2nd ERA-Can + International Symposium on Arctic and
Marine Research Infrastructure
24-25 September 2015

Background

In September 2013, the ERA-Can II project organized and hosted a symposium on Arctic and marine research infrastructure. Held in Rome, Italy, the symposium brought together 40 senior granting agency officials, research infrastructure managers and leading researchers from across Europe, the United States and Canada. Triggered by both common interests and the signing of the trilateral Galway Statement on Atlantic Ocean Cooperation, the symposium marked the first time that science leaders and decision-makers from these three jurisdictions came together to discuss the future development and coordination of Arctic and marine research infrastructures.

2nd ERA-Can + International Symposium on Arctic and Marine Research Infrastructure

Sponsored by the ERA-Can + Project, and in collaboration with the European Commission Directorate General, Research and Innovation, Infrastructures Unit, and the Canada Foundation for Innovation, the 2nd Trilateral symposium was conceived as a follow up of the Rome Symposium and brought together top researchers, facility managers and funding agency officials from Europe, the Unites States and Canada. The goal was to continue the discussions started in 2013 on how best to maximise the development and use of the research infrastructures that are necessary to conduct cutting-edge research in Arctic and marine environments. Dalhousie University acted as hosts for the symposium and provided an excellent venue that all participants enjoyed.

The central question emerging from the Rome Symposium was how to develop a process for coherent international scientific planning to make optimal use of the complex and expensive research infrastructures that are necessary to conduct leading-edge research in the remote and hostile Arctic and marine environments. The Rome Symposium began the discussions on how such a process might be developed.

Since the first Symposium, the USA-Canada-EU Arctic Working Group and the USA-Canada-EU Marine Working Group have both signed 'Statements of Purpose', confirming their intent to work towards the leveraging of opportunities for the shared use of infrastructure and installations. Given these developments, this symposium was intended to build on progress to date and facilitate further discussions on how to increase collaboration in the development and use of Arctic and marine research infrastructures.

Objectives:

- Continue the high-level discussions on how a coherent international scientific planning process can be developed;
- Assess the progress made to date by the various agencies, organizations, and working groups involved;
- Identify and prioritize next steps in moving the discussions forward, and more generally; and,
- Further the core objectives of the Galway Statement to foster cooperation and collaboration, notably regarding use and access to research infrastructures, in areas of common scientific interest between the three signatories.

1st DAY – 24th of September

The first day of the two-day symposium was opened by a presentation from **John Risley**, Chief Executive Officer of Clearwater Fine Foods Ltd., on the value of Arctic and marine research for society. In his presentation, Mr. Risley went to great lengths to explain how scientific research is the basis on which Clearwater Foods has been successful. By tapping into the expertise of researchers across Atlantic Canada, Clearwater Foods has not only been able to increase its seafood harvesting capacity, but has developed a range of technologies that allow it to do so in a sustainable way. Mr. Risley repeatedly emphasized that using science to both understand aquatic environments and develop more effective technologies is the key to long-term success. For example, Clearwater has put in place sophisticated biological monitoring and evaluation systems to ensure that lobsters are harvested and shipped around the world at exactly the right stage in their life-cycle. These process dramatically reduce losses in transportation, limits over-harvesting, and improves the quality of the product sold to customers. In another example, Clearwater is now using some of the most advanced sonar imaging systems, installed directly on fishing vessels, to determine the maturity of scallops while they are still growing on the seabed. This allows the company to avoid harvesting scallops that are not yet mature, prevent the over-exploitation of specific areas, and identify with great precision the most productive scallop beds.

Mr. Risley's strong and enthusiastic support for science and its value, not only for his own company, but for society in general, set the tone for the symposium, and signaled the importance of building international collaborations that can help ensure the long-term sustainable exploitation of marine resources.

1st PLENARY SESSION – Implementation of the Galway Statement on Atlantic Research Cooperation: Progress to date and next steps from the Marine Working Group

The first plenary session focused on the progress to date by the **Galway Marine Working Group**. Presentations were made by the Working Group co-chairs from Canada, EU and USA.

Representatives from the Marine Working Group:

- **Arran McPherson**, Director General, Ecosystem Sciences, Department of Fisheries and Oceans, Government of Canada
- **Wolfgang Wittke,** Policy Officer, Relations with Canada and the USA, DG Research and Innovation, European Commission
- **Terry Schaefer,** International Activities Office, National Oceanographic and Atmospheric Administration

The Transatlantic Research Alliance, which is the direct outcome of the Galway Statement on Atlantic Research Cooperation signed by all parties in May 2013, has led to the creation of both the Marine and the Arctic Working Groups. The task of these working groups is to identify research topics of common interest, prioritize associated research activities and develop coordination networks. The co-chairs of the Marine Working Group reported that these tasks are now well under way and several implementation events have already taken place in 2014 and 2015. Many others are now scheduled over the next several months.

The priority areas for cooperation identified by the Marine Working Group are defined under 'statements of purpose'. The statements of purpose constitute a framework for research cooperation and specify the roles that each national group will undertake. In this framework, three specific sub-working groups have been established to work on three specific priority research areas;

- ✓ Aquaculture
- ✓ Oceans Literacy
- ✓ Seabed Mapping

The sub-working groups are now conducting surveys of existing research activities in all three jurisdictions and designing the programs of research that will be used to guide specific research activities. The seabed

mapping initiative is now fully underway and the first highly detailed surveying transits of the Atlantic, from Canada to Ireland, have been completed.

In addition to these specific research activities, the Galway Statement has also prompted the establishment of several associated EU-Canada-US research consortiums. Supported largely through the European Commission's 'Galway tagged' marine and Arctic thematic areas, these new research consortiums include:

- EU-PolarNET, which compliments and extends into the international arena, the work of ArcticNet, a Canadian-funded Network of Centres of Excellence (NCE).
- AtlantOS, which brings together the research capacity of European and American research initiatives with MEOPAR, the Dalhousie University based-NCE on ocean observation, prediction and risk assessment.
- DiscardLess, which focuses on building a coherent tri-lateral research network to explore new ways of reducing and eliminating pollutants and waste dumped into the Atlantic Ocean.
- AqaSpace, which will focus on improving water quality for aquaculture by using a comprehensive ecosystem approach and new technologies for marine spatial planning.

2nd PLENARY SESSION - Implementation of the Galway Statement on Atlantic Research Cooperation: Progress to date and next steps from the Arctic Working Group

Representatives from the Arctic Working Group:

- **David Scott**, President, Polar Knowledge Canada
- **Andrea Tilche**, Head of the Climate Action and Earth Observation Unit, European Commission
- **Eric Saltzman,** Section Head, Arctic Science, National Science Foundation

The co-chairs of the Arctic Working Group emphasized that through geography, ocean dynamics, climatic conditions, human activities and many other factors, the Arctic and Atlantic marine environments are strongly linked to one another. This reality was the rationale for the formation of the Transatlantic Ocean Research Alliance and its two specific, but linked, working groups. Since the signing of the Galway Statement, the Arctic Working Group has triggered improved cooperation between US, European and Canadian research groups. This increased cooperation has led to the decision to invest in a consistent package of Arctic research activities in the 2016-17 Work Programme of the European Commission's Horizon 2020 Framework. The central purpose of these research funding opportunities is to focus international research efforts on climate change issues, which, it is hoped, will attract further US and Canadian investments.

For the Arctic Working Group, the shared strategy is based on a three-step process, structured as follows:

- ✓ Sharing information among jurisdictions on the existing research investments related to the priority areas for cooperation;
- ✓ Engaging in joint priority setting of actions for four areas of cooperation; and,
- ✓ Aligning and integrating the planning and programming of current research activities in the US, Europe and Canada.

Although substantial research collaboration already takes place between US, European and Canadian researchers, progress to date on defining priorities and planning research activities has been slowed by the transition here in Canada of the Polar Research Commission into its new entity as Polar Knowledge Canada. The EU PolarNet, however, has been established and is now organizing efforts to implement the direction provided by the Arctic Working Group.

3rd PLENARY SESSION - The Funders' perspective, moderated by David Barnard, President of the University of Manitoba

Speakers:

Gilles Patry, President and CEO, Canada Foundation for Innovation

Antonio Di Giulio, Head of Unit, Infrastructures, European Commission, DG Research and Innovation

Eric Saltzman, Section Head, Arctic Science, National Science Foundation

The third plenary session focused on the Funders' perspective. As all three speakers emphasized, international collaboration is increasingly important for the advancement of science across all areas and particularly where there is common interest in geographic regions such as the Atlantic Ocean and the Arctic. This is especially the case in areas such as Arctic and marine research where jurisdictional responsibilities are shared and where the cost of conducting research is high. This session focused on how various research funding bodies in Europe, the United States and Canada are defining and articulating their international collaboration strategies, how these strategies relate to the objectives of the Galway Statement and what opportunities are emerging in relation to Arctic and marine research.

As the panel participants made clear, there are a number of emerging opportunities, as well as challenges, in providing inter-jurisdictional support for Arctic and marine research. At the highest level, there is increasing emphasis being placed on the strategic aspects of fostering international collaboration and this is the starting point for the implementation of specific funding, networking and organizational activities. For example, the European Commission's Blue Growth Strategy is now being translated into a broad range of

targeted calls for proposals that are in large part designed to accommodate and facilitate international engagement and participation.

As the panel participants made clear, however, the key to overcoming the challenges in providing support for international research collaborations is effective and consistent communication of existing opportunities and on-going engagement at all levels, from individual researchers, to research organizations, to funding agencies. For example, Dr. Gilles Patry, the President of CFI, talked about the possibilities of multi-jurisdictional research infrastructure funding and how this can be accommodated within CFI's existing program structure. These opportunities, however, are not well known either in Canada or in the United States and Europe. International engagement and communication projects, such as ERA-Can+, can improve the situation significantly and the considerable increase in research collaboration between Canada and the EU member states is strong evidence of their value.

4th PLENARY SESSION - Example of on-going and emerging international cooperation, moderated by Martha Crago, Vice-President Research, Dalhousie University

The third Plenary provided a range of examples of on-going and emerging international cooperation:

- ✓ **AtlantOS, Douglas Wallace,** Canada Excellence Research Chair in Ocean Science and Technology, Dalhousie University and **Jan-Stefan Fritz,** German Marine Research Consortium.
- ✓ **ODIP2, Serge Scory**, Royal Belgian Institute of Natural Sciences (RBINS), Head of the Belgian Marine Data Centre.
- ✓ **COOPEUS, Mairi Best**, Consultant on Ocean Observing and Research Infrastructure Development; Adjunct Professor, Laurentian University. Currently consultant to EMSO and member of their Interim Office working on the development of the consortium organizational infrastructure and the establishment of the EMSO ERIC.
- ✓ **CHONe, Paul Snelgrove,** CHONe Network Director, Department of Ocean Sciences, Memorial University of Newfoundland.
- ✓ **Ocean Tracking Network, Sara Iverson,** Scientific Director, Ocean Tracking Network, Dalhousie University

The AtlantOS Project: Funded through the European Commission's Horizon 2020 programme, AtlantOS is developing in-situ Atlantic Ocean Observations for a better management and sustainable exploitation of the maritime resources. The project is coordinated by the GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany. AtlantOS is a research and innovation project that fosters the integration of ocean observing activities across all disciplines for the Atlantic, considering European as well as non-European partners. The

overarching goal of AtlantOS is the integration of the so far loosely-coordinated set of existing ocean observing activities into a sustainable, efficient, and fit-for-purpose Integrated Atlantic Ocean Observing System (IAOOS). The IAOOS will form the ocean in-situ observing backbone of the Copernicus Marine Monitoring system, which is the marine part of the European Earth Observation Programme.

The ODIP 2 project: The Ocean Data Interoperability Platform project is developing interoperability between existing regional data infrastructures in the EU, the US, Canada and Australia. Through a series of international workshops a number of prototype interoperability solutions are being developed. These prototype systems will be implemented by the regional data infrastructures to provide users with open access to high quality multidisciplinary ocean research data and associated services.

The COOPEUS project: This European Commission-funded project is strengthening the cooperation between the US and the EU in the field of environmental research infrastructures. In the specific field of ocean observatories, two associated research projects, EMSO and OOI, are working on a tsunami wave detection system. Eventually this preliminary work could help in the future implementation of a common, harmonized sensor registry and quality assessment/control process.

These sessions provided the senior officials from participating funding agencies an opportunity to gain valuable insights into the advances being made in Arctic and marine science and the unique characteristics of operating research infrastructures in extremely harsh and challenging environments.

2nd DAY – 25th of September

The second day was opened by **Mr. Jim Balsilie**, Chairman Sustainable Development Technology Canada; Founder/Current Chair of the Centre for International Governance Innovation and Founder of the Arctic Research Foundation.

Mr. Balsillie's presentation principally related to his role as Founder of the Arctic Research Foundation and he enthusiastically recalled the search for the Franklin Expedition vessels and how this led to the purchase, outfitting and certification of a dedicated in-shore research vessel – The *Marty Bergmann*. The success of the search for the Franklin Expedition ships was, in very large part, the result of having access to a properly fitted research vessel that had the specific capabilities to operate in shallow Arctic waters. The success of the Franklin search has now led the Arctic Research Foundation to consider purchasing and outfitting additional vessels to be essentially generic Arctic research platforms, and in particular, platforms that are capable of providing researchers with access to areas of the Arctic that a traditional large-scale icebreaker

cannot enter. The Arctic Research Foundation is also developing a fleet of mobile, containerized research laboratories that can be located at high-priority research sites. These mobile laboratories will increase the ability of researchers to undertake a broad range of new research activities that take advantage of the environmental characteristics of specific locations.

Mr. Balsille emphasized the need to lever the resources of many different jurisdictions, research support agencies, government departments and major research initiatives if the challenges of Arctic research are to be effectively tackled. No one nation or research community can ever hope address the vast range of research needed in the Arctic by itself. The resources required, the territory to cover and the range of questions to address are simply too vast, complex and pressing. Collaboration at all levels will be necessary if challenges such as the impacts of climate change are to be effectively addressed.

The Symposium Participants then moved into Break-Out Sessions which were structured as follows:

1) **Mapping research priorities to infrastructure needs**: considering the marine, terrestrial and atmospheric environments, what are the major research advances and changes in research priorities that will likely result in gaps in the current international suite of research infrastructures?

Chair: Kate Moran, President and CEO, Ocean Networks Canada

Results from this session:

*C*onsidering the marine, terrestrial and atmospheric environments, the discussion held during the first breakout session was on the major research advances and changes in research priorities that will likely result in gaps in the current international suite of research infrastructures.

After an initial identification from each participant of the main gaps in the research infrastructures landscape, the discussion was structured on four main points:

- ✓ The need for and possible development of large-scale research platforms, such as icebreakers, communication networks and research stations;
- ✓ Foundational aspects of research infrastructures, especially in relation to communications;
- ✓ Possible opportunities for new forms of integrated research infrastructures, including cabled ocean observatories, glider fleets, floating and moored buoy systems, and research stations; and,
- ✓ The sensors issue, including common standards for sensor calibration, technology development for harsh environments, and efficient means of data capture in remote locations.

PLATFORMS

One of the most significant gaps in Arctic research is the lack of data collected during the winter period. This is largely due to the inability of researchers to access the vast majority of Artic territory, both land and sea. The consensus view is that there is a pressing need to access the Arctic during winter in several ways. One is the organization of ice camps that can be used scientific teams and accessed by aircraft of various types. The more effective solution, however, is overwintering by appropriately fitted ships that can provide mobile laboratories, accommodation facilities and safety and emergency rescue capabilities. Such facilities and capabilities can only be established through a multi-national collaboration to share the effort and to plan a common plan of action. With only one research icebreaker, Canada simply does not have the ability to do this alone.

Some limited capabilities are, however, being installed. For example, the "Multidisciplinary drifting Observatory for the Study of Arctic Climate" (MOSAiC) project[1] which represents a good international collaboration from different countries to improve the year-round, detailed, and comprehensive measurements from the atmosphere through the sea-ice and into the ocean of the central Arctic Basin.

FOUNDATIONAL ASPECTS OF RESEARCH INFRASTRUCTURES

One of the foundational aspects highlighted in the discussion is the need for underwater navigation and the data telemetry systems in the Arctic Ocean. The main recommendation coming out from the discussion is the organization of a trilateral working group that can develop a technology roadmap. This roadmap would follow a staged approach, using prototypes and test beds followed by phased adoption of proven instruments. The potential cost of such technology is very high and coordination among the main participants is necessary in order to identify the best and most efficient strategy.

A second foundational aspect discussed is the lack of communication and tele-communications in the Arctic areas. This represents a major barrier to conducting research and is one of the most difficult to overcome. Two options were discussed; the installation of dedicated communication micro-satellites and/or the installation of an optic fibre cable network in order to make the communication in the Arctic more efficient. Any further discussion on this matter should involve the three most relevant countries, USA, Canada and Greenland.

[1] http://www.mosaicobservatory.org/

POSSIBLE OPPORTUNITIES

The discussion made clear that many possible opportunities exist to improve the current international suite of research infrastructures. These include establishing port facilities in the north areas, the use of military vessels in conjunction with military and coast guard training exercises, the purchase and re-fitting of shallow-water vessels, the systematic and consistent involvement of Arctic coastal communities, and the increasing the involvement of industry.

All these opportunities for improving the marine and arctic research infrastructures can be summarized in a common recommendation which states that there is a strong need of a tri-lateral organizational mechanism to pursue these opportunities and enable them for science priorities.

SENSORS

The main needs related to sensors are in the areas of biology and biogeochemistry, including:

- ✓ Biofouling of equipment
- ✓ Interoperability between sensor networks
- ✓ Quality control of both the technology and the data gathered
- ✓ Standards for materials, data, operational deployment, etc.

Senor technologies capable of functioning in the Arctic are currently very limited and this in itself offers a substantial opportunity for cutting-edge engineering and technology commercialization.

2) **International scientific planning:** would a coherent international scientific planning process for shared infrastructure be a useful way forward to ensure the leveraging of opportunities and longer-term collaboration? What are the most effective models and how can they be linked to the national funding cycles and related planning and decision processes? What are the persistent and recognized hurdles and which opportunities can be envisaged?

Chairs: **James Drummond,** Professor of Physics and Atmospheric Sciences, Dalhousie University, and **Terry Callaghan, Project Coordinator,** INTERACT

Results from this session:

The two chairs of the session drafted a series of key questions to guide the discussion.

Would more international co-ordination on the use of infrastructures accelerate the science?

Both large-scale science programs and smaller-scale science efforts benefit from international co-operation and co-ordination and being part of a network can benefit both, particularly through the sharing of existing and new infrastructure.

What are the most effective models and how can they be linked to the national funding cycles and related planning and decision processes?

The ongoing dialog between funding agencies, infrastructure operators and scientists is essential. Funding agencies should consider accepting other funding agencies' evaluations of proposals. Beside this aspect there is need of both international and national support for infrastructures at all scales.

What are the persistent and recognized hurdles and which opportunities can be envisaged?

The hurdles are represented by the difficulty of coordinated funding among national and international partners together with the long-term sustainability of infrastructure, measurements and expertise of personnel.

Regarding the opportunities, first of all Russia should be part of the equation. Capacity building and training of young scientists, technical staff and managers can represent another opportunity together with the "Celebration of our success" that must be communicated to the wider world. For example, the INTERACT model for networked terrestrial infrastructure and the EuroFleet for ships are working well and could probably be replicated in other areas. The networks facilitate the "one-stop" shopping for hazards and other fast-reaction needs while the coordinated observations and capabilities within networks and the standardization of measurement methodologies provide researchers with efficient and effective means of gathering observational data.

Would more international co-ordination on the use of infrastructures accelerate the science?

The simple answer is "yes". Some research questions, such as the environmental impacts of climate change, are so large and complex that they require an international approach. There has to be recognition that science has a range of scales that are fairly distinct but interact. At one extreme are large pan-global programs and at the other, local studies for local problems. Local studies can benefit from interaction with the larger scale programs and vice versa. This, however, requires organizational resources to gather, review, package and share in a systematic and consistent way. At the moment, there are very few organizations with a mandate or the resources to do such work.

There is a need to co-ordinate both funding of new infrastructure and the maintenance of existing relevant infrastructure. This is particularly important for long term studies and being part of a network can benefit both existing and new infrastructure, as well as smaller players by access to a larger community.

What are the most effective models and how can they *be linked to the national funding cycles and related planning and decision processes?*

The ongoing dialogue between funding agencies, infrastructure operators and scientists is essential and the funding agencies need to foster a consistent method of "bottom up" collaboration between groups. Coordination of funding deadlines is very desirable and the main issue to be clarified is if the proposal deadlines are appropriate in all cases. Funding agencies should consider accepting other funding agencies' evaluations of proposals, as well as considering the constraints imposed by legal structures on networks.

3) **Sharing information on research capabilities**: one of the key elements in developing research collaborations is the systematic and organized sharing of information. Should the development of a joint European – USA – Canada web portal for Arctic and marine research agendas, outcomes, infrastructure inventories, activity schedules, etc., be considered? If so, who would be responsible for managing such a portal? Are there other viable alternatives available?

Chairs: David Hik, University of Alberta, **Brian Moorman,** University of Calgary and Arctic Institute of North America

Results from this session:

One of the key elements in developing research collaborations is the systematic and organized sharing of information. The third break-out session on sharing information on research capabilities was initiated with a short *tour de table* introducing the 11 participants and an introduction to the break-out session's topic. The first question focused on whether there was a need for a joint web portal or not.

WEB PLATFORMS

Several opportunities were identified by the group, including the substantial benefit of such a platform for networking and connecting to new research groups internationally. The identification of new players in the Arctic and marine research domain was regarded as particularly important in the context of an overall growth of multi- and interdisciplinarity. A possible web-platform could also be a single entry point ("one-stop-shop") for Arctic and marine research information that now needs to be collected from many different sources. It was noted that various sources of information are already available. The envisioned web-platform should first offer a place to merge the information already retrievable, but be set up in a way that

it can be extended later on. An extension could be targeted at filling gaps or at extending the geographical outreach of the platform (potentially even world-wide).

The issues identified in realizing such a platform were manifold. Decisions of what scope and what detail of data coverage should be envisioned and need to be taken, along at least the following dimensions:
1) horizontal (e.g.: geographical) and vertical (e.g.: content diversity) coverage
2) what topics and areas to cover (e.g.: splitting Arctic and marine or not?)
3) what users and stakeholders need to be or can be addressed.

DATA MANAGEMENT

A second important issue that was discussed focused on data management. A central question was on how web-portal project participants can be encouraged to update and feed the content management system regularly and in timely manner. Further issues related to data management were privacy (who should have access to what parts of the platform?), security (are there critical information elements that should not be shared publicly?) and accessibility (especially when it comes to world-wide coverage).

RESOURCES

The third strand of issues clustered around the question of resources, including the need of start-up or seed funding for establishing a platform and limited but long-term funding for maintenance.

The group generally considered it a useful idea to establish a web-platform as described above. Based on this, the next decision must be on who the audience, stakeholders and users of such a platform are. It was considered sensible to start with an inventory of data and information that already exists to ensure that the new platform is not a replication of already available elements ("let's not re-invent the wheel"). It was acknowledged that Arctic and marine researchers need to be thought of as two user groups, but given scarce resources and existing overlaps, the platform should be a single entry point for both of the fields, at least as a first step. It was recommended to start the web-platform project with an organization that already exists and might already have experience and networks in the relevant fields (as opposed to establishing a new one for this task). Funding should derive from a range of diverse funding sources.

4) **Building integrated international research data collections and access systems**: research data is becoming one of the central elements in building research collaborations. Many countries and disciplines are in the process of developing comprehensive and integrated data systems. Would it be useful to work

towards linking up these national and multi-disciplinary data systems? If so, who would take responsibility for such work?

Chairs: Julie Friddell, Associate Director, Canadian Cryospheric Information Network/Polar Data Catalogue, University of Waterloo and **Dugan O'Neil,** Chief Science Officer, Compute Canada

Results from this session:

The main questions highlighted for the discussion were:

Should we build integrated international research data collection and access systems? And is it useful to link Arctic and marine data repositories?

Yes we should build integrated international research data collection and access systems and yes, we should link Arctic and marine repositories. But it might also make sense to link other repositories like those from the atmospheric community. The group disagreed, however, with the 2013 Rome symposium conclusion that a single repository system is required. Instead, all existing systems should be linked using new standards and agreed upon inter-operability protocols. Both data and metadata should be linked in parallel.

What are the benefits?

Having integrated systems/linked repositories will certainly facilitate science by helping researchers to better access and use available data. The linked repositories could also lead to the development of new collaborations and partnerships, triggering new ideas and more inter-disciplinary work.

What are the barriers?

Barriers/challenges include:

- ✓ the lack of a governance body and structure to oversee this work;
- ✓ the costs and amount of work required to build integrated systems that connect all major data gathering sources (i.e. government, industry, universities/research institutes, not for profits);
- ✓ security and privacy concerns (e.g. health data);
- ✓ the wide variety of Arctic data types that need to be considered in developing such systems;
- ✓ IT capabilities (software, technical and human capacity);
- ✓ community needs that are constantly evolving;
- ✓ raising awareness among scientists of the new linked data systems and ensuring they have the knowledge, skills and motivation to use the systems (perhaps new funding models could *require* scientist to share their data);

- ✓ commercialization issues (i.e. need to ensure those who produce the data get credit); and,
- ✓ policy and legal issues (i.e. need to ensure legal protection is provided to agencies that share data externally so they are not held accountable).

Who will set the path and do the work required?

There is currently no high level governance structure/coordinating body to develop and oversee the proposed international research data collection and access systems. Who could take this role? Possible champions might include: the Research Data Alliance (RDA) which currently has an international network or the Arctic Council and marine and atmospheric working groups. Groups like GEO and ICES could be consulted as they have started to think about integrated international systems. Companies like Google might be able to do the actual work. The network of integrated systems must include Russia, Japan, South Korea, China, etc. It was agreed however, that there is a need to start small and then grow to link more and more repositories over time.

How might the integrated systems be funded?

Funding could potentially be sought from Horizon 2020, JPIs or the Belmont Forum. CFI offers up to $2 million per project and Compute Canada is always interested in pilots. Or there are private funders like Google, shipping or oil companies who benefit from the resulting research. However, the research community must consider the public perception of the latter (e.g. that they influence research results).

Conclusions

Since the signing of the Galway Statement on Atlantic Research Cooperation in 2013, significant progress has been made in fostering international collaboration in marine and Arctic research. Both the 2013 Rome Symposium and the 2015 Halifax Symposium made clear, however, the much remains to be done. And while the differences between the various jurisdictions involved are becoming well known, the process of finding pathways to overcome these differences is just beginning.

Most encouraging, however, is that the discussions at the Halifax Symposium focused on roles, responsibilities and opportunities. Common ground on both the scientific and strategic policy interests of all three jurisdictions involved has now been identified and articulated. The symposium participants all agreed that the research challenges in both the marine and Arctic environments are at such as scale, in terms of their importance to society, their difficulty to address, and the costs involved, that they require sustained international collaboration. This in itself represents a significant step forward. The central questions now revolve around issues of communication, coordination, alignment and inclusion.

For example, the symposium participants clearly articulated that the sharing of information, from data produced by specific research projects, to inventories of research infrastructures, to national-level science planning, is one of the most important means to fostering international collaboration and coordination. Today, the sharing of information can be accomplished far more efficiently and effectively than at any time in the past, but questions still remain in relation to roles, responsibilities and sources of financial support.

The symposium also made clear that all those stakeholders who need to be involved in the multi-lateral discussions around challenges and opportunities in Arctic and marine research are not yet at the table. This is particularly the case with Russian scientists and Russian science agencies. It is also, to some extent, the case with the private sector and with science-based government departments and organizations. As the participants in one of the breakout sessions emphasized, there is a growing need for the research community to communicate with the wider world that international collaboration is both possible and that it works. This in itself will help bring additional stakeholders into the discussions and ultimately lead to more substantial and positive impacts on society and on the marine and Arctic environments.

Symposium Organizing Team:
Martina DeSole, Association for the Promotion of Research in Europe (APRE)
Elena Maffia, APRE
Debbie Kemp, Global Affairs Canada
David Moorman, Canada Foundation for Innovation

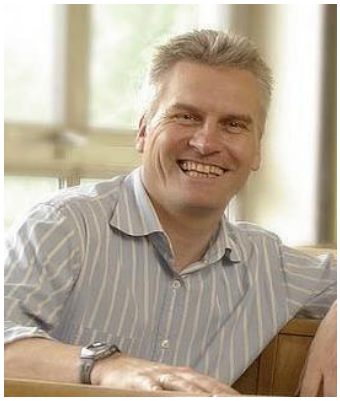
SPEAKERS

Thursday, 24 September

MARTHA CRAGO

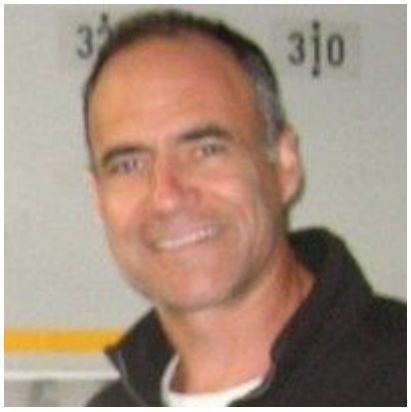
RICHARD FLORIZONE

WOLFGANG WITTKE



TERRY SCHAEFER

DAVID SCOTT



JOHN RISLEY

ANDREA TILCHE

ERIC SALTZMAN

DAVID BARNARD

ANTONIO DI GIULIO

GILLES PATRY

DOUGLAS WALLACE

SERGE SCORY

MAIRI BEST

PAUL SNELGROVE

SARA IVERSON

Friday, 25 September

JIM BALSILLIE

KATE MORAN

JAMES DRUMMOND

TERRY CALLAGHAN

DAVID HIK

BRIAN MOORMAN

JULIE FRIDDELL

DUGAN O'NEIL

LOUIS FORTIER

DAVID BARBER

ERA-Can + Halifax Tri-lateral Symposium on Arctic and Marine Research Infrastructure

Confirmed Participants

	Participant	Organization	E-mail address
USA Participants			
USA	Jeremy Mathis	National Oceanographic and Atmospheric Administration	Jeremy.mathis@noaa.gov
USA	Terry Schaefer	National Oceanographic and Atmospheric Administration	Terry.schaefer@noaa.gov
USA	Eric Saltzman	National Science Foundation	esaltzma@nsf.gov
USA	Uwe Send	Scripps Institute of Oceanography	usend@ucsd.edu
USA	Heidi Sosik	Woods Hole Oceanographic Institution	hsosik@whoi.edu
USA	Don Rice	National Science Foundation	drice@nsf.gov
USA	William Ambrose	National Science Foundation	wabrose@nsf.gov
USA	Julie Morris	US Global Change Research Program	jmorris@usgcrp.gov
USA	Arthur Lerner Lam	Lamont-Doherty Earth Observatory	lerner@ldeo.columbia.edu
Canadian Participants			
CAN	John Risley	Clearwater Fine Foods	
CAN	Martin Raillard	Polar Knowledge Canada	Martin.raillard@polar.gc.ca
CAN	Jim Drummond	Dalhousie University, CNNRO	James.drummond@dal.ca
CAN	Pat Rodee	Dalhousie University	Pat.rodee@dal.ca
CAN	Doug Wallace	Dalhousie University and MEOPAR	douglas.wallace@dal.ca
CAN	Marcel Babin	Université Laval	Marcel.babin@takuvik.ulaval.ca
CAN	David Barber	University of Manitoba	David.barber@umanitoba.ca
CAN	David Barnard	University of Manitoba	jocelyn.striemer@umanitoba.ca
CAN	Kate Moran	Oceans Network Canada	kmoran@uvic.ca
CAN	Paul Snelgrove	Memorial University of Newfoundland and Labrador	psnelgro@mun.ca
CAN	Sara Iverson	Dalhousie University and Ocean Tracking Network	Sara.iverson@dal.ca
CAN	Fred Whoriskey	Dalhousie University	fwhoriskey@dal.ca
CAN	David Hik	University of Alberta	dhik@ualberta.ca
CAN	Julie Friddell	University of Waterloo	Julie.friddell@uwaterloo.ca
CAN	Brian Moorman	University of Calgary and Arctic Institute of North America	moorman@ucalgary.ca
CAN	Randy Gillespie	Memorial University and Centre for Applied Ocean Technology	Randy.gillespie@mi.mun.ca
CAN	Brad deYoung	Memorial University and MEOPAR	bdeyoung@mun.ca
CAN	Martha Crago	Dalhousie University	Martha.crago@dal.ca
CAN	Richard Florizone	Dalhousie University	Richard.Florizone@Dal.Ca
CAN	Ariane Plourde	Université de Québec à Rimouski	Ariane.plourde@uqar.ca
CAN	Sylvie Boucher	Canada Foundation for Innovation	Sylvie.boucher@innovation.ca
CAN	Olivier Gagnon	Canada Foundation for Innovation	olivier.gagnon@innovation.ca

CAN	David Scott	Polar Knowledge Canada	Davidj.scott@polarcom.gc.ca
CAN	Jim Balsillie	Arctic Research Foundation	karen@amolino.com
CAN	Ralf Bachmayer	Memorial University	bachmayer@mun.ca
CAN	Maribeth Murray	University of Calgary and Arctic Institute of North America	murraym@ucalgary.ca
CAN	Nikki Macdonald	Ocean Networks Canada	nikkimac@uvic.ca
CAN	Arran McPherson	Department of Fisheries and Oceans	arran.mcpherson@dfo-mpo.gc.ca
CAN	Rear Admiral John Newton	Royal Canadian Navy	Natasha.Mang@forces.gc.ca
CAN	Louis Fortier	ArcticNet	Louis.Fortier@bio.ulaval.ca
CAN	Martin Fortier	ArcticNet	Martin.Fortier@arcticnet.ulaval.ca
CAN	Michel Gosselin	Université du Québec à Rimouski	michel_gosselin@uqar.ca
CAN	John Osler	Atlantic Research Centre, Defence Research and Development Canada	john.osler@drdc-rddc.gc.ca
CAN	Karen Davison	Department of Fisheries and Oceans	Karen.Davison@dfo-mpo.gc.ca
CAN	Julie La Roche	Dalhousie University	Julie.Laroche@Dal.Ca
CAN	Stephen Locke	Natural Resources Canada	slocke@nrcan.gc.ca
CAN	Claude Hillaire-Marcel	Geotop-UQAM	chm@uqam.ca
CAN	Francine Desharnais	Atlantic Research Centre, Defence Research and Development Canada	Francine.desharnais@drdc-rddc.gc.ca
CAN	Kostylev, Vladimir	Natural Resources Canada	Vladimir.Kostylev@NRCan-RNCan.gc.ca
CAN	Dugan O'Neil	Compute Canada	dugan.oneil@computecanada.ca
CAN	Arran McPherson	Ecosystem Sciences, Department of Fisheries and Oceans	Arran.McPherson@dfo-mpo.gc.ca
CAN	Gilles Patry	Canada Foundation for Innovation	Gilles.patry@innovation.ca
CAN	Charles Lin	Environment Canada	charles.lin@ec.gc.ca
CAN	Oksana Schimnowski	University of Manitoba	Oksana@arcticresearchfoundation.ca
CAN	Glen Condran	Department of Fisheries and Oceans	Glen.condran@dfo-mpo.gc.ca
CAN	Helen Murphy	Universities Canada	hmurphy@univcan.ca
CAN	Richard Marceau	Memorial University of Newfoundland and Labrador	vp.research@mun.ca
CAN	Michael Bhardwaj	Canada Foundation for Innovation	Michael.Bhardwaj@innovation.ca
CAN	David LeBlanc	Polar Knowledge Canada	David.leblanc@polar.gc.ca
CAN	Pierre Normand	Canada Foundation for Innovation	Pierre.normand@innovation.ca
CAN	Sherry Niven	Department of Fisheries and Oceans	Sherry.Niven@dfo-mpo.gc.ca

CAN	Dan Hutt	Defence Research and Development Canada	daniel.hutt@drdc-rddc.gc.ca
CAN	Melanie Vanstone	Industry Canada	melanie.vanstone@ic.gc.ca
CAN	Hal Ritchie	Environment Canada	Hal.Ritchie@EC.GC.CA
CAN	Mike Gill	Polar Knowledge Canada	mike.gill@polar.gc.ca
CAN	Ronald Newhook	Marine Institute of Memorial University	Ron.Newhook@mi.mun.ca
CAN	Pierre Lavoie	Defence Research and Development Canada	Pierre.lavoie@drdc-rddc.gc.ca
CAN	Brigitte Leblon	University of New Brunswick	bleblon@unb.ca
CAN	Darren Gilmore	Public Policy Forum	Darren.gilmour@ppforum.ca
CAN	Rhonda Moore	Public Policy Forum	Rhonda.moore@ppforum.ca
European Participants			
EU	Nicole Biebow	Alfred Wegener Institute	Nicole.biebow@awi.de
EU	Terry Callaghan	INTERACT	Terry.callaghan@btinternet.com
EU	Veronica Willmott-Puig	Alfred Wegener Institute	Veronica.willmott@awi.de
EU	Jose Joaquin Hernandez Britto	PLOCAN	Joaquin.britto@plocan.eu
EU	Margareta Johansson	INTERACT	Margareta.johansson@nateko.lu.se
EU	Serge Scory	Royal Belgian Institute	Serge.scory@mumm.ac.be
EU	Mairi Best	EMSO	Mmrbest.interimoffice@emso-eu.org
EU	James Gavigan	Delegation of the European Union to the USA	Julia.garcia-pascual@eeas.europa.eu
EU	Andrea Tilche	European Commission	Andrea.tilche@ec.europa.eu
EU	Attilio Gambardella	European Commission	Attilio.gambardella@ec.europa.eu
EU	Daniel-Constantin Strugariu	European Commission	Daniel-constantin.strugariu@ec.europa.eu
EU	Antonio Di Giulio	European Commission	Antonio.di-giulio@ec.europa.eu
EU	Jon Børre Ørbaek	Research Council of Norway	jbo@forskningsradet.no
EU	Wolfgang Wittke	European Commission	Wolfgang.Wittke@ec.europa.eu
EU	Luigi Scarpa de Masellis	European Commission	Luigi.SCARPA-DE-MASELLIS@eeas.europa.eu
EU	Pascal Morin	IPEV - Institut polaire français	pascal.morin@ipev.fr
EU	Lauri Laakso	Finnish Meteorological Institute	lauri.laakso@fmi.fi
EU	Margareta Johansson	INTERACT	margareta.johansson@nateko.lu.se
EU	Jan-Stefan Fritz	German Marine Research Consortium	fritz@deutsche-meeresforschung.de
EU	Viki Bodnarova	EURAXESS	Viktoria.bodnarova@euraxess.net
EU	Jan Rene Larsen	AMAP	jan.rene.larsen@amap.no
EU	Margaret Rae	Marine Institute, Ireland	margaret.rae@marine.ie
EU	Patricia Killian	Marine Institute, Ireland	Patricia.Killian@marine.ie
EU	Vianney Pichereau	LabexMER	vianney.pichereau@univ-brest.fr
EU	Philippe Potin	UPMC Roscoff	potin@sb-roscoff.fr
EU	Nathalie Morata	IUEM, University of Western Brittany	nathalie.morata@univ-brest.fr
ERA-Can + Partners			
EU	Martina De Sole	ERA-Can + and APRE	desole@apre.it

EU	Elena Maffia	ERA-Can + and APRE	maffia@apre.it
EU	Isabella Wagner	ERA-Can+ and ZSI	wagner@zsi.at
EU	Johanna Fullman	ERA-Can+ and DLR	Johanna.fuellmann@dlr.de
CAN	Debbie Kemp	ERA-Can+ and DFATD	Debbie.kemp@international.gc.ca
CAN	Claire Millington	ERA-Can + and Universities Canada	cmillington@univcan.ca
CAN	Gabriella Dew	ERA-Can + and Universities Canada	gdew@univcan.ca
EU	Xavier Morise	ERA-Can+ and CNRS	Cnrs-office@ambascience-usa.org