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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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TABLE OF CONTENTS

SUMMARY vi

AZMP SYNTHESIS WORKSHOP SESSION 1– PHYSICS 1

COMPLEMENTING THE AZMP; MODEL-BASED OCEANOGRAPHIC CONDITIONS IN THE GSL IN 2017 – JOËL CHASSÉ 1

UPDATE ON MODELLING – MARITIMES REGION – DAVID BRICKMAN 1

UPDATE ON OCEAN CLIMATE MODELLING OVER THE NEWFOUNDLAND AND LABRADOR SHELF – GUOQI HAN 2

RECENT CHANGES IN NEWFOUNDLAND AND LABRADOR WATERS PART I – A DIVE INTO SEVEN DECADES OF OCEANIC OBSERVATIONS – FRÉDÉRIC CYR 3

RECENT CHANGES IN NEWFOUNDLAND AND LABRADOR WATERS PART II: ON THE LOW-FREQUENCY VARIABILITY OF THE NW ATLANTIC – ALI MORIDNEJAD 4

CLIMATE VARIABILITY AND TREND OFF NEWFOUNDLAND AND LABRADOR OVER 1979–2010 – GUOQI HAN 5

CIRCULATION AND RENEWAL OF SAGUENAY FJORD WATERS – PETER GALBRAITH 6

EXPLORATORY WORK ON DERIVING INSHORE CURRENTS IN ATLANTIC CANADA USING SATELLITE ALTIMETRY DATA – GUOQI HAN 6

AZMP SYNTHESIS WORKSHOP SESSION 2– BIOGEOCHEMISTRY 7

TRACE GASES NITROUS OXIDE (N_2O) AND METHANE (CH_4) IN THE ST. LAWRENCE ESTUARY AND GULF – MICHAEL SCARRATT 7

PROGRESS ON PHYTOPLANKTON RESEARCH IN THE NWA – EMMANUEL DEVRED 8

TIMING OF THE BLOOM: RESULTS FROM DIFFERENT ANALYTICAL METHODS – NICOLAS LAMBERT 8

USING OPTIMAL AND REALIZED HABITAT MODELS TO ASSESS THE UNDERLYING MECHANISMS OF *CALANUS* POPULATION RESPONSES TO FUTURE CLIMATE CHANGE IN THE NORTHWEST ATLANTIC – STÉPHANE PLOURDE 9

MODELLING APPROACHES TO UNDERSTANDING *CALANUS* SPATIAL VARIABILITY – CATHERINE L. JOHNSON 10

BODY SIZE/CONDITION IN *C. FINMARCHICUS* – STÉPHANE PLOURDE AND PIERRE PEPIN 11

REVIEW OF PHYSICAL AND BIOGEOCHEMICAL CONDITIONS IN THE NORTHWEST ATLANTIC – SESSION 1 12

PHYSICAL CONDITIONS IN THE LABRADOR SEA (AZOMP) IN 2017 – IGOR YASHAYAEV 12

PHYSICAL OCEANOGRAPHIC CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELVES – FRÉDÉRIC CYR 14

BIOGEOCHEMICAL CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELVES – GARY MAILLET 14

LABRADOR CURRENT TRANSPORT FROM VESSEL-MOUNTED ADCP MEASUREMENTS – GUOQI HAN 15

PHYSICAL OCEANOGRAPHIC CONDITIONS IN THE GULF OF ST.LAWRENCE – PETER GALBRAITH 15

BIOGEOCHEMICAL CONDITIONS IN THE GULF OF ST. LAWRENCE – MARJOLAINE BLAIS 16
REVIEW OF PHYSICAL AND BIOGEOCHEMICAL CONDITIONS IN THE NORTHWEST ATLANTIC – SESSION 2 17
PHYSICAL OCEANOGRAPHIC AND METEOROLOGICAL CONDITIONS ON THE SCOTIAN SHELF AND IN THE GULF OF MAINE DURING 2017 – DAVID HEBERT 17
BIOGEOCHEMICAL CONDITIONS ON THE SCOTIAN SHELF AND IN THE EASTERN GULF OF MAINE – CATHERINE L. JOHNSON 17
2017 BEDFORD BASIN CONDITIONS – ANDREW COGSWELL 19
THE CARBONATE SYSTEM IN THE NORTH ATLANTIC – PIERRE PEPIN, STEVE PUNSHON, MICHEL STARR 20
SUMMARY OF ZONAL SCORECARDS/REVIEW AND AGREEMENT OF SAR BULLETS – PIERRE PEPIN, PETER GALBRAITH 22
AZMP BUSINESS MEETNG – SESSION 1 22
MATTERS ARISING IN 2017 – PIERRE PEPIN 22
REGIONAL SUMMARY OF ACTIVITIES – ANDREW COGSWELL, GARY MAILLET, PETER GALBRAITH 23
DATA MANAGEMENT PROGRESS AND ISSUE OVERVIEW – SHELLEY BOND 27
SUMMARY OF THE OCEAN DATA MANAGEMENT SUBCOMMITTEE – MATHIEU OUELLET 28
AZMP BUSINESS MEETNG – SESSION 2 30
OCEAN SCIENCES FRAMEWORK / ACCASP / UPDATE FROM NATIONAL CAPITAL REGION (NCR) – ANDREW STEWART, DENISE JOY 30
UPDATE ON REMOTE SENSING AT BIO – CARLA CAVERHILL 30
A CLIMATOLOGY OF NUTRIENT MEASUREMENTS FROM NEWFOUNDLAND – GINA DOYLE 31
ADCP MEASUREMENTS ON THE NEWFOUNDLAND SHELF AND SLOPE – STEPHEN SNOOK 32
METADATA FOR THE BAY OF FUNDY LONG-TERM HYDROGRAPHIC MONITORING STATIONS – FREDERICK J. FIFE 33
VIKING BUOY OPERATIONS, CHALLENGES AND PLANS – PETER GALBRAITH 34
GLIDER OPERATIONS – DAVID HEBERT 36
AZMP BUSINESS MEETING- SESSION 3 36
SUMMARY OF ACTION ITEMS/ISSUES IDENTIFIED FROM LOGISTICS, DATA MANAGEMENT, AND WORKSHOP MEETINGS 36
AZMP REPORTING 36
MATTERS ARISING 37
WORK PLAN FOR 2018–19 37
REFERENCES CITED 37
APPENDIX I – TERMS OF REFERENCE 39
APPENDIX II – MEETING AGENDA 40

APPENDIX III – MEETING PARTICIPANTS 44

SUMMARY

The Atlantic Zone Monitoring Program (AZMP) was implemented in 1998 with the aim of collecting and analyzing the biological, chemical, and physical field data that are necessary to:

1. Characterize and understand the causes of oceanic variability at the seasonal, inter-annual, and decadal scales;
2. Provide multidisciplinary datasets that can be used to establish relationships among the biological, chemical, and physical variables; and
3. Provide adequate data to support the sound development of ocean activities.

AZMP scientists meet annually to review the activities of the Program and assess business, operational and logistic issues that need regional/zonal intervention or that must be brought to the attention of the DFO Atlantic Science Directors Committee. The year 2009 marked the 10th anniversary of ocean observation by AZMP. In March 2010, AZMP scientists initiated an effort to synthesize and integrate the oceanographic conditions observed in the Atlantic Zone since 1999, to identify trends or changes, and to provide a critical assessment of the information available. In 2014, the Atlantic Zone Offshore Monitoring Program (AZOMP) began providing an overview of the oceanographic conditions in the Labrador Sea. In 2018, the AZMP scientists reconvened in Montréal from March 20th to 23rd to continue work on the synthesis, discuss logistic and operational issues, review recent oceanographic conditions within the zone, update the plans for the integration and synthesis exercise, and finalize the plan of work for the current year.

AZMP SYNTHESIS WORKSHOP SESSION 1– PHYSICS

Rapporteur – Catherine Johnson

COMPLEMENTING THE AZMP; MODEL-BASED OCEANOGRAPHIC CONDITIONS IN THE GSL IN 2017 – JOËL CHASSÉ

Collaborators: D. Brickman, N. Lambert, P. Galbraith

We presented the recent progress related to the development of a three-dimensional ice–ocean modelling system for the Gulf of St. Lawrence, Scotian Shelf, and Gulf of Maine (GSL-SS-GoM). The goal of the study is to produce an ice–ocean hindcast, covering 1948–2017, to fill the data gaps in the observational system to support fisheries studies, stock connectivity studies, invasive species research, bio-geochemical modelling, climate change studies, and so on. The hydrodynamic model (NEMO-OPA) is coupled to an ice model (LIM) and is driven with the NCEP (National Center for Environmental Prediction) atmospheric forcing interpolated to the model grid. The model also includes tidal forcing and freshwater runoff of the 78 main rivers within the domain. All of the data required to force the model from 1948 to 2017 have been collected. The NCEP temperatures were adjusted (corrected) with historical observations from nine stations around the GSL. Boundary conditions were fine tuned to reproduce the main circulation features of the study domain. These circulation features include the cyclonic circulation in the GoM, the Nova Scotia coastal current, the along-slope Scotian Shelf current, circulation around Western Bank, the Anticosti Gyre, and the Gaspé Current. The model results compare very well with observed sea-surface temperature (SST) and observed temperature and salinity profiles. The modelling approach is proving to be useful in filling data gaps for the GSL-SS-GoM. The model results were formatted to present monthly anomalies that are complementary to the State of the Gulf of St. Lawrence for time periods when there are no observed data. Typical variables are salinity, currents, and transport on sections, which are not available from observations. Such long-time series are very useful for ecosystem research.

Discussion

The model already includes a hydrology component with freshwater runoff, which is included in AZMP state of the GSL reporting (e.g., very high freshwater input in May 2017). Circulation patterns, transport, and estuarine amplification are also included in the reporting. Additional products that could be included are monthly air temperature anomalies, monthly cloud cover anomalies, wind stress anomalies, and wind speed anomalies. Model validation has included SST (model – NCEP or CMC [Canadian Meteorological Center] forced vs. remote sensing). Bottom temperature does not perform as well because the boundary conditions are still climatological; this needs to be developed more. The new 1948–2017 scorecards for SST and bottom temperatures provide a longer-term perspective. Monthly salinity anomalies show propagation of anomalously high inflow of river water. The model is not perfect but it is still useful for many questions. Topics suggested for discussion to be held after the three presentations on modelling include whether there should be a model-based state of the GSL report, whether a zonal approach to reporting on model results should be included in standard products, and which variables are the most useful and from which models.

UPDATE ON MODELLING – MARITIMES REGION – DAVID BRICKMAN

Collaborators: Z. Wang

The presentation contained two main sections. The first one summarized Brickman's ongoing work on seasonal prediction of ocean conditions in Maritime Canadian waters. This included his

forecast ice predictions for the AZMP cruise period and a preliminary report on the predictability of ocean bottom temperatures indicating the differences of such a study compared to the work done on atmospheric seasonal prediction.

The second section of the presentation was an update and summary on the use of the BNAM model simulations to understand ocean processes in the North Atlantic region. BNAM is the high resolution (~1/12 deg) Bedford Institute of Oceanography (BIO) North Atlantic Model run by Zeliang Wang. The model, run in hindcast mode, starts in 1990 and goes to the current year. This included an update on the study of the recent warming events observed on the Scotian Shelf, GSL, and Gulf of Maine, which has been reported at the AZMP meeting in previous years. Further details of this study are available in Brickman et al. (2018).

Discussion

Two models, CANOPA MC (Maritimes) and BNAM were included in this talk. CANOPA MC is a legacy model used for seasonal forecasts, whereas the BNAM model is more useful going forward. The latter is costly to run with only monthly outputs.

Seasonal forecasting was motivated by bottom temperature needs for management, e.g., for snow crab. Seasonal forecasts are forced by output from CanSIPS (Canadian Seasonal to Inter-annual Prediction System) and are run monthly for the upcoming 12 months. One of the output products is a forecast of ice conditions that is used for AZMP mission planning (e.g. Cabot Strait area). The bottom temperature predictions are used in fisheries applications. A systematic approach is underway to do a “categorical skill assessment” for bottom temperature predictions. The approach used by CCCMa (Canadian Centre for Climate Modelling and Analysis) might prove to be “too generous” for bottom temperature analyses.

The BIO North Atlantic Model runs in hindcast (from 1990) and forecast modes (ACCASP, Aquatic Change Climate Adaptation Services Program related). BNAM output is used in the annual AZMP Maritimes Region reporting. It has also been used to assess current stream variability in Atlantic Canadian waters, shifts in the Labrador Current system as well as changes in the Atlantic meridional overturning circulation (AMOC). In addition, it was used in a recently published paper (Brickman et al. 2018) about the mechanism behind the changes in ocean conditions on the Scotian Shelf in the 2010s: The model shows skill in simulating various data, in particular the positive slope in temperature during the last 10 years. From analysis of the model run it is found that anomalies originate from the interaction between the Gulf Stream and the Labrador Current at the tail of the Grand Banks (south of Newfoundland). This interaction results in the creation of anomalous subsurface warm/salty (or cold/fresh) eddies that travel east-to-west along the shelfbreak. These “blobs” penetrate into the Gulf of St. Lawrence, onto the Scotian Shelf, and into the Gulf of Maine via deep channels along the shelfbreak. The observed warming trend can be attributed to an increase in the frequency of creation of warm anomalies during the last decade. The model result shows the importance of processes at the Tail of the Banks in contributing to ocean variability in the GSL/SS/GoM regions.

UPDATE ON OCEAN CLIMATE MODELLING OVER THE NEWFOUNDLAND AND LABRADOR SHELF – GUOQI HAN

Collaborators: Z. Ma, J. Chassé, Z. Long, W. Perrie

The objective of this project is to provide high-resolution hindcasts and projections of ocean and ice conditions for the Newfoundland and Labrador Shelf from 1981 to 2099. In the past year, we completed and improved projection runs for CanESM2, HadGEM2, and MPI-ESM models under Representation Concentration Pathway 8.5 (RCP8.5, a high emission scenario), as well as MPI-ESM under RCP4.5 (a median emission scenario) for the projection

period of 2011–2099. The sea-surface temperature and the bottom temperature at Station 27 are likely to increase by 4°C over the projection period. The sea-surface salinity and bottom salinity at Station 27 are likely to decrease by 1.5 and 0.5 over 2011–2099, respectively. By the end of the 21st century, the winter sea-ice extent south of 55°N is likely to decrease by 90% (relative to the 1981–2010 mean).

Discussion

Model validation was done for mean state and seasonal cycle for temperature, salinity, currents, and sea ice. A few more runs with RCP4.5 will be done along with analysis of projections in RCP8.5 and RCP4.5.

The following discussion concerns the points outlined at the end of the first presentation. On the question of whether there should be a model-based state of the ocean presented as a separate or additional report, several concerns were voiced. Since there is not yet a single best model, it is not possible to take a common zonal approach. Furthermore, the Environment Canada (EC) products that the models require do not currently have a reanalysis; if/when an EC reanalysis is developed, it would be useful to use this approach. Currently, some of the model results are integrated into the research documents, but it is hard to include enough details to make it clear what the limitations of the models are, and a dedicated model research document could help to rectify this situation. However, there was concern about the workload required to put together a zonal modelling research document. Overall, the consensus was to focus on reporting model products where they complement the data in the near term, and include model results in the Science Advisory Report (SAR) if possible.

There was also a discussion clarifying whether any of the models includes data assimilation and whether a data assimilation model incorporating observations would be useful. The current models can only do pure simulations, not assimilation, and reporting must be done with a two-year time lag due to the requirement for forcing products. It was noted that transport information is useful and could be included in reporting. Inputs for the models such as GEM are an important point, and this needs to be prioritized for providing information to clients. The precision is not as important as the trend. There is a plan to include more ocean data in the outputs of Environment and Climate Change Canada (ECCC) hindcast models. Assimilation in GIOPS (Global Ice-Ocean Prediction System) is farther down the road. In comparison to using the models to fill in the gaps, data assimilation is not necessarily going to improve on that mode.

The BNAM model, or alternatively something like HYCOM (Hybrid Coordinate Ocean Model), was identified as the best approach for addressing the intrusion of warm bottom water intrusions into the deep GSL.

RECENT CHANGES IN NEWFOUNDLAND AND LABRADOR WATERS PART I – A DIVE INTO SEVEN DECADES OF OCEANIC OBSERVATIONS – FRÉDÉRIC CYR

Collaborators: P. Pepin, A. Moridnejad

Newfoundland and Labrador (NL) shelves are located on a crossroads of the Atlantic meridional overturning circulation (AMOC). Systematic hydrographic observations of this unique system have been carried out by Fisheries and Oceans Canada since 1948. The observation program was reinforced in 1999 with the creation of the AZMP, with enhanced seasonal coverage that also targets biogeochemical observations. Here we review nearly seven decades of oceanic observations, with an emphasis on low-frequency variability and climatic cycles. The relationships between the hydrodynamics and the biochemical measurements are discussed as well.

Discussion

The NL shelves are a crossroads of the AMOC, but it is changing; this is evident in the Atlantic Multi-decadal Oscillation (AMO) variability. AMOC is weak when AMO is positive and temperature is warm, and it shows long-frequency variability. Drivers include the North Atlantic Oscillation (NAO)—when the pressure difference is high, Labrador Sea temperature is low—and it explains a lot of temperature variability in the North Atlantic. Anthropogenic warming is overlayed on that, with 93% of global warming absorbed into the ocean. NL shelf data availability is reasonable since the 1940s, so one can look at changes in Northwest Atlantic water masses and biogeochemistry in relation to the NAO (this was an ACCASP transition project). Preliminary results for the inshore Avalon Peninsula area show distinct changes in the cold intermediate layer (CIL) “core temperature”. There was a strong interdecadal variability pattern; warm mid-1950s to mid-1970s, cold mid-1980s to mid-1990s, then warming until recently. There are similar low-frequency changes in salinity. Salinity was higher when it was cool. What are the drivers? Relationships with the AMO were evaluated, but they were not clear. Alheit et al. (2014) found relationships between AMO and pelagic fish population variability in the NE Atlantic; how is this related to Northwest Atlantic patterns? An examination of the nitrate/phosphate ratio showed a shift from more Pacific waters to more Atlantic waters from the early 2000s to the 2010s (Benetti et al. 2017). In AZMP data, the ratio shifts as well—so how is this related to drivers? One idea is to look at the Arctic Ocean Oscillation, which explains sea surface height (SSH) patterns. Since the 1990s, an anticyclonic pattern has dominated, leading to less export of water from the Arctic into the Atlantic; this is consistent with the observed changes in AZMP. Next, empirical orthogonal functions (EOFs) will be used to look at spatio-temporal changes.

A point of clarification was made that it was not necessary to control for spatial change in the study because it was focused only on the inshore. Links to Arctic circulation and processes are complicated and need more attention. Similarly, the relationship between changes in the source water formation and nutrients need further study. The influence of the NAO as a driver of Atlantic zone conditions changed starting in around 2000, and this is related to changes in the spatial position of the zones with low-pressure differences. A more regionally relevant index should be developed to address this change.

RECENT CHANGES IN NEWFOUNDLAND AND LABRADOR WATERS PART II: ON THE LOW-FREQUENCY VARIABILITY OF THE NW ATLANTIC – ALI MORIDNEJAD

Collaborators: F. Cyr, P. Pepin

In the second part of this presentation, empirical orthogonal functions (EOFs) and principal component analyses (PCA) are performed on GLORYS monthly reanalyses in order to highlight spatio-temporal patterns responsible for the variability of the Northwest Atlantic Ocean. This project was funded by DFO's ACCASP initiative on climate change (January–March 2018). Preliminary results are presented here, such as temperature and salinity maps along Flemish Cap AZMP section. These results will be further used to interpret *in situ* observations presented in Part I.

Discussion

The method used is data decomposition. Climate data have a lot of dimensions, and these dimensions need to be reduced. Traditionally this was done with EOFs or PCA to see how the dominant modes change over time. However, this method does not have *a priori* physical knowledge and is region dependent. The alternative is singular value decomposition, i.e., decomposition into three different matrices, x,y,t, and calculate eigenvectors of the matrices. This alternative is called “rotational EOFs”—the first order approximation of the data is kept but

many of the dimensions are eliminated. The leading model and PCA reflect the annual cycle. Various modes highlight different patterns/potential processes, so a bit more interpretation and development are required.

It was noted that GLORYS has been updated to 1/12 degree resolution that would better resolve dynamics at a small scale at key areas like at Tail of the Bank; using the updated data might avoid some of the potential artifacts. However, GLORYS is mostly model and not a lot of observations since it is based on Argo float data. It was also noted that seasonal variability overwhelms the other patterns, suggesting that it might make sense to remove the annual signal first. This is not the case in the deep water, so it might not be necessary. Although this approach can only be applied to regular data, there are related approaches that could be used for irregular data.

CLIMATE VARIABILITY AND TREND OFF NEWFOUNDLAND AND LABRADOR OVER 1979–2010 – GUOQI HAN

Collaborators: Z. Ma, N. Chen

A coupled ice–ocean model (NEMO-OPA) with a horizontal resolution of 7 km is used to examine climate trend and variability of ocean and ice conditions over the NL shelves for the period from 1979 to 2010. Daily surface atmospheric forcing is applied and monthly open boundary conditions are prescribed. The interannual variability and trend of model temperature and salinity agree with observations at Station 27 near St. John's. The model sea-ice extent south of 55°N shows significant multiyear variability and a declining trend consistent with observations. The modelled volume transport of the inshore Labrador Current agrees approximately with that estimated from observations. For the inshore Labrador Current, the volume transport shows an increase, due mainly to a baroclinic component in the north and to a barotropic component in the south. The freshwater transport shows an increase due mainly to the increase of the volume transport. For the offshore Labrador Current, the volume transport does not show a trend; it is stronger in the middle period and weak in the two ends. The freshwater transport decreases due mainly to the salinity increase.

Discussion

Temperature at 20 m contrasts in 1991 (colder) and 2000 (warmer), with significant differences in sea ice for these two years. Temperature and salinity trends are well characterized by the model on the Flemish Cap. Summer volume transport estimates were compared between the model and acoustic Doppler current profiler (ADCP), but this is challenging due to the time scales of the observations. The model does a good job on sea-ice extent south of 55 degrees. Volume transport at Seal Island section has increased in the inshore (up to 2010), but at the shelf break it was more dome shaped over the time series. Shelf-edge transport was mainly driven by NAO variability. The difference between Seal Island and Flemish Cap transport is accounted for by a decrease in offshore flow. The importance of baroclinic transport declines downstream—it is strong at the northern boundary. Remote forcing makes a stronger contribution at Seal Island. Freshwater transport at Seal Island increased inshore and decreased at the shelf edge and in total. Freshwater increased inshore mainly due to volume transport. At the shelf edge, freshwater transport decreased due to the salinity increase. Drivers of ice production might also affect local or upstream conditions.

The comparison between the model and ADCP observations was limited to a short period and small area since ship-based ADCP observations along the Flemish Cap (corrected for tidal variability) were used. The differences in time scales between model output and ADCP observations can be problematic, but are probably not a big issue in the inshore. The next step is to compare the model to AZMP observations.

CIRCULATION AND RENEWAL OF SAGUENAY FJORD WATERS – PETER GALBRAITH

Collaborators: D. Bourgault, C. Chavanne, L. Gostiaux, H. van Haren

Recent research done since 2010 in the Saguenay Fjord that has resulted in three primary publications is summarized. Waters that renew the Saguenay Fjord are a mix of existing Saguenay waters and denser St. Lawrence Estuary (SLE) waters present at the first sill. In summer, the salinities of waters present at the outer sill are usually low, and Saguenay Intermediate Water is formed and intrudes into the Fjord at mid-depth. However, in summer 2017, a denser renewal event penetrated almost to the bottom in the inner basin. In winter, the salinities of waters being mixed are higher and Saguenay Deep Water is formed, renewing the Fjord's inner basin from the bottom up. In late winter, the coldest SLE waters of the year appear at the sill, and the low-density layer intrudes at the subsurface. A similar but warm-water subsurface renewal can occur during the spring freshet. The annual salinity cycle of SLE water present at the outer sill controls the renewal density and depth. It was shown to be synchronous with the salinity cycle between 20 and 70 m depth at Rimouski station, 100 km away. Near complete renewal of the Fjord occasionally occurs within only a few months, but it can take up to six months to renew waters at the head of the Fjord, where cold waters are found in summer and warm waters in winter. During calm periods, the density of the inner basin diminishes by strong turbulent mixing—about 10 times stronger than at similar depths in the SLE—allowing later renewals. The next steps in this research include monitoring of the bottom temperature and salinity at the entrance of the inner basin. In summer 2018, a one-week cruise will look at mixing rates (deploying a VMP [vertical microstructure profiler] and mooring a high-precision thermistor array in collaboration with Hans van Haren, NIOZ – Royal Netherlands Institute for Sea Research) with one week of ship time (*Coriolis II*) and a small craft.

Discussion

Modelling could help to identify the drivers that result in a strong relationship between conditions at Station Rimouski and the mouth of the Saguenay Fjord.

EXPLORATORY WORK ON DERIVING INSHORE CURRENTS IN ATLANTIC CANADA USING SATELLITE ALTIMETRY DATA – GUOQI HAN

Collaborators: N. Chen

The inshore Labrador Current and the Nova Scotian Current, which is the outflow of the GSL, are important current features off eastern Canada and can significantly affect physical and biological environments off eastern Canada and the northeastern United States on seasonal and interannual time scales. So far, there is no long-term *in situ* monitoring of the two coastal currents. In this study, we explore the potential for monitoring the strengths of these flows on seasonal and interannual bases using satellite altimetry data. The geostrophic current anomalies are derived from along-track altimetry data. The currents are stronger in fall and winter and weaker in spring and summer, and they show substantial interannual variations. The strength of the inshore Labrador Current has an increasing trend over the study period while the Nova Scotia Current has little trend.

Discussion

Satellite altimetry data was used to estimate geostrophic flow on the inner shelves. The Southeast Grand Banks section shows not only seasonal variability consistent with existing knowledge but also substantial interannual variability. The GSL transect across Labrador Current shows the largest flow in winter and fall. The SS inner shelf transects are consistent—

they show larger flow in winter and fall. The interannual variability of the Eastern and Western SS shows a similar pattern, but the central SS is a bit different. The next task will be to compare to observations prior to development of an index. This is an opportunity to make more of a connection among the regions.

There was also a discussion of the streamline figure in Brickman et al. (2016), about the fact that what comes in at the Strait of Belle Isle (SBI) must go out at Cabot Strait. Peak SBI inflow is at the end of the year and in January. However, satellite altimetry is not appropriate to investigate the dynamics in SBI because the area is now large enough to determine differences in sea-level elevation.

AZMP SYNTHESIS WORKSHOP SESSION 2– BIOGEOCHEMISTRY

Rapporteur – Frédéric Cyr

TRACE GASES NITROUS OXIDE (N_2O) AND METHANE (CH_4) IN THE ST. LAWRENCE ESTUARY AND GULF – MICHAEL SCARRATT

Collaborators: S. Michaud, Y. Li, H. Xie

Dissolved nitrous oxide (N_2O) was measured in seawater during AZMP and other oceanographic missions in the St. Lawrence Estuary and Gulf in autumn (October–November) between 2009 and 2017. Methane (CH_4) samples were collected on four AZMP missions in 2016 and 2017. Sample profiles were collected using a Niskin bottle rosette, transferred without bubbles into sample vials, and analyzed using gas chromatography (purge-and-trap method for N_2O; headspace method for CH_4). N_2O concentrations were generally near saturation in surface waters, with higher values in deeper water and in proximity to the sediments. Maximum values (ca. 200% saturation N_2O) were observed in deep (>250 m) hypoxic (O_2 <2 mL/L) waters along the axis of the Laurentian Channel, a pattern that was broadly consistent from year to year. Surface N_2O concentrations generally increased from near saturation in the open waters of the Gulf to supersaturated values in the Estuary, likely sustained by upwelling of N_2O-rich water from greater depth. This low-oxygen, high-nutrient deep water has been isolated from the atmosphere for several years during its passage from the Atlantic toward the upwelling region in the Estuary. N_2O accumulation is therefore likely derived from microbially mediated nitrification in the hypoxic regions of the water column. In the case of CH_4, surface concentrations were near saturation across most of the Gulf, with higher values in the Estuary and extremely high values in the upper reaches of the Saguenay Fjord. Profiles show a strong CH_4 source in the (presumably anoxic) sediments at the top of the Fjord, which upwells and is advected downstream in the buoyant surface layer. In the Estuary and Gulf, CH_4 profiles show a subsurface peak around 8 nM associated with the CIL and occasional very high values (>500 nM) near the sediments in deep water. These deep peaks appear to be associated with sediment pockmarks, which are known CH_4 sources. Samples were also collected for carbon isotope analysis (pending), which is expected to clarify the contributions of geological vs. biological sources of CH_4.

Discussion

N_2O is the third most important greenhouse gas with respect to the extent to which it causes warming of the atmosphere (after dioxide carbon [CO_2] and CH_4). Its global warming potential is about 300 times that of CO_2. Atmospheric N_2O levels are continuously increasing. The ocean is a net source of N_2O. In the ocean, nitrification produces N_2O in oxic waters (also by denitrification in anoxic water, but this is not important in the GSL). There has been a slight increase of N_2O concentrations near the bottom since 2009. N_2O is lowest near Cabot Strait and highest in the Estuary, and maximum N_2O concentrations are found at depth.

CH_4 is the second most important greenhouse gas. The coastal ocean is a source of CH_4. CH_4 profiles from the Saguenay Fjord transect show a hot spot at the head of the Fjord that influences distribution in the rest of the Fjord (higher concentration near the surface, switching to nearly homogeneous vertical distributions approaching the mouth of the Fjord). In the Gulf, higher CH_4 concentrations are found in the subsurface (CIL depth), possibly due to solubility changes with temperature. Near-bottom plumes in the GSL may come from pockmarks– small craters (10–100 m diameter) in the seabed caused by fluids (gas and liquids) erupting through the sediments.

PROGRESS ON PHYTOPLANKTON RESEARCH IN THE NWA – EMMANUEL DEVRED

Collaborators: X. Liu, R. McIver, S. Clay

Presentation of recent advances in the phytoplankton research at BIO (three projects).

Project 1 – Phytoplankton assemblage at station Halifax-2

Halifax-2 is a fixed station on the Scotian Shelf sampled twice per month for phytoplankton assemblage. Diatoms dominate the spring bloom while flagellates and dinoflagellates are more abundant in summer and fall. In general, abundances have declined by ~5% over the last 20 years. On-going study on the influence of environmental factors suggests that the mixed layer depth and stratification are more important than nutrients. A study of the vertical chlorophyll a (chl a) profiles suggests two groups: “well-mixed” and deep chlorophyll maximum (DCM). Integrated fall chl a concentration has been decreasing since 1999 while DCM depth has been increasing for the same period.

Project 2 – Satellite chl a in the GSL

This project aimed at trying to relate satellite observations to *in situ* chl a concentration (derived biomass from chl a concentration). Three satellites are compared (SeaWiFS, MODIS, VIIRS). Six subregions of the Northwest Atlantic were examined for remote sensing detection of phytoplankton. Most subregions showed a biomass drop since 2010.

Project 3 – Flow cytometry

It is hard to find someone to process the data; data from 2016 have been processed and 2017 data were processed by mid-March 2018. We need to discuss a zonal strategy (coordination with Québec Region for protocol, cross-calibration, etc.).

A new instrument being tested is the FluoroSea. It processes a small volume, so it needs to be deployed for a long time to get a decent-sized sample. BIO is also equipped with a FlowCam (Alice Ortman).

Discussion

Nil

TIMING OF THE BLOOM: RESULTS FROM DIFFERENT ANALYTICAL METHODS – NICOLAS LAMBERT

Collaborators: D. Lavoie

The purpose of the presentation was to show different analytical methods used to determine the timing of the spring phytoplankton bloom. We used the chl a concentration simulated by our biogeochemical model to test three different methods to determine the first day of the bloom. The methods presented show similar results in the GSL, but the results differ on the SS and in

the GoM. The current method used with remote sensing data (20% of the maximum surface chl a is used as a threshold value for bloom initiation) presents some issues, particularly when the bloom amplitude is low. The two other methods presented (fixed threshold value of 1.2 g/m³ and 10% of the difference between the spring maximum and the winter minimum surface chl a) seem to resolve those problems. Additional discussions about the relevance of the present method and the way it can be improved upon are needed.

Discussion

They used the same model for the GSL as J. Chassé, with the addition of biogeochemical variables (NPZD [nutrients, phytoplankton, zooplankton, detritus] model), dissolved oxygen, pH; this represents an addition of 11 variables and 19 interactions). Primary production is one of the hardest parameters to model. Each method they used to identify the start of the bloom (i.e., the day of the year) has a downside and will give different results. As part of an ACCASP project, they want to use the best method and project the evolution of the start of the bloom in a climate projection model.

A concern was raised about the fact that BIO is using the 20% criteria. In recent years, there were problems with bloom initiation date, and that might be related to a problem with their criterion. Since there are climatology data for each box, it was suggested that the same exercise could be done in each box and the best criterion, which would need to be standard for the entire zone, would be chosen.

Chl a concentrations were based on model output for the surface cell (6 m) but the analyses did not make use of the BIO algorithm currently used to provide metrics of the spring phytoplankton bloom.

USING OPTIMAL AND REALIZED HABITAT MODELS TO ASSESS THE UNDERLYING MECHANISMS OF *CALANUS* POPULATION RESPONSES TO FUTURE CLIMATE CHANGE IN THE NORTHWEST ATLANTIC – STÉPHANE PLOURDE

Collaborators: C. Lehoux, F. Maps, P. Pepin, C.L. Johnson, Z. Wang, D. Brickman

During the last decade, several habitat and niche models were developed to predict future changes in spatial distributions of the dominant planktonic copepod species of the genus *Calanus* in response to ocean warming in the North Atlantic. Here, we combined realized and optimal habitat models based on abundance and life history traits, respectively, to estimate potential changes in population abundances and to assess the underlying dynamics of *Calanus* responses to future climate change in the Northwest Atlantic. Firstly, realized habitat models were built with depth-integrated plankton net abundance data collected during the 1999–2012 period in the Northwest Atlantic by AZMP. Secondly, optimal habitat models were used to characterize the response of key individual and population dynamics parameters to environmental conditions during the active (mortality/survival during egg-CI, body size of late stages) and dormant (metabolism and diapause duration) phases of *Calanus* life cycle. Using these models, future changes in abundance and dynamics of *Calanus* species were then estimated using a climatology of a set of indices describing environmental conditions in the surface and deep habitats for the 1999–2012 (present) and 2066–2085 (future) periods derived from a climate run of the NEMO-OPA model using the RCP 8.5 scenario (high CO_2 emission scenario). Results were used to describe how changes in distribution, abundance, and phenology of *Calanus* species towards the end of the present century could be explained by key processes occurring at various stages of their life cycle.

Discussion

They recycled the Albouy-Boyer et al. (2016) GAMs (Generalized Additive Models), but removed mixed effect of year-month. Results show improvement compared to the Albouy-Boyer et al. (2016) paper. An enormous increase in *Paracalanus* spp. is expected (but not in GSL or north of 48°N). The model shows potential changes in egg survival rate: generally higher survival in the early season and lower in the late season except for NL, where there are no changes. Potential changes in diapause duration are also expected: mostly a reduction of duration by ~50 days max (greater in southern areas). Ocean warming should have a negative effect on *C. finmarchicus* in GoM and SS, a neutral effect in GSL, and positive effect in NL. Changes in environmental conditions should have a negative effect on arctic species such as *C. glacialis* and *C. hyperboreus*.

MODELLING APPROACHES TO UNDERSTANDING *CALANUS* SPATIAL VARIABILITY – CATHERINE L. JOHNSON

Collaborators: C. Brennan, S. Plourde, K. Krumhansl, C. Lehoux, D. Lavoie, J. Chassé, W. Gentleman, F. Maps

Copepods of the species *Calanus* are large, energy-rich, biomass-dominant zooplankton on the Canadian Atlantic shelves and key prey to North Atlantic right whales (NARW), planktivorous fish, and other upper trophic level species. Abundances of the traditionally dominant copepod *Calanus finmarchicus* have been low across the Atlantic Zone since the early 2010s, and abundances of its arctic congener *Calanus hyperboreus* have also been low on the SS and more recently in the southern GSL (sGSL). The goal of this project was to develop a dynamical model to improve predictions of spatial distributions of *Calanus* abundance on the SS and in the GSL, building on AZMP observations and statistical modelling. At this stage of model development, hybrid estimates of *Calanus* distributions from statistical and particle tracking models are presented, focusing on NARW feeding habitats in the sGSL. The model approach was set up as a four-step process, involving the particle tracking model (Step 1), representing advection, dispersion, and vertical swimming towards target depths based on statistical models of vertical distribution, and Individual Based Models (IBMs) for *C. finmarchicus* and *C. hyperboreus* development and mortality (Step 2) to estimate changes in developmental stage distribution and abundance over the 30-day model runs. Model runs were initialized with *Calanus* spatial distributions and abundance from GAM monthly fields, and two-day average velocity and temperature fields from the CANOPA MC model were used in particle tracking and IBMs. Monthly average 3D model products of late-stage *Calanus* abundance by stage, species, and activity (active/diapause) (Step 3) were validated based on ground-truthing (comparison against available observations in the sGSL), model intercomparison (vs. GAM predicted abundance), and sensitivity analysis (Step 4). Learning from model validation will drive improvement in the next phase of model development (Step 4). The model was challenged to reproduce monthly changes in mean abundance levels across the region, so we developed a correction factor to adjust the model to the GAM's regional monthly mean abundance in order to compare distribution patterns. Patterns of model misfit were characterized and used to identify periods when processes not parameterized in the model may be important (e.g., ontogenetic migration, variable mortality). The adjusted model improved predictions relative to GAMs of late-stage *Calanus* spatial abundance in the sGSL. Particle tracks and associated abundance information highlighted the importance of transport into the sGSL from the SLE and Laurentian Channel (i.e., deep upstream source regions) of early stage and active late-stage *Calanus*. The model can be used to estimate the time and space distribution of NARW foraging habitat. In the next phase of model development, we plan to expand the IBM to a full population development model and to test hypotheses about drivers of large changes observed in past decade.

Discussion

In June, there is a large active population in near-surface waters. In the deep Laurentian Channel, there is always a high abundance of *Calanus* in diapause, which is not surprising. A "corrected model" (to adjust GAMs to regional monthly mean abundance) was built to facilitate comparison of spatial distributions among observations, GAMs, and dynamical model outputs. The model is useful to provide information on timing. It was pointed out that transports are important to determine *Calanus* spatial distribution.

BODY SIZE/CONDITION IN *C. FINMARCHICUS* – STÉPHANE PLOURDE AND PIERRE PEPIN

Collaborators: C.L. Johnson, T. O'Brien

This was a presentation in three parts on the status of research on copepod size and lipid content (for GSL and Newfoundland and Scotian shelves).

Part 1 - Variation of size in the GSL

The objectives were to describe the interannual variations in prosome length and lipid content for *C. finmarchicus* at stage CV and CVIf. Four areas were considered: the Estuary and western, eastern, and southern Gulf. There is interannual variability in length and larger interannual variations in oil sac fullness compared to length. Between 2008 and 2009, there was not much difference in prosome length, but a large difference in oil sac fullness.

Part 2 - Amount of lipids for CV class in NL

They cited the paper from Deep Sea Research (Pepin and Head, 2009). Animals were collected from 1000 m max tows at the beginning and end of different sections, and a cumulative density function (CDF) was used. Conditions that lead to larger energy reserves and larger C5 copepodites in the fall are associated with strong adult survival in spring *and*/*or* delayed emergence/spawning; rapid cohort development during the summer; and the onset of a second generation in the fall. Cooler water temperatures are beneficial to *Calanus* condition in the spring while rapid rate of warming at the start of the summer and warmer conditions in the fall favour the accumulation of energy reserves and stronger survival and a greater likelihood of a second generation in the fall.

Part 3 - ICES (International Council for the Exploration of the Sea) - Working Group on Zooplankton Ecology: analysis of North Atlantic community changes

The ICES Working Group on Zooplankton Ecology (WGZE) three-year terms of reference (ToR) for 2018–2020 include ToR E: "Analyze changes in the geographic distributions, seasonal patterns, and interannual trends of Arctic and North Atlantic macro- and meso-zooplankton species." The intent of this ToR is to develop comparative analyses of changes in zooplankton communities across the ICES region that address changes in subdominant (non-*Calanus*) species and take advantage of the broad spatial coverage in time series included in WGZE reporting. As a pilot study, changes in copepod communities were assessed for the combined Maritimes AZMP and NOAA (US National Oceanic and Atmospheric Administration) EcoMon GoM zooplankton data sets, using a "pentadal rank shift" approach. This initial analysis looked at the time period during which sampling by both programs overlapped (1999–2016; specifically the 15 years from 2002–2016) as well as 30 years of extended EcoMon data and five-year series (e.g., 2002–2006, 2007–2011, and 2012–2016; the latter is a period of record warm water temperatures in this region). The pilot analysis focused on a few dominant and subdominant species that were common to both data sets (*Calanus finmarchicus*, *Metridia lucens*, and *Temora longicornus*) and found that changes in rank were observed mainly during

the warm 2012–2016 period. This type of analysis could be expanded to the entire WGZE region and its large species collection. The ToR E study will be an evolving process, changing and improving as new results and new ideas are developed from the data and the participants. There will likely be a collection of analyses and subanalyses applied, addressing different questions as well as the different capabilities of the various data sets. Input, feedback, comments, and guidance are welcome from the participants and larger working group. The first step required to initiate the project will be compilation of data from participants. For optimal development of the project, data are needed at the maximum taxonomic, spatial, and temporal resolution available.

Discussion

Calanus are larger in the SLE and GSL. There are important interannual variations of prosome length, but prosome length of both stages were smaller across the region from the late 2000s to 2015, maybe in response to warmer conditions. Oil sac fullness variations are coherent with life history, and there are also large interannual variations. Conditions for larger energy reserves in *Calanus* individuals are:

1. strong adult survival in spring or delayed spawning;
2. rapid cohort development during summer, and
3. onset of a second generation in the fall.

There was a recommendation for AZMP to start quantifying development state during surveys as an index of “state” for key taxa.

A pertinent question for our region that is related to the ToR is how North Atlantic mesozooplankton communities are changing in response to environment changes (and why). Ideas were also presented for a pilot study on “pentadal rank shift,” e.g., in 2002–2012, *C. finmarchicus* ranked one to three 73% of the time, but only 39% of the time in 2012–2016. It would be good for AZMP to participate in this WGZE (working group is meeting simultaneous to the AZMP 2018 annual meeting). However, the working group would need access to full AZMP data. A discussion followed about if and how our data should be shared.

REVIEW OF PHYSICAL AND BIOGEOCHEMICAL CONDITIONS IN THE NORTHWEST ATLANTIC – SESSION 1

Rapporteur – David Bélanger

PHYSICAL CONDITIONS IN THE LABRADOR SEA (AZOMP) IN 2017 – IGOR YASHAYAEV

Collaborators: M. Ringuette

The Atlantic Zone Off-Shelf Monitoring Program (AZOMP) provides observations of variability in the ocean climate and plankton affecting regional climate and ecosystems off Atlantic Canada and the global climate system. This year posed a challenge because it was not possible to carry out our regular field campaign in the Labrador Sea. The network of profiling Argo floats proved to be instrumental for monitoring year-round variability, but their number in the Labrador Sea was limited in 2017.

In the Labrador Sea, surface heat losses in winter result in the formation of dense waters, which drive the global ocean overturning circulation and ventilation of the deep layers. In the winter of 2016–17, as in the previous winter, the mid-high latitude North Atlantic experienced more moderate surface heat loss in the region than in the winter of 2014–2015, which was characterized by the highest heat losses in more than two decades. Despite the weaker heat

loss from the ocean to the atmosphere in the following two years, water column preconditioning caused by convective mixing in the previous years led nevertheless to the most significant formation, in terms of volume and depth, of Labrador Sea Water (LSW) since 1994. Similarly to 2016, the temperature and salinity profiles obtained by the Argo floats showed that the winter mixed layer and hence convection in the central Labrador Sea reached 2000 m in 2017, exceeding the mixed layer depths of 1,600 and 1,700 m in 2014 and 2015, respectively. The 2017 vintage of LSW is associated with low temperature (<.3°C) and salinity (<34.86) between 1,000 and 1,700 m. The winter convection in 2016 and the one that followed it last year (2017) are arguably the deepest since the record of 2400 m in 1994, and the resulting LSW year class is one of the largest ever observed outside of the early 1990s. This also suggests that the strong winter convection in 2017 further added to increased gas (dissolved oxygen, anthropogenic gases, and carbon dioxide) uptakes and consequently respective gas concentrations in the Labrador Sea in the lower part of the 0–2,000 m layer, but this could be confirmed from direct ship-based measurements.

The progressive cooling of the top 2,000 m along with the deep and intense winter mixing during the four consecutive winters of 2013–14, 2014–15, 2015–16, and 2016–17 have interrupted the general warming and stratification-building trend that has persisted in the intermediate waters of the Labrador Sea since the mid-1990s.

Interannual variability in Labrador Sea ocean heat content and cumulative surface heat loss during the cooling seasons indicates that anomalously strong winter atmospheric cooling associated with the NAO is continuing to drive the recurrent convection. In turn, recurrent deep convection is contributing to decadal-scale variability in deep-water properties and transport across and from the subpolar North Atlantic (by the ocean's western boundary and interior pathways) and potentially in the AMOC.

Both upper (0–200 m) and deeper (200–2,000 m) layers have been cooling since 2010. However, the freshening trend seen in the newly formed or newly ventilated LSW between 2011 and 2016 reversed in 2016, making the LSW formed in the winter of 2017 the densest since the mid-1990s.

As a result of the cancellation of the spring research survey, we were not able to update the rate of decline in pH, previously reported as a mean rate of -0.002 y^{-1} from 1994 to 2016, nor was it possible to assess the state of *Calanus finmarchicus*, the dominant mesozooplankton in the western and central region of the Labrador Sea, following the record lows reported in 2016. Unusually intense cloud cover in the spring also prevented an assessment of the characteristics of the spring phytoplankton bloom throughout much of the region. However, the occurrence of a fall bloom again this year seems to indicate that this feature is becoming more the norm than the exception.

Discussion

Intensifying the deployment of Argo floats in the Labrador Sea is essential for a better understanding of the physical oceanographic processes in the northwest Atlantic. Moreover, there is a need for extra workforce to produce a research document on Argo float deployments. There are biogeochemical data available from Argo floats for the Labrador Sea, and the AZMP group should try to link the observations from the Labrador Sea with the trends observed in the AZMP surveys.

It was suggested that zooplankton deeper than 100 m should be sampled; it was agreed that this is a good idea, but that it would require additional funding.

PHYSICAL OCEANOGRAPHIC CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELVES – FRÉDÉRIC CYR

Collaborators: NAFC Oceanography Section

A review of environmental conditions on NL shelves was presented for 2017. After a short context on large-scale forcing, a summary of monitoring effort (Station 27, AZMP, and multi-species surveys) was presented. Overall, 2017 was close to normal. The air temperature in the region was slightly above normal, except for a cold spring. The surface temperature was generally below normal and the volume of the CIL has been increasing over the last four years. A large widespread cold anomaly was found in fall over the NL shelves. The AMO also seems to be entering a decreasing phase after a positive phase that started in the early 2000s.

Discussion

It was pointed out that the water was fresher despite a lower-than-normal volume of sea ice. Lower salinity might be related to increased river input. It was also mentioned that it would be useful to insert bottle depths on the dissolved O_2 plot.

The dissolved oxygen anomaly in the Flemish Pass may be the result of influx of water from the Labrador Sea. A time series of conditions in the Pass could be compared with conditions measured in the deep ocean.

Because the NL region is at the boundary between the NAO low and a high-pressure system, it may be worthwhile to explore alternate indices of atmospheric forcing.

BIOGEOCHEMICAL CONDITIONS ON THE NEWFOUNDLAND AND LABRADOR SHELVES – GARY MAILLET

Collaborators: P. Pepin, D. Bélanger

Seasonal oceanographic surveys across standard sections by AZMP combined with synoptic satellite ocean colour data provide relatively good spatial and temporal assessments of biogeochemical indices and lower trophic levels in 2017. In general, seasonal surveys along the standard Newfoundland and Labrador sections indicated a reduction in inventories of macronutrients. The reduction in available macronutrient pools coincided with a reduction in phytoplankton biomass along all standard sections during the same time period. Despite the reduction in nutrient inventories and associated biomass of phytoplankton in recent years, the abundance of many different functional groups representing different components of zooplankton have increased steadily during the available time series. Higher abundances of a keystone calanoid copepod (*Pseudocalanus* spp.) and other small warm/cold water copepods along with benthic invertebrates and gelatinous zooplankton have been observed across the standard sections. The transition to smaller taxa combined with lower abundance of the large energy-rich calanoid copepod (*Calanus finmarchicus*) has resulted in a shift in the community composition of zooplankton. The change in community composition is consistent with the general reduction in zooplankton biomass observed in recent years. The evaluation of a number of physical indices, including ocean climate indicators, indicates an association with primary and secondary production indices and may represent important drivers in the ecosystem.

Discussion

The late departure of the fall survey resulted from the breakdown of the charter vessel, which may have an impact on the representativeness of the data. Additional QC/QA procedures will be applied before the information is integrated into the time series.

The decline in zooplankton biomass while there appears to be an increase in the overall abundance of organisms is the result of the decrease in the abundance of large copepods (*C. finmarchicus*) and an increase in the abundance of small copepods (*Pseudocalanus* spp.).

LABRADOR CURRENT TRANSPORT FROM VESSEL-MOUNTED ADCP MEASUREMENTS – GUOQI HAN

Collaborators: E. Colbourne, S. Snook, D. Senciall

The annual-mean Labrador Current transport index shows that the Labrador Current transport over the Labrador and northeastern Newfoundland Slope was out of phase with that over the Scotian Slope for most of the years between 1993 and 2017. The transport was strongest in the early 1990s and weakest in the mid-2000s over the Labrador and northeastern Newfoundland Slope, and opposite over the Scotian Slope. The Labrador Current transport index was positively and negatively correlated with the winter NAO index over the Labrador and northeastern Newfoundland Slope and over the Scotian Slope, respectively. In the past three years, the Labrador Current was close to its normal strength. In 2017 its annual-mean transport was above normal by about one standard deviation over the Labrador and northeastern Newfoundland Slope and below normal by about one standard deviation over the Scotian Slope.

Discussion

Nil

PHYSICAL OCEANOGRAPHIC CONDITIONS IN THE GULF OF ST.LAWRENCE – PETER GALBRAITH

An overview of physical oceanographic conditions in the GSL in 2017 was presented. The annual average freshwater runoff of the St. Lawrence River measured at Québec City and its combination with rivers flowing into the Estuary (RIVSUM II) were both at the highest levels since 1974. Sea-ice cover had the sixth lowest maximum volume since 1969. Sea-surface temperatures averaged over the GSL were near normal or above normal from May to November 2017, leading to an above-normal May–November average (+0.6°C, +0.9 SD). The August CIL showed a warmer-than-normal minimum temperature (+0.8 SD) and lower-than-normal volume colder than 1°C (-0.6 SD), but the seasonally averaged minimum temperature index was near normal. Deep-water temperatures have been increasing overall in the Gulf, with inward advection from Cabot Strait. The GSL's average temperature decreased from the 2015 record highs at 150 and 200 m, remaining above normal (2.7°C, +0.5 SD and 5.0°C, +1.4 SD), and decreased slightly at 250 m (6.0°C, +2.7 SD) from the 2016 record high, but increased to a new record level at 300 m (6.3°C, +5.0 SD). The bottom area covered by waters warmer than 6°C decreased in 2017 in Anticosti Channel and Esquiman Channel, but increased sharply in the central Gulf and made its first appearance in the northwest Gulf.

Discussion

As a follow-up on this presentation with regards to SST products, it was mentioned that BIO's remote sensing group has monthly composites built on daily SST anomalies. Also, it would be useful to monitor temperature in the SBI because salmon use this route to access the Gulf.

Concerns were raised about linking physical changes to impacts on the food web in the SAR. Mentioning it during a press release would be more appropriate.

The late season intrusion of ice through the SBI consisted of second-year ice.

The major changes in temperature in the Gulf are of concern to the biologists in the region and some investigations about the potential impact on marine organisms.

BIOGEOCHEMICAL CONDITIONS IN THE GULF OF ST. LAWRENCE – MARJOLAINE BLAIS

Collaborators: P. Galbraith, M. Scarratt, S. Plourde, L. Devine, C. Lehoux, C. Caverhill, C. Porter, M. Starr, L. St-Amand, I. St-Pierre

We present an overview of the biochemical conditions in the GSL in 2017. Nitrate inventories in the surface layer (0–50 m) were generally near normal everywhere in the GSL. However, they were above normal in deep waters of the eastern GSL (eGSL); this has been observed since 2012 and is associated with intrusions of warm and salty waters. Vertically integrated chl a was below normal in wGSL and above normal in sGSL during summer and fall. In sGSL, the chl a positive anomaly measured was actually the strongest recorded since 2002. However, according to satellite imagery, the spring bloom amplitude was generally below normal everywhere in GSL, including sGSL. Data based on satellites show that annually averaged surface chl a was near normal throughout the GSL despite low spring biomass. Dinoflagellate abundance reached a record low at Rimouski station, while they were above normal at Shediac Valley, along with flagellates and ciliates. In 2017, zooplankton biomass was below average everywhere in the GSL. The main zooplankton functional groups and species abundances were all above normal in eGSL while *C. finmarchicus*, *Pseudocalanus* spp., and total copepod abundances showed negative anomalies elsewhere. This is the first time since 2012–2013 that negative anomalies were recorded for *Pseudocalanus* spp. The decrease in the average weight per individual in recent years indicates that small zooplankton taxa are becoming more important in the overall community. Moreover, higher-than-normal abundances of warm-water-associated copepod species were again observed in 2017, continuing a trend observed since 2011. Population development indices suggest that *C. finmarchicus* development was delayed in wGSL and eGSL in 2017. In wGSL, this is contrary to what has been observed in recent years while in eGSL, *C. finmarchicus* development has mostly been delayed since 2013. The decreased proportion of adults (copepodite stage CVI) in *C. hyperboreus* and *C. glacialis* populations during fall in 2012 and 2015–2017 could indicate a transition from a multiyear to an annual life cycle. Finally, O_2 concentrations at 300 m reached their lowest concentration measured so far in several GSL regions during 2017. Negative anomalies in deep O_2 concentrations were especially strong in the central GSL and in Cabot Strait regions. These dynamics could reflect the influence of warmer-than-normal deep waters and a St. Lawrence freshwater runoff well above the normal in May and June 2017.

Discussion

It was suggested that reporting on the biomass:abundance zooplankton ratio could be useful to track trends in zooplankton size class. It would also be useful to include new indices to assess benthic–pelagic coupling and zooplankton community structure in future AZMP reports considering that 1) the energy from large copepods is mostly retained in the pelagic environment while energy from small copepods gets mostly transferred to the benthic environment, and 2) an increase in the proportion of benthic larva in the zooplankton was observed in Newfoundland. Finally, it was mentioned that *Calanus hyperboreus* reproduction will likely be affected by warming temperatures in future years.

The reprocessing of satellite data after 2012 should not affect patterns in the anomalies.

REVIEW OF PHYSICAL AND BIOGEOCHEMICAL CONDITIONS IN THE NORTHWEST ATLANTIC – SESSION 2

Rapporteur – Marjolaine Blais

PHYSICAL OCEANOGRAPHIC AND METEOROLOGICAL CONDITIONS ON THE SCOTIAN SHELF AND IN THE GULF OF MAINE DURING 2017 – DAVID HEBERT

Collaborators: D. Brickman, R. Pettipas

The two Maritimes missions were conducted on charter vessels. The spring mission was at the normal period but the fall mission was two months later than the normal sampling period. In 2017, air temperatures anomalies were positive for all sites, ranging from +0.6°C (+0.8 SD) at Boston to +1.0°C (1.3 SD) at Halifax. Satellite-based sea-surface temperatures were above the 1981–2010 average temperatures, with values ranging from 0.7°C (1.2 SD) for Cabot Strait to 1.9°C (3.0 SD) in the western SS. The annual surface temperatures anomalies at St. Andrews and Halifax were +0.8°C (+1.5 SD), a decrease of 0.6°C from 2016, and +0.7°C (+1.0 SD), a decrease of 0.3°C from 2016. Water temperatures at select sites and depth ranged from 0.4°C (0.7 SD) to 1.6°C (3.0 SD) above normal, with a record high for Georges Basin at 200 m and second highest values for Cabot Strait at 200–300 m and Emerald Basin at 250 m. The July bottom temperatures for the shelf portions of NAFO (North Atlantic Fisheries Organization) Regions 4Vn, 4Vs, 4W, and 4X were 0.7°C (1.6 SD), 1.3°C (1.9 SD), 0.8°C (1.1 SD), and 1.6°C (2.2 SD), respectively, above the 1981–2010 average values. Compared to the record year of 2014 for 4Vn, 2017 was the fourth warmest year, 0.5°C below the record. The year 2017 was 5th warmest year in NAFO Region 4Vs; 2015 was the 2nd warmest year. For 2017, 4X was the 4th warmest year, which was 0.6°C lower than the record year of 2012. A composite index, consisting of 20 ocean temperature time series from surface to bottom across the region, indicated that 2017 was the third warmest of 48 years (2016 was the second warmest and 2012 was the warmest), with an averaged normalized anomaly of +1.7 SD relative to the 1981–2010 period.

Discussion

Most presentations of physical data show shifts in the seasonality of different metrics, such as the timing of cooling. There was a discussion about how we could use changes in these metrics to help with the interpretation of biological data. Considering the uncertainties associated with our sampling design in regards to the seasonality of any metrics, it could be more appropriate to use multivariate analysis or to look at different metrics and see if they are consistent. Some interesting metrics to look at could include sea-surface temperature, timing of the spring bloom, and water column stratification. Signals or trends that are already seen in some metrics are interesting in themselves, but it is mostly how they propagate through the ecosystem that matters. These analyses would not necessarily be part of the SAR.

BIOGEOCHEMICAL CONDITIONS ON THE SCOTIAN SHELF AND IN THE EASTERN GULF OF MAINE – CATHERINE L. JOHNSON

Collaborators: E. Devred, B. Casault, J. Spry, E. Head

Biogeochemical conditions on the Scotian Shelf and in the GoM during 2017 were assessed in the context of continued warmer-than-average surface and near-bottom ocean temperatures, a pattern that started in 2008, and continued higher-than-average stratification. In 2017, deep nitrate, silicate, and phosphate anomalies were all strongly negative. Remote sensing observations indicated phytoplankton spring blooms of low magnitude throughout the region. At Halifax-2, the spring bloom was very deep and had a late start and a short duration, suggesting

that bloom magnitude could be greater than recorded by remote sensing in the central Scotian Shelf. The phytoplankton community at Halifax-2 was dominated by small flagellates for most of the summer and fall, likely reflecting the influence of water-column stratification during those seasons. Zooplankton biomass and abundances of *Calanus finmarchicus* and the small copepod Pseudocalanus spp. continued to be lower than average. Abundance levels of total copepods and total non-copepods were both below or near average on the eastern and central SS and above or near average on the western Scotian Shelf and at the high-frequency time series stations. This pattern was also evident in warm shelf copepods. The abundance of arctic Calanus, an indicator of cold water on the Scotian Shelf, continued to be lower than average, while higher-than-average warm offshore copepod abundance suggests a greater contribution of offshore waters to the Scotian Shelf in recent years, especially in the central and western regions. Several types of new metrics that could extend representation of the major lower trophic level changes observed in recent years were tested. First, dominant modes of variability in the pelagic habitat have been characterized using PCA of annual metrics of phenology, zooplankton community, and physical ocean conditions for a study of the influence of pelagic habitat variability on pelagic fish stock metrics. Second, zooplankton and phytoplankton succession patterns and the influence of annual-scale environmental variability have been examined using redundancy analysis and partial redundancy analysis and may provide an approach to developing a multivariate metric of interannual variability in community succession. Third, iterative improvements are being made to estimates of Calanus distribution and abundance in the GSL and on the Scotian Shelf using GAMs and particle tracking models; products from this work could be added to future reporting. Fourth, validation of remote sensing of large and small phytoplankton size classes has been completed, and seasonal and interannual metrics of phytoplankton size could be developed for AZMP reporting. In addition, depth-integrated chlorophyll estimates could be developed from remote sensing based on statistically derived chlorophyll profiles, as has already been implemented in the primary production model of the remote sensing group. Beyond adding new metrics to annual AZMP reporting, there is a need for more coordination and support for sharing data products and tools developed from AZMP data.

Discussion

A concern was raised about the integration of multivariate analysis as part of the SAR considering that the SAR must stay accessible to the general public and that the interpretation of such analysis is complex. The comparison with a reference period is easy to understand and should probably stay our main way of reporting the changes.

There was a discussion about the accuracy of remote sensing to document changes in phytoplankton size classes. One of the main concerns is that changes in phytoplankton community size structure would only be documented in the very few top metres of the water column. However, it seems that based on several *in situ* fluorescence profiles, it is possible to recognize some typical profiles. For instance, low surface biomass is typically associated with DCM. But still, it might be difficult to know the thickness of the DCM, and gliders could be an effective way of collecting more information on the chlorophyll maximum. In any case, remote sensing data should be validated with *in situ* profiles to make sure that they are representative of real conditions, especially considering that there seems to be a few inconsistencies with satellite data. Validation should be made across the entire zone but will start with fixed stations since these are where most data are collected. It is hoped that these validations will be presented at the next AZMP annual meeting.

Changes in nutrients on the Scotian Shelf were similar to the ones observed in Labrador. These changes are associated with changes in water mass composition (contribution of slope water

vs. Labrador water). A model is being built to look at conditions in upstream areas in order to determine the water source along Scotian and Newfoundland shelves.

2017 BEDFORD BASIN CONDITIONS – ANDREW COGSWELL

Collaborators: K. Pauley, T. Perry, K. MacIsaac, J. Spry

The Compass Station or HL_00 (44° 41' 37" N, 63° 38' 25" W) has been occupied weekly as part of the Bedford Basin Monitoring Program (BBMP) since 1999. Regular occupations consist of a CTD equipped with a standard suite of sensors and a vertical net tow for zooplankton identification and enumeration using AZMP protocols. Water samples are collected in Niskin bottles for a variety of analyses at 2, 5, 10, and 60 m. Only zooplankton samples from 1999–2002 and 2012–2017 have been analyzed and entered into the BioChem database, thus only the CTD sensor and bottle data is reported upon in this summary of 2017 conditions.

For ease of interpretation, surface conditions are expressed as the mean conditions at 2, 5, and 10 m. There is a strong seasonal agreement between these depths for the physical and chemical conditions being measured and generally a minor difference in magnitude.

Surface conditions in 2017 were warmer (+0.72 SD) than normal compared to the climatology (2000–2015). This was the seventh warmest year of the temperature time series (1992–2017) and is the fifth positive anomaly above +0.50 SD since 2010. Surface water was generally more saline than normal throughout the year, while density was slightly negative in response to warmer-than-normal surface conditions. Monthly anomalies for surface temperature in 2017 showed warmer-than-normal conditions in the winter (Jan–Feb) followed by cooler-than-normal conditions over the spring and summer. This was followed by much warmer conditions in the late summer and fall, with record warm surface conditions from Oct–Dec (+2.75, +3.02, and +1.62 S.D.). This represents the warmest fall surface conditions for the BBMP time series.

Bottom conditions are generally stable within the basin unless otherwise perturbed by periodic intrusions of shelf water (Kerrigan et al. 2017). This year, temperature conditions remained at or slightly below the long-term climatology throughout the year, while salinity and density were consistently below normal. This continues a trend of negative annual bottom salinity and salinity anomalies stretching back to 2010. However, at the end of the year, a significant intrusion of shelf water resulted in a return to more saline than normal conditions for the beginning of 2018.

Surface nutrient conditions (nitrate, nitrite, ammonia, phosphate, and silicate) continue their trend of anomalously lower-than-normal concentrations. In particular, there has been a year-round drop in surface and bottom phosphate concentrations since 2010. This drop in concentration has likely been driven by three contributing factors: 1) phosphate concentrations on the shelf are currently anomalously lower than normal; 2) two primary water treatment facilities began operations in 2008; and 3) in 2010, new rules came into effect that reduce the concentration of phosphate in detergents from 2.2% to 0.5%. This raises the question concerning the relative contributions of these factors. Early research by Petrie and Yeats (1990) suggested that the relative influence of shelf water on basin phosphate concentrations is roughly equivalent to the impact of soluble phosphate in municipal effluent. This contrasts with nitrate, which is roughly 30–40 times more influenced by shelf water than effluent. It stands to reason then that a drop in phosphate caused by treated effluent (as a result of removal of suspended solids containing roughly 25–30% of total phosphate) would not necessarily correspond to a drop in nitrate and that their relative concentrations, if entirely driven by shelf processes, would not likely change rapidly over time. Concentrations in 2017 fall within the relative seasonal concentrations observed since 2011, and this provides more evidence that local basin sources are largely influencing the change.

Pigments from HPLC (High-Performance Liquid Chromatography) were compiled into three representative groups based on the identified proportions of seven diagnostic pigments (Utiz et al. 2006). These groups are:

- **Picoplankton** – Chl b and zeaxanthin
- **Nanoplankton** - Hex-fucoxanthin, but-fucoxanthin, and alloxanthin
- **Microplankton** - Fucoxanthin and peridinin

Surface concentrations of pico-, nano-, and microplankton pigments were higher than normal for the year compared to the long-term climatology. Picoplankton pigments were higher than normal throughout the spring and summer, with May values the highest on record for the second consecutive year (+4.84 and +5.63 S.D.). This continues a trend of increasing picoplankton pigments over the second half of the time series, particularly (but not exclusively) during the spring and summer months.

Discussion

There were questions about the effects of the phosphate decline on the phytoplankton community, which are not clear since there was a problem with flow cytometry samples and no samples are collected for phytoplankton taxonomic identification due to a lack of personal. The speed at which water is replaced within Bedford Basin is highly variable, ranging from one week to over a year in deeper sections. The water renewal process is mostly dependent upon storms since there is a 20 m sill at the entrance of the basin. Even though O_2 concentrations were not part of the presentation, this information is collected and analysed.

THE CARBONATE SYSTEM IN THE NORTH ATLANTIC – PIERRE PEPIN, STEVE PUNSHON, MICHEL STARR

Collaborators: K. Azetsu-Scott, A. Cogswell, D. Childs, M. Faulkner, J. Chassé

Presentation in three parts on the status of research of the carbonate system on the Newfoundland and Scotian shelves and in the GSL.

Part 1 – Carbonate on the Newfoundland Shelf

Data were available from the fall of 2014 and throughout the 2015 and 2016 although coverage was poor during the latter. Profiles across the Flemish Cap section demonstrated the typical profiles of pH for the region. Higher pH values (> 8) occurred throughout the water column in areas off the continental shelf whereas there was generally a notable gradient from surface to bottom across most of the continental shelf, with values of ~7.8-7.9 near the bottom. Most surface pH values on the Flemish Cap section ranged from 8.0 to 8.12, whereas near bottom (or 150 m for areas off the shelf) ranged from 7.9 to 8.05. There was a notable decline in pH in the fall of 2015, with average pH of 7.9 in the surface and 7.8 near the bottom. Aragonite under-saturation was more likely to occur in the cold intermediate layer (temperature < 0°C) or in more saline water masses (salinity > 34).

Part 2 – Ocean acidification in the Maritimes AZMP region during 2017 and a summary of results from core monitoring lines since 2014

Ocean acidification conditions for spring and fall 2017 on the core Maritimes AZMP monitoring lines (Cabot Strait, Louisbourg, Halifax, and Brown's Bank sections) were presented using section plots of aragonite saturation state (Ωar). Time series plots from the inception of routine sampling in 2014 were shown for Ωar and the carbonate system parameters (total inorganic carbon, pH, and total alkalinity [TA]). The Cabot Strait line was distinct in having lower TA and Ωar than the other three lines, while the influence of warm, high alkalinity water on Ωar was

seen offshore along the southern Scotian Shelf sections. The effect of seasonal temperature variations on *in situ* pH was noted.

Part 3 –Ocean chemistry conditions in the GSL

A summary of ocean acidification conditions in the SLE and GSL was presented. Selected datasets were considered in detail, including seasonal and annual comparisons of underway surface and bottom water pCO_2, pH, and carbonate saturation states from AZMP (March, June, and November) and multi-species (August–September) surveys, two high-frequency SeaFET pH sensors moored in the SLE and sGSL, and a 10-year dataset of weekly carbonate system measurements from the Lower SLE (LSLE). These latter observations were also compared to historic data to evaluate how pH and saturation levels have evolved in the SLE. Several persistent zones of corrosive bottom waters with undersaturated aragonite levels were found in the SLE and GSL, and notably at the head of the Laurentian, Anticosti, and Esquiman channels. These latter zones correspond to the hypoxic waters previously documented by Gilbert et al. (2005). The pH in the LSLE bottom waters decreased by nearly 0.1 unit over the past decade, with a new record of 7.528 in 2017. This decline is much higher than the global average of 0.02 pH units per decade. As a consequence, the saturation states of the bottom waters of the LSLE decreased with respect to calcite and aragonite over the last decade. Today, the bottom waters in the LSLE are not only under-saturated with respect to aragonite but also in calcite. Surprisingly, undersaturated waters with respect to both aragonite and calcite were also found in the shallow sGSL at the end of summer in 2017. The potential impacts on marine fauna and mechanisms that control the spatio-temporal variability of pH and saturation states with respect to calcite and aragonite were discussed.

Discussion

There was a discussion about the way the carbonate system data should be reported since we are working with very small amounts of data. We are certainly not at a point where we can report this effectively in the SAR, but some trends can already be seen. pH is probably the best index to report, both in surface and deep waters, but we should also report on aragonite saturation states. The latter could be reported as a proportion of stations below a certain percentage of aragonite saturation. Since the carbonate system is closely related to temperature and salinity, a characterization of water masses could be included as part of the report on the carbonate system.

The question was raised about whether there should be a research document to report specifically on the carbonate system. That is an option to consider if someone is willing to take the lead on that. In conclusion, there seems to be very interesting and different ways to report on the carbonate system, and there should be a second meeting with only the people concerned to discuss reporting.

Challenges associated with representation of regional variability were also discussed. It was agreed that we should ensure that AZMP surveys are as comprehensive as they can be and that we would rely mostly on these surveys to collect samples on the carbonate system. Suggestions to increase the dataset and regional variability representativeness included sample collection during the mackerel survey in the GSL and use of the Viking buoy at Station 27, which has a pH sensor. However, it seems that pH sensors on CTDs are unreliable unless they are calibrated frequently since they tend to drift even during a single mission.

SUMMARY OF ZONAL SCORECARDS/REVIEW AND AGREEMENT OF SAR BULLETS – PIERRE PEPIN, PETER GALBRAITH

The whole group agreed on the presentation of zonal scorecards and SAR bullets. Scorecards of the SAR and research documents will now use a new reference period (1999–2015 instead of 1999–2010), and the group agreed on a new paragraph explaining the implications of a change in the reference period. Some modifications to the SAR text were also suggested to improve its readability for a larger audience. Breakout groups (physics, biogeochemistry, Labrador Sea) then reviewed and edited the SAR text.

AZMP BUSINESS MEETNG – SESSION 1

Rapporteur – Michael Scarratt

MATTERS ARISING IN 2017 – PIERRE PEPIN

- Logistics and Data Management issues have been dealt with by the respective working groups (Tuesday meetings)
- Vessel availability remains an issue.
- This is the fifth year of oceanographic equipment rust-out funding—Still need clarification from NCR?
    - Top two items submitted from each region in 2017 were funded but more remains.
- The SOTO (State of the Ocean) report for the Atlantic has been prepared and will provide an initial standard for other regions for this type of report.
    - In previous years, Pacific SOTO was a more ad hoc exercise based on the existing process in Pacific Region, and that will not serve as a national model.
- An overview was given of a recent ACCASP (Aquatic Change Climate Adaptation Services Program) evaluation on the incorporation of environmental information in the advisory process (CSAS stock assessments) – this will have an impact on oceanography and on AZMP scientists.
    - 46% of assessments use “climate, oceanographic, ecological” (COE) information in formulating hypotheses.
    - 21% use quantitative information.
    - 36% use COE in the interpretation.
    - 27% use COE in the advice.
    - The inclusion of COE varies depending on the species and region being assessed.
    - There is a general decline in the inclusion of COE from hypotheses to the advisory parts of the process.
    - It is mostly used in providing advice on harvest control rules.
    - Climate *per se* is incorporated in assessments but its use is variable.
    - Better inclusion in Pacific Region assessments.
    - The ACCASP evaluation group prepared a summary; it will provide a global perspective comparing Canada to other countries and will propose three categories of possible approaches to move forward.
    - ACCASP group recommends including COE in all stock assessment advisory processes (including a mandatory structure and SAR bullets).
    - ACCASP group recommends realignment of resources to facilitate improved research capacity in this area.
    - CSAS will hold a formal review on this in May 2018.

Discussion

There are plans to develop a common approach for the inclusion of climate, oceanographic and ecological information in the advisory process. The goal is to achieve broad implementation of the approach in the next three years.

REGIONAL SUMMARY OF ACTIVITIES – ANDREW COGSWELL, GARY MAILLET, PETER GALBRAITH

Each region provided a summary of their field activities, collaborations, data sharing, in-kind support, progress, issues capital acquisition program, and logistics.

Part 1 – Industry day at BIO

A recent “industry day” was held at BIO with invited industry members and science participants from all Atlantic regions to discuss ship chartering options.

The 2018 field season should be covered by Coast Guard with existing vessels (this remains to be confirmed). For the 2019 field season, DFO should advise industry on the need for charter vessels. A considerable amount of work has been required to draft the Request for Proposals, but Ottawa has been providing help. The requests are being handled on a mission-by-mission basis at the moment.

Discussion

Comment: CCGS (Canadian Coast Guard Ship) *Hudson* will be out of service for at least 6 months in 2019. The Hudson is scheduled to retire in 2022, but a new ship may not be ready for a long time, so there may be a prolonged period of chartering necessary. Some options/issues are:

- Containerized labs adapted for different missions?
- Options to charter a variety of ships?
- How much support to contractors is necessary from DFO?
- A pool of potential vendors is necessary, but they need to be guaranteed work to be interested.
- Getting assurance from Ottawa that there will be support for this issue is essential.

Requirements for the fisheries vessels (if necessary) are being addressed by the Population Ecology Division under the direction of Kent Smedbol (Division Manager).

The first new fisheries science vessel has been delivered and sea trials are forthcoming. Other ships are to be delivered 6–8 months apart after that, but the shipyard is suing a subcontractor, which may delay this. Jennifer Vollrath is the Ottawa contact for these questions. It is unclear whether the lawsuit against the SeaSpan shipyard will affect these plans.

Comment: A comparative fishing program is planned, which implies continued operations by CCGS *Alfred Needler* and CCGS *Teleost* through 2019. They will be replaced in that order.

Part 2 – Maritimes Region operations in 2017

Fixed station sampling in 2017 was similar to recent years with occupations of Halifax 2 (17), Prince 5 (11), and Shediac (10), although sampling at Halifax 2 has declined for the second year in a row mostly due to pressures on the primary sampling platform, the *Sigma-T*. Intended core sampling was accomplished for the spring and fall shelf surveys. Charter vessels were utilized in the spring (*Coriolis II*) and fall (R/V *Endeavor*) in response to the extensive CCGS

Hudson refit. Unfortunately, a replacement vessel could not be identified for the Labrador Sea mission so the trip was cancelled. Otherwise there was reduced sampling due to the shorter duration winter multi-species survey and some missed southern central shelf coverage during the summer multi-species survey.

The reduced availability of oceanographic platforms continues to adversely impact the completion of surveys (Labrador Sea) and the sampling frequency during surveys (winter multi-species survey). This problem is not expected to improve in the foreseeable future, but solutions to mitigate program impacts are being investigated. The 2018 field season for the shelf surveys are projected to be accommodated by the CCGS *Hudson*, but with a refit planned for 2019, extensive effort has been diverted to the chartering process for 2019. Support from the Office of Partnership and Collaboration in Ottawa and collaboration between the regions has been critical in meeting this additional demand posed by the chartering process. AZMP staff will continue to be involved by evaluating vendor bids leading up to the 2019 field season.

A review of capital spending was provided for each region for the 2017–18 fiscal year along with projected capital spending for the 2018–19 field season. It should be noted that the final capital allocations may be adjusted for the 2018–19 field season, so an alternate list of proposed capital items should be made in anticipation for each region. This is the final year of the Monitoring Program's capital funding, which has been critical in modernizing our monitoring equipment over the last five years.

This year, the AZMP Maritimes spring and fall surveys acted as a platform for 12 ancillary projects. Of these, four were highlighted and include the collection of nutrients and hydrography across the Northeast Channel and GoM in support of a cooperative agreement with Northeast Regional Association of Coastal Ocean Observing Systems (NERACOOS); critical platform support for an acoustic mooring mammal survey; the collection of CTD-rosette water samples for Dr. Erin Bertrand of Dalhousie University to assess how organic and organometallic micronutrients influence primary productivity and the phytoplankton community structure on the Scotian Shelf; and the recovery of the final year of a mooring array near and within the St. Anns Bank marine protected area (MPA) to learn more about the physical conditions in this area.

Discussion

Coriolis II is not appropriate for the offshore spring survey, it rolls too much (25 degrees off centreline).

Endeavour is a much more suitable platform, although it has quite a low freeboard. Ecosystem trawl surveys have some gaps in February, March, and July, but the Gulf multi-species survey was OK. Overall station occupations are in line with previous years except for the Labrador Sea mission, which did not occur due to the unavailability of a suitable ship. Sample analyses are ongoing and occupy a significant proportion of the budget (especially zooplankton taxonomy). The national capital budget for equipment renewal, both at-sea and laboratory, in each region (BIO, NL, Gulf, QC, C&A, PAC) has been approved.

Anticipated missions in 2018:

- Spring trawl mission has no space for AZMP staff;
- Spring AZMP mission coming soon;
- Other missions are planned, including small-vessel missions that should have more flexibility this year compared to 2017.

Shediac Valley station will at least be sampled by Quebec region during the regular GSL missions. There has been a discussion over the past few years about shifting the sampling

responsibility towards both the Gulf and Quebec region. BIO certainly puts in a valiant effort to attempt Shediac sampling but it is a lot of travel and a big commitment to get back and forth. Gulf is now equipped with what they need to do the work, but finding technicians to actually get out there on a regular basis has been a challenge so far.

Part 3 – Newfoundland Region operations in 2017

Newfoundland Region completed their standard AZMP surveys in 2017 with varying success rates. The spring survey, TEL173, took place from April 6–23, 2017, and 99% of the planned sampling was completed. In addition to this, one mooring in the LC-AOI (Laurentian Channel Area of Interest) was recovered, refurbished, and redeployed. The summer survey, TEL176, took place from July 8–28, 2017, and 99% of the planned sampling was completed. In addition, we recovered, refurbished, and redeployed two moorings in support of the OSNAP (Overturning in the Subpolar North Atlantic Program); deployed and recovered one AZFP (Acoustic Zooplankton Fisk Profiler) mooring at Station 27; and implemented E-Log into our standard data collection protocol. Our fall mission took place from November 11 – December 16, 2017, onboard a charter vessel. Due to complications with the ship, only 44% of the planned sampling was completed. In addition to this, one mooring was recovered and one AZFP mooring was deployed at Station 27. Multi-species surveys in the region were highly successful in 2017, with 409 trawl CTDs and 26 XBTs (expendable bathythermographs) collected. In the fall, with two ships operating, we collected 713 trawl CTDs and 18 XBTs.

At the NL high-frequency station, Station 27, we saw a reduced frequency in sampling in 2017 due to limited vessel availability especially in winter. The number of occupations represents the second lowest in the 19-year time series. In addition to regular sampling, there has been a T-S mooring at Station 27 since 2014 with regular, yearly redeployments. As well, NL region has deployed a Viking buoy and AZFP mooring at Station 27 in 2017 to fill in the gaps left from reduced sampling. While this provides more data, there is still a gap left from the lack of water samples.

Despite the successes experienced by Newfoundland Region in 2017, some issues were noted. Staffing continues to be an issue in our region as there has been little progress in backfilling positions left by retirement and departing staff. As well, the aging fleet and reduced reliability of Coast Guard vessels has required Newfoundland Region to charter vessels to complete the fall AZMP survey. The consequences associated with this present challenges to the region both logistically and financially. In addition, maintenance of the Viking buoy and occupation of the high frequency station in the region could be improved with the addition of a small boat in the section/branch capable of completing this work.

Discussion

The new mini-rosettes installed on the CCGS *Teleost* and CCGS *Needler* have allowed reduced XBT use but have not improved temporal coverage. A mooring was deployed but lost in winter months. A Viking buoy was deployed for eight months, along with other moorings including a zooplankton mooring. The Viking profiler fills in the gaps of ship coverage. There were some gaps in the record caused by mechanical problems with the profiler winch, but these were repaired. In total, there were 355 profiles notwithstanding gaps in coverage. Thus, it was a very successful first year. A SeaFET pH sensor is installed on the buoy, and pCO_2 is coming soon.

Scientific collaborations are ongoing, including OSNAP, aquatic resources, Environment and Climate Change Canada (ECCC), Oceans sector, operational oceanography (Fraser Davidson), and others.

It was pointed out that charter vessels present additional costs, complicate logistics, and increase dangers. Also, the lack of a small vessel for Station 27 is an ongoing problem. A dedicated boat is needed within the section to adequately service this station.

Deployment of the Viking buoy must wait until June because of ice, but it can stay in the water until February before ice returns.

BIO can occupy Station 27 in April when the AZOMP survey transits through the area.

Despite the possibility of extra resources being made available via the “3-whales” Memorandum to Cabinet for additional multi-species survey zooplankton samples, time constraints on those surveys are too great to permit additional sample collections that cannot be obtained from the trawl itself.

Part 4 – Québec Region operations in 2017

All four surveys were done successfully in 2017, thus Quebec Region was not as affected as other regions by Coast Guard ship issues. In fact, Coast Guard graciously provided the CCGS *Earl Grey* for the March survey, which was done by helicopter until 2015. A total of 74 full-depth rosette stations were done. Samples were taken for methane analyses for Huixiang Xie (Institut des Sciences de la mer [ISMER], University of Québec at Rimouski [UQAR]) and a bird observer was on board for François Bolduc (ECCC). The June survey was done aboard the CCGS *Teleost* and included stations in the Saguenay Fjord and the middle Estuary. Again, methane samples were taken, this time with an ISMER student on board. A bird observer and a marine mammal observer were also present. In August, 105 stations were done on the multi-species survey aboard the *Teleost*. The *Coriolis II* was chartered for the fall survey, which included a week of sampling with a joint project with Quebec-Ocean in the Saguenay Fjord and in the Estuary up to Quebec City.

A logistics issue worth reporting are difficulties with biological sampling at the Shediac Valley high frequency station, as the site was only visited eight times in 2017 (five by IML, two by Kevin Pauley at BIO, and one during the multi-species Southern Gulf survey). Gulf Region has acquired equipment and it is hoped that they can start covering this station to some extent during the upcoming 2018 season. It is also worth noting that IML does not sample as many bottle depths as BIO, so it might be worth harmonizing the protocol.

Lastly, in 2017 we welcomed Marjolaine Blais to the IML AZMP team in a new BI-03 position tasked with reporting on biochemical conditions. Her previous experience was mostly in Arctic programs as a research assistant at ISMER.

Discussion

The 2017 winter survey was performed on CCGS *Earl Grey* due to helicopter restrictions, and a reasonable coverage was achieved despite icebreaking time constraints. A helicopter will be used in 2018.The June *Teleost* survey was successful, and so were mooring deployments, including acoustic moorings. However, many problems related to the moorings occurred during the year (e.g., breakages, accidents) caused by design flaws. These can be corrected. The decline in BIO visits to Shediac Valley is very evident. Joël Chassé may be able to send a new employee from Moncton to learn and help with Shediac Valley. This may eventually lead to some visits of Shediac Valley station by Gulf Region. Viking buoys are operational at both Québec Region high-frequency monitoring stations.

DATA MANAGEMENT PROGRESS AND ISSUE OVERVIEW – SHELLEY BOND

Collaborators: M. Ouellet, J. Holden, D. Fishman, D. Cardoso, L. Devine

An overview of recent data management activities in the four regions was presented. Québec Region has updated their quality control (QC) procedures to include ocean acidification variables (pH, alkalinity), and IMTS (Information Management – Technology Services) support has recently become available to get IML's data archive back online for public access (data requests are currently handled by personnel). IML continues to process Gulf Region CTD and discrete data and will work with the newly hired Gulf Region data manager. With the new data management resources in place, the two regions will engage more frequently in order to share expertise (i.e., training), standardize approaches (e.g., quality control protocols), and establish transactional expectations (e.g., templates for sample submission). Newfoundland and Labrador plans to modernize their processing and will move toward the ocean data format (ODF) for several datatypes; they are using procedures developed by other labs to process, QC, and load discrete data. They have compiled a nutrient climatology and have begun exploring how to handle Viking buoy data. Gulf Region recently appointed a data manager. He is learning about the data management in the region and exploring the best way forward given the past informal and lack of data management in the Gulf Region. Maritimes Region continues to use ELog (electronic field notes) and is developing a sample tracking system using bar codes. They have explored making more data available on the Federal Geospatial Platform and open.canada.ca and plan to add Viking buoy and glider data to their data streams. Maritimes has lead data managers for each of the four divisions. The "reboot" of Maritimes BioChem data has stalled because of the loss of the dedicated FTE (full-time equivalents): AZMP data from 2013 and on are available, but not before. Some data like plankton can probably be reinstated; multi-species surveys have not yet been addressed. The regions plan to work together to move the data management initiative forward, and the committee feels that a face-to-face meeting would be advantageous if funds are made available.

Discussion

Dave Fishman and Diana Cardoso have been welcomed in new positions, and Patricia Pernica is at the DFO service desk in Dorval. Despite recent hires, most discussions focused on the lack of personnel to achieve data management tasks. For instance, one of the data managers notes that she cannot focus all her time on AZMP. She may be able to provide some of her and her employees' time to this but must cover other programs also. The expertise is there but not the capacity. We need a reinvestment for data management like that which was provided for the at-sea program a couple of years ago. This is not fundamentally a regional issue—it should be a national issue, and a tiny amount of money would get us much more value. Shared Services is one impediment, but data management also does not get the resources it needs in the regions. The creation of a website to support database access, such as exists elsewhere, is an ongoing project with IMTS that is supposed to finish this year, but some people doubt its potential success. Security issues are a major impediment to this project.

Oceanographic variables (physical, chemical) will predominate in any use of our data by stock assessment processes and should be the focus of our efforts. Biological data will be less often used. It was noted that there are also data format issues, and conversions between data formats (e.g., ODF and NetCDF [Network Common Data Form]) could be improved.

The data management group work plan is progressing: there is better data tracking and incremental improvement in other areas.

A test case is being developed using selected data for the BioChem collaboration with Newfoundland Region. IML's quality control routine, which has been extended recently, will be adopted. Workflow is efficient and a user guide has been prepared.

The issue of data management does not receive top attention from directors—they tend to ignore it. It could be mentioned in the ACCASP CSAS review process that data management is a major issue and ease of access is critical. This will be important for integrating COE (climate, oceanographic, ecological) information into stock assessments. This may help with the BioChem reboot, which has stalled. Three dedicated FTE to finish the BioChem reboot at BIO would be required to complete the task. Currently, there is insufficient support for this. The SSDMSC (Science Data Management Steering Committee) funding envelope could be used, but we need to submit a proposal. We could be proactive and provide suggestions. Requirements will be relayed for consideration by the national fund.

Access to CTD data from other regions is problematic. MEDS (Marine Environmental Data Service) is one option, but it is not as efficient as NOAA's NODC service (National Oceanographic Data Center). If funding could be secured, term personnel could be hired, but this raises challenges of training and is only a stopgap rather than an ideal solution. MEDS is currently working with IMTS on a capital project called Modernization of Data Integration Processes (MODIP) to allow public interactive access to its database of physical oceanographic data.

Action item:

- The Chair indicates that he will prepare a briefing note to directors regarding resources to support more regular meetings and interaction between data managers in AZMP regions. The direct interactions to date have been very helpful and should be reinforced to assure further progress.
- Andrew Cogswell will relay requirements to Tobias Spears for consideration by the national fund.

SUMMARY OF THE OCEAN DATA MANAGEMENT SUBCOMMITTEE – MATHIEU OUELLET

Collaborators: S. Bond, D. Cardoso, L. Devine, D. Fishman, J. Holden

An overview of the Ocean Data Management Subcommittee and its position relative to the Science Data Management Steering Committee, the Science Executive Committee, and other committees defined in the Oceans Science Framework was presented. The subcommittee has representation from all DFO regions and is chaired by the head of the MEDS of the Ocean Science Branch (Ottawa). It met three times during the 2017–2018 year and devised a work plan of which a high-level summary was presented. The work plan aims to prepare oceanographic data between regions so as to enable interoperability when implementation of additional technologies becomes possible by:

1. mapping the codes used by all regions who use codes to represent parameters and units to the British Oceanographic Data Center list of usage parameter codes, which is used internationally;
2. making moored ADCP data from all DFO regions available to the public in a common data format using the international "climate forecasting" convention;
3. rationalizing inventories of mooring data across DFO to address potential duplicates; and

4. doing national consultations for the development of data models used in the Information Technology (IT) modernization project at MEDS.

The work plan also acknowledges the data management work carried out jointly with the glider working group, which established real-time data flow for both types of gliders owned by DFO, and a delayed-mode data flow at BIO, which is carrying out the first mission likely to return delayed-mode data. The work plan recognizes the challenges associated with the data management aspect of moorings equipped with Viking buoys and fixed-site profilers and proposed considerations for a data management plan to be submitted to the Oceans Science Coordination Committee (OSCC) to request the funding of one national position, regionally located, to handle the data management of instruments associated with those moorings. Finally, the work plan addresses international data exchange to determine an optimal data flow from DFO to various international specialized or thematic data centres, to facilitate synchronization and avoid duplication of work and data as much as possible. The presentation paid special attention to initiatives related to ocean acidification, such as NOAA's Ocean Carbon Data System, recognized and sponsored by bodies of the IOC (Intergovernmental Oceanographic Commission) and WMO (World Meteorological Organization). As per the work plan, data exchanges involving scientists directly will be coordinated nationally and restarted wherever they were interrupted.

Discussion

Regarding Viking buoy data management, MEDS proposes a central archive with a dedicated FTE located in a region. This will be suggested to OSCC. However, telecommunication cost budgeting is necessary, and we should decide if real-time data acquisition should occur through Multi-Électronique Inc. or IMTS.

It is important to use an expandable data model that is machine readable. International data exchange was removed from MEDS' data policy, but it is important that it be re-established. Many NGOs (non-governmental organizations) have established many different services with no overall coordination—some are data repositories, +some include metadata only. Many data archives have gaps due to, e.g., principal investigator retirements, and there are often long lags between data processing and availability.

An international data management scheme concerning carbon-related data was presented. OCADS (Ocean Carbon Data System) was developed by NOAA. Only BIO is contributing from Canada, but other regions will follow. GO-SHIP is essentially Phase3 of WOCE (World Ocean Circulation Experiment). It focuses on a number of deep ocean lines like WOCE did. CCHDO (CLIVAR and Carbon Hydrographic Data Office) is also focused on high-quality deep ocean data, but this program would also like to include coastal data. BIO currently contributes to this program and will begin pulling data from BioChem. Thus data from other regions could be included with minimal additional effort. JCOMMOPS (Joint Technical Commission for Oceanography and Marine Meteorology *in situ* Observing Programmes Support Centre) is not a data centre–the group functions as a project coordinator. NOAA's World Ocean Database (WOD) interacts with CCHDO and incorporates the same data. MEDS currently provides data to WOD. MEDS has a challenge to renew/continue these international submissions without duplication or errors.

There is a task force looking at cloud storage. There are some issues with processing that will need to be resolved, but for storage it may be a good solution. Long-term archives may be cost effective, but transmission costs for regular use and computing will be prohibitive. Costs and billing certainly are an issue, especially where continuity is important. We cannot risk losing data, and there is the risk of double billing among other issues.

AZMP BUSINESS MEETNG – SESSION 2

Rapporteur – Gary Maillet

OCEAN SCIENCES FRAMEWORK / ACCASP / UPDATE FROM NATIONAL CAPITAL REGION (NCR) – ANDREW STEWART, DENISE JOY

Summary not provided.

Discussion

The AZMP capital ISN allocation has been approved and will be coordinated through the AZMP Chair to DFO Regions. Concerns were raised about IT issues that place restrictions on dissemination of scientific data with outside organizations that have systems in place to host and display data products (e.g., St. Lawrence Global Observatory [SLGO]).Concerns were also raised that regional data management groups do not have sufficient resources to assist with development of the Canada Integrated Ocean Observing System (CIOOS). In response to these concerns, NCR funding initiatives were identified and discussed to assist efforts in support of further development of CIOOS.

Current funding approvals for ACCASP in the 2018–2019 fiscal period were reviewed. Concerns were raised about the need to improve reporting relationships between Fisheries and Oceans and Environment Canada for ACCASP initiatives. Distribution and proper identification of ACCASP Ocean Chemistry component funds to regional centres was raised.

Further efforts are required to improve coordination among regions to achieve national objectives of the Ocean Acidification (OA) program as part of ACCASP. Reporting on the ACCASP OA program will follow a three-year rotating cycle between Pacific, Central and Arctic, and Atlantic Regions.

UPDATE ON REMOTE SENSING AT BIO – CARLA CAVERHILL

Both VIIRS and MODIS/Aqua datasets have been reprocessed (R2018). The VIIRS L2 processing is complete and the images on the website and stats on the ftp site are for R2018. The new reprocessing gives lower values of chl a in most areas, except in high chl a spots where the chl a estimates can be higher than for R2014. There are fewer pixels that are flagged “PROD FAIL”, so it is felt that this new dataset is an improvement. An *in situ* validation will be redone this spring. MODIS L2 processing is underway and will continue for the next two months. The website and ftp site are being updated at a rate of about one year per week. The entire MODIS mission has been reprocessed to R2018 using L3 data. Those stats are available on request. R2014 data for both VIIRS and MODIS are still available for comparison purposes on the ftp site. The address for the ftp site has been updated.

It was decided not to change the reference period for either MODIS (2003–10) or AVHRR (1999–2010) until 2020. SST monthly climatology maps based on daily climatology have been produced.

The OLCI dataset (2016–present) has been reprocessed (V2.23), and validation with BIO’s *in situ* data will be redone this spring. OLCI has 300 m resolution and a neural net chl a product that is promising for coastal waters. A second OLCI sensor will be launched in April 2018. The Japanese sensor SGLI (Second-Generation Global Imager) on GCOM-C was launched in December 2017, and the data should be available in April 2018. It has a resolution of 250 m. Having three high-resolution ocean colour sensors flying at the same time bodes well for coastal remote sensing. However, the validation phase will continue for months to years.

The primary production estimate has been computed for 2017, based on VIIRS chlorophyll. Stats are available on request. Primary production and chl a from VIIRS and MODIS R2018 are estimated for the extended North Atlantic (39–82°N, 42–95°W), even though the maps on the website only show the AZMP area.

Plans for 2018 include developing a method for estimating integrated chl a at AZMP fixed stations from satellite data and an *in situ* database of chl a vertical distribution. It is also planned to add research products to operational stream (e.g., diatoms), improve the temporal resolution of the primary production estimate, and reprocess the SeaWiFS dataset to R2018.

Discussion

Concerns about the changes in reprocessing of archived and current ocean colour data and how to best communicate the differences with various regional leads to ensure consistency in reporting were raised. To solve this problem, various approaches were discussed such as completion of a technical report, the formation of a subgroup to identify proper metrics for dissemination, or a simple email list to communicate the current status of large-scale imagery statistical subregions. In any case, documentation should be appended to ocean colour data files to identify status of reprocessing to ensure consistency in results reported by regional leads. Finally, improvement in ocean colour imagery for coastal applications was discussed. The new OLCI sensor shows considerable improvements over the previous sensor and methods allow a better understanding of inshore dynamics.

Action item:

- Peter Galbraith will communicate updated details regarding calculation of monthly averaged data from daily observations.

A CLIMATOLOGY OF NUTRIENT MEASUREMENTS FROM NEWFOUNDLAND – GINA DOYLE

In order to develop nutrient climatologies for this region, data were analyzed across standard sections by season, station, and depth. The analysis focused on the main macronutrients phosphate (PO_4), nitrate (NO_3 including nitrite NO_2), and silicate (Si). Statistics of central tendency were calculated for each nutrient, including mean, standard deviation, quartiles, and percentiles, using all available data from 1999 through 2016. Some findings can be generalized across all sections and seasons. The mean nutrient concentrations were generally stratified, being lowest at the surface and increasing with depth. There were a few exceptions to this, the most obvious being Si and PO_4 values in the fall, which had little stratification. The Flemish Cap and Bonavista sections had the highest overall concentrations for all three nutrients in all seasons. Patterns along sections varied among nutrients. Nutrient concentrations exhibited variable cross-shelf gradients along the standard sections, with higher levels often associated with changes in bathymetry (i.e., shelf break and slope water regions). Silicate levels exhibited some notable differences compared to the other macronutrients, with higher concentrations inshore in many cases and higher levels of variability along some sections.

Uptake of phosphate during spring was evident, with low concentrations in the upper water column (0–50 m) across the standard sections. Lower levels in the upper water column extended into summer and were associated with higher levels of stratification causing a rapid gradient (nutricline) at about 50–75 m in depth. With increased wind mixing during autumn, phosphate levels increased in the upper water column but varied across the standard sections in terms of the rate of replenishment.

Uptake of nitrate was also evident during spring, but the range of concentrations showed the largest changes compared to the other macronutrients. Similar levels of depletion were

observed in the upper 50 m during summer along with a sharp nutricline during summer. Replenishment of nitrate in the autumn varied by latitude, with continuing low levels observed along the southern sections in contrast to northern regions, which had more replete conditions. Uptake of silicate was also apparent during spring but was reduced on the northeast Newfoundland Shelf compared to the Grand Bank and southernmost sections, where draw down was more extensive. In summer, there was widespread near-surface depletion of silicate concentrations along with the nutricline at 50–75 m. Silicate values were highest in fall, and like nitrate, recovery from surface depletion increased toward the north. Seasonal changes in nutrient concentrations for the high-frequency sampled coastal station located in the deep Avalon Channel followed expected changes, with rapid biological uptake in the spring, continued depletion in the upper water column due to strong vertical stratification in the late spring and summer, followed by replenishment from deeper waters during the autumn and winter from wind-induced mixing.

The climatologies are currently being used to improve the limited number of observations in the BioChem and World Ocean Atlas (WOA) databases for better quality control and assurance analyses, increasing efficiencies, and providing increased confidence in the regional data for the Newfoundland and Labrador Region. Additional efforts are underway to evaluate changes in water mass composition and the potential for climate change to impact the inventories of macronutrients in the ecosystem.

Discussion

A technical report is in preparation to describe additional details of the nutrient atlas for the Newfoundland and Labrador Region.

Planning has begun on archiving nutrient data in national and international archives. The need to include data quality flags along with proper documentation with the information was suggested to ensure that poor quality or suspect data are not used in various analyses. Implementation of quality checks and assurance protocols will follow the standardized procedures developed by IML.

ADCP MEASUREMENTS ON THE NEWFOUNDLAND SHELF AND SLOPE – STEPHEN SNOOK

Collaborators: E. Colbourne, G. Han, D. Senciall

Archived data from ship-mounted Teledyne RDI Ocean Surveyor ADCPs were used to measure currents and transport along the standard Flemish Cap (47°N) and Seal Island sections for the years 2007–17. The ADCP data were collected using RDI VmDas and processed using the CODAS3 software suite developed by the University of Hawaii. The data were quality controlled with a percent good threshold of 70–80%. Absolute currents were determined by subtracting ship motion as determined by the ship's 3D DGPS system. Currents were then de-tided using tidal predictions obtained from a numerical high-resolution two-dimensional tidal model. Data from each survey were used to construct cross-sections of the current field for each section and their seasonal means. Volume transport estimates of the inshore and offshore Labrador Current were computed by extrapolating the current measurements to the surface and integrating over the water column from the surface to bottom or to 620 m depth.

The Labrador Current both on the Grand Banks and off southern Labrador exhibits considerable annual and seasonal variability, varying spatially from 50 km to more than 100 km wide at the shelf break, with peak currents exceeding 50 cm/s in some years. The inshore branch is generally weak, with average currents <10 cm/s and typical transports from 0.5 to 1 Sv, although during the summer of 2017 inshore current speeds along the coast of Labrador

exceeded 30 cm/s with a transport >2 Sv. The flow is much stronger at the shelf break of the Grand Banks and the Flemish Pass, with a total transport of about 8 Sv during the spring 2017 and seasonal averages varying from 4 Sv during the summer to 6.3 Sv during the spring. The transport in the offshore branch east of Flemish Cap, although weak in 2017 (2 Sv), is strong in some years (up to 12 Sv in 2015), with seasonal means between 3 and 6.2 Sv with the maximum again occurring during spring. In the offshore branch along the Seal Island section, the current extends from the 200 m isobath (AZMP station SI-9) to seaward of SI-14 (2600 m). Maximum speeds >60 cm/s with a transport of about 10 Sv were observed during the summers of 2016 and 2017. However, the measured transport during the fall, except for 2013, was generally weaker than expected. An examination of the current structure in 2009 shows a strong baroclinic jet at the shelf break centred at the 300 m isobath (SI-11) with a strong barotropic flow containing about 80% of the total transport seaward of SI-12 (600 m) and extending beyond SI-14 (2,600 m). The Labrador Current transport in the Flemish Pass estimated using a coupled ocean–ice model shows summer values ranging from 3.5 to 5.3 Sv compared to a mean of 4 Sv measured by the ship-mounted ADCPs. Along the Seal Island section, modelled summer transport was 10.9 compared to 7.6 Sv measured by the ADCPs, while the fall measurements were significantly lower than model estimates.

Discussion

Current meter information for mooring platforms was suggested as a means to ground-truth ship-mounted ADCPs since geostrophic calculations do not necessarily capture the entire signal. The limitations of ship-based measurements were also highlighted given the short-term nature (in space and time) of the respective data. Despite these caveats, transport volumes can be estimated from the standard sections to provide more information on interannual variability in transport across the zone.

METADATA FOR THE BAY OF FUNDY LONG-TERM HYDROGRAPHIC MONITORING STATIONS – FREDERICK J. FIFE

Collaborators: F. Page, B. Chang

Stations Prince 5 and Prince 6 are located in the Bay of Fundy and in the St. Croix River estuary respectively. Seawater temperature at the surface and at different depths down to near bottom has been measured and recorded at regular intervals at these two monitoring stations for more than one hundred years by St. Andrews Biological Station staff. The precision of these data must be determined before being used in climate studies. There were many different instruments used over the years. We now have to verify that the measuring devices used have been properly catalogued and calibrated. This information must be included with the data as metadata. The aim is to convey to future users “all details about study context, data collection, quality control and assurance as well as analytical procedures from the beginning of a research project and then including this descriptive information in the metadata.“ (Kervin et al. 2013). This metadata file is being prepared following the *Ecological Archives* metadata content standard, which is based on the format described in Michener et al. (1997). “Information about sampling designs, research methods, and identification of project personnel is central to interpreting and using data.”

Discussion

Retrospective analysis of plankton samples collected during the early 1900s to determine basic community composition was suggested for comparisons with contemporary populations. This comparison could be quite revealing given the time differences between current and earlier plankton collections.

VIKING BUOY OPERATIONS, CHALLENGES AND PLANS – PETER GALBRAITH

Collaborators: S. Snook, A. Cogswell

This talk summarized Viking buoy operations in 2017–18, plans for 2018, and AZMP logistics and data management group discussions held on March 20, 2018. The four new buoys performed well (1,208 casts at Rimouski station; 866 casts at Shediac Valley although it's an older buoy from IML; 543 casts at East Southern Gulf, a new station occupied by Gulf Region's Viking buoy; 349 casts at Station 27; 113 casts by March 21 in Bedford Basin) overall, but Station 27 suffered from two mini-winch interruptions and a failed ADCP.

Data acquisition and management was divided into three tasks:

1. Real-time acquisition is currently done through Multi-Électronique; data are then provided to DFO via Dropbox or ftp. Delayed mode is also done through Multi-Électronique after download of the recovered buoy controller. Plans are evolving with IMTS staff at IML, who want to take the data acquisition task over nationally, similar to what they do with the Canadian Hydrography Service's water level monitoring. The AZMP group sees advantages continuing with Multi-Électronique, such as quick software tweaks and firmware upgrades, and proposes to include services in a standing offer to be made with Multi-Électronique along with buoy spare parts.
2. Real-time data monitoring is done to make sure systems are working:
    a. CTD casts are plotted once a day by Peter Galbraith as isotherms and isohalines along with the date and time of the last cast; these are available on DFO intranet.
    b. Peter Galbraith plans to build an intranet web site displaying the status of each instrument and showing data by month compared to available (or eventual) climatologies. He will develop a "last pass" QC for these data before their long-term archive.
3. Long-term archive:
    a. A national data management plan was initiated by the OSDM subcommittee chaired by Mathieu Ouellet.
    b. OSDM is proposing that a new FTE be assigned to this task nationally, located in one of the operating regions.
    c. BIO is working on a project to encapsulate Bedford Basin Monitoring data streams, including the Viking buoy, into NetCDF.

Sensors:

1. BIO is looking to add AIS (tracking system) on the buoy prior to moving it to Halifax-2.
2. Rowe Technology ADCPs were good performers, with bottom track to 330 m in good surface conditions, but the instrument failed to work correctly at Station 27. It was returned to the company and fixed under warranty, but data were not recoverable.
    a. IML's older fleet of Viking buoys use RDI AZMP instruments, so it is possible to switch.
3. The group looks forward to getting feedback from BIO as they are the only ones equipped with CO_2-Pro and surface dissolved oxygen sensors.
4. The group looks forward to getting feedback from Newfoundland and Labrador Region as they are the only ones equipped with nitrate sensors (SUNA).

5. The group would appreciate feedback on the usefulness of radiometers. They need expensive calibration every year. They are mounted centrally under the buoy for equal shading, but shading is an issue. There was a Rimouski station field test of a “baby buoy” attached to the main buoy. The group needs to speak with Simon Bélanger (UQAR) with whom this was done.
6. The pH sensors (SeaFet) is also problematic. They are sensitive to freezing temperatures and require at least annual calibration.

Upcoming in 2018:

1. Newfoundland and Labrador Region will assume responsibility for the satellite transmission cost for Station 27 (about $450 per month). It might be useful to install a cell repeater.
2. WiFi range will be upgraded from 50 ft to 500 ft.
3. Buoys will be equipped with Vemco VR2C fish tag receivers and these data will be transmitted in real time (Martin Castonguay).
4. Rimouski station mini-winch to be field-tested for new cable guide, allowing profiling depth to be increased to 350 m (Roger Pigeon).
5. Rimouski station SBE-49 profiler to be field-tested for oxygen (Rinko-Ft) and fluorometer (Cyclops-7 chlorophyll) with an extra mini board added to the CTD (Roger Pigeon).
6. Need to create a standing offer with Multi-Électronique for all buoy parts and services (Roger Pigeon).
7. Create a maintenance guide, with photos and video (Roger Pigeon) and schedule.

Challenges:

1. Deployment and recovery:
    a. Some IML buoys have been added to the CCG buoy tender program along with their navigation buoys.
    b. Some are deployed and recovered using AZMP surveys, but this leads to late-season starts.
2. Emergency maintenance:
    a. IML has strong history of piloting their own small crafts, which are used to visit the Rimouski station buoy (located 12 nautical miles offshore).
    b. What to do in other regions?
3. Calibration and maintenance:
    a. Regions obtained 20K for each **NEW** buoy (major relative shortfall in Québec Region, with 20K to operate five buoys. They would like to request 10K per extra buoy from Ocean Science Observation and Monitoring [OSOM].)
    b. Suggest creating a pool of spare parts and possibly some sensors, available to all, maintained at IML and funded by OSOM.

Discussion

Plans are currently underway to obtain a standing offer arrangement with Multi-Électronique for buoy equipment, sensors, calibration and repair services, and general spare parts. The interest of US partners (e.g., NERACOOS, ERDDAP programs) to obtain all Viking buoy data was raised.

It was also mentioned that servicing of buoys by DFO technical staff requires a risk analysis to ensure staff are properly trained and protected given the dynamic nature of these small platforms.

Finally, efforts are underway to outfit the Viking buoy CTDs with dissolved oxygen sensors (Rinko-Ft) and chlorophyll fluorescence fluorometers to provide some biogeochemical measurements in addition to temperature and salinity. Additional efforts are also underway to implement use of pCO_2 sensors for near-surface and atmospheric measurements.

GLIDER OPERATIONS – DAVID HEBERT

Initially, there will be two types of gliders and centres: open-ocean gliders based at the Institute of Ocean Sciences (IOS) and coastal-ocean gliders based at the BIO. The two open-ocean gliders would be used to occupy Line P (three-month round trip time with profiles to 1,000 m). Two of the coastal-ocean gliders would be used to occupy the Halifax Line (round trip time of one month, profiles as deep as 700 m). The other coastal-ocean gliders would be available for use by other DFO scientists, including some of the other monitoring sections. Request for their use would be through a Letter of Intent (LOI) process with the decision made by OSOM Committee. There are still open issues on the operation costs as to whether the facility is responsible for them or the proposer.

Discussion

The use of wave glider technology was raised, but technical challenges with sea-state considerations still remain the main obstacle for use of this remote monitoring system in the North Atlantic. IT issues were also raised as a logistical consideration given remote sensing technologies such as ocean gliders normally fall outside of Shared Services agreements.

AZMP BUSINESS MEETING- SESSION 3

Rapporteur – Jennifer Holden

SUMMARY OF ACTION ITEMS/ISSUES IDENTIFIED FROM LOGISTICS, DATA MANAGEMENT, AND WORKSHOP MEETINGS

The logistics and data management groups gave summary presentations. The need for a potential request for additional staffing to assist with the BioChem reboot issue at BIO and a centralized person to address data from the Viking buoys were identified.

AZMP REPORTING

Standardizing oxygen calibration across regions was discussed. Currently, each region collects samples at slightly different intervals (some regions use every bottle; some only use surface and bottom, etc.).

Action item:

Marjolaine Blais, Frédéric Cyr, and Andrew Cogswell will coordinate in order to homogenize O_2 sampling protocols across regions.

The need for a standard way to report oxygen was discussed. NL suggested oxygen could be covered in the physical report, particularly if results are derived from the CTD measurements. IML currently includes data derived from bottle sampling in the biogeochemical report, but does not include CTD data.

Ocean Acidification reporting was discussed. Since total alkalinity and dissolved inorganic carbon (DIC) are closely linked with the physical data, it could be reported in the physical

research document (though not necessarily for the SAR). A zonal response document would be preferred, but might add complications.

The draft SAR was reviewed and agreed upon after minor revisions.

MATTERS ARISING

Chair succession plan

Peter Galbraith will be taking over the role of AZMP Chair in 2018. Chair duties and committee responsibilities will transition from Pierre Pepin to the new chair over the course of the year. Pierre proposed the need for a vice-chair to help take on some of the duties and responsibilities, and will prepare a summary to address this matter.

WORK PLAN FOR 2018–19

All regions are expecting to have their research documents prepared by this summer. Under the new regulations, these documents will need to be translated before they are published. The Labrador Sea research document will include the last two years.

Action item:

Marjolaine Blais and Laure Devine will coordinate the proceedings for this meeting, and the presentations will be made available in GCpedia.

The usefulness of a mid-term meeting was discussed. Potential topics for this year's mid-term meeting could include satellite imagery in the Gulf, as well as carbonates. IML was volunteered as a location with a potential meeting time of late September/early October. It was also suggested that the mid-term meeting would be a good place to engage academia.

Finally, AZMP 2019 was discussed. The group was satisfied with the current meeting location and March timeframe. Logistics for the AZMP 2019 meeting will be coordinated by the out-going chair.

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APPENDIX I – TERMS OF REFERENCE

Twentieth Annual Meeting of the Atlantic Zone Monitoring Program (AZMP) Zonal Peer Review – Newfoundland and Labrador, Québec, Maritimes and Gulf Regions

March 20-23, 2018
Montreal, QC

Chairperson: Pierre Pepin

Context

The Atlantic Zone Monitoring Program (AZMP) was implemented in 1998 with the aim of collecting and analyzing the biological, chemical, and physical field data that are necessary to:

1. Characterize and understand the causes of oceanic variability at the seasonal, interannual, and decadal scales,
2. Provide multidisciplinary data sets that can be used to establish relationships among the biological, chemical, and physical variables, and
3. Provide adequate data to support the sound development of ocean activities.

The program sampling strategy is based on:

1. Seasonal and opportunistic sampling along sections to quantify the oceanographic variability in the Canadian NW Atlantic shelf region,
2. Higher-frequency temporal sampling at more accessible fixed sites to monitor the shorter time scale dynamics in representative areas,
3. Fish survey and remote sensing data to provide broader spatial coverage and a context to interpret other data, and
4. Data from other existing monitoring programs such as CPR (Continuous Plankton Recorder) lines, sea level network, nearshore long-term temperature monitoring, toxic algae monitoring, or from other external organizations (e.g., winds and air temperatures from Environment Canada) to complement AZMP data.
5. The collected data are edited and archived in databases managed by DFO's Integrated Science Data Management (ISDM) Branch.

Objectives

1. Assess the biological, chemical and physical oceanographic conditions since 1999 through a peer review of the outcomes of monitoring activities in the four Atlantic regions;
2. Synthesize the multidisciplinary information gathered over the course of the programme;
3. Evaluate and develop new data products aimed at meeting client needs based on regional input;
4. Review the activities of the Atlantic Zone Monitoring Program during 2017 and assess business, operational, logistical, database and remote sensing activities that require regional/zonal intervention or that need to be brought to the attention of Science Directors.

Expected Publications

- Science Advisory Report
- Research Documents
- Proceedings

Participants

- DFO Science Branch
- Environment Canada

APPENDIX II – MEETING AGENDA

20th Annual meeting of the Atlantic Zone Monitoring Program March 20-23, 2018

Delta Hotel, 475 Avenue Président Kennedy, Montréal, QC

Tuesday, March 20: Physics & Biogeochemistry

Rapporteur – Catherine Johnson (am) and Frédéric Cyr (pm)

09:00 – 09:15	Pierre Pepin	Welcome and Introductions
09:15 – 12:00	Workshop Session 1 - Physics	• Complementing the AZMP; Model based oceanographic conditions in the GSL in 2017 – Joël Chassé • Update on modelling – Maritime region – David Brickman • Update on ocean climate modelling over the NL Shelf. – Guoqi Han • Recent changes in Newfoundland and Labrador waters part one: A dive into 7 decades of oceanic observations – Frédéric Cyr • Recent changes in Newfoundland and Labrador waters part two On the low frequency variability of the NW Atlantic – Ali Moridnejad • Ocean climate variability over the NL Shelf: 1979-2010 – Guoqi Han • Saguenay Fjord water renewals – Peter Galbraith • Exploratory work for the inshore currents from satellite altimetry: the inshore Labrador Current, the Nova Scotia Current, and the current in the GSL. – Guoqi Han
12:00 – 13:00	-	*Lunch Break*
13:00 – 16:50	Workshop Session 2 – Biogeochemistry	• Trace gas measurements from the AZMP cruises in the GSL – Michael Scarratt • Progress on phytoplankton research in the NWA – Emmanuel Devred • Timing of the bloom: results from different analytical methods – Nicolas Lambert • Using optimal and realized habitat models to assess the underlying mechanisms of *Calanus* population responses to future climate change in the northwest Atlantic – Stéphane Plourde • Modeling approaches to understanding *Calanus* spatial variability – Catherine Johnson • Body size/condition in *Calanus finmarchicus*. Stéphane Plourde and Pierre Pepin
16:50 – 17:00	Pierre Pepin	Summing up

NOTE: There is a parallel meeting for the Data Management and Logistics working groups, and for people involved with Viking buoys.

Tuesday, March 22: AZMP Business Meeting

Rapporteurs: Michael Scarratt (AM) & Gary Maillet (PM)

Session 3	-	-
09:00 – 09:30	Pierre Pepin	Welcome and Introduction / Acceptance of Agenda Outline of meeting goals Review of Issues 2017 Matters arising
09:30 – 10:30	Andrew Cogswell, Gary Maillet, Stephen Snook, Peter Galbraith	Regional summary of activities Collaborations/Data sharing/In-kind support Progress / Issues Capital Acquisition Program Logistics
10:30 – 10:50	-	*Health Break*
10:50 – 12:15	Laure Devine, Shelley Bond, Jennifer Holden, Mathieu Ouellet, Diana Cardoso	Data Management Progress & Issue Overview (All) Summary of the ODMC committee and the state of data submission to international data centers and to the GTS (Ouellet/Cardoso)
12:15 – 13:15	-	*Lunch Break*
Session 4	-	-
13:15 – 14:00	Andrew Stewart, Denise Joy	Ocean Sciences Framework / ACCASP / Update from NRC
14:00 – 14:20	Carla Caverhill	Update on Remote Sensing at BIO
14:20 – 14:40	Gina Doyle	A climatology of nutrient measurements from NL
14:40 – 15:00	Stephen Snook	ADCP Measurements on the NL Shelf and Slope
15:00 – 15:20	Frederick J. Fife	Metadata for Bay of Fundy long-term hydrographic monitoring stations
15:20 – 15:40	-	*Health Break*
15:40 – 16:30	Peter Galbraith, Stephen Snook, Andrew Cogswell, Dave Hebert	Viking Buoy Operations, Challenges and Plans Glider Operations
16:30 – 17:00	-	General Discussion – Matters Arising
17:00		Close
17:00 – 18:30	-	Permanent Management Coordination Committee

Wednesday, March 21: Review of physical and biogeochemical conditions in the Northwest Atlantic

Review of physical and biogeochemical conditions in the Northwest Atlantic
Rapporteurs: David Bélanger (AM) & Marjolaine Blais (PM)

09:00 – 09:15	Pierre Pepin	Welcome and Introduction
09:15 – 09:50	Igor Yashayaev	Physical conditions in the Labrador Sea (AZOMP) in 2017
09:50 – 10:10	Frédéric Cyr & Guoqi Han	Physical oceanographic conditions on the Newfoundland and Labrador Shelves
10:10 – 10:40	Gary Maillet, David Bélanger & Pierre Pepin	Biogeochemical conditions on the Newfoundland and Labrador Shelves
10:40 – 11:00	-	*Health Break*
11:00 – 11:30	Peter Galbraith	Physical oceanographic conditions in the Gulf of St. Lawrence
11:30 – 12:00	Marjolaine Blais, Stéphane Plourde & Michael Scarratt	Biogeochemical conditions in the Gulf of St. Lawrence
12:00 – 13:00	-	*Lunch*
13:00 – 13:20	Dave Hebert / Dave Brickman	Physical oceanographic and meteorological conditions on the Scotian Shelf and in the Gulf of Maine
13:20 – 14:00	Catherine Johnson & Benoit Casault	Biogeochemical conditions on the Scotian Shelf and in the Gulf of Maine
14:00 – 14:10	Andrew Cogswell	Bedford Basin Monitoring Program
14:10 – 15:10	Pierre Pepin	Carbonate and O_2 observations on the Newfoundland Shelf
-	Steve Punshon / Andrew Cogswell	The carbonate system of the Scotian Shelf
-	Michel Starr	Ocean chemistry conditions in the Gulf of St. Lawrence
-	-	Discussion on Ocean Chemistry: OA, hypoxia (including fluctuations in O2 concentrations), and interaction with changing T/S
15:10 – 15:30	-	*Health Break*
15:30 – 16:15	Peter Galbraith & Pierre Pepin	Summary of Zonal Scorecards Review and agreement of SAR bullets Draft “Change in Reference Period” – Biogeochemical
16:15 – 16:45	-	Breakout groups (Physical/Biogeochemical/LabSea) to start review and edit draft SAR text
16:45 – 17:00	-	Issues arising from review groups
17:00	-	Close

Friday, March 23: Integration and Synthesis

Rapporteur: Jennifer Holden

Session 5	-	Wrap-up
09:00 – 09:30	Pierre Pepin	Summary of action items/issues identified from logistic, data management and workshop meetings
09:30 – 10:30	Pierre Pepin and Peter Galbraith	Review of draft SAR
10:30 – 10:50	-	Health Break
10:50 – 11:45	-	Matters Arising – Chair succession plan Work plan for 2018-19 [1] Zonal SAR (Completion date) [2] Research Documents to be produced [3] Any other publications [4] Abstracts (5 April 2018) [5] Rapporteur Notes (13 April 2018) [6] Proceedings (???) [7] PDF copies of presentations Meeting Format 2019 Mid-term Meeting – possible dates/location Proposed dates (19-22 March, 2019) Alternate (12-15 March, 2019) [1] Tuesday workshop? [2] Wednesday – Friday midday (Review/Business)
11:45 – 12:00	-	Close

APPENDIX III – MEETING PARTICIPANTS

Participant	Affilliation
Pierre Pepin	DFO – NL Region
Gary Maillet	DFO – NL Region
Eugene Colbourne	DFO – NL Region
Guoqi Han	DFO – NL Region
Jinshan Xu	DFO – NL Region
Frédéric Cyr	DFO – NL Region
David Bélanger	DFO – NL Region
Jennifer Holden	DFO – NL Region
Sara J. Lewis	DFO – NL Region
Stephen Snook	DFO – NL Region
Peter Galbraith	DFO – Québec Region/IML
Stéphane Plourde	DFO – Québec Region/IML
Michel Starr	DFO – Québec Region/IML
Michael Scarratt	DFO – Québec Region/IML
Laure Devine	DFO – Québec Region/IML
Marjolaine Blais	DFO – Québec Region/IML
Nicolas Lambert	DFO – Québec Region/IML
Joël Chassé	DFO – Gulf Region/IML
David Fishman	DFO – Gulf Region
David Brickman	DFO – Maritimes Region (BIO)
David Hebert	DFO – Maritimes Region (BIO)
Catherine Johnson	DFO – Maritimes Region (BIO)
Andrew Cogswell	DFO – Maritimes Region (BIO)
Shelley Bond	DFO – Maritimes Region (BIO)
Benoit Casault	DFO – Maritimes Region (BIO)
Carla Caverhill	DFO – Maritimes Region (BIO)
Diana Cardoso	DFO – Maritimes Region (BIO)
Jack F. Fife (SABS)	DFO – Maritimes Region (BIO)
Blair Greenan	DFO – Maritimes Region (BIO)
Emmanuel Devred	DFO – Maritimes Region (BIO)
Igor Yashayaev	DFO – Maritimes Region (BIO)
Stephen Punshon	DFO – Maritimes Region (BIO)
Mathieu Ouellet	DFO – NCR – MEDS
Denise Joy	DFO – NCR
Andrew Stewart	DFO – NCR