## Workshop and Meeting Agendas

The Ecosystem Studies of Subarctic and Arctic Seas (ESSAS) program requested and received support from IASC for full or partial support for five Early Career Scientists (Ryan Rykaczewski , USA; Marta Gluchowska , Poland; Sofia Ferreira, UK/Denmark; Cathleen Vestfals, USA; Natalia Monferrer, France) to participate in the ESSAS Open Science Meeting and associated workshops in Tromsø, Norway, from June 11-15, 2017.

The overall theme of the 2017 Ecosystem Studies of the Subarctic and Arctic Seas (ESSAS) Open Science Meeting was "*Moving in, out, and across Arctic and Subarctic Marine Ecosystems: Shifting Boundaries of Water, Ice, Flora, Fauna, People and Institutions*". The theme highlights the dynamic nature of these Marine Ecosystems in a time of rapid change, and the implications for people that depend on the services provided by these systems. The conference drew a total of 187 participants from 17 countries with a majority from Norway (89), the US (37), Japan (18), and Canada (10). Presentations touched on all aspects of marine ecosystems and were grouped into the following sessions:

S1. Paleo-Ecology
S2. Advection and mixing and their ecosystem impacts
S3. Timing/phenology and match-mismatch: are they critical issues?
S4. Shifting habitats, persistent hot spots, and the distribution of benthos, plankton, fish, seabirds and marine mammals - observations, models, mechanisms and effects
S5. Subarctic and Arctic Marine Ecosystems under Climate Change
S6. Multiple Stressors
S7. Ocean Acidification
S8. Science, Policy and Management
S9. General Open Session

Prior to the Open Science Meeting, four separate workshops were held on June 11, 2017:

WKS1. Paleo-Ecology of Subarctic and Arctic Seas (PESAS) Planning Workshop
WKS2. Climate change impacts on nearshore fish habitats in the Arctic
WKS3. Using natural analogues to investigate the effects of climate change and ocean acidification on northern ecosystems
WKS4. Arctic and sub-Arctic climate change impacts: a transdisciplinary perspective

Cathleen Vestfals participated in WKS1, Natalia Monferrer participated in parts of WKS1 and WKS4, and Sofia Ferreira was one of the co-conveners of WKS4. Full workshops descriptions and agendas are attached.

In addition, all supported Early Career Scientists participated in and presented at the Open Science Meeting:

- Ryan Rykaczewski gave an invited keynote presentation in Session 2 (Advection and mixing and their ecosystem impacts). The title of his presentation was "*Variability in the transport and latitude of the North Pacific Current: consequences for northeastern Pacific ecosystems*".
- Marta Gluchowska presented a talk on "*Functional traits of zooplankton in Arctic fjords: spatial/temporal patterns and role of Atlantic water advection*" in session 2.
- Sofia Ferreira presented a talk on "*Linking phenology and productivity to Calanus copepods across the Northeast Pacific through satellite ocean colour*" in session 3 (Timing/phenology and match-mismatch: are they critical issues?)
- Cathleen Vestfals presented a talk on "*Exploring the dispersal and connectivity of Arctic cod and saffron cod early life stages in the Pacific Arctic using a biophysical transport model*" in session 4 (Shifting habitats, persistent hot spots, and the distribution of benthos, plankton, fish, seabirds and marine mammals - observations, models, mechanisms and effects).
- Natalia Monferrer presented a talk on "*Why do some redfish grow big and others don't?*" in session 9 (General Open Session).

A complete schedule for the open science meeting is attached.

# Summary Report

The ESSAS meeting covered a wide variety of topics, documenting changes that have occurred in arctic and subarctic seas from the distant to recent past, the processes that led to these changes, and how future changes are likely to further affect these marine ecosystems. Several sessions examined the consequences of changes in Arctic marine ecosystems for people who depend upon these ecosystems and how people and communities cope with changes in the goods and services that they derive from these ecosystems. To put the present day changes in a longer perspective, a workshop and session on the paleo-ecology of these systems examined changes in temperature and sea-ice conditions in the distant past. A special volume of the ICES Journal of Marine Science is in preparation to publish proceedings of the meeting.

Some highlights from the meeting

- Increasing borealization is evident at the Subarctic/Arctic boundary, but appears more pronounced in the Atlantic Arctic than in the Pacific Arctic
- Subarctic and Arctic regions have experienced both gradual changes and unusual events in recent years that are most likely climate-related, including anomalous warm conditions and unusual mortality events.
- *The probability of extreme or unusual events is expected to increase and disruptions of food webs, fish populations and existing fisheries associated with warm events are likely*
- Inter- and trans-disciplinary approaches and training spanning the natural and social sciences is essential to understanding the impacts of these changes

**Summary of workshops and sessions**

***WKS1 – Paleo-Ecology of Subarctic and Arctic Seas (PESAS) Planning Workshop***

The PESAS working group was established as part of ESSAS three years ago, in an effort to bring together scientists from diverse fields to discuss the reconstruction of past environments and the impacts of environmental changes on human populations. This was the third in a series of workshops and was convened by Drs. Ben Fitzhugh and Lester Lembke-Jene to bring together results of the first three years of the working group and to discuss goals and priorities for the next three years. Results from PESAS's first three years will be published as a special issue in the coming year.

***WKS2 – Climate change impacts on nearshore fish habitats in the Arctic***

The Bioenergetics Working Group of ESSAS aims to evaluate how climate impacts on prey quality and thermal regimes may influence the growth and energy content of gadid species in high latitude ecosystems. This workshop, convened by Drs. Ben Laurel, Alexei Pinchuk, Trond Kristiansen and Ron Heintz, brought together plankton and fish experts working in the nearshore regions of Newfoundland/Labrador, the Alaskan Chukchi and Beaufort Sea, the Barents Sea, Iceland and the Russian Arctic. Presentations focused on how environmental conditions drive seasonal and interannual variability in nearshore fish communities. Some scientific highlights include (1) the dominant role that local winds and advection can play in determining short-term fluctuations in species composition in

some nearshore environments and (2) the importance of thermal conditions in determining productivity of coastal nursery habitats for juvenile cod.

***WKS3 – Using natural analogues to investigate the effects of climate change and ocean acidification on northern ecosystems***

This workshop brought together international experts with experience in 1) monitoring carbonate chemistry across spatial and temporal gradients at high latitudes, 2) using natural analogues to assess the effects of predicted ocean acidification at different levels of biological organization, and 3) the effects of elevated pCO2 and low carbonate saturation on high latitude species. Together, these experts discussed the effects of climate change and ocean acidification in Subarctic and Arctic ecosystems. Discussions focused on documenting the importance of using natural analogues to investigate the effects of climate change and ocean acidification in Subarctic and Arctic ecosystems, identifying suitable natural analogue sites for future research in the Atlantic, Pacific, and Polar Oceans, and forming a strong cross-disciplinary group of experienced researchers to support future applications for funding work on this topic. One outcome from the workshop was the desire to establish a formal ESSAS working group to continue this work. The workshop was convened by Sam Rastrick, Tina Kutti, Melissa Chierici, Marco Milazzo, Jason Hall-Spencer, and Agneta Fransson.

***WKS4 – Arctic and subarctic climate change impacts: a transdisciplinary perspective***

This workshop was hosted by Dr. Sofia Ferreira, Dr. Alexandros Kokkalis, Giovanni Romagnoni, and Prof. Marko Lindroos, former members of the Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change (NorMER, http://www.normer.uio.no/) network. Throughout the day, the 22 participants brainstormed ways to measure the success of interdisciplinary research programs. Even though WKS4 had three main objectives, the participants decided to only focus on the second one, which was to investigate whether interdisciplinary research is a valuable tool for management.

**Scientific Sessions, ESSAS Open Science Meeting**

***S1 – Paleo-Ecology***

The session featured talks from a wide variety of disciplines ranging from paleo-oceanography to archaeology and more recent human history dimensions of Subarctic and Arctic marine ecosystems. Most presentations in this session were on collaborative, integrative and synthetic work that explored systemic linkages between climate change, ecological change, and human/societal change. Although a few presenters discussed changes to earth's natural systems spanning hundreds of thousands of years, most of the research in this session focused on changes that have occurred since the last glaciation. Human impacts on marine ecosystems were discussed across broad time scales in both the Pacific and Atlantic Subarctic and Arctic regions.

***S2 – Advection and mixing and their ecosystem impacts***

Presenters in this session discussed how advection and mixing influence marine ecosystems through their effects on hydrography and delivery of nutrients, which impact organisms from primary producers

to marine mammals and seabirds. Topics discussed included the roles these forces play in determining the distributions and concentrations of fresh water, sea ice, nutrients, primary production, zooplankton and some fish species, as well as how these factors impact higher trophic level organisms.

***S3 – Timing/phenology and match-mismatch: are they critical issues?***

Based on the talks presented, the match or mismatch between the timing of primary production, the emergence of zooplankton, hatching of fish larvae, and feeding migrations of upper trophic level predators can indeed be a critical factor in determining successful feeding and the success or failure of year classes in populations of consumers and predators. Presenters in this session discussed observational evidence for the importance of timing in Subarctic and Arctic ecosystems, as well as the mechanisms that lead to a match or mismatch between consumers and producers or between predators and their prey.

***S4 – Shifting habitats, persistent hot spots, and the distribution of benthos, plankton, fish, seabirds and marine mammals - observations, models, mechanisms and effects***

This session examined mechanisms that link organisms to biophysical habitats and explored if and how the distributions of these organisms will shift or persist in a changing climate. Presentations focused on identifying which habitats will undergo changes and which will remain stable as the climates of subarctic and Arctic marine ecosystems change, predicting effects on upper trophic level species, and determining how "borealization" will affect ecosystem structure in these regions. Additionally, links between shifting habitats, populations and human dimensions such as fisheries and wildlife management strategies were explored.

***S5 – Subarctic and Arctic Marine Ecosystems under Climate Change***

The main focus of this session was predicting what changes in atmospheric climate, oceanography, ecology, fish, fisheries and human institutions in the Subarctic and Arctic regions might be expected as earth's climate continues to change. Discussions included identifying the sources and magnitude of uncertainty in predictions of change, how predictions can be improved, and determining the viability and pitfalls of using data from the past to predict what will happen in the future.

***S6 – Multiple Stressors***

The myriad of challenges impacting marine organisms in the Subarctic and Arctic do not occur in isolation, but rather occur simultaneously and may mitigate or exacerbate one another's effects. Speakers in this session addressed issues including the combined effects of climate change, ocean acidification, invasive species, fishing, oil and gas exploration and extraction, mineral extractions, transportation and more.

***S7 – Ocean Acidification***

The formation and transport of corrosive waters in the Subarctic and Arctic is expected to impact biological systems in these regions. This issue is considered particularly important at high latitudes because ocean acidification is expected to be more pronounced in the colder regions of the planet. Presenters discussed the most recent observations of ocean acidification in the Subarctic and Arctic, as well as the impacts of corrosive waters on organisms and ecosystems in these areas.

***S8 – Science, Policy and Management***

This session went beyond impacts to explore how science can most effectively influence policy and management decisions, what policymakers and managers require from scientists, and how communications between scientists, resource users, and managers can be improved. The aim was to integrate experiences from social and natural scientists, economists, resource users, and managers. Speakers focused on specific examples and examined the successes and challenges of different science-to-policy experiences.

## Description for IASC website

The ESSAS Open Science Meeting took place in Tromsø, Norway, in June 2017 and included nine sessions relating to the central theme of **Moving in, out and across the Subarctic and Arctic marine ecosystems: shifting boundaries of water, ice, flora, fauna, people and institutions.** During the last decades there has been a rapid increase in the air and sea temperatures in the Arctic and a corresponding decline in summer sea-ice cover in the Arctic Ocean, including changes in the timing of ice retreat in the spring and ice formation in the fall, as well as a decrease in the thickness and the loss of multiyear ice. In the Subarctic seas there have also been large changes in sea temperatures but with considerable spatial variability. For example, generally warm conditions have been observed in the Nordic Seas of the North Atlantic while in the Bering Sea temperature conditions have varied between warm and cold periods with corresponding decreases and increases in winter sea-ice cover, respectively. These changes in the water and ice properties have resulted in changes in the biogeochemistry and ecology of these regions including increased ocean acidification as well as northward expansion of plankton and fish. This borealization has been more pronounced in the open Atlantic Arctic gateway compared to the Pacific Arctic. Growth rates, recruitment levels and phenology are also changing, resulting in increased abundances of some species and decreases in others. Changes in distribution and abundance of fish populations are resulting in changes in fisheries. For example, in some areas invasive species have resulted in the development of new fisheries while the loss of traditionally harvested stocks in other areas has caused those fisheries to disappear. This has resulted in challenges to fisheries management related to historical fishing rights, e.g. Atlantic mackerel in the North Atlantic. The ESSAS meeting documented changes that have occurred in the distant to recent past, the processes that led to these changes, and how future changes are likely to further affect these marine ecosystems. Several sessions examined the consequences of a changing environment for people who depend upon these ecosystems and how people and communities cope with changes in the goods and services that they derive from these ecosystems. To put the present day in a longer perspective, a session on the paleo-ecology of ecosystems and people in Subarctic and Arctic regions examined changes in temperature and sea-ice conditions in the distant past. A special volume of the ICES Journal of Marine Science is in preparation to publish some of the proceedings of the meeting.