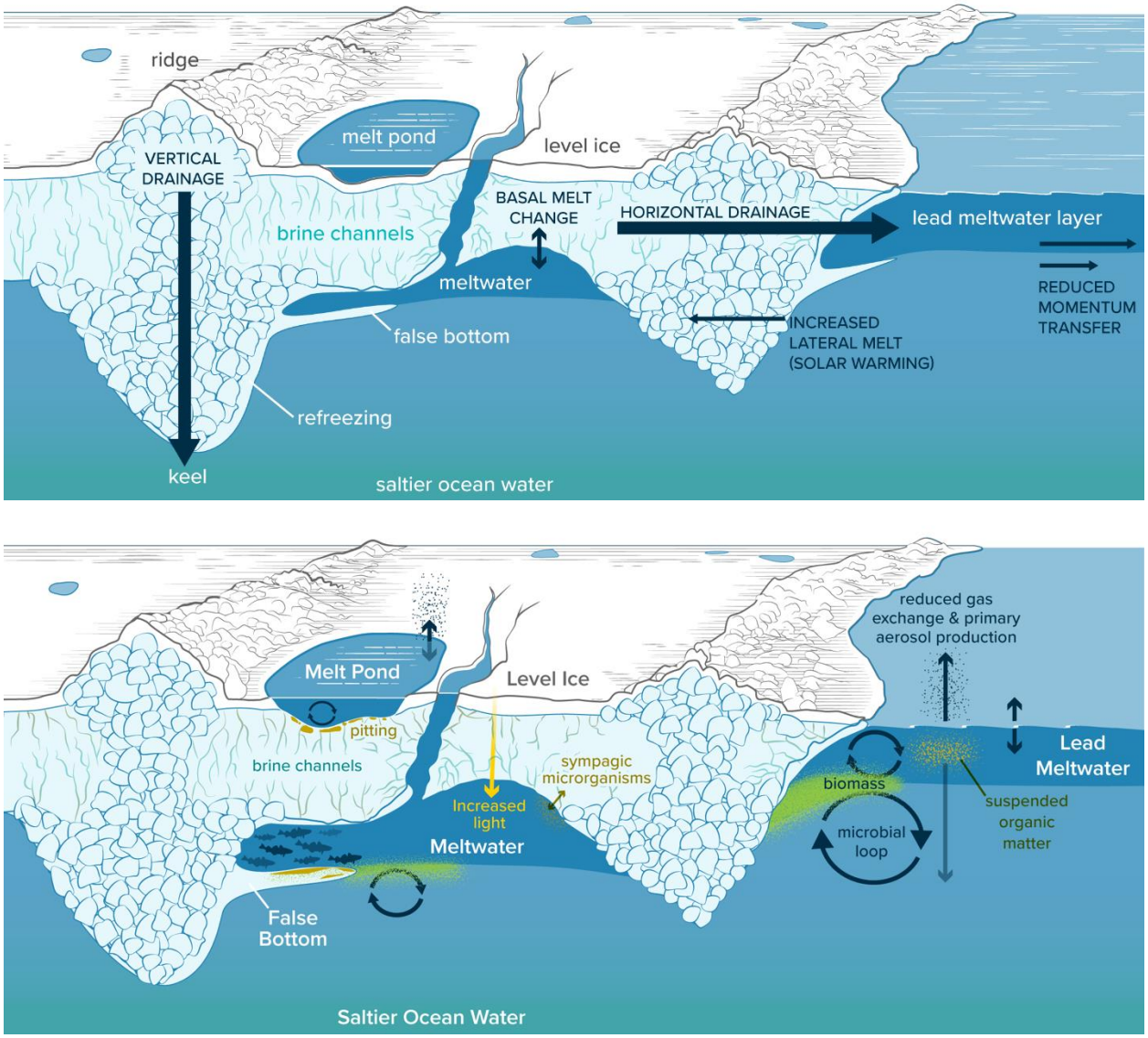

Figure 1. (a) Physical processes driving meltwater surface stratification in the Arctic pack ice, and (b) biogeochemical processes affected by these features. Figures reproduced from Smith *et al.* (2023, In Review).

Justification for a SCOR Working Group (WG):

Studying these freshwater layers requires a diverse range of knowledge from many spheres of ocean research: observationalists, modelers, and remote sensing experts; physical and biological oceanographers; atmospheric scientists and biogeochemists; Arctic and Antarctic scientists. Given this range of expertise, the topic is beyond the scope of national-level funding, requiring significant international cooperation. Previous experience following the MOSAiC expedition suggests that this topic has wide interest: a "Meltwater Discussion Group" rapidly grew to over 60 members, facilitated informal presentations of data, and stimulated discussions and comparison across datasets during regular online meetings. The presence of thin, meltwater layers, while known by individual researchers, has been allocated limited importance in the scientific literature. We now seek to stimulate conversation among the larger scientific community to understand further the role of these features in the Arctic, and to investigate similar phenomena in the Antarctic sea-ice zone.

Given prior upper-ocean observations in the Arctic and Antarctic melt seasons, this working group will seek to understand how meltwater layers can be parameterized into 1D, Regional, and Global Climate Models (GCMs) to represent their role in polar and global ocean and climate. In particular, how meltwater stratification impacts both upper-ocean and sea-ice evolution, and places significant limitations on climatically-important ocean-atmosphere gas and aerosol exchange. The input and recommendation from our WG would provide timely

improvements for the climate models that are currently in development for the next Climate Model Intercomparison Project (CMIP) phase – CMIP7. Timing of this working group also aligns well with growing interest in poorly-represented aspects of the coupled Arctic system, as preparations commence for the next International Polar Year in 2032.

Work in the polar regions requires strong cooperation and collaboration, and are often limited in regional/ disciplinary scope. This Working Group will coordinate cross-cutting observations of meltwater features on recent and upcoming polar expeditions. These include Antarctic expeditions by the RV *Kronprins Haakon* (Norway) to the King Haakon VII Sea, the annual Palmer Long Term Ecological Research (LTER) cruise by the RV Laurence M. Gould (USA), the planned Australian expedition to the East Antarctic (2026), and the Rothera Antarctic Time-Series (UK), as well as upcoming Arctic cruises ArtofMelt (2023), ArcWatch (2023, 2024) and GEOEO 2024. Key research personnel from these field activities are involved in the working group, which will increase capacity and opportunity for coordinated observation during these efforts. This group will facilitate multi-disciplinary analysis of recent results from MOSAiC (Central Arctic, 2019-2020) and the NASA-funded SASSIE (Salinity and Stratification at the Sea-Ice Edge; 2022) projects, and identify other, smaller field efforts. SASSIE focussed on identifying sea-surface salinity anomalies along the Beaufort sea-ice edge, and targeted development of satellite salinity observations which can identify any fresher surface stratified layers with increasing accuracy. The WG will provide a platform for dissemination of numerous upcoming opportunities in polar fieldwork, and will leverage our activities to encourage access to Arctic and Antarctic fieldwork by researchers from developing countries, especially early-career researchers (ECRs).

Terms of Reference (199 of 250 words)

Objective 1.
Identify and compile existing observations of fine-scale upper/surface ocean stratification in the Arctic and Antarctic, physical conditions driving formation of upper-ocean stratification features, and the associated biological and biogeochemical processes within stratified surface layers. These conditions may be forced at up to basin-wide scales.

Objective 2.
Synthesize prior observations across varied spatial and temporal gradients to develop conceptual models of the physical drivers, and the subsequent effects on ecosystems and biogeochemical processes. Here, we aim to identify the most important aspects of the feature for the oceanographic and polar research communities along with key unknowns to guide future work.

Objective 3.
Define recommendations for the observational community to incorporate measurements of the near-surface stratification routinely in observational programs and campaigns, through the modification or altered use of existing technology, and potential development of new instrumentation.

Objective 4.
Utilize fine-scale process modeling to develop model parameterisations as priority for future incorporation into global climate models, using the observational database from Objective 1 and improved knowledge from Objective 2. These parameterizations will connect conditions for pre-conditioning meltwater layers with the biogeochemical and ecological impacts.

Objective 5.
Facilitate international community and capacity building, and cross-cutting opportunities for sustainable polar science.

Working Plan (997 of 1000 words)

Regular communication across the team is essential for the delivery of the Working Group Plan:

1. WG Member Meetings (hybrid: in-person and online) will be called annually, coordinated with international science meetings (see timeline). We aim to host at least 2 of these in developing countries to target opportunities for hybrid training workshops.
2. WG science meetings (online) will be hosted 3-4x annually for informal progress discussions, novel data observations and introduction to new collaborators.
3. Internal communication will use online platforms (Slack, Google Drive, and email), to support coordinated preparation of WG deliverables.
4. ECR-led Objective Teams will comprise WG members with specific expertise to complete deliverables.

Objective 1.
We will compile a comprehensive review of existing data and literature on surface (<1m) fine-scale meltwater stratification in the Arctic basin and Antarctic seasonal ice zone. This will combine datasets from public repositories (e.g. Pangaea, UK Polar Data Centre, NSF Arctic Data Centre, Australian Antarctic Data Centre, Norwegian Polar Data Centre) and unpublished datasets identified through outreach and networking activities. These will be combined into a unified observational database **(O1)**, as a basis for our synthesis **(O2)** and model parameterisation **(O3)**. This database will be described open access.

Objective 2.
We will publish a synthesis paper (peer-reviewed, open access) collating existing observations **(O1)** and identifying gaps in knowledge on the meltwater stratification in the Arctic and Antarctic. This paper will lay out a structural model on how fine-scale meltwater layers form through the interactions of ocean, cryosphere and atmosphere, and the effects on the biological and biogeochemical systems throughout the seasonal cycle **(O2)**. We will additionally compile a White Paper for the Research Community, describing the importance of surface stratification in both polar oceans **(O2** and **O5)**. The White Paper will focus on the key impacts on ice-ocean and ocean-atmosphere exchange and biological activity most necessary to constrain and incorporate into future climate models, and will be presented at significant international research planning meetings in the following years.

Objective 3.
We will compile a '*Best Practice Guide*', outlining methodologies proven as the optimum way of observing and documenting these fine-scale processes. This will encourage comparable measurements across sampling platforms (ice-station, ship-based, small boat, or autonomous), and provides a standard framework to plan future meltwater measurements. For this purpose, existing sensors and samplers will operate in near-surface conditions during both Antarctic and Arctic expeditions undertaken by WG members, and modifications and novel instrumentation will be developed where appropriate. Alongside this, we champion autonomous instruments in ice-covered regions with limited vessel access.

Objective 4.
The meltwater thickness is thinner than can be explicitly represented in climate models. We will begin by reviewing 1D, regional 3D, and global-scale climate models in representing these features, then use priorities determined from prior observations **(O1** and **O2)** to create test cases in each type of model. We do not expect to explicitly represent lenses in climate models, but to propose parameterizations of the impacts on heat, momentum, and gas exchanges using relationships with observed drivers **(O1)**. We will propose recipes for how parameterizations can be implemented, coupled with published, open-source code for CESM2 (a CMIP model). Ultimately, these parameterizations will be proposed for consideration in CMIP7 models to better predict changes under future scenarios, particularly in an ice-free Arctic.

Objective 5.
We will actively work to expand the meltwater community beyond our members and existing network. This will begin with the coordination of online meetings 3-4x annually, comprising discussion of unpublished datasets, manuscripts in review, or questions for future fieldwork. Researchers with relevant expertise beyond WG members will be encouraged. Annually, we will encourage existing and new ECR into leadership roles,

particularly to lead the organisation of online workshops highlighting aspects of our WG research. We will highlight availability of science collaboration opportunities through field campaigns **(O3)** and visiting fellowship programs. In particular, we will encourage expedition opportunities for ECRs and representatives from developing countries.

Timeline

Year 1 - 2024

1. First online WG meeting (Q1) to define Objective Teams and Team Leaders
2. Regular online science meetings (Q2, Q4) with discussion and updates from Objective Teams **(O5)**.
3. Start of database compilation **(O1)**.
4. Ongoing literature review and initial outline of White Paper **(O2)**.
5. ECR-Led workshop (Q3): *Current Understanding of Surface Meltwater Stratification in the Polar Oceans*. **(O5)**.
6. First in-person meeting (SCAR Open Science Conference, Pucón, Chile (Q3) or AGU Fall Meeting, Washington D.C.) (Q4) **(O1-5)**.

Year 2 - 2025

1. Online meetings (Q1, Q2, Q3) for science discussions, insights from field observations and Objective Team updates **(O5)**.
2. Completion of the online surface stratification database, preparation of the data paper **(O1)** and initial model development **(O3**).
3. Preparation and publication of the White Paper **(O2)**.
4. Ongoing compilation of synthesis manuscript **(O2)**.
5. ECR-Led online workshop (Q3): *Balancing the Scale: Improving Interdisciplinary Sampling Resolution for Fine-Scale Stratification using Existing Methodology* **(O5).**
6. On-going fieldwork observing meltwater layers using existing and modified sampling techniques and technologies.
7. Annual WG in-person meeting, including White Paper presentation (Gordon Research Conference on Polar Marine Science, Tuscany, Italy) **(O5).**

Year 3 - 2026

1. Publication of the synthesis paper on *Polar meltwater stratified layers in the Arctic and Southern Oceans* **(O2)**.
2. Continued development of model parameterisations **(O4)**.
3. Delivery of Saroma-Ko Lagoon Sea-Ice Summer School, Japan in partnership with BEPSII and CIce2Clouds **(O5)**.
4. Ongoing fieldwork, including testing of modified or novel sampling methods **(O3)**.
5. Publication of the *Best Practice Guide for sampling in strongly-stratified surface conditions* **(O3)**.
6. ECR-Led online workshop (Oct): *Research and Training Opportunities in the Polar Sciences* in partnership with APECS **(O5)**.
7. Annual WG in-person meeting and presentation of our *Best Practice Guide* at AGU Ocean Sciences Meeting 2026 (TBD), where we will propose a dedicated session on this topic **(O5)**.

Year 4 - 2027

1. Publication of report on model parameterisations and model testing code (CESM2) **(O4)**.
2. Continuation of online WG meetings (O5).
3. Final WG in-person meeting (Location TBD, Planned in a developing country).

Deliverables (249 of 250 words)

Objective 1.

1. An open access database of existing datasets on surface meltwater stratification from publicly available archives, hosted open access at PANGAEA (Germany).

2. A data descriptor paper in *Scientific Data* summarising datasets compiled in the database.

Objective 2.

3. A peer-reviewed, open-access synthesis paper, submitted to *Frontiers in Marine Science,* describing meltwater stratification in the Arctic and Antarctic, throughout the spring-summer-autumn transitions

4. Compilation of a 'White Paper' on the topic of surface meltwater stratification in both the Arctic and Antarctic, in preparation for the 5th International Polar Year (2032).

Objective 3.

5. Publication of a '*Best Practice Guide for sampling in strongly-stratified surface conditions*', at Ocean Best Practices System (OBPS), to evaluate current and new sampling technologies and their optimal use for generating stratified layer observations.

Objective 4.

6. Compilation of a model parameterization outline for processes occurring in ocean, sea-ice, biosphere and atmosphere in relation to the surface stratification, to be published open access, in a journal to be determined.

7. Publication of model code for preliminary parameterization into CMIP7 models (CESM2 and recipe for other model inclusion), in an open access data repository (e.g. Pangaea, Zenodo).

Objective 5.

8. Online resources (including a Youtube Channel) of lectures and training materials, based on the ECR-chaired online discussion meetings and the three dedicated workshops.

9. Partner with existing WG BEPSII and CIce2Clouds in the delivery of the Saroma-Ko Lagoon sea-ice Summer School in Japan, 2026,, and collaborate in production of online resources (e.g. BEPSII Podcast https://podcasters.spotify.com/pod/show/bepsii-sea-ice).

Capacity Building max 1500 words; Currently 1258 words

Approach: foundations for expertise

Our working group will build self-sustaining capacity for understanding upper-ocean processes in polar and global oceans by focusing on three key areas: international collaboration, early-career researcher (ECR) engagement, and open research.

International collaboration. Polar research, even more than other oceanographic efforts, requires international coordination due to the accessibility challenges and scale of research campaigns. Due to the geographical constraints, Arctic research is typically undertaken by nations with an Arctic Ocean border, whereas Antarctic research tends towards more global representation. We will reach out to established and emerging polar research institutes, particularly those in developing countries with limited opportunities for Arctic or Antarctic research, and will promote our WG through existing organisations: SOLAS (Surface Ocean, Lower Atmosphere Study), SOOS (Southern Ocean Observing System), SCAR (Scientific Committee on Antarctic Research), SCOR (Scientific committee on Oceanic Research), IASC (International Arctic Science Committee), ICARP (International Conference on Arctic Research Planning), AGU (American Geophysical Union) , EGU (European Geosciences Union). In particular, we would reach out to the national programs of developing countries, questioning how we can incorporate associations with our research into their current research themes and budgets. In particular, we will target collaboration with the Austral Summer Institute (ASI) in Chile to offer intensive graduate training, with the potential for this to be intensive and in-person. We will provide opportunities for other non-polar countries to get involved, by driving research questions and data collection, and actively publicising available research activities and funding.

To facilitate communication, we will work alongside the SCOR Committee on Capacity Development, and work with existing WG to compile our list of national polar research organisations, Association of Polar Early Career Scientists (APECS) national committees, Young Earth Systems Scientists (YESS), Interdisciplinary Marine Early Career Networks (IMECaN), PSECCO (Polar Science Early Career Community Office), Early Career Ocean professionals (ECOPs), Polar Impact Network, international and national working groups, NGOs and non-profit organisations we can contact to advertise our activities. As part of our research is based in the Arctic, we will work with the IASC Action Group on Indigenous Involvement (AGII) to ensure inclusion of all Arctic member states. This is a priority action for IASC which we actively support. In addition to using SCOR WG funding particularly to support scientists from developing countries, we will advocate for outside financial travel support through other avenues.

Early Career Researcher engagement. Two major challenges in building capacity for ECRs in polar science are identifying relevant individuals and decreasing barriers and gatekeeping in the community. We will work closely with APECS in developing workshops and research opportunities (e.g., student placements for sampling on cruises of opportunity) to identify ECR with relevant expertise and interest. In particular, we will connect with APECS networks in less traditionally polar nations (such as South Africa, Malaysia and Brazil) to provide these opportunities to ECRs from these nations and build capacity more broadly and equitably. Additionally, hybrid research workshops (see: International Collaboration) will lower barriers and provide foundational knowledge for those with less background. Collaboration with CICE-2-Clouds and BEPSII to provide Arctic-relevant training at the Japanese Saroma-Ko Lagoon summer school in 2026 will similarly increase accessibility of WG topics. This summer school will particularly target training ECRs from developing nations in the Asia region. As part of all of these efforts, we will work to identify mentors and networking opportunities for new researchers. All of these activities provide empowerment and training of ECRs to work in an increasingly interdisciplinary research environment. In summary, the WG will prioritize supporting ECRs from diverse backgrounds as the next generation of oceanographers and polar researchers by providing them opportunities and support wherever possible.

Open research. All processes and products will be shared in accessible and open channels, under FAIR guiding principles for scientific data management and stewardship (Find, Access, Interoperate and Reuse

data with none or minimal human intervention). Online database (O1) will be fully public and easily findable, hosted at Pangaea (Germany) and assigned a digital Object Identifier (DOI) for ease of sharing. The development of new modeling and observational capabilities will be done following best practice for open science, including use of code repositories (e.g., Github). Additionally, we will aim to produce accessible online resources, such as educational videos on a youtube channel (as an outcome of hybrid workshops and joint summer schools) to facilitate knowledge transfer for researchers just coming to these topics in the future. We will use open, online forums such as Slack for discussion to lower the bar for accessing expertise and asking questions.

Specific activities: building a network

Working Group activities will produce a foundational network for understanding meltwater and upper-ocean stratification in polar regions. Activities including talks and workshops at international meetings and research workshops/trainings to help build the network further. Outcomes including observational guides and model parameterization development will be produced in such a way that a wide range of researchers with diverse backgrounds and expertise will be positioned to apply them and contribute to future research.

Representation at International Meetings: We will ensure attendance by at least one of our members at the following key Polar Science conferences. We will encourage our members to share their plans for attendance at conferences, and in particular we will aim to submit an abstract to present the findings of our White Paper at as many conferences as possible.

- SCAR Open Science Conference in 2024 (Pucón, Chile) and 2026 (Oslo, Norway)
- Arctic Science Summit Week (ASSW) in 2024 (Edinburgh, UK) and 2025 (Boulder, USA)
- The Fourth International Conference on Arctic Research Planning (ICARP IV) in 2025 (Boulder, USA)
- Arctic Frontiers in 2024 (Tromso, Norway), 2025 (TBD), and 2026 (TBD)
- AGU Ocean Sciences Meeting in 2026 (Location TBD)
- International Symposium on Arctic Research in 2025 (Japan)

Research workshops. Once a year, we will host a hybrid research workshop and training based on a different aspect of our WG topic. These will be based in different developing countries, and particularly target participation from the region, with hybrid participation possible for participants globally. Potential example topics include:

1. 2024: *Synthesizing Current Understanding of Surface Meltwater Stratification in the Polar Oceans*.
2. 2025: *Balancing the Scale: Improving Sampling Resolution for Fine-Scale Stratification using Existing Methodology*
3. 2026: *Research and Training Opportunities in the Polar Sciences [tentatively to be proposed as program at Austral Summer Institute (ASI), at University of Concepcion, Chile]*

Topics will be chosen to maximize capacity building potential in the developing nation in which they are hosted. For example, a workshop hosted in Chile, which is traditionally stronger in Antarctic research, may focus on Arctic research and earth system modeling. It is our intention that these workshops will be chaired by one or two ECR, either from our member list, or ideally from our growing network, giving opportunities for PhD students who have little to no experience with meeting preparation and hosting. These workshops will aim to have 3-4 speakers presenting on the workshop theme, and therefore we can invite speakers from developing countries, as well as ensure equal representation of male and female scientists. We will disseminate information on these workshops through our contacts list detailed above. In order to facilitate communication, we will ask attendees at each workshop to a Slack workspace which we can also use to send messages to all members. Hybrid meetings will minimize limitations on international travel from developing countries due to cost, however we will also make all reasonable efforts to encourage in-person attendance at our annual meetings, in particular due to the post-covid recognition of the importance of these interactions.

Working Group Composition (430 of 500 words)

Expertise: Our working group will include 10 full and 10 associate members with expertise that spans the Arctic and Antarctic regions, with a suitably complementary spread of expertise in physical, chemical, and biological processes. The membership includes researchers who focus on field observations, as well as in developing satellite observational algorithms, and expertise in developing climate model parameterizations with global application. This spread ensures that the results will be impactful and accessible for the wider interdisciplinary oceanographic community.

Distribution: We have extended our membership across 12 different countries, with an equal gender split, and many different career stages with representation from 8 early career scientists (40%). In addition, all three co-chairs are female ECRs. We have three members who work in developing countries with Antarctic research programs, and hope to develop additional connections through Objective 5 (capacity building).

Full Members

Name	**Gender**	**Place of Work**	**Career Stage**	**Expertise relevant to proposal**
Alison Webb (Co-chair)	F	UK	ECR	Biogeochemical cycles, Gas exchange, Arctic/ Antarctic microbial ecology
Maddie Smith (Co-chair)	F	USA	ECR	Physical properties of sea-ice; small-scale sea-ice-ocean interactions in Arctic & Antarctic
Zoe Koenig (Co-chair)	F	Norway	ECR	Arctic Ocean physical oceanography, ocean mixing
Benjamin Rabe	M	Germany	Research Scientist	Arctic ice and freshwater related processes, Autonomous observations
Klaus Meiners	M	Australia	Research Scientist	sea-ice Ecology and biogeochemistry. Under-ice remote sensing
Camille Lique	F	France	Research Scientist	Arctic Ocean dynamics and numerical modelling
Andrea Piñones	F	Chile	Professor	Physical oceanography of the Southern Ocean, Bio-physical coupling.
Naoya Kanna	M	Japan	ECR	Arctic and Antarctic glacial meltwater, biogeochemical cycling of trace metals
Bruno Tremblay	M	Canada	Professor	sea-ice modelling, freshwater budgeting
Liyang Zhan	M	China	Senior Research Scientist	BGC cycling, sea-air gas fluxes

Associate Members

Name	Gender	Place of Work	Career Stage	Expertise relevant to proposal
Hugh Venables	M	UK	Research Scientist	Southern Ocean mixing, autonomous gliders, year-round Antarctic marginal ice zone sampling
Letizia Tedesco	F	Finland	Senior Research Scientist	Sea-ice biogeochemical modelling, sea-ice ecology and ecosystems, CMIP
Tokoloho Rampai	F	South Africa	Lecturer	sea-ice structural and mechanical properties
Mario Hoppmann	M	Germany	ECR	sea-ice physical properties, (autonomous) instrumentation
Jessie Creamean	F	USA	Research Scientist	Ice nucleating particles, aerosols, sea-ice/ ocean/ atmosphere interactions
Emelia Chamberlain	F	USA	ECR	Arctic marine microbial ecology, biogeochemistry, marine genomics, ecological modeling
Mats Granskog	M	Norway	Senior Research Scientist	Physical-chemical-biological coupling in Arctic sea-ice and upper ocean, including freshwater layers below ice
Sebastien Moreau	M	Norway	Senior Research scientist	Southern Ocean and sea-ice biology and biogeochemistry
Nick Golledge	M	NZ	Professor	Antarctic meltwater modelling, glaciology
Erica Rosenblum	F	Canada	ECR	Arctic surface salinity modelling, ice-ocean interactions

Working Group contributions (441 of 500 words)

Alison Webb (ECR) focuses on the biogeochemistry of elemental cycles within the ocean-sea-ice-atmospheric system, in both the Arctic and Antarctic. She has studied marine microbial communities both in the field and the laboratory to determine the production and consumption of biogenic trace gases.

Maddie Smith's (ECR) research focuses on the small-scale physics of the upper ocean and sea-ice in the Arctic and Antarctic sea-ice zones. She was involved in the MOSAiC expedition, leading a review of Arctic meltwater layer processes, and additionally has relevant experience in upper-ocean turbulence in both Polar Oceans and in working on global sea-ice model parameterization development.

Zoe Koenig (ECR) research focuses on the ice-ocean interaction in the Arctic. She was involved in the MOSAiC expedition, involved in two studies looking at the under-ice turbulence.

Benjamin Rabe research focuses on the upper Arctic Ocean stratification, feedback with ice and atmosphere, biophysical feedback and large-scale freshwater variability. He has been strongly involved in MOSAiC, co-leading the physical oceanography work and the distributed observations with autonomous ice-tethered instruments, co-leading one leg of the MOSAiC expedition, and being part of the Ocean Observations and Climate Physics Panel (OOPC; GOOS/GCOS/WCRP) and the Northern Oceans Regional Panel (NORP; CLIVAR/CliC).

Klaus Meiners research revolves around understanding the impacts of changing ice-scapes on coupled physical-biogeochemical-ecological processes in the Antarctic sea-ice zone. He is involved in a variety of Australian and international field-campaigns studying physical drivers of primary production in Antarctic land-fast sea-ice, pack ice and marginal-ice-zone areas.

Camille Lique research centers around understanding variability and change in the Arctic Ocean dynamics and its connection to global ocean circulation and climate, using numerical models and observations. She sits on the scientific steering group of the WCRP's Climate and the Cryosphere project (CliC)

Andrea Piñones research focuses in understanding the role of ocean dynamics in the transport, pathways and connectivity of marine organism at different spatial and temporal scales in the Southern Ocean, particularly along the western Antarctic Peninsula.

Naoya Kanna's (ECR) research focuses on the trace metals cycles in the ice-covered ocean. He was involved in some field expeditions performed in the Arctic Ocean (NABOS expedition), Greenlandic glacial fjord, and Antarctic sea-ice zone.

Bruno Tremblay research focuses on short-term to seasonal forecast and decadal projection of Arctic ice, including the study of the mechanisms responsible for the transition to a seasonally ice-free Arctic, using numerical models and observations.

Liyang Zhan research focuses on the biogeochemical cycles of trace gases in the ocean and their exchange at the ocean-ice-atmosphere interfaces. He is now involved in Chinese National Arctic and Antarctic Research expedition (CHINARE) projects and has studied trace gases in the Southern Ocean and Arctic Ocean**.**

Relationship to other international programs and SCOR Working groups (407 of 500 words)

Through our working group membership, we have close contacts and ongoing scientific collaborations with key members of relevant SCOR and SCAR working groups: ECV-Ice, CIce2Clouds BEPSII, ASPeCt (Antarctic Sea-ice Processes and Climate), OASIS (Ocean-Atmosphere-Sea-Ice-Snowpack), AntClimNow (Near Term Variability and Prediction of the Antarctic Climate System) and SOOS, many members of which have been included in prior Arctic-focused meltwater stratification discussions, and we hope will continue to do so in the future. Our WG membership includes current members from several of these groups, enabling coordination and communication. The deliverables from these working groups will provide the fundamental knowledge to develop some of the proposed model parameterizations in the current proposal. These other working groups have existing infrastructure/ plans which we will coordinate with (e.g. joint preparation of the Saroma-ko sea-ice school in 2026, coordinated hybrid workshops, co-proposal of dedicated science sessions at international meetings, and research cruises). We will build upon the capacity and knowledge built up through these previous working groups to continue to lobby for the importance of polar research at national and international levels.

We have members already involved in the ICARP-IV (2025) process, and we aim to participate in the workshops and town hall meetings taking place later in 2023. Through the publication of our white paper (**O2**) we will push for meltwater stratification to be included as a key research priority in 2025-2035. This WG addresses key science priorities from the Horizon 2020 projects CRiceS (Climate Relevant interactions and feedbacks: the key role of sea-ice and Snow) and PolarRES, and Ocean:Ice (Ocean-Cryosphere Exchanges in Antarctica: Impacts on Climate and the Earth system). In addition, FINESS fits into the SOLAS core cross-cutting themes, where stratification due to meltwater is mentioned as a priority, but crucially, the references provided documented weaker stratification and at lower resolution than that which is the subject of focus for this working group. These large-scale, long-term funded projects allow us to access a broad international polar research community beyond that we have access to in isolation. Members of our WG are also on the panels for Northern and Southern Oceans Regional Panels (NOPR and SORP), and we will aim to coordinate with newly developing organisations and Working Groups, such as BioGeoSCAPES.

With a strong representation of ECR, we will link heavily with APECS and other early-career networks with AGU Ocean Sciences and EGU in developing many of the proposed activities (including workshops and conference sessions) to identify relevant early-career expertise.

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