Second GOA-ON North American Hub Meeting Report
Universidad del Mar 16-18 December 2019

The Global Ocean Acidification Observing Network (GOA-ON) Executive Council has encouraged grass-roots formation of regional hubs to foster communities of practice for the efficient collection, analysis and synthesis of comparable and geographically distributed data and models to assess ocean acidification and its effects, and to support development of adaptation tools such as model forecasts. As a result, the GOA-ON North American Hub was established in September 2017 to serve the ocean acidification community in Canada, Mexico, and the United States of America to support the development of synthesis products, support the observing system via training, develop uniform quality control procedures, and develop OA messages for policy makers and the general public, and established a Hub website (see http://goa-on.org/regional_hubs/north_america/about/introduction.php).

The second in-person meeting of the GOA-ON North American Ocean Acidification Hub was held 16-18 December 2019 at the Universidad del Mar, Huatulco, México, and was attended by 26 hub members from Canada, Mexico, and the United States. This workshop built upon the goals and initiatives established in the hub's inaugural meeting in 2018. The meeting included updates on current ocean acidification research efforts in the region, future capacity building opportunities, and reassessing the near- and long-term priorities of the regional hub.

Figure 1. Participants at the North American Hub meeting at the Universidad del Mar, Huatulco, Mexico 16-18 December 2019. From left to right: Dr. Antonio López Serrano (Universidad del Mar, UMAR), Dra. T. Leticia Espinosa Carreón (Instituto Politécnico Nacional), Biol. E. Jacqueline Campiran Martínez (UMAR), Biol. Mar. Lorena Velásquez Mejía (UMAR), Isaac Espinoza Ramírez (Universidad Autónoma de Baja California, UABC), Dr. Wei Jun Cai (University of Delaware, UDEL), Alejandra Navarrete (The Ocean Foundation, TOF), MS. Alicia Cheripka (National Oceanic and Atmospheric Administration, NOAA), Dr. Richard Feely (NOAA), Dr. Cecilia Chapa Balcorta (UMAR), Dr. Nina Bednarsek (Southern California Coastal Water Research Project, SCCWRP) , Dr. Jan Newton (University of Washington, UW), Dra. Julia P. Díaz Martínez (UMAR), Dr. J. Martín Hernández Ayón (UABC), Dr. Francisco Benitez Villalobos (UMAR), Dr. Dwight Gledhill (NOAA), Dra. Ma. Luisa Leal Acosta (UMAR), Dr. Liqing Jiang (NOAA), Hidrobiól. Montserrat Flores Ramírez (UMAR), Dra. Ma. Auxilio Esparza Álvarez (UMAR).

1. GOA-ON Background and Goals

The Global Ocean Acidification Observing Network (GOA-ON) was established in 2012 as an international partnership to:

1. **Document the status and progress of <u>ocean acidification</u>** in open-ocean, coastal, estuarine, and coral reef environments, specifically to *identify spatial patterns and temporal trends; document & assess variation to infer driving mechanisms; quantify rates of change*

2. **Understand the <u>impacts</u> of ocean acidification on diverse marine ecosystems and societies**, specifically to *measure biological responses to chemical changes; quantify rates of change & identify areas of vulnerability or resilience,*

3. **<u>Support forecasts</u> of ocean acidification conditions,** specifically to *provide spatially and temporally-resolved chemical & biological data to be used in developing models for societally-relevant analyses & projections*

To meet these three goals of GOA-ON, the international workshops of scientific community has defined the rationale, design, and locations of components for an international ocean acidification observing network, taking into account existing activities; a minimum suite of measurement parameters; a strategy for data quality assurance and for data distribution; and the requirements for international program integration in a Requirements and Governance Plan (Newton et al., 2015). This Plan specifies that GOA-ON requires capacity for several facets of the observing system: physical infrastructure, operations and maintenance, data QA/QC, analytical and synthesis activities, and the globally distributed intellectual infrastructure to sustain this. The system must cover diverse ecosystem types, oceanic to coastal, and utilize various observing platforms. The Plan specifies two data quality objectives, climate and weather, to cover the two different types of questions researchers have with the required data quality needed to address these. A global approach is needed because processes are occurring at global scales; therefore, we need to go beyond local measurements and observe on global scales in order to understand OA and its drivers correctly. We need information and data products that can inform policy and the public with respect to global and local status of OA and implications for overall ecosystem health (status) of the planet. We need sufficient data and understanding to develop predictive skills and early warning systems. This requires coverage at appropriate scales, nesting local observations within global context. Ocean acidification is a global condition with local effects. We need local through global scale observations in order to get either correct. This issue demands our coordination, networked skill, and open analysis. The global scientific community is not homogenous with respect to these capacities. GOA-ON has employed several tactics to overcome this: 1) members have come together to establish regional communities of practice, or regional 'hubs', that allow members to network, share expertise, and increase visibility of these efforts, such as the North American Hub this workshop is about; 2) GOA-ON has worked with partners on training workshops, mostly in developing countries and launched the Pier-2-Peer mentoring program; 3) GOA-ON developed a data portal allowing members to input and view data, metadata, and develop synthesis products; and 4) GOA-ON has a website for access to news and events, relevant resources and documents, the data portal, and regional hub websites.

GOA-ON is recognized for its contributions on global and local scales, playing a role in supporting the UNESCO Sustainable Development Goal 14.3 on marine acidity, as well as illuminating local conditions for uses such as aquaculture. The establishment of the North American Hub of GOA-ON allows members in Canada, United States, and Mexico to come together to identify and prioritize their needs and opportunities for regional collaboration to maximize our efforts.

2. GOA-ON Regional Hubs

The five regional hubs enable geographically-specific coordination and expertise to address hub-specific needs and gaps in monitoring. The Hubs have representation on the GOA-ON Executive Council and follow GOA-ON best practices. The GOA-ON Secretariat provides liaison with the Hubs as follows:

- Michael Acquafredda, NOAA OA Program - North American Hub, PI-TOA, LAOCA
- Dr. Katherina Schoo, IOC-UNESCO - WESTPAC, Northeast Atlantic Hub
- Ms. Marine Lebrec, IAEA OA International Coordination Centre (OA-ICC), OA-Africa, OA Mediterranean Hub

3. Goals of the GOA-ON North American Regional Hub

The North American Hub members had two preliminary introductory meetings in September 2017 and February of 2018 which were focused on recommending goals for the Hub and the preparing the groundwork for the first face-to-face meeting hosted by the Hakai Institute in Victoria, British Columbia in October 2018 and the second was held 16-18 December 2019 at the Universidad del Mar, Huatulco, México. The following is a summary of the Hub member deliberations at the second meeting by topic to address the goals and priorities of the Hub.

The defined goals of the North American Hub are to:

1. Assess the current readiness of the observing network.
2. Provide integration of the global network through ocean acidification synthesis product development.
3. Assist in data management and making data available, particularly by ensuring that all observation platforms are represented on the GOA-ON data portal.
4. Standardize best practices for measurement methods, as well as experimental and calibration protocols for the carbonate system, consistent with GOA-ON.
5. Encourage the implementation and maintenance of long-term time series for the carbonate system, biological, and ecological parameters where appropriate.
6. Build capacity of members of the network through training, technology transfer, and knowledge exchange (e.g. observation, experimentation, modeling, and synthesis).
7. Coordinate and communicate among global, regional, and local/national programs.
8. Evaluate OA trajectories and biological responses for different types of ecosystems (e.g. estuaries, coastal, open sea) under a variety of scenarios).

9. Develop a scientific outreach program including a regional acidification assessment to inform the communities, policymakers and other stakeholders (industry managers, foundation leaders) about ocean acidification.

4. Ocean Acidification Program Updates by Country

1. United States Ocean NOAA Ocean Acidification Program Activities

NOAA's Ocean Acidification Program (OAP) was established in 2011 in direct compliance with the U.S. Federal Ocean Acidification Research and Monitoring Act (FOARAM). As a Congressionally mandated program within the agency, the OAP and the science it advances represents an important element in fulfilling the agencies mission. The program mission is to better prepare society to respond to ocean acidification by fostering interdisciplinary research, monitoring, forecasting, and community outreach engaged through both national and international partnerships. The OA-ICC and GOA-ON represent the key international partnerships with which the program is engaged. NOAA has cruises and buoys, but is looking to expand its monitoring effort through the addition of more buoys and adding surface and subsurface autonomous sensor packages that can better integrate into global monitoring programs. However, data validation will continue to be a significant challenge as well. NOAA and its sister agencies will promote strategic coordination of observing infrastructure and process monitoring including regionally targeted observing optimization studies within coastal, estuarine, coral reef, and shelf environments. This includes modeling studies designed to determine the best approach for long-term observing, as well as studies that inform maximal use of existing observing assets and provide an objective analysis of future observing needs. Work will expand to develop models that will tell us how things will change in nearshore regions. Many of our model forecasts are for surface waters, so we need to expand the observations, models and sensitivity studies to emphasize organisms in subsurface water, shouldn't that be included as a lot of organisms sensitive to OA live in subsurface waters. NOAA will support regional OA vulnerability assessments research projects that will synthesize information at a regional scale (e.g., Large Marine Ecosystem, large estuary or collection of small estuaries, and state or collection of states in US waters) to determine where societal vulnerabilities to ocean acidification exist or are emerging, in order to provide actionable information for marine resource decision makers.

The Gulf of Mexico Ecosystems and Carbon Cycle (GOMECC) cruises are part of NOAA's Ocean Acidification Program (OAP)'s portfolio for monitoring OA trends along the coastal waters of the U.S. The third GOMECC cruise (GOMECC-3) occurred during the summer of 2017 and, for the first time, included both Mexican and Cuban waters of the Gulf of Mexico. The cruise included participants from Mexico and the U.S. A comparison between GOMECC-1 (2007) and GOMECC-3 in a transect off Galveston, TX showed an increase of the OMZ and potentially, an acidification rate of the order of -0.012 pH units per year. In terms of biological sampling, oblique net tows were conducted along all transects (51 stations in total). Samples were preserved for ichtyoplankton and calcifiers (pteropods) community structure. This in combination with a Mexican cruise conducted at the same time (XIXIMI-6), allowed for the first time to have plankton samples of the entire region.

With regard to eggs and larvae, 250+ species were identified, of which 4% correspond to invasive species from the Pacific/Indian. About 37% of the species identified for the Atlantic had not been previously found in the Gulf of Mexico, and will now be added to different registries. Principal Component Analysis (PCA) where OA parameters are included will allow for determination of whether OA is playing a role in the plankton distribution and variability. With regards to pteropods, the community structure and distribution has been analyzed. Our Mexican colleagues do not have the capacity to study shell conditions yet and are looking forward to establishing connections with scientists in the US who can provide training, lab access or other options.

2. Canadian OA Community of Practice

The Canadian Ocean Acidification Community of Practice was established in 2018 to work together to accomplish the following goals and priorities: 1) Collate data and share best practices; 2) Leverage existing data sharing networks; 3) Improve linkage between groups; and 4) Develop regional hubs in Canada. During the 2020-2022 period, the Community of Practice is placing a high priority on increasing the quality and accessibility of Canada's ocean acidification and ancillary data. They are also committed to linking researchers with industry to respond to OA events and for the purpose of developing procedures and methods to reduce aquaculture losses. They are initiation a Sensor Pilot Project to create a strong collaboration between industry and researchers to develop an integrated monitoring network for ocean acidification. They also plan to maintain a catalog of ongoing OA research, collaborations and infrastructure in Canada. Another point of focus is on assisting policy makers to address the social and economic impacts of ocean acidification in Canadian waters.

3. Mexico OA Program

Mexico has contributed in the North American Hub meetings as well as participation in the development of Regional Action Plan on ocean acidification for Latin America and Caribbean (2019) which documents four goals for individual countries from Latin America:

1. Better understand and quantify the changes that are occurring in the ocean;
2. Understand the consequences of those changes on ecosystems and society;
3. Rapidly communicate that information to policymakers and resource managers; and
4. Ensure that politicians, decision-makers and policy-makers are armed with the latest research results to help make the best decisions in light of these increasingly serious conditions.

Mexico is making excellent advancements on Goal 1 and they are just getting started on Goals 2 thru 4. In addition, Mexico recently published the first synthesis of the state of current knowledge of the carbon cycle in aquatic and terrestrial ecosystems in Mexico by the Mexican Carbon Program (PMC) was raised as the scientific counterpart of the government in the JNACP (Joint North American Carbon Program, today CarboNA) to implement strategies on the subject at the level of North America (Canada, USA and Mexico), according to the Memorandum of Understanding signed between the three countries. The PMC currently has more than 350 active members of more than 30 national institutions. The objective of the PMC is to coordinate the scientific activity associated with the carbon cycle, aimed at generating elements for public policies and development of mitigation and adaptation actions, as well as the reduction of

vulnerabilities, for Mexican society. In accordance with its Scientific Plan prepared in 2008, with support from the Instituto Nacional de Ecologia, it was proposed to make a Report on the State of the Carbon Cycle (RECC) to establish the baseline of the stores and flows of greenhouse gases in Mexico, within the Blue Agenda (ocean and coast) and Green (land). The synthesis State of the Carbon Cycle in Mexico: Blue and Green Agenda, is the First Report that represents a significant contribution to the dissemination of knowledge of the carbon cycle in Mexico and its effect on climate change. This work, carried out by numerous specialists, reflects the state of current knowledge of the carbon cycle and its interactions in aquatic and terrestrial ecosystems. A chapter specific for OA was included on this synthesis.

5. Arctic Ocean Acidification (Wei-Jun Cai)

The Arctic Ocean margins are experiencing rapid changes due to melting sea ice. Air-sea exchange is enhanced along the margins, but basins are not. Rapid CO_2 invasion from the atmosphere into the highly stratified and shallow surface water is the main reason for the limited CO_2 uptake capacity in the ice-free areas. Seawater warming also accelerates this exchange. Surface seawater is being acidified by this CO_2 invasion while subsurface-water is acidified by the increased PWW intrusion and possibly increased surface export of organic matter. Sea-ice melt amplifies the seasonality of pCO_2 as well as increases the Revelle Factor, thus leading to rapid increase in decadal pCO_2 increase and rate of ocean acidification in the Canada Basin.

6. Established DFO Canada-NOAA Partnership

We've had excellent discussions with the DFO-NOAA Monitoring Working Group Collaborative in November 2019. They recommended that a great place to conduct process studies to resolve some rates of change and shelf-basin interactions would be near the Viking array; not only is there a good observational infrastructure there, but DFO and NOAA are both active in that region and already collaborating together on OA projects. They are thinking about some high-resolution hydrographic lines, with discrete sampling that would over-resolve the carbon system along a salinity gradient. This process study could answer questions about benthic rates and fluxes. They did begin discussing what such a project might look like. There was a suggestion that ROPOS can help pursue their goals for data collection near the seabed in the region. The group decided to continue the dialogue including discussions about how they might be able to provide support for any potential projects.

6.1 Arctic Hub Connection

It is recommended that a representative of the Arctic Hub participate with the North American Hub in the development of the North American synthesis product and have regular exchanges of information with the North American Hub.

7. Biological Responses

Drs. Nina Bednarsek and Piero Calosi discussed biological responses to ocean acidification in open-ocean and coastal waters surrounding North America. The recent research on pteropods indicated high sensitivity to ocean acidification in the coastal waters of the Northeast Pacific with strong evidence for thinning and extensive dissolution of the shells under low aragonite saturation state conditions. This is particularly true in the Salish Sea where the extent and duration of aragonite undersaturation is greatest. The studies to date mostly linked the biological changes to variations in temperature and aragonite saturation state. The question that came up was: "Has there been a similar analysis with pH? Is there a laboratory system in place where you can decouple pH and aragonite saturation? Some of these ideas maybe appropriate for future lab studies.

Research on Dungeness crab megalopae off the Washington and Oregon coasts provided new evidence for significant dissolution of the calcium carbonate structures in the carapace under current conditions in nearshore waters where the vertical calcite gradient was highest. Under the most severe conditions, the ridging structure of the carapace showed evidence for exposed calcite crystals that were undergoing substantial dissolution. In addition, dissolution in the calcified neuritic canals caused destabilization and loss of the mechanoreceptor setae that provide sensory and behavior functions within the larvae. Future research is needed to understand how these impacts are transmitted through the different life stages and transgenerational exposures. Finally, the scientists emphasized the need to better understand ecosystem and community responses to multi-stressor interactions.

Discussion

- Future cruises to develop understanding of the connection between the chemistry and the biology.
- From the logistic side, it seems like a higher sampling of organisms, would be a more effective path be to utilize fisheries sampling efforts as opposed to using WACOA cruises?
- When you are thinking of more specific markers you need a very good grasp on the carbonate system at the same time, and so a WACOA-type cruise would be more beneficial.
- New technology may get science to that larger data collection. Is this something the NA hub could be working towards? How can we pull all the pieces together?
- First there should be an inventory for the North American region. What are the spatial and temporal scales? We have enough of an arsenal to integrate what the hub currently has after a discussion on what we have and what we want.
- This can also be brought to the GOMEC 4 cruise in the Gulf of Mexico and the Atlantic.

7. Collaborations and Capacity Building

1. Capacity Building

In support of GOA-ON's 1st goal in improving our understanding of OA conditions (which was the need to expand monitoring geographically), we have taken two main approaches: The Pier2Peer Mentorship Program and Direct Assistance such as the GOA-ON Kits in a Box and Trainings. Pier-2-Peer is the GOA-ON's scientific mentorship program that matches senior OA researchers with early career scientists to facilitate an exchange of expertise and provide a platform for international collaboration. The North America Hub is very involved with the Pier-2-Peer program, contributing 43 out of 82 mentors. Having so many long-standing and engaged mentors has made the NA hub an example to the rest of the organization of how the program can be successful at connecting people from around the globe. Mentors provide various forms of support including: collaboration on projects, general professional development advice, information exchange, proposal writing, basic training, and data analysis help. Members in the program receive a monthly newsletter, the Pier Review, with OA news, info about upcoming conferences and workshops, list of potential funding opportunities, and links to open-access papers. The Pier-2-Peer program, through The Ocean Foundation, also encourages capacity building and collaborations through small scholarships available to mentees in the program. There have been 9 scholarships awarded so far, and the next deadline for proposals is Jan 31, 2020.

The GOA-ON Kits and the associated trainings have given numerous countries in Africa, Latin America, and the Pacific Islands the ability to establish local ocean chemistry monitoring. These kits include the necessary tools and methods to collect quality ocean acidification parameters. These include physical "hardware" such as in situ pH sensors (iSAMI), materials for bottle sampling and preservation, and Total Alkalinity titration system. Methods, trainings, data quality control (through a Pier-2-Peer mentor), and other supportive efforts are also provided. There is one kit to be housed in Mexico, provided by the Ocean Foundation. Canada's DFO has a plan to purchase 20 kits over the next few years, with 6 already having been bought. They intend to have a few of the kits go to indigenous tribes to build capacity with those communities.
Discussion of how to recruit more mentees from the hub for the Pier-2-Peer program (if needed) and what additional ways can the Pier-2-Peer program support mentor/mentee pairs in the North American Hub.

8. Data Exchanges and the North American Hub

Jan Newton queued up this discussion by asking the group three questions: How can we facilitate data exchanges between the three countries? What data synthesis products can we collaborate on? What web tools will help us communicate as we want and need to?

Relevant to the first question is how can we get more data into NCEI from all countries? How can we get more data onto the GOA-ON data portal from all countries? And can we synchronize or better connect GOA-ON and NCEI to facilitate that? What should we be thinking about with respect to SDG 14.3.1? How can we enable rewards, like doi's, to stimulate response?

Relevant to the second question was considering Chemistry (both conditions and anthropogenic contribution), Biology, Modeling, Societal data products, should we segment topically? Or should we identify a theme, like where are conditions most extreme? Should there be one large overview that doesn't go into detail but provides the whole continent view?

Relevant to the third question was what content do we want on the North American website that is not already there? Do we want an OA Information Exchange North American Hub group chat?

Discussion

- How can we facilitate data exchanges between the 3 countries? Get more data into NCEI and GOA-ON, connect to 14.3.1 It is possible to utilize rewards like journal requirements do. Effort should be made to make data easy to access and only have to submit once. It sounds great but how to make it happen (Submit to NCEI and then have that disseminated as needed). It is important to note that not everyone is not putting their data into NCEI. GOA-ON helps make those other data available and is visual. GOA-ON needs to be flexible with NCEI though as it is a US entity (issues with other countries access) GOA-ON Data Portal: The desire is to be able to discover and visualize (and link) data on the GOA-ON portal.

- Data quality; When the data is displayed, a lot is in near-time, but working to display longer time sets. Have those longer time sets gone through QA/QC? The Providers fill out the metadata and evaluate their quality. Any user can make the decision on the quality.

- What North American Hub data synthesis products can we collaborate on?

    - Chemistry (Summary of Conditions, Anthropogenic contribution). We are close to the point where we can do a North America assessment on OA that the NA Hub can contribute to with the Arctic Hub.

    - Biology: Start with an assessment. Combine modeling with observations and genetic analysis. And sensitivity. We can have a wider vision of how key species respond to OA. Look at what is possible on a shorter timeline, connect the smaller pieces in order to be more strategic in our approach. Put more ecosystem context on the biological observations.

    - Modeling-provide results to check ourselves and comment on how well our observations are doing. GFDL output for North America.

9. Near- and Long-Term Priorities for the GOA-ON North American Hub

- **Cruise Plans for FY 2020 and 2021**. Coordination on upcoming cruises (ACOA in 2021, WCOA in 2020 or 2021, and other non-NOAA cruises), perhaps by creating a team on the Ocean Acidification Information Exchange (OAIE) about maximizing ship time sharing etc.
    - Cruise Coordination approved by DFO-NOAA to fill gaps.
- Create a page on the OA Information Exchange to coordinate North American Hub activities
    - maximizing ship time sharing (US, Canadian, and Mexican cruises)
    - Add cruise report so people can tie into it for future cruises.
    - coordinate on future projects
    - Chemical team: Cecilia, Wei-Jun, Martin, Liqing, Leticia, Wiley, Jessica, Dwight

    - Bio: Nina, Jan, Cecilia, most of the Mexican attendees

- **Create a data synthesis paper** to review state of the ocean acidification science across North American regions (3-yr effort). This will require a lead writing team and funding to carry out the synthesis.
    - Wiley Evans, Wei Jun Cai, Martin Hernandez-Ayon, Nina Bednarsek, co-leads.
        - Summary documents of what is happening in various regions. This would be best effected to work on the synthesis document as a starting point. (or 2-3 individual papers to kick start the synthesis document).
        - Follow up with individual efforts to be added into the synthesis.

- Efforts to enhance the submission of data sets among our North America countries via the GOA-ON data portal (http://portal.goa-on.org/) are moving forward. Current work is being done to get NA hub members to know how to input metadata to GOA-ON and submit to NCEI.
    - Jan Newton and Liqing Zhang to create a paper on how to streamline the process.
    - Send out an email reminding of the purpose and links to add data to the data portal.
- **Create a comprehensive inventory** of who's doing what in each country. Using DFO-NOAA inventory as a template.
- Initiating a training workshop on determining secular trends in time series data to support development of new data synthesis technology in the GOA-ON community
- **Develop a long-term strategy for CRMs**, including freshwater and estuarine applications.
    - Collaborate with other hubs to work out a global plan.
    - Engage with NIST to get CRMs moved over, starting with a letter from North American Hub co-chairs.
- **Encourage collaborative studies** and personnel exchanges
    - Expanding efforts to advance OA science training and Pier-2-Peer collaborations within the Hub for the next year
    - Additional Trainings (modeling, biological, and societal), Tiers of support (discussion, trainings, equipment)
- Create recommendations for biological standards of sampling.
    - Have cross fertilization between research teams and regions.
    - Increased coordination with biology being a part of it.

GOA-ON North American Hub Meeting Agenda

Monday 16 December 2019, Huatulco Campus

8:30 Welcome – Cecilia Chapa Balcorta, Universidad del Mar, Puerto Ángel, México and Antonio Lopez Director of the Oceanology department at Universidad de Mar (20 Minutes)

8:50 Introduction and History – Richard Feely, PMEL/NOAA (20 Minutes) Charge: Address

Goals of the Hub and Charge for the meeting. 1) Define our Mission Statement; 2) What is the readiness of the observing system and what are its strengths and weaknesses; 3) How can we improve data accessibility and data product development; and 4) What kinds of "best-practices" products would be most useful to the Hub?

9:10 Goals of the GOA-ON and GOA-ON Data Portal -Jan Newton, University of Washington (30 Minutes + 20 Minute discussion) Charge: Goals and Objectives of GOA-ON and how they relate to the GOA-ON website and GOA-ON Data Portal.

10:00 Morning Break (15 Minutes)

10:15 Overview of Mexico OA Program – Martín Hernández, Universidad Autónoma de Baja California (45 Minutes + 15 Minute discussion) Charge: Provide an overview of the Mexican Ocean Acidification Program and provide examples of how it can best interface with the United States and Canada networks. Can we share results and produce joint publications and data products?

11:15 Overview of Canada Community of Practice Program – Brent Else, University of Calgary (45 Minute + 15 Minutes discussion) Charge: Provide an overview of the Canadian Community of Practice Program and provide examples of how it can best interface with the United States and Mexico networks. Can we collaborate on cruises in different years to provide more coverage? Can we share results and produce joint publications and data products?

12:15 Lunch (75 minutes)

13:30 Overview of US OA Program – Libby Jewett, NOAA OAP (45 Minute + 15 Minute discussion) Charge: Provide an overview of the US Ocean Acidification Program and provide examples of how it can best interface with Canada and Mexico. How can we share results and produce joint publications and data products? How can we share approaches for analyzing timeseries data? Can we have a joint data and information exchange?

14:30 Overview of Biological Responses to OA – Helen Gurney-Smith, Fisheries and Oceans Canada (30 Minutes + 10 Minute discussion) Charge: Provide an overview of what we know about biological responses to ocean acidification and how we can enhance our field programs to address these responses.

15:10 Afternoon Break (20 Minutes)

15:30 Overview of Development and Applicability of indicators for Ocean Acidification – Nina Bednarsek, Southern California Coastal Water Research Project (30 Minutes + 10 Minute discussion) Charge: Provide an overview of what we know about the use of biological indicators and how we can use them to support field observations, modeling activities and management decisions.

16:10 North American Hub priorities - Discussion Leader: Richard Feely (30 Minutes + 20 Minute discussion) Charge: Discuss how what we have learned today can be utilized to address the major priorities of the North American Hub.

17:00 Adjourn for the day and Group Dinner (TBD)

Tuesday December 17, 2019, Huatulco Campus

9:00 Opportunities for Training and Best Practices – Discussion Leader: Alicia Cheripka, NOAA OAP (30 Minutes + 30 Minute discussion) Charge: Discuss how development of best practices and training events can be implemented to encourage collaboration among Hub members. What Pier-2-Peer and GOA-ON training opportunities are available for the North American Hub community?

10:00 Opportunities for Collaboration – Discussion Leaders: Debby Ianson, DFO, Canada (30 Minutes + 30 Minute discussion) Charge: Discuss how cruise activities, training activities, and modeling can be enhanced to encourage collaboration among Hub members.

11:00 Morning Break (30 Minutes)

11:30 Data Exchanges and North American Hub Website - Discussion Leader: Jan Newton, University of Washington (30 Minutes + 30 Minute discussion) Charge: How can we facilitate data exchanges between the three countries? What synthesis products can we collaborate on?

12:30 Lunch (90 minutes)

14:00 GOA-ON North American Synthesis Manuscript Outline Discussion Leaders: Wiley Evans and Wei Jun Cai (30 Minutes + 30 Minute discussion)

15:00 Afternoon Break (30 minutes)

15:30 Meeting Summary and Final discussion - Richard Feely - (30 Minute + 30 Minute discussion) Charge: Provide a summary of the meeting and define the next steps.

16:30 Adjourn for the day

Wednesday December 18, 2019, Puerto Ángel Campus

9:00 Dr. Martín Hernández Ayón will present the Mexican Carbon Program International

Recognition Award to Dr. Richard Feely (30 minutes)

9:30 Seminar by Dr. Richard Feely (40 Minutes + 20 Minutes discussion).

10:30 Morning break (30 Minutes)

11:00 Seminar by Dr. Wei Jun Cai (40 Minutes + 20 Minutes discussion).

12:00 Seminar by Dr. Jan Newton (40 Minutes + 20 Minutes discussion).

13:00 Adjourn Meeting

GOA-ON North American Hub Meeting Workshop Participants

In attendance at Hualtuco:

Dr. Antonio López Serrano (Universidad del Mar, UMAR)
Dra. T. Leticia Espinosa Carreón (Instituto Politécnico Nacional)
Biol. E. Jacqueline Campiran Martínez (UMAR)
Biol. Mar. Lorena Velásquez Mejía (UMAR)
Dr. Isaac Espinoza Ramírez (Universidad Autónoma de Baja California, UABC)
Dr. Wei Jun Cai (University of Delaware, UDEL)
Ms. Alejandra Navarrete (The Ocean Foundation, TOF)
Ms. Alicia Cheripka (National Oceanic and Atmospheric Administration, NOAA)
Dr. Richard Feely (NOAA)
Dra. Cecilia Chapa Balcorta (UMAR)
Dra. Nina Bednarsek (Southern California Coastal Water Research Project, SCCWRP)
Dra. Jan Newton (University of Washington, UW)
Dra. Julia P. Díaz Martínez (UMAR)
Dr. J. Martín Hernández Ayón (UABC)
Dr. Francisco Benitez Villalobos (UMAR)
Dr. Dwight Gledhill (NOAA)
Dra. Ma. Luisa Leal Acosta (UMAR)
Dr. Liqing Jiang (NOAA)
Hidrobiól. Montserrat Flores Ramírez (UMAR)
Dra. Ma. Auxilio Esparza Álvarez (UMAR)

In attendance via remote internet connection:

Ms. Heather Almeda (Canadian Ocean Acidification Community of Practice, MEOPAR, Canada)
Dr. Piero Calosi (Université du Québec à Rimouski)
Dra. Jessica Cross (NOAA)
Dr. Wiley Evans (Hakai Institute, Canada)
Dra. Iria Gimenez (Hakai Institute and UBC)
Dr. Brent Else (University of Calgary, Canada)
Dra. Debby Ianson (DFO, Canada)
Dr. Douglas Wallace (MEOPAR, Canada)