MASTS DPMS Case Study Report:

2015 Extended Ellett Line Workshop: Shaping the future and celebrating 40 years of science

SAMS. April 27-28 2015

Organizers: Stefan Gary, Penny Holliday, Stuart Cunningham, and Clare Johnson

Figure 1: Photo of workshop participants (Appendix A) on the beach near SAMS.

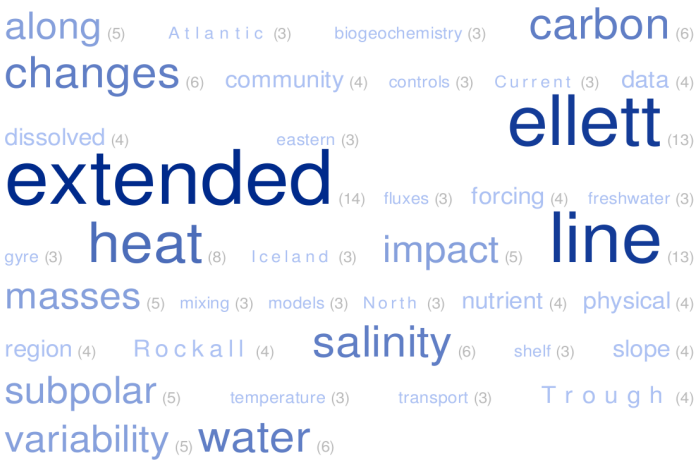

Figure 2: Word cloud based on the research questions enumerated by participants (Appendix B) created by TagCrowd.com (Creative Commons 4.0).

Introduction

The Extended Ellett Line is an annual, long-term, full-depth deep ocean hydrographic section (Figure 3). The 2015 occupation represents the 40th year of data collection in the Rockall Trough and to mark this milestone, 36 scientists (Appendix A) gathered to talk about past achievements as well as discuss potential future objectives, research questions, and collaborations. The workshop was divided into two parts: a series of talks to set the stage for the discussion and a series of group work activities to discuss the strategic vision for the EEL, elicit research questions, and build community.

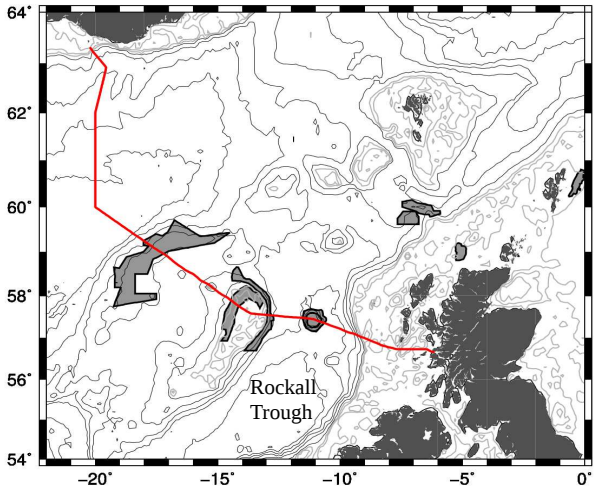

Figure 3: Map of the Extended Ellett Line (EEL) repeat hydrographic section (red line). Stations on the original Ellett Line, spanning the Scottish Shelf and Rockall Trough, have been occupied at least once every year since 1975. Temperature, salinity, oxygen, and nutrients are the core observations collected each year; some years additional variables are also measured. Also shown in grey shading are the nearby offshore Marine Protected Areas.

Part 1: Oral presentations

During the workshop, there were a total of 17 oral presentations spanning the physics, biogeochemistry, biology, and ecology of the eastern subpolar North Atlantic as well as the potential impact of this science on society and policy. The individual presentations, along with presenters, are listed in Appendix C, the schedule for the workshop. Given the dynamic discussions after the presentations, the presentations were successful in engaging workshop participants.

Part 2: Group work

The second part of the workshop, on April 28, consisted of a series of concurrent breakout discussions, a dynamic group exercise in mapping options for the EEL strategy, and an enumeration of research questions and summary.

Concurrent breakout sessions

Workshop participants suggested questions for concurrent breakout discussions (Appendix C). The major points arising from these discussions are:

1) There is interest from the biogeochemical community to obtain regular core-top sediment samples (40 cm long) along the EEL, going from the coastal stations all the way to the deep ocean. Synchronous water column and sediment samples would allow for assessing the sediment nutrient regeneration rates and the direct ground truthing of proxy data (e.g. sponge spicules).

2) Closing the heat budget for this region is an active research topic. Data synergies and gaps need to be identified in order to leverage the existing observing programmes in the eastern subpolar North Atlantic, of which the EEL is a long-term contributor.

3) There is a silicate decline at some locations in the eastern subpolar North Atlantic but the EEL hydrography shows no trend in silicate. Developing a nutrient budget in this region by compiling data, averaging along isopycnals, and computing nutrient fluxes will likely help to address this silicate question, which may have impacts on the ecosystems and fisheries in the area.

4) The EEL crosses a region whose relatively fragile benthic ecosystems are in Marine Protected Areas and need additional study (Figure 3). EEL cruises are a potential platform for the quick deployment and recovery of landers that will help integrate observations of benthic biology with the EEL physics data.

5) For the dissemination of EEL results and data, one must keep in mind the intended audience as well as the necessary effort. In addition to publications and data centres, EEL data is will suited for ICES reports and review papers. Efficient additional activities could be to post EEL outputs on the website, make an EEL infographic, and share video from sea. Dissemination may also be achieved via international and interdisciplinary collaborations.

6) It is important to be able to distinguish large-scale patterns from local variability. Due to lack of data, this distinction is more difficult for biogeochemistry than physics so model output is currently used for estimating the natural variability of the biogeochemistry. The plans for annual carbon sampling on the EEL make it well-positioned to be a leader in quantifying the interannual variability of the carbon cycle in this region.

7) The southern tip of Rockall Bank is a key area for searching for Subarctic Intermediate Water (SAIW) and then attempting to predict the downstream impacts on ecosystems and fisheries. Argo floats and hydrographic data can help determine a metric for SAIW volume flux and the EEL data may be useful for quantifying the downstream presence of SAIW.

Mapping EEL strategy options

Over the course of a dynamic group activity, participants were asked to first enumerate, and then sort, the long-term and short-term goals and actions they found relevant to the EEL programme. A summary of these goals and actions, *as highlighted by workshop participants*, is presented in Figure 4 (next page). Increased dissemination and coordination is a recurring theme among the the goals and actions. Furthermore, expanding the diversity of data collected, with an eye to integrating physical observations with biological and biogeochemical observations, was identified as an area for growth. Developing this synergy is particularly important as it may pave the way for identifying the physical controls on ecosystems, fisheries, and biogeochemistry.

At the centre of the near- and long-term strategy the EEL lies data. Participants identified a need for an interdisciplinary EEL data inventory. In order to build a data inventory, it was agreed that representatives from all disciplines must be forward and proactive in communicating metadata with the whole EEL community. Furthermore, the process of writing review papers appears to be a good venue for bringing together data sets that may be otherwise unknown.

Research questions and summary

The research questions listed by workshop participants are listed in Appendix B and are summarized at a glance in the word cloud on the title page (Figure 2). The overwhelming majority of interdisciplinary questions focus on identifying the dominant physical controls on other processes. While the exact questions and interests of the EEL community may change in the future, it is clear that we want to pursue the careful, and eventually systematic, integration of data across disciplines.

Acknowledgements:
We are grateful for MASTS support through the MASTS Dynamics and Properties of Marine Systems (DPMS) Research Theme Case Study: The Extended Ellett Line.

Near-term goals

Dissementation through: knowledge transfer, social media, website, expert list.

Coordination through: building community, exploring collaborative funding routes, submit to SPAG

Build on existing hydrography and nutrient data and include opportunistic sampling for benthic biology and biogeochemistry.

Long-term goals

Raise profile via knowledge exchange.

Extend to Greenland.

Expand the range of observations, diversifying to include especially: biogeochemistry, benthic biology, glaciology, models, and shelf dynamics, while also purposefully integrating interdisciplinary data.

Add student training opportunities.

Streamline data access and create a data inventory.

Near-term actions

Perform studies.

Continue sampling.

Get people together.

Write review papers with emphasis on a biogeochemistry review paper.

Prepare an infographic.

Report on this workshop.

Long-term actions

Pursue funding for international collaborations.

Add conventional and new sensors to moorings and gliders.

Expand the winter dataset with moorings and gliders.

Integrate process studies better.

Close the heat, salt, and freshwater budget of the North Atlantic.

Figure 4: Summary of the EEL strategy, sorted into goals and actions, as summarized by workshop participants.

Appendix A: List of workshop participants

William Austin, University of St Andrews/SAMS
Bee Berx, Marine Scotland
Tim Brand, SAMS
Katelin Childers, Stony Brook University / Potsdam Institute for Climate Impact Research
Elizabeth Comer, University of Southampton
Finlo Cottier, SAMS
Kirsty Crocket, SAMS
Stuart Cunningham, SAMS
Keith Davidson, SAMS
Stefan Gary, SAMS
Colin Griffiths, SAMS
Susan Hartman, NOC
*Hjálmar Hátún, Faroe Marine Research Institute
Pierre Helaouët, SAFHOS
*Stephanie Henson, NOC
Sheila Heymans, SAMS
Penny Holliday, NOC
Kerry Howell, Plymouth University
David Hughes, SAMS
Matthew Humphreys, University of Southampton
Mark Inall, SAMS
Clare Johnson, SAMS
Caroline Kivimae, NOC
Peter Lamont, SAMS
Karin Margretha H. Larsen, Faroe Marine Research Institute
Fraser Macdonald, SAMS
Alice Marzocchi, University of Bristol
Bhavani Narayanaswamy, SAMS
Glenn Nolan, Marine Institute
*Jennifer Riley, NOC
*Richard Sanders, NOC
Natalia Serpetti, SAMS
Jirina Stehlikova, SAMS
Robert Turnewitsch, SAMS
Kamila Walicka, SAMS
*Martin White, NUI Galway

*Invited speaker

Appendix B: Questions list grouped loosely by discipline

Biology and Ecology

1) What are the physical divers of sponge aggregation distributions? (The goal is to produce better distribution models.)

2) What are the physical drivers of seamount community structure?

3) How does the Taylor Column on Anton Dohn Seamount influence larval dispersal and connectivity?

4) What is the impact of ocean-shelf interaction on nutrient and zooplankton fluxes?

5) Why do mackerel avoid the central Iceland Basin?

6) What controls the depth of winter mixing and timing of restratification? Is there an impact on primary production, the benthos, fisheries, or cetaceans?

7) Are there long-term changes in the benthic community that can be attributed to changes in temperature, salinity, phytoplankton, and nutrients?

8) Would it be of interest to couple EEL data with CPR to obtain a broader view on the potential impact of hydrographic features in planktonic communities?

Physics

1) What is the time of emergence for trends in [pick-your-favorite-variable] at the EEL?

2) Salinity pulses along the continental slope are fast near the shelf by lagged (1-2 years) in the Rockall Trough. How can we distinguish between the two branches?

3) What is the forcing of the sub-decadal salinity pulses along the continental shelf and Rockall Trough? Specifically, what is the impact of the wind stress curl?

4) What is the signal of Si/salinity/P/N/temperature in core water masses along the Eastern N. Atlantic Margin?

5) What is the seasonal cycle of volume, heat, and freshwater transports in the eastern subpolar North Atlantic?

6) What is the heat transport between Iceland and Scotland?

7) What is the heat budget of the northern North Atlantic?

8) What forcing (advection, buoyancy, wind) drives the ocean heat content, overturning, and horizontal circulation changes in the subpolar gyre? The Iceland, Labrador, and Irminger basins may be forced differently.

9) Are eddies important for heat and freshwater fluxes?

Physics (continued)

10) Is air-sea exchange on Hatton Plateau important for UK climate?

11) What forcing sets/controls the strength and variability of the European Slope Current?

12) If the European Slope Current has declined but eastern boundary flow increased in the last 10-15 years, what are the relative roles of deep versus slope currents in heat and salt fluxes from the Rockall Trough to the Nordic Seas?

13) Which model best represents the Extended Ellett Line observations? (Does the answer depend entirely on context?)

14) How well do numerical models reproduce the "snapshot" observations of physical properties along the Extended Ellett Line?

15) How influential is horizontal and vertical mixing in the inter-gyre region in modulating inter-decadal variability in temperature and salinity at the Rockall Trough on the Extended Ellett Line?

16) Can we understand the post-2011 salinity decline in subarctic intermediate water and the impact of subpolar water mixing?

17) What is the long-term variability in heat, salt, and mass transport across the Extended Ellett Line? Can these time series be extended through connections with other data – moorings, satellites, etc.?

18) What explains the variability in the permanent pycnocline?

Biogeochemistry

1) What is the Redfield/stoichometric ratio N:P:O:C:Si in the subpolar gyre? Does it change with water masses and time?

2) Does increased dissolved inorganic carbon, due to subpolar gyre contraction, inhibit uptake of anthropogenic CO_2 at the EEL?

3) How does interannual variability propagate in time and space and through the physical controls on biogeochemistry and onto biology?

4) What is the role of dissolved organic carbon on the shelf versus the open ocean?

5) How do water masses acquire their Nd isotope compositions and dissolved fractions?

6) Can water masses along the EEL be characterised by the rare earth element concentrations in the dissolved fraction?

7) Is there evidence of non-Redfieldian nutrient dynamics at the EEL?

8) What are the sediment nutrient regeneration rates along the EEL?

Biogeochemistry (continued)

9) How efficient at carbon sequestration is the EEL region? How/why does carbon sequestration vary interannually and decadally?

10) How will changing Arctic-Atlantic exchange affect the biology, biogeochemistry, freshwater, heat content, nutrients, circulation, and community structure of the Extended Ellett Line region?

11) How will climate change affect the biogeochemistry in the Extended Ellett Line region? What can we learn from contemporary data? Do predictions match our expectations?

Policy

1) What are the policy implications for the EEL data set?

Appendix C: Workshop schedule

The 2015 Extended Ellett Line Workshop:
Shaping the future and celebrating 40 years of science
27 - 28 April 2015
Sheina Marshall Building, SAMS, Oban

Aim: to recognize and renew the Extended Ellett Line (EEL) science program by bringing together a diverse community of scientists to discuss achievements over the past 4 decades and to define key outstanding questions.

April 27: Day 1: Invited keynote talks and 15 minute talks

9:00 Introduction:
Aims/objectives of the workshop (*Stefan Gary*)
History, objectives, achievements of the EEL program (*Penny Holliday*)

9:30 Keynote talk on physical variability (*Martin White*)
10:15 Multi-decadal variability of potential temperature, salinity, and transport in the eastern subpolar North Atlantic (*Penny Holliday*)
10:30 The Faroe Current: T-S properties and volume/heat transports (*Karin M. Larsen*)
10:45 The North Atlantic subpolar circulation in an eddy-resolving global *ocean* model: strengths and weaknesses of NEMO (*Alice Marzocchi*)

11:00 Tea, coffee and biscuits

11:30 Keynote talk on biogeochemical processes and variability (*Richard Sanders*)
12:15 Oxygen and Hydrogen isotopes in seawater as constraints on water mass mixing and changes in source water contribution (*William Austin*)
12:30 Multi-decadal accumulation of anthropogenic CO2 at the Extended Ellett Line (*Matthew Humphreys*)

12:45 Lunch

14:00 Keynote talk on plankton community variability (*Stephanie Henson*)
14:45 Keynote talk on physical controls of ecosystems and fisheries (*Hjálmar Hátún*)

15:30 Tea, coffee and biscuits

16:00 Maps, modelling and sustainable management of the deep-sea ecosystem: opportunities for collaboration (*Kerry Howell*)

April 27: Day 1 (Continued)

16:15 Linking the past and present to help predict the future: Using environmental drivers to understand and predict changes in deep-sea biological communities (*Bhavani Narayanaswamy*)

16:30 Nutrients on the EEL (*Clare Johnson*)

16:45 Searching for sedimentary imprints of ocean dynamics (*Robert Turnewitsch*)

17:00 Optional tour of SAMS, beach, networking

18:00 Dinner at SAMS

Carrot and Coriander Soup (vegetarian)

Roast Chicken with Stuffing
(for participants who did not specify a preference)
or
Spinach and Ricotta Tortellini Bake
(only for participants who specified vegetarian)

Cranachan

20:30 Car/bus/taxi back to Oban

April 28: Day 2: Discussion

9:00 Keynote talk on communication, stakeholders and policy-making (*Jennifer Riley*)

9:45 Introduction to breakout sessions (*Stefan Gary*)

10:00 Concurrent breakouts session 1, parts A-F

A Where are the most promising sites for a sedimentary archive of deep water overflow along the EEL? (*William Austin*)

B Could collaborations between observational projects in the region establish local heat budgets in the area? (*Katelin Childers*)

C What results could be obtained if we observed late winter (pre-bloom) nutrient concentrations along the EEL? (*Hjálmar Hátún*)

D How do we incorporate benthic biological work into the EEL? What are there possibilities to collect/turn over moorings/landers? (*Kerry Howell*)

10:45 Feedback from breakouts

11:00 Tea, coffee and biscuits

April 28: Day 2 (Continued)

11:30 Concurrent breakouts session 2, parts G - L

E What is the best way to disseminate regional data collected by EEL and other programs? (*Katelin Childers*)

F How relevant are changes in variables observed at the EEL to changes in the wider North Atlantic and Nordic Seas? (*Matthew Humphries*)

G How do we introduce a palaeoceanography element in the EEL programme? What about the use of neodymium and other geochemical tracers? Which characteristics of WTROW can be exploited for the purposes of palaeo-reconstruction of overflow intensity? (*Kirsty Crocket and Alice Marzocchi*)

H The presence of SubArctic Intermediate Water (SAIW) on the eastern side of the Rockall Plateau seems to be a critical metric for marine climate and ecosystems. Can a metric of *SAIW presence* be established with EEL data (maybe combined with the Irish sections farther south)? (*Hjálmar Hátún and Martin White*)

12:15 Feedback from breakouts

12:30 Sensitivity of the subpolar gyre index to the calculation parameters (*Bee Berx*)

12:45 Cetation and fish research from oceanographic cruises (*Clare Embling via Kerry Howell*)

13:00 Lunch

14:00 Mapping strategic opportunities of the EEL

15:30 Tea, coffee and biscuits

16:00 Listing of research questions and final summary