

Minutes: North American OA Hub members meeting, May 20th 2021

In attendance:

Co-chairs: **Dick Feely, Helen Gurney-Smith, Jose Martin Hernandez-Ayon,**

Members: Jan Newton (GOA-ON co-chair), Brent Else, Henry Ruhl, Joan Sanchez, Joe Schumacker, Katie Wrubel, Kristina Barclay, Kumiko Azetsu-Scott, Leticia Barbero, Emily Osborne, Lisa Miller, Wei-Jun Cai, Liqing Jiang, Nina Bednarsek, Chris Pearce, Todd Martz, Andrew Dickson, Tommy Moore, Shea Wyatt, Meg Chadsey, Emma Cross, Doug Wallace, Kerri Dobson, Alex Harper, Carl Gouldman, Catherine Alves, Chris Sabine, Francisco Chavez, Leticia Espinosa, Luis Eduardo Calderon, Mariana Cupul Cortes, Melissa Melendez, Nicolai von Oppeln-Bronikowski, Cathy Cosca, Cecilia Chapa Balcorta, Clarissa Anderson, Emily Hall, Gilberto Cardoso, Halle Berger, Kim Houston, Sosa Avalos Ramon

Agenda:

- Welcome and introductory remarks (5 minutes: Dick Feely)
- Update from Canada (15 minutes: Helen Gurney-Smith, Brent Else)
- Update from USA (15 minutes: Dick Feely, Jan Newton)
- Update from Mexico (15 minutes: Jose Martin Hernandez Ayon)
- Additional updates:
 - o Gulf of Mexico OA synthesis paper (10 minutes: Emily Osborne)
- Open discussion on any current recommendations/priorities:
 - o Cruise plans for FY21
 - o Create a page on the OA Information Exchange
 - o Create a data synthesis paper
 - o Efforts to enhance the submission of data sets
 - o Create a comprehensive inventory of activities in each country
 - o Initiate a training workshop on determining secular trends
 - o Develop a long-term strategy for CRMs
 - o Encourage collaborative studies
 - o Create recommendations for biological standards

Intro remarks:

- This meeting is a timely opportunity to see where we are and where we are headed – what changes we may want to make and what future directions we want to pursue over the next couple of years. GOA-ON EC meeting on hubs is next week. We will report on the North American Hub based on the results from today's meeting. We also need to discuss when/where we want to hold our third meeting in FY 2022 and its corresponding agenda.

Gulf of Mexico synthesis paper (Osborne):

- Plan to be released by the end of 2021.
- Cai: More recent 2017 onward data may not be included – he will send it to Emily to be included.

Open discussion:

- Cruise plans:
 - o Hauri emailed re Alaska work - 2 major areas in Gulf of Alaska and in Chukchi Sea – Gulf of Alaska maintained time series. Cruise also supports significant modelling effort. Similar activities in Chukchi Sea with time series work, cruises, and some glider development

work. As part of an ongoing chemical and biological synthesis effort. Request that Hauri gives presentation at next meeting - add to 2022 plans?

- Page on OAIE:

- Newton: The hub has previously discussed having a page for the NA hub on OAIE. Could be useful for keeping in touch with others and asking questions in between meetings, sharing cruise plans etc. Answer previously was yes. It has not yet been established so we would like reaffirmation that this is what the hub members want to do. Thoughts?
- Feely: Is there a way to link the OAIE N American Hub team page with the N American hub website itself and make sure they are being crosschecked properly?
- Newton: Yes - North American Hub doesn't exploit power of website enough. Content is correct, but could be updated more often.
- Dickson: I have used OAIE site and it is better than nothing, but it is not a good forum for a large group of people to have discussions as it is hard to keep different pieces separate (tangled structure). Hub should think more carefully as to what you want to achieve. If you want a town crier situation to tell people about things, an OAIE team would work, but most info there is via questions and corresponding responses.
- Simone: If you have suggestions on ways to improve it, it would be valuable. Indexing/tagging things would be a way that we could move towards making it more useable.
- Newton: OAIE team would need to have more purpose than just town crier. OAIE is meant to be the town hall where the members can discuss items. I.e. someone would announce cruise and others could get involved and ask questions. Dickson is saying that the present structure of OAIE has some deficiencies in terms of what is helpful for communication. Due to different threads etc.
- Dickson: Because it is like Facebook... you don't necessarily notice that new info you care about has turned up. Yes, you can get the digest if you have set up correctly, but if people talk more broadly within a thread, things can get lost. It is hard to keep sub-threads separate and easily findable again.
- Feely: Critical to mention to webmaster of OAIE. Indexing would be extremely helpful to clearly find the topics you are looking for to find what has been discussed on something in the past.
- Newton: Will be helpful to tell the developers of OAIE. Do we want to create a team on OAIE for the N American hub? Or happy with status quo and using our website more effectively? Conversations would not occur through the website? Only want to establish if we will use it?
- Feely: Yes, encourage the establishment of OAIE team, better than nothing. Having the list of people here – would allow us to communicate a lot more effectively than now.
- Newton: Ok, we can solicit content for the website and encourage people to check out the OAIE team (via Kerri). Kerri can help us initiate exchange and increase communication on various platforms.
- Feely: Action item to start N American Twitter (Kerri).

- Synthesis paper:

- Feely: Cai and Evans had discussed working on a synthesis of the Hub regional OA science. However, other synthesis efforts have taken place since. Now, we need to reconsider the nature of our synthesis activities. Open discussion of where we are now?

- Cai: No crystal clear idea. Gulf of Mexico synthesis was a good move. Depends on the community interest. Happy to hear others input. Especially from Wiley.
 - Feely: Unfortunately, Wiley could not make it to this meeting, but we have had a separate discussion. He had a similar opinion with regards to all other synthesis activities ongoing, and that we need to rethink the synthesis paper. Beginning to think that a series of papers for different regions would make more sense than one for the broad synthesis of North America. I would say that the best thing we could do is for Cai and Evans to get together to discuss this with community. At the next face-to-face meeting, we can come up with a plan that folks are comfortable with. Talk with EC at meeting and assess where we are and what makes the most sense going forward. How to integrate Canadian synthesis activities, with Arctic etc., where we think we might want to expand those activities. Suggest to table this item and have it as an action item for addressing at the next meeting and next EC meeting.
 - Cai: That would be good timing, and would give extra time to see more data etc. If we look at the different regional contrasting variability, and in the overall context of North America, having synthesis by region would be a better approach. Simultaneous regional syntheses.
 - Feely: At our last meeting in Mexico, we were uncertain as to whether we wanted to have a synthesis paper on chemistry separate from biology. When you talk to the group, get a sense of where we are with respect to that as well. Perhaps North American wide chemistry synthesis, whereas biology would be more in tune per region? Give that some thought as well.
- Efforts to enhance submission of datasets:
- Newton: Talked about this in Mexico. Involved with this with Liqing Jiang leading. Unfortunately, not funded.
 - Dick: Liqing Jiang, North America wide synthesis products that we have been working on which was funded. Provided the critical tools that are now publically available to synthesize datasets and provide an analysis of data in terms of quality in individual samples – compared all datasets together, to provide analysis of each cruise datasets. Will be publically available once paper is published. Can now make comparisons of own datasets with North American hub dataset. Provides something to compare against. Can draw from the dataset as a tool, add in new datasets etc. Approaches to look at dataset and identify outlines (primary tool). Very good at doing just that. Will continue to advocate for adding new datasets to the data product – continuing discussions. Follow through on this at next meeting to see where we are. Hoping community agrees that having a fully synthesized dataset and adding to it so we know quality of datasets is high priority. The paper itself provides a very clear set of approaches of how to go through and analyze dataset. Good protocol! Would be good to have a demonstration at the next face-to-face meeting – seeing how that works will be very useful. Comments?
 - Cai: Good combination to look at North America wide OA issue.
 - Feely: Agenda item for next face-to-face meeting and for discussion at next EC meeting.
 - Newton: GOA-ON is working on making it easier to submit data, too. Standby for updates from GOA-ON.
 - Jiang: Update from NCEI prospective. In past, management effort for OA PIs only. New team member, so can handle data from anybody. Building new user-friendly online data submission system which will be available in June. Concern on genomic and eDNA data –

unfamiliar with this data but will explore to make sure it can be handled. Please send some if you have any.

- Gurney-Smith: How NCEI might work towards incorporating eDNA? So many different levels at which data might be submitted somewhere, so having a convo in person about where to send raw data, what sorts of data products would be more useful to submit to NCEI for end-users could be beneficial for international community. Could have a session in-person at next meeting. Discussion on what we measure, and what data we submit from that.
 - Feely: NOAA OAP is having workshops on this topic (biological indicators). Opportunity to discuss in more details, but agree it should be a major topic for future meetings.
- Activities in each country:
- Feely: Action item to upload today's presentation to the North American hub website (Kerri). From there we can develop OAIE discussion items. Agree?
 - Newton: Sounds good.
- Training workshop:
- Newton: Had a workshop that Sutton led at University of Washington, to discuss how to do secular trends and how to assess coastal data. Short EOS article about recommendations. More recently, Sutton has proposed turning this into a best practices manuscript which can be broadly shared. That is in the process. Excellent workshop, write to Jan if you have any questions. Stay tuned for best practices.
 - Hernandez-Ayon: Such protocols would be great to be shared on the website, too!
 - Gurney-Smith: DFO-NOAA seed funding (about \$100K USD) is being used to facilitate people coming on cruises, technique sharing, collaboration on projects with species of joint interest, facilitated student exchanges, development of technical reports etc. Can this be continued?
 - Gurney-Smith: Is international GOA-ON Peer2Peer mentor/mentee relationships going on. For example, I'm a mentor for a student in the U.S. and I'm sure others are too. I think this would be useful to highlight in here.
Feely: Yes, there are several examples of GOA-ON Peer2Peer relationships that are still ongoing.
 -
 - Newton: Yes, we should have resources button on the North American hub website. If you have any other ideas regarding the website, please let us know (all).
- Develop long term strategy for CRMs:
- Newton: There is a working group with Jewett and Currie. No update, but it is of high concern for GOA-ON.
 - Dickson: Discussions with Jewett, Busch, Edmunds with regards to the idea. Not aware of a more international working group. Gave a presentation which is available via OAIE. Not clear how this will continue if/when Dickson resigns. Would production remain at Scripps? Would it move to alternative location? Or more than one location, which would have benefit of improving international availability and the resilience. Unsure where discussions are – hope of community surge to say what we need and that it would get funded. Having the WG think about it is a great thing.
 - Feely: Federal agencies in the US are committed to resolving the problem – they are reaching out and getting input/advice as much as possible, looking at many alternatives

to see which would be the best option. International level – looking to reach out to other international groups to see if it is possible to find another lab in another country which would be capable to do this too. Working together with Dickson. Also has to be a funding stream which has to be identified in order to continue the support. ICC and GOA-ON reaching out to international community via survey. North American Hub - important to reach out to Canada and Mexico to address the issue as much as possible. What would you like to see as a good solution? As we develop in US, we will convey the info and we really will need the response from everyone. One of the things is that Dickson has recently been funded by NSF for the next few years. Dickson fully supports the decisions and there will be overlap and collaboration in handover.

- Next face-to-face meeting:
 - o Could utilize Ocean Sciences meeting in 2022, in Hawai'i? Could gather and pull in people virtually? Or hold at a site which would be easier to travel to? Sabine could host in-person, if tagged on to OS 2022.
 - o Cai: Not 100% sure it will be face-to-face and going to HI is already hard without COVID-19.
 - o Feely: Are members happy to travel to separate site in 2022? People should respond back to this question in writing. Action item to email us with your responses to this (everyone). Try to respond one way or the other so that we can get a good sense. Action item to send out a survey/questionnaire with regards to what people's feelings are (Kerri and Jan).

GOA-ON Hub Report Template 2021

Hub Name: North American Ocean Acidification Network

Geographic scope (countries involved or region): Canada, United States of America, Mexico

Number of members to date: 141

Do you have a steering committee? Y/N: Y

How are the Co-Chairs chosen for the hub?: Selected by the GOA-ON Executive Council or by the Membership

How are members chosen to join the hub?: Complete the Application Form

Objective 1: Share information about the readiness of the Observing Network

Objective 2: Assist in Data Management

Objective 3: Promote “Best Practices” within the Hub’s domain to be consistent with GOA-ON

Objective 4: Provide integration of the global network through synthesis product development

List of activities in the past 18 Months (add more rows as needed)

Name/short title of event	Location	Number of participants (estimate)	Short Summary
Synthesis of surface chemical data for carbon parameters	North American Coastal Waters	24	Synthesis report on the physical and chemical controls of surface water carbonate data for North American Coastal Waters. Cai et al. (2020). Nature Commun., 11, 2691, doi: 10.1038/s41467-020-16530-z,
Synthesis of Time Series Data	North American Coastal Waters	32	Workshop report on the analysis of time series data and the determination of anthropogenic trends. Sutton et al (2019): <u>Autonomous seawater pCO₂ and pH time series from 40 surface buoys and the emergence of anthropogenic trends</u> . Earth Syst. Sci. Data, 11, 421–439, doi: 10.5194/essd-11-421-2019
Developed synthesized Quality controlled data product on coastal cruise data	North American Coastal Waters	30	Coastal Ocean Data Analysis Product in North America (CODAP-NA): An internally consistent data product for discrete inorganic carbon, oxygen, and nutrients on the North American ocean margins. (Jiang et al., in press).
Developed new technologies for observing carbon chemistry with autonomous vehicles	North American Coastal Waters	13	Report on the development and evaluation of new technologies for carbon dioxide measurements on surface ocean autonomous vehicles. Sabine et al (2020): <u>Evaluation of a new carbon dioxide system for autonomous</u>

			surface vehicles. <i>J. Atmos. Oceanic Tech.</i> , 37(8), 1305–1317, doi: 10.1175/JTECH-D-20-0010.1
The second in person meeting of the GOA-ON North American Ocean Acidification Hub was held 16-18 December 2019	North American Coastal Waters: Universidad del Mar, Huatulco, México,	26	The North American Hub Meeting 16-18 December 2019 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.

Other Achievements:

- *Completed and published workshop report on the determination of acidification trends in coastal waters (Sutton, A.J., and J.A. Newton (2020): Reaching consensus on assessments of ocean acidification trends. EOS, 101, doi: 10.1029/2020EO150944).*
- *Completed model evaluation for projecting acidification in coastal waters (Siedlecki, S.A., D. Pilcher, E.M. Howard, C. Deutsch, P. MacCready, E.L. Norton, H. Frenzel, J. Newton, R.A. Feely, S.R. Alin, and T. Klinger (2021): Coastal processes modify projections of some climate-driven stressors in the California Current System. Biogeosciences, 18(9), 2871–2890, doi: 10.5194/bg-18-2871-2021.*
- *Pre-cruise coordination meetings since last year for the WCOA21 cruise from Canada to Mexico.*
- *DFO/NOAA OA Working Groups collaborative projects (ongoing)*
- *Publication: Niemi, A., Bednaršek, N., Michel, C., Feely, R.A., Williams, W., Azetsu-Scott, K., Walkusz, W., Reist, J.D., 2021. Biological Impact of Ocean Acidification in the Canadian Arctic: Widespread Severe Pteropod Shell Dissolution in Amundsen Gulf. Front. Mar. Sci. 8, 1–16. <https://doi.org/10.3389/fmars.2021.600184>*
- *Ocean Networks Canada workshop on in situ sensors for ocean acidification research with publication: Sastri, A.R., Christian, J.R., Achterberg, E.P., Atamanchuk, D., Buck, J.J.H., Bresnahan, P., Duke, P.J., Evans, W., Gonski, S.F., Johnson, B., Juniper, S.K., Mihaly, S., Miller, L.A., Morley, M., Murphy, D., Nakaoka, S., Ono, T., Parker, G., Simpson, K., Tsunoda, T., 2019. Perspectives on in situ sensors for ocean acidification research. Front. Mar. Sci. <https://doi.org/10.3389/fmars.2019.00653>*
- *PICES North Pacific Ocean acidification synthesis report: Christian, J.R., Ono, T., 2019. Ocean Acidification and Deoxygenation in the North Pacific Ocean. PICES Spec. Publ. 5, 116.*

What activities are planned for the next 12 months

- *Continue to develop and publish synthesis papers on acidification in North American Coastal Waters provided postdoc support is provided by GOA-ON.*
- *Continue to develop a detailed publication of “Best Practices” on the determination of acidification trends in coastal waters.*
- *Completed the synthesis for the paper review on the Gulf of Mexico between researchers from EUA and Mexico from different institutions. The preliminary title is: Ocean Acidification in the Gulf of Mexico: Drivers, Impacts, and Unknowns*
- *Complete the science paper title: Temporal variability of the aragonite saturation horizon in the Pacific region of the Baja California peninsula, Mexico*

- *Complete the science paper title: Reclassification of Upper Waters Mass of the Gulf of Mexico by Linking Physical and Biogeochemical Features*
- *WCOA cruise Canada to Mexico June 2021*
- *GOMECC cruise Gulf of Mexico September 2021*
- *MBARI cruise EUA-Mexico May 2022*
- *Next Ocean Science “Hawaii”: Hub meeting (Face-to-Face or virtual)*
- *Canadian cruises (9 total): Atlantic – DFO cruises in Labrador Sea and Scotian shelf, starting June, 2021 (AZOMP, AZMP, AZMP Bedford Basin, Eastern Shore Islands); Arctic – Davis Strait (Aug, 2021), Amundsen Science (Aug – Nov, 2021); Pacific – Queen Charlotte Sound cruises (DFO La Perouse cruise, May, 2021 and mooring cruise, June, 2021, and WCOA cruise)*
- *Underway system on M/V Seaspans Royal – British Columbia: beginning Aug, 2021, collaboration with Hakai Institute*
- *C-PROOF Glider in Queen Charlotte Sound (collaboration between UVic, UBC, Hakai Institute, C-PROOF, DFO)*
- *Canadian white paper on the state of Canada’s OA knowledge (in progress)*

What support is desired from GOA-ON to help the hub grow and achieve its objectives

- *Postdoc support for preparing the North American Acidification Synthesis Report.*
- *Support for enhancing the usefulness of the North American Hub Webpage and interoperability with the OAIE.*
- *We are excited to participate in GOA-ON’s OA Week, as it becomes scheduled.*
- *Seed funding would support collaborative opportunities, facilitating knowledge exchange and data sharing*

North American



Ocean Acidification Network

http://goa-on.org/regional_hubs/north_america/about/introduction.php



North American
OA Network

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About

Activities

Canada OA

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Mexico OA



North American Ocean Acidification Network

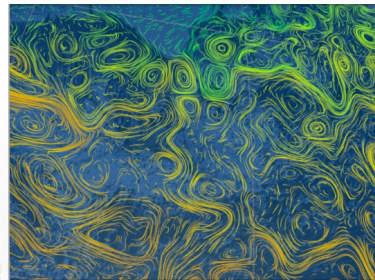


The North American Ocean Acidification Hub is being established to serve the countries of Canada, United States, and Mexico. The Global Ocean Acidification Observing Network (GOA-ON) has encouraged grass-roots formation of regional hubs to foster communities of practice for the efficient collection of comparable and geographically distributed data to assess ocean acidification and its effects and to support adaptation tools like model forecasts.



Goals

The goals of the North American GOA-ON regional hub are to:



- Share information about readiness of the Observing Network
- Assist in data management
- Promote community "best-practices" within a hub's domain consistent with GOA-ON
- Provide integration of the global network through synthesis product development

Name: North American Ocean and Coastal Acidification (NAOCA)

North American Ocean Acidification Network

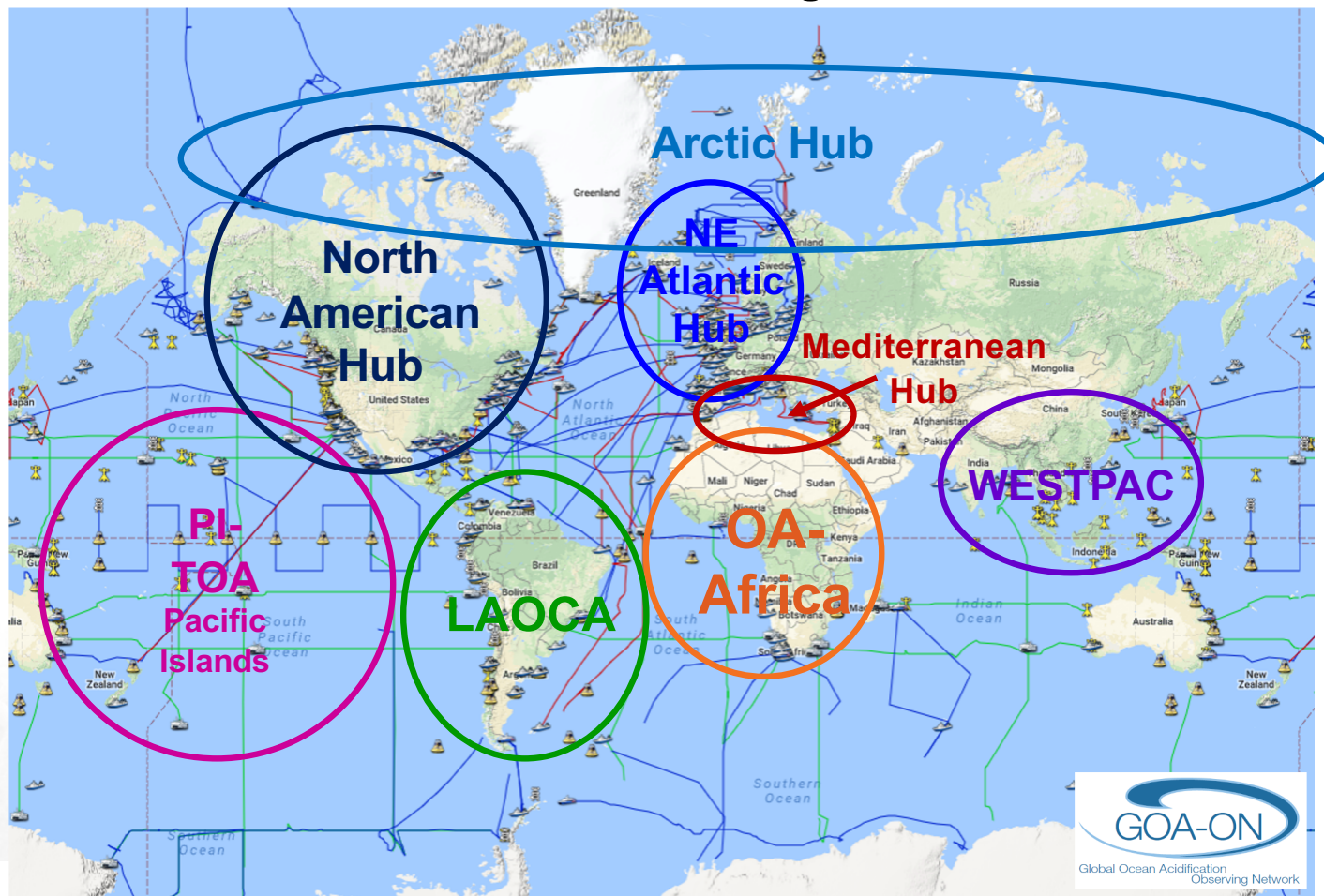


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- Activities
- Canada OA
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GOA-ON Regional Hubs





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Virtual North American Hub Meeting

May 20, 2021

Agenda

1. Welcome and Introductory Remarks (Richard Feely; 5 min).
2. Update from Canada (Helen Gurney-Smith, Brent Else, 15 min).
3. Update from USA (Richard Feely, Jan Newton, Leticia Barbaro, 15 min).
4. Update from Mexico (Jose Martin Hernandez-Ayon, 15 min).
5. Gulf of Mexico OA Synthesis Paper (Emily Osborne, 10 min).
6. Open Discussion on Current Priorities Including
 - Cruise Plans for FY 2021 & 2022
 - Create a page on the OA Information Exchange
 - Create a data synthesis paper
 - Efforts to enhance the submission of data sets
 - Create a comprehensive inventory of activities in each country
 - Summary of a training workshop on determining secular trends
 - Develop a long-term strategy for CRMs
 - Encourage collaborative studies
 - Next Face-to-Face Meeting of the North American Hub



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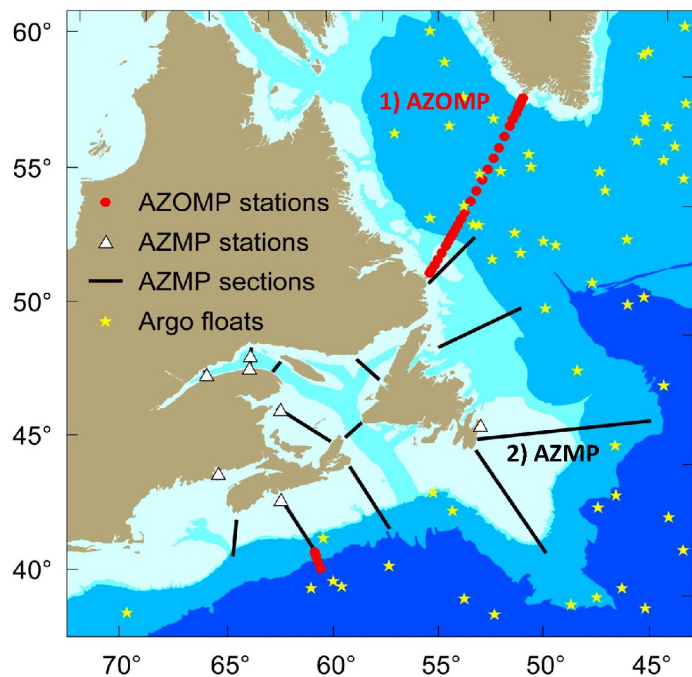
Canada OA

United States OA

Mexico OA



Cruises Atlantic



1) AZOMP

- The Labrador Sea, GO-SHIP line
- Planned May-June, 2021

2) AZMP

- Planned May, 2021, Sep—Oct, 2021)

3) AZMP-Bedford Basin

- Weekly, resumed Oct., 2020

4) Eastern Shore Islands Area

- OA baseline survey for MPA
- Planned Aug, 2021

Contact: Kumiko Azetsu-Scott



North American Ocean Acidification Network



http://goa-on.org/regional_hubs/north_america/about/introduction.php

North American OA Network

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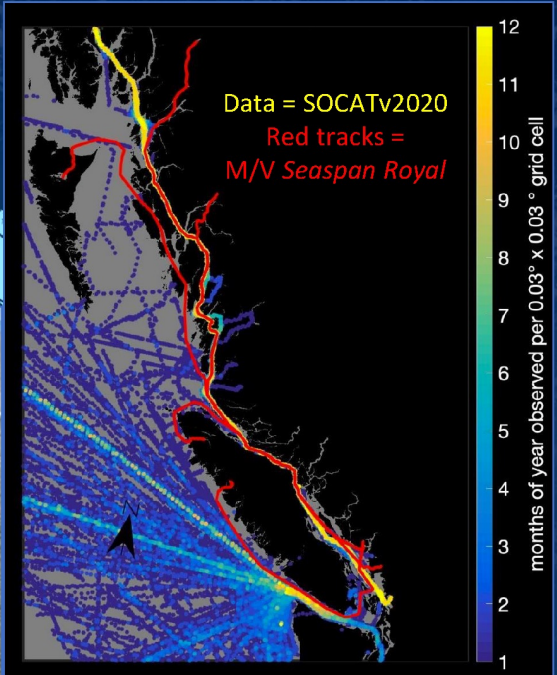
GOA-ON Data Portal

Underway

M/V Seaspan Royal

- Underway surface ocean and marine boundary layer measurements
- Beginning August 2021!**

Contact: Wiley Evans



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http://goa-on.org/regional_hubs/north_america/about/introduction.php



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Community Resources



 Fisheries and Oceans
Canada

 Pêches et Océans
Canada

OA CoP Resources

- 1) Map of Canada's OA resources
- 2) COAST to Coast OA Sensor Package
- 3) Database of Canadian OA research outputs and experts
- 4) OA CoP Communication Plan

oceanacidification.ca

Contacts: Kristina Barclay, Brent Else, Helen Gurney-Smith

DFO Resources

**Aquatic Climate Change Adaptation Services
Program (ACCASP)**

Contacts: Emily Smits, Denise Joy

North American Ocean Acidification Network

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Mexico OA



Synthesis Studies Pacific



University
of Victoria



Fisheries and Oceans
Canada

Pêches et Océans
Canada



CANADA'S MARINE
CARBON SINK PROJECT

- 1) PICES North Pacific OA synthesis report**
 - Collaborators: Alin, Bednarsek, Feely, Hernandez Ayon
 - Contacts: James Christian, Sonia Batten
- 2) A Submesoscale Modelling Approach to the Past, Present, and Future Carbonate Chemistry Balance of the Salish Sea**
 - Contacts: Tereza Jarníková, Debby Ianson, Susan Allen
- 3) Using Endmember Models to Estimate Seasonal Carbonate Chemistry and Acidification in Temperate Estuaries; (Integrated Coastal Acidification Program)**
 - Contacts: Ellie Simpson, Karen Kohfeld, Debby Ianson
- 4) Estimating the NE Pacific Ocean CO₂ Flux using a Neural Network Approach**
 - Contacts: Patrick Duke, Roberta Hamme, Debby Ianson



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Summary

- **Planned Cruises (2021) = 9 total**
 - 4 Atlantic
 - 2 Arctic
 - 3 Pacific
 - **Moorings = 6 total**
 - 1 Atlantic
 - 5 Pacific
 - **Gliders = 1 total (Pacific)**
 - **Underway = 1 total (Pacific)**
 - **Models = 2 total**
 - 1 Global
 - 1 NE Pacific
 - **Observational Studies = 10 Total**
 - 5 Arctic
 - 5 Pacific
 - **Synthesis Studies = 5 total**
 - 1 National
 - 4 Pacific
 - **Biological Studies = 9 total**
 - 1 Atlantic
 - 8 Pacific
 - **Community Resources = 5 total**
 - 4 OA CoP
 - 1 DFO
- **And more!!**



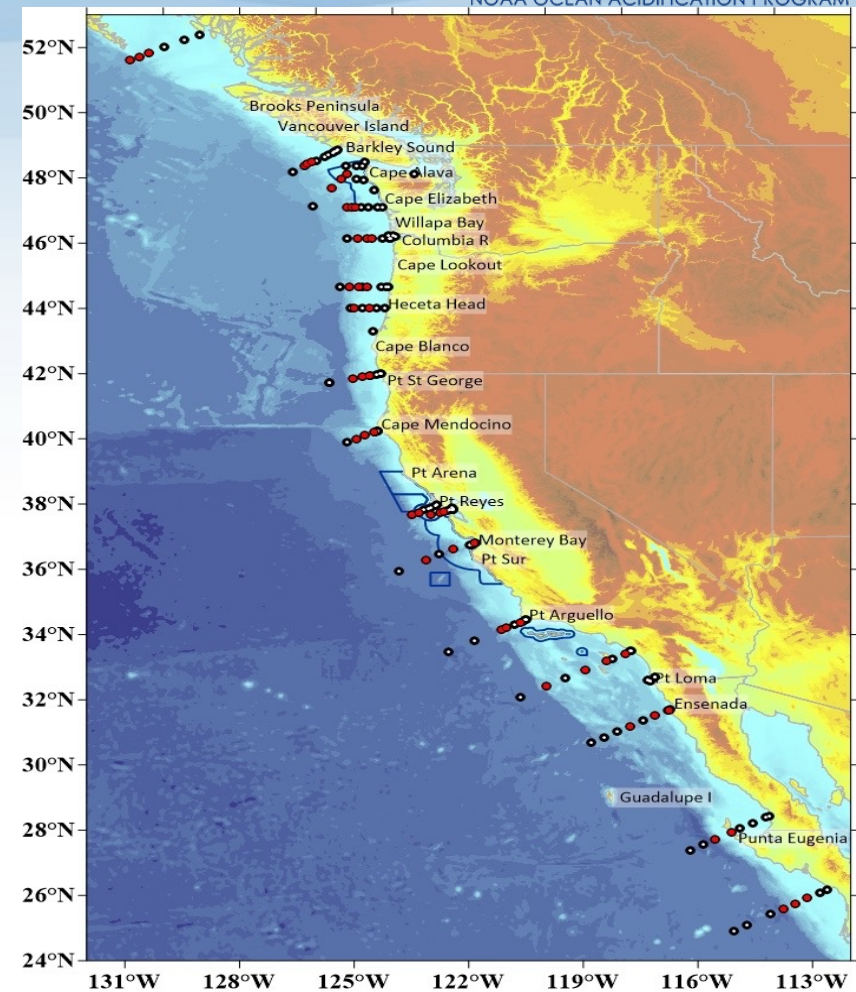
NOAA OCEAN ACIDIFICATION PROGRAM



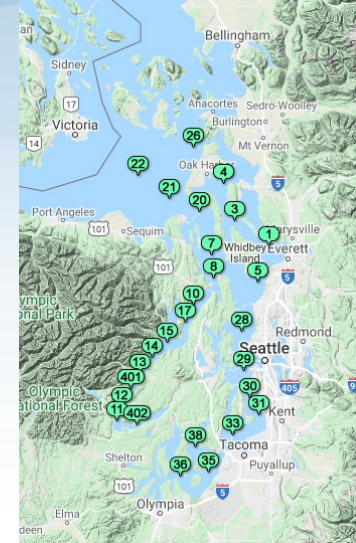
NOAA OCEAN ACIDIFICATION PROGRAM

WCOA 2021 OCEAN ACIDIFICATION CRUISE GOALS

1. Determine changes in water column properties over space and time.
2. Provide validation for the sensors for all OA observing system assets deployed in the region.
1. Provide combined chemical-biological measurements for the entire region to compare with regional studies of higher temporal resolution.
4. Show how the combined stressors of increased temperature, acidification, and hypoxia affect the responses of marine organisms and communities.



Washington OA Center: *Water chemistry & plankton seasonal surveys*



- Carbon variables, oxygen, nutrients, chlorophyll
- Microzooplankton, net plankton, eDNA
- Pteropod and megalopa shell dissolution analyses
- Temperature, salinity, weather, methane
- ES-60 acoustics

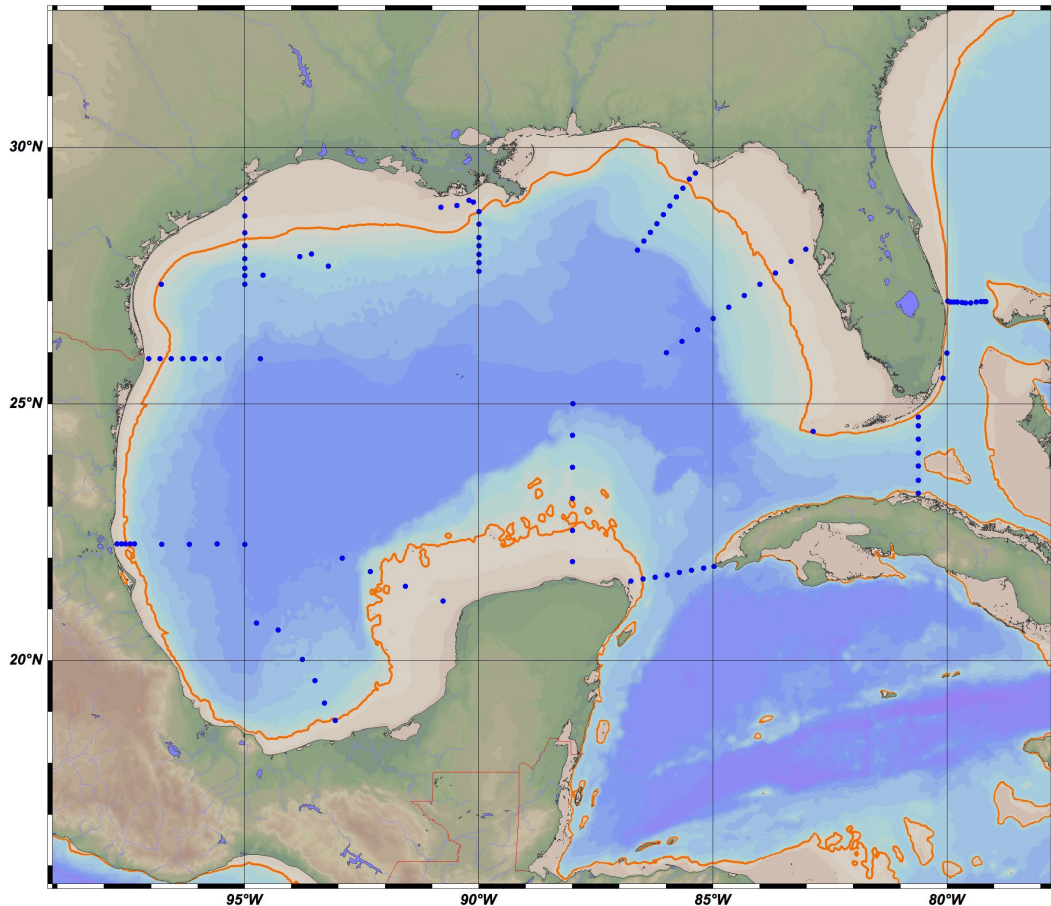
- April, July, Sept 2014 to present

- Bednaršek N, Newton JA, Beck MW, Alin SR, Feely RA, Christman N, and Klinger T. 2020. Severe biological effects under present-day estuarine acidification in the seasonally variable Salish Sea. *Sci Total Environment*: <https://doi.org/10.1016/j.scitotenv.2020.142689>
- Jacobs-Palmer E, Gallego R, Cribari K, Keller AG and Kelly RP. 2021. Environmental DNA metabarcoding for simultaneous monitoring and ecological assessment of many harmful algae. *Front. Ecol. Evol.*: <https://doi.org/10.3389/fevo.2021.612107>
- Alin, S, Newton, JA, Feely, RA, and others. In prep. A decade-long cruise time-series in the Salish Sea (North America): Spatial and temporal variability in and persistent effects of a major marine heatwave on physical and biogeochemical estuarine conditions.
- Siedlecki, SA, Pilcher, D, Howard, EM, Deutsch, C, MacCready, P, Norton, EL, Frenzel, H, Newton, J, Feely, RA, Alin, SR, and Klinger, T. 2021. Coastal processes modify projections of some climate-driven stressors in the California Current System, *Biogeosciences*: <https://doi.org/10.5194/bg-18-2871-2021>



2021 GOMECC-4

Gulf Of Mexico Ecosystems and Carbon Cycle Cruise



September 14 – October 23, 2021
Departure/Arrival: Miami, FL

- Fed. Institutions: NOAA (AOML, SEFSC), USGS, NPS (land based)
- US universities: UM, USM, USF, NCSU, ULL, Udel, TAMUCC
- Mexican institutions: UABC, CICESE, ECOSUR
- Cuban institutions: CEAC

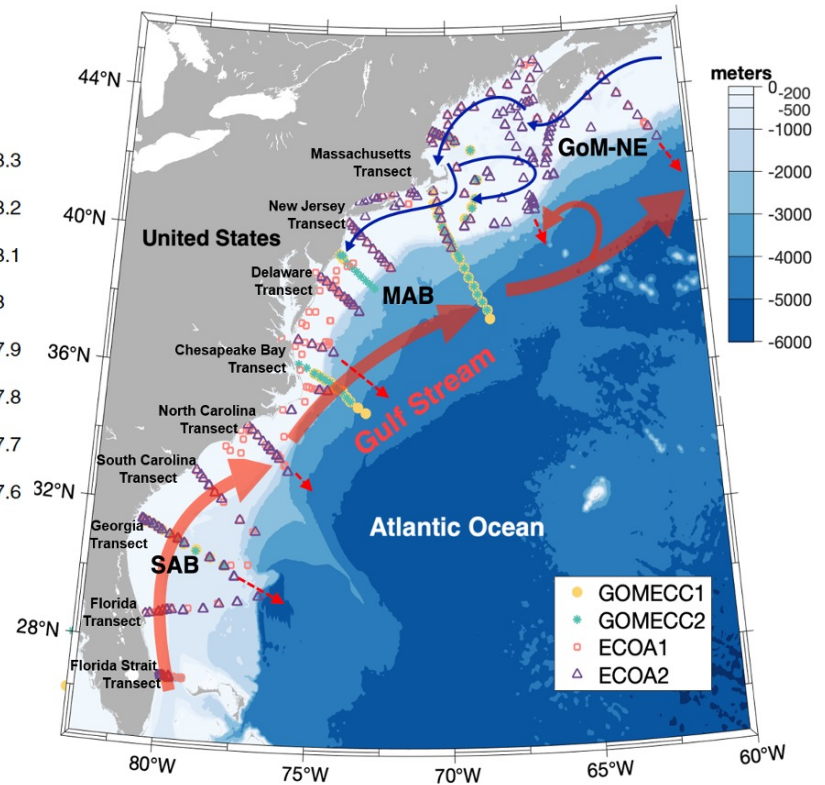
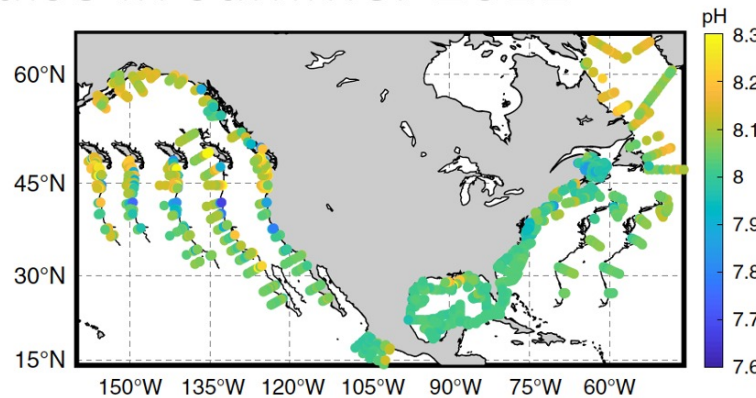
East Coast Ocean Acidification (ECO) cruise in summer 2022

Leaders:

Joe Salisbury, University of New Hampshire

Wei-Jun Cai, University of Delaware

Collaborators: Rik Wanninkhof at NOAA-AOML and other regional and local OA stakeholders



Map and transects: A summary of transects and stations of our past cruises in 2007 (GOMECC 1), 2012 (GOMECC 2), 2015 (ECOA 1) and 2018 (ECOA 2). Red arrows are proposed extension to 2000m water depth for ECOA 3 in summer 2022.

Analytical parameters:

On discrete water samples: 1) DIC, 2) spec-pH, 3) TA, 4) d13C-DIC, 5) DO, and 6) Nutrients

On underway measurements: T, S, DO, pCO₂, O₂/Ar, TA, and pH; also optical parameters.

Biological parameters: NPP, NCP (from O₂/Ar), Community Respiration (CR), others to be added after discussion with the community.

Technology: Calibrated air-sea CO₂ Instrumentation



1990s: developed at MBARI
2000s: modified at PMEL
2011: NOAA tech transfer award
Today: 38 sites in NOAA network



2010: MAPCO₂ modified for surface vehicles
Today: ASVCO₂ has been deployed on > 24 missions;



Coastal Data Analysis Product – North American (CODAP-NA)

3,292 oceanographic profiles from 61 research cruises

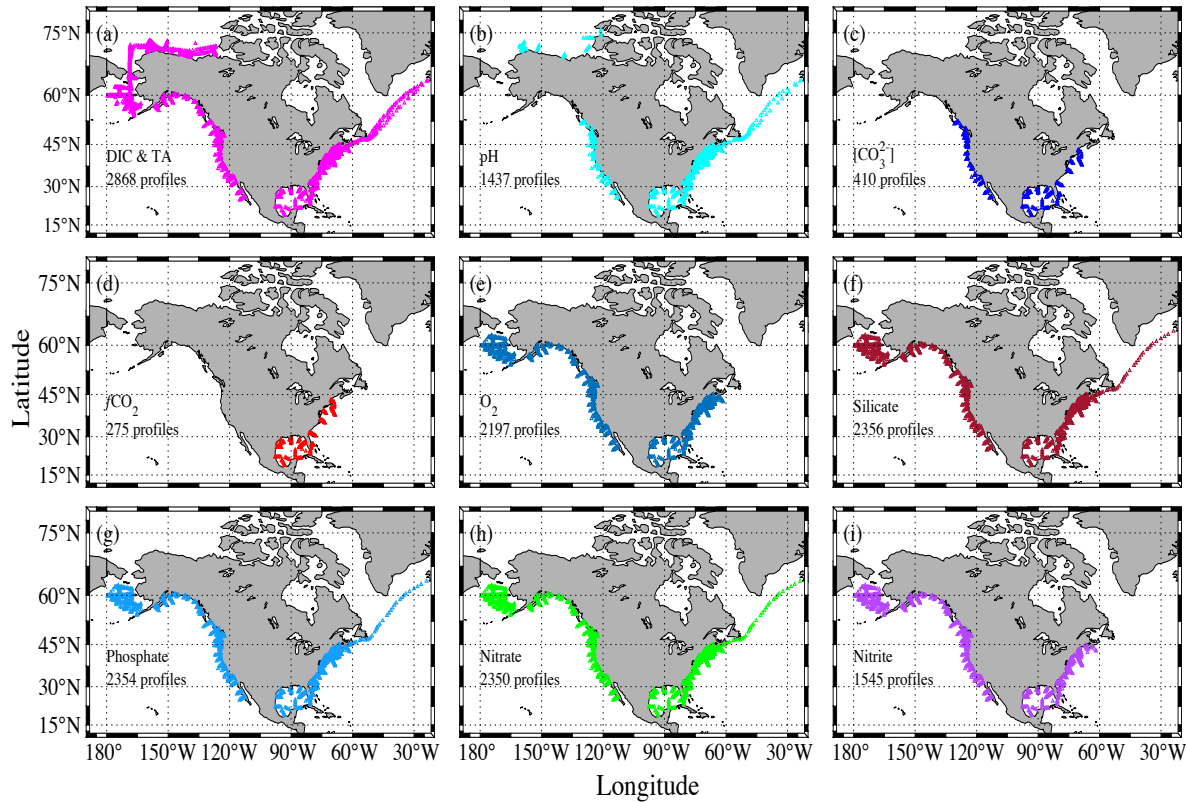


Figure 1. Sampling stations for major parameters

Jiang et al., in press

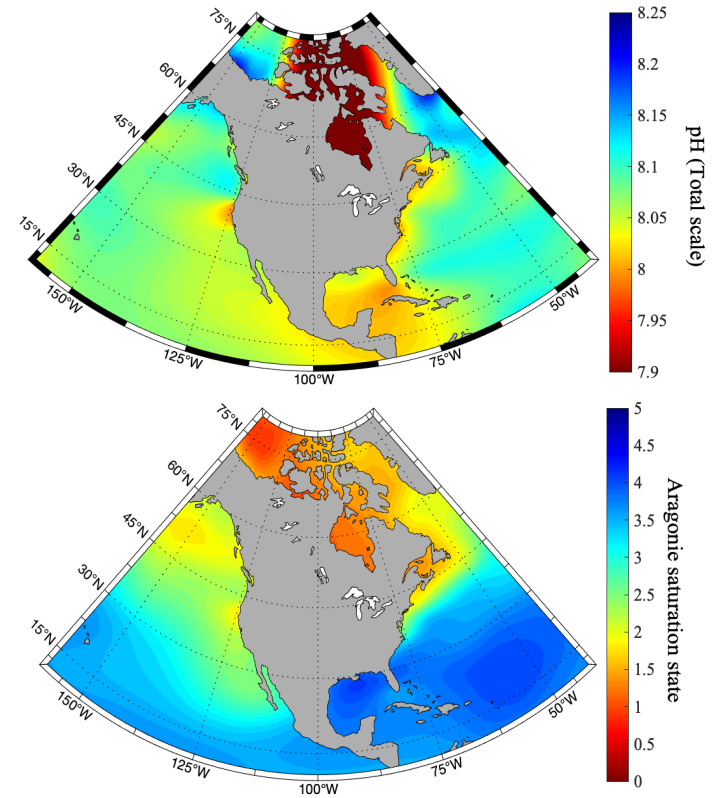


Figure 2. Climatological distribution of pH and Aragonite

North American Ocean Acidification Network



http://goa-on.org/regional_hubs/north_america/about/introduction.php



North American
OA Network

Select Language ▼

About

Activities

Canada OA

United States OA

Mexico OA



GOA-ON Data Portal



Global Ocean Acidification
Observing Network



North American
OA Network



Ocean Acidification
International
Coordination Centre
OA-ICC

Update OA Mexico 2021

J. Martín Hernández Ayón



Universidad Autónoma
de Baja California,
Ensenada, México



North American



Ocean Acidification Network

http://goa-on.org/regional_hubs/north_america/about/introduction.php



North American OA Network

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About

Activities

Canada OA

United States OA

Mexico OA

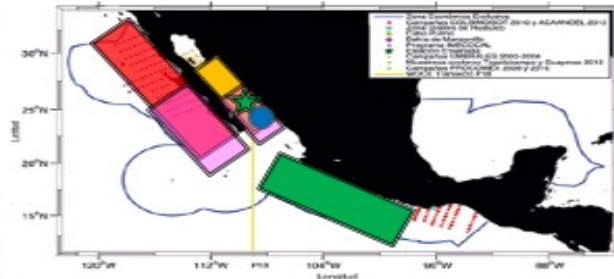


Monitoring coastal areas:

Dra. Leticia Espinosa
IPN-CIIDIR Sinaloa

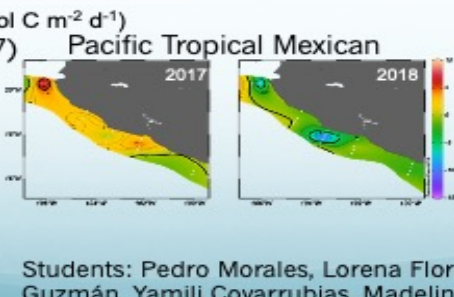
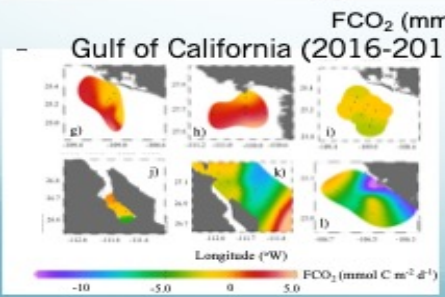


Dr. Gilberto Gaxiola C.



In collaborations with SEMAR, UNAM-ICML and INAPESCA, we are monitoring:

- 2016-2018 the Gulf of California
- 2017-2019 the Pacific Tropical Mexican
- 2019 Baja California Sur and Gulf of California
- 2020 Baja California, Baja California Sur and Gulf of California
- 2017 Sinaloa buoy
- 2021 El Elefante reef



Students: Pedro Morales, Lorena Flores, Itahi de la Cruz, Lizbeth Guzmán, Yamili Covarrubias, Madeline Molina, Perla Silva

North American Ocean Acidification Network



http://goa-on.org/regional_hubs/north_america/about/introduction.php



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Mexico OA



Dr. Daniel Pech
dpech@ecosur.mx

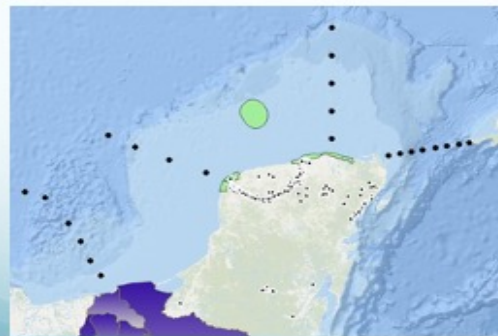
BIOMARCCA: Marine biodiversity and climate change lab

Ongoing research

The role of groundwater flow of the carbonate system from karstic environments.

Potential impacts of pH and $\Omega_{\text{aragonite}}$ on the distribution and diversity patterns of pteropods from the Gulf of Mexico. ECOSUR-CICESE-NOAA

Biochemistry of the carbonate system in the Yucatan continental Shelf. IIO – UABC, CIGoM



Tomada de <https://www.xenotes.com/es/que-son-los-cenotes/>



North American



Ocean Acidification Network

http://goa-on.org/regional_hubs/north_america/about/introduction.php



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United States OA

Mexico OA



GOA-ON Data Portal

XIII INTERNATIONAL CARBON
SYMPOSIUM IN MÉXICO
MONTERREY, NUEVO LEÓN

First Call

Monterrey, Nuevo León
October 13 to 15, 2021

Main topic:
Natural Climate Solutions and Carbon Markets:
towards an effective carbon neutrality

VIRTUAL EVENT

PMG
Programa Mexicano del Carbono
RED TEMÁTICA DEL CONACYT

May 21

Name: North American Ocean and Coastal Acidification (NAOCA)

North American Ocean Acidification Network

http://goa-on.org/regional_hubs/north_america/about/introduction.php



North American OA Network

Select Language ▼

About

Activities

Canada OA

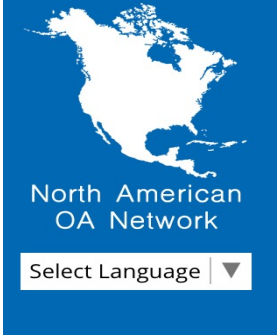
United States OA

Mexico OA



North American Ocean Acidification Network Summary

Planned Cruises	Time-series	Underway	Gliders	Models
Atlantic 4	46	10	2	8
Arctic 2				
Pacific 5				
Gulf of Mexico 2				
			Community Resources	Workshops
Observational Studies	Biological Studies	Synthesis Studies		
10	3	7	4	1



About

Activities

Canada OA

United States OA

Mexico OA



http://goa-on.org/regional_hubs/north_america/about/introduction.php

Key Hub Accomplishments and Recommendations

- 1. Coordinate Cruise Plans for FY 2021 and 2022.** Coordination of US (WCOA21 and GOMECC4 in 2021 and other non-NOAA cruises; 9 Canadian cruises; and 2 Mexican cruises), by creating a team on the Ocean Acidification Information Exchange (OAIE) about maximizing shiptime sharing etc. Cruise Coordination approved by DFO-NOAA to fill gaps. Time-series measurements at 46 locations within the Hub region. 8 Models being Implemented.
- 2. Create data synthesis and best practices papers** to review ocean acidification science across North American regions (2 published; several underway; one region-wide under consideration). This will require a writing team to carry out the synthesis (Wei Jun Cai , Wiley Evans, Martin Hernandez-Ayon, co-leads). Question: Will GOA-ON provide support for this effort?
- 3. Develop a data exchange platform** on the North American Hub Website using the GOA-ON Data Portal. Question: Will GOA-ON provide support for this effort to make sure we all can get access to the data?
- 4. Create an inventory** of who's doing what in each country.
- 5. Support development of new data synthesis technology** in the GOA-ON community (i.e., time-series analysis, empirical algorithm development, eDNA, Flow cytometry, etc).
- 6. Provide input for a long-term strategy for CRMs**, including estuarine applications.
- 7. Encourage collaborative studies** and personnel exchanges (Pier-to-Peer).
- 8. Next Face-to-Face Meeting of the North American Hub (February 2022).**

Canada Updates

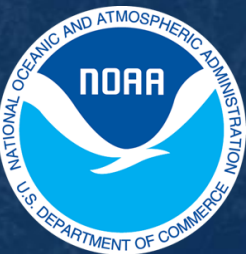
GOA-ON NA Hub Meeting – May 20, 2021

Helen Gurney-Smith, Brent Else, Kristina Barclay



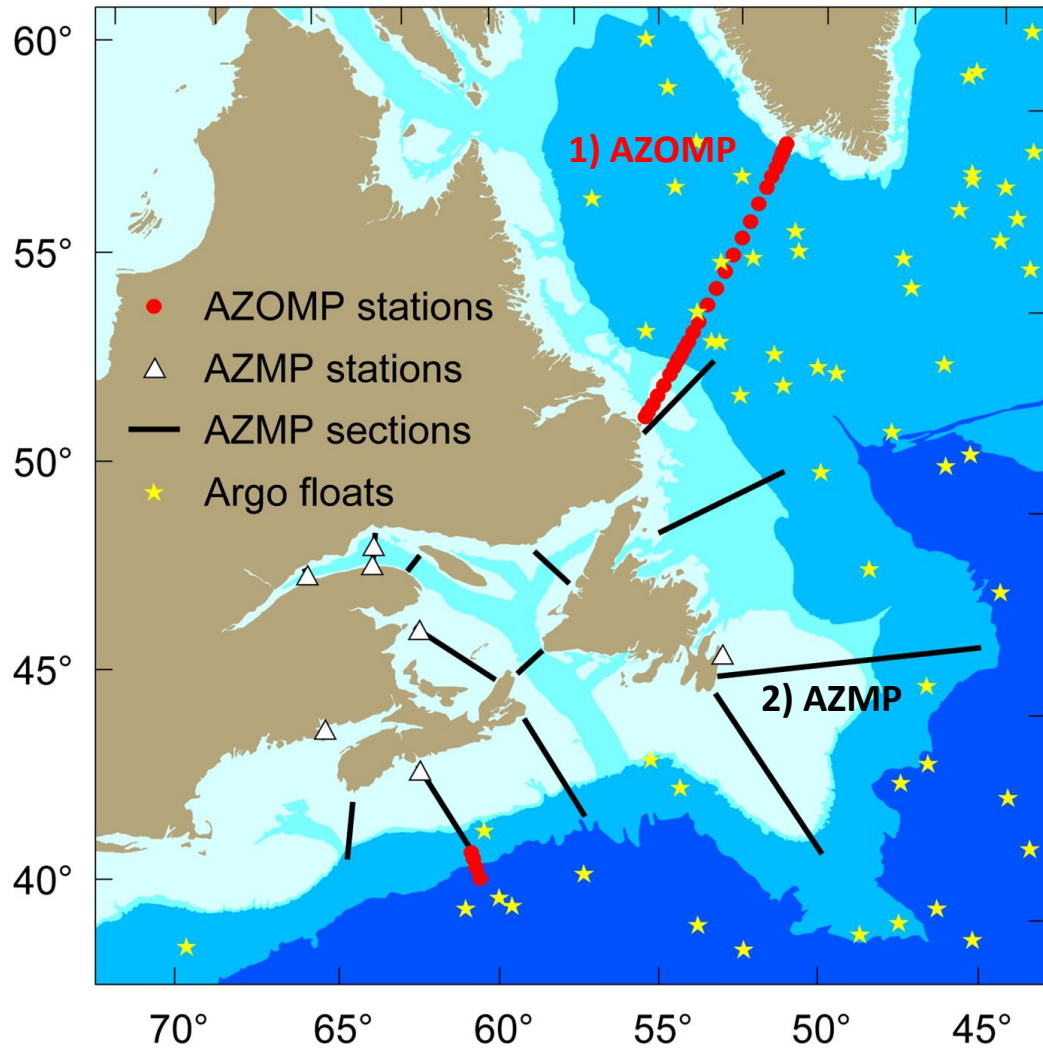
DFO Partnerships and Funding

- Main DFO contacts: Denise Joy, Emily Smits
- **DFO/NOAA joint OA Working Groups**
 - NA Collaborators: NOAA
 - Monitoring & Research, Experimentation and Modelling Working Groups
 - Active collaborations
- **Aquatic Climate Change Adaptation Services Program (ACCASP)**
Ocean Chemistry Funding
 - **Sustainable Development Goal 14.3.1 Reporting**
 - Representative sites in Atlantic, Arctic, and Pacific oceans
 - International effort through IOC-UNESCO



Cruises

Atlantic



1) AZOMP

- The Labrador Sea, GO-SHIP line
- Planned May-June, 2021

2) AZMP

- Planned May, 2021, Sep—Oct, 2021)

3) AZMP-Bedford Basin

- Weekly, resumed Oct., 2020

4) Eastern Shore Islands Area

- OA baseline survey for MPA
- Planned Aug, 2021

Contact: Kumiko Azetsu-Scott



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Cruises

Pacific

1) DFO La Perouse

- Planned late May 2021

2) DFO Mooring Cruise

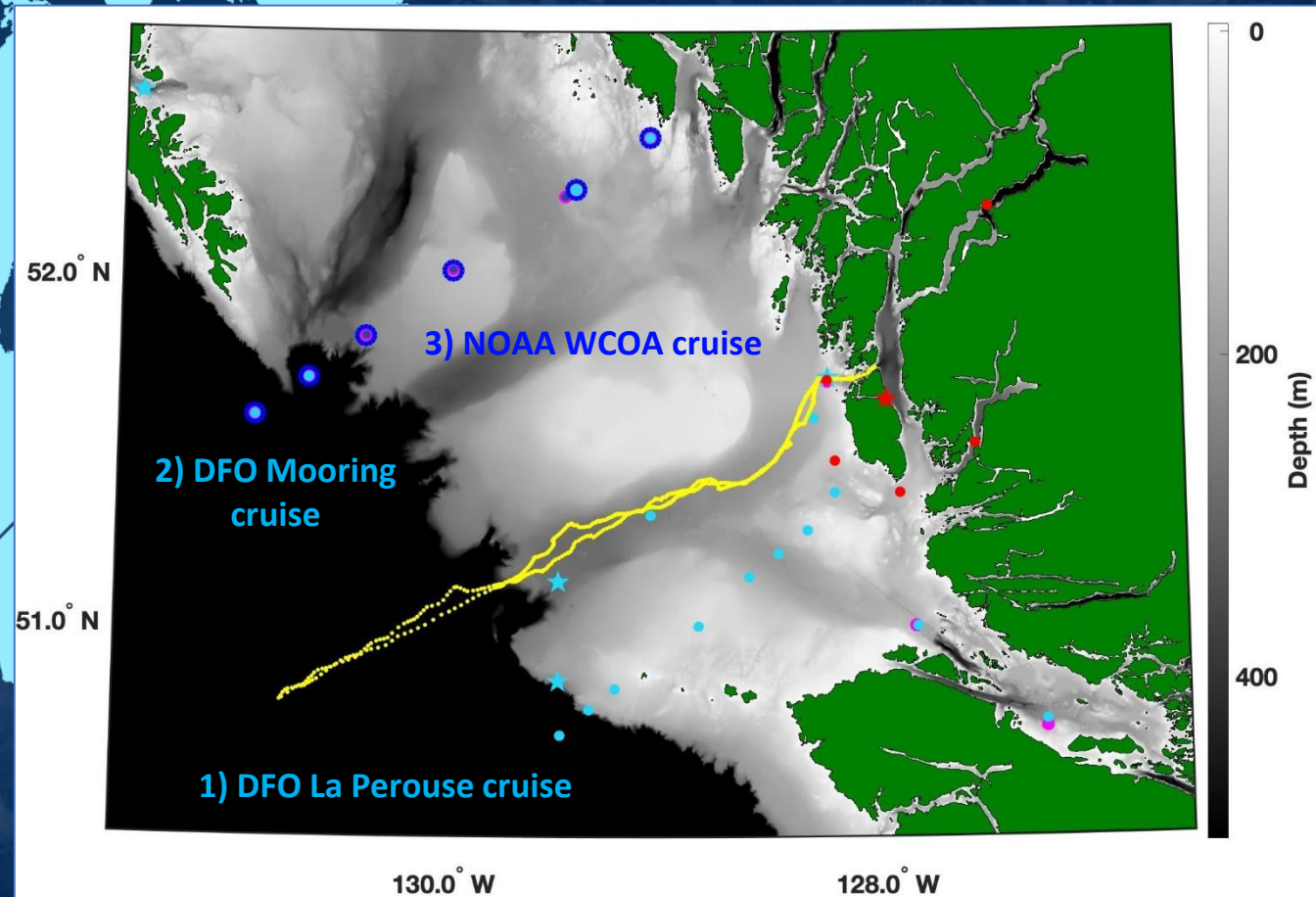
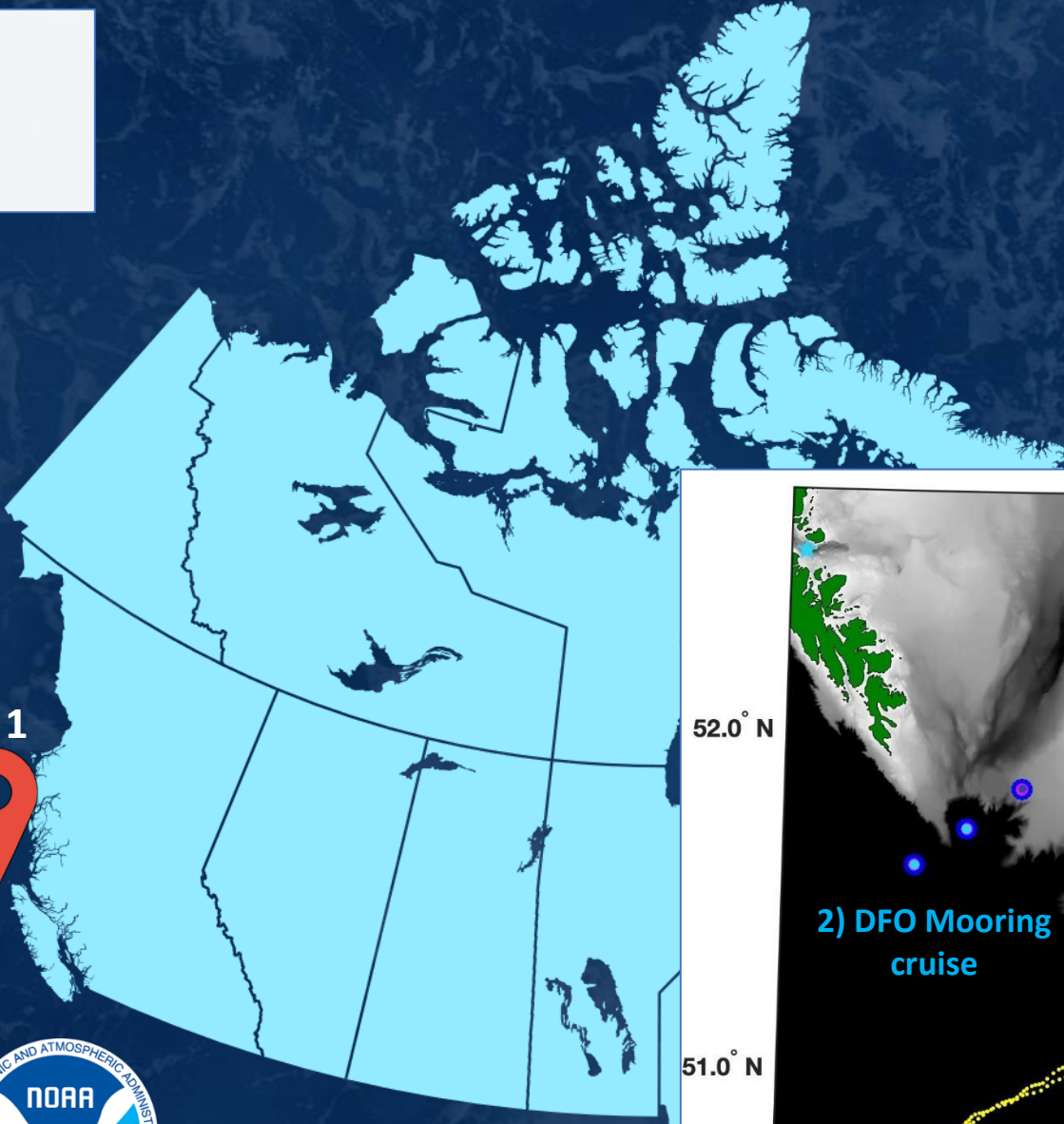
- June 10 2021

3) NOAA WCOA Cruise

- Planned June 28 – 29 2021

- Additional samples, Hakai and DFO

Contact: Wiley Evans



Hakai
Science on the Coastal Margin



Fisheries and Oceans
Canada

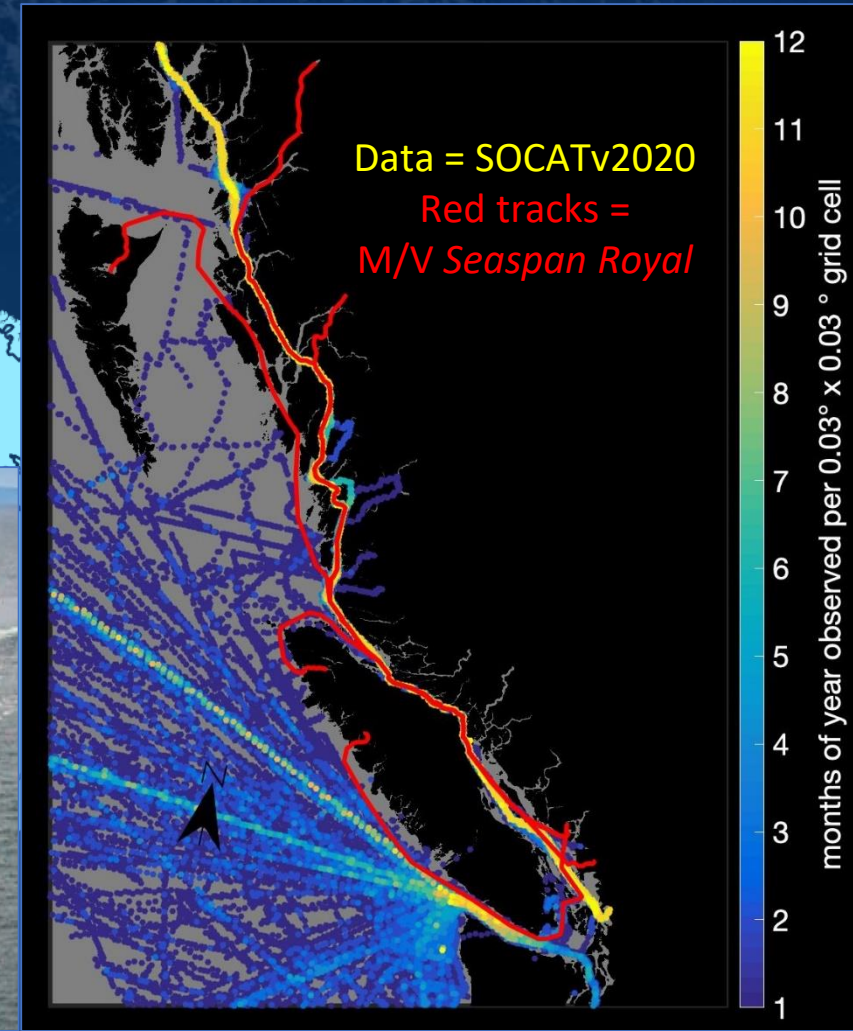
Pêches et Océans
Canada

Underway

M/V *Seaspan Royal*

- Underway surface ocean and marine boundary layer measurements
- **Beginning August 2021!**

Contact: Wiley Evans

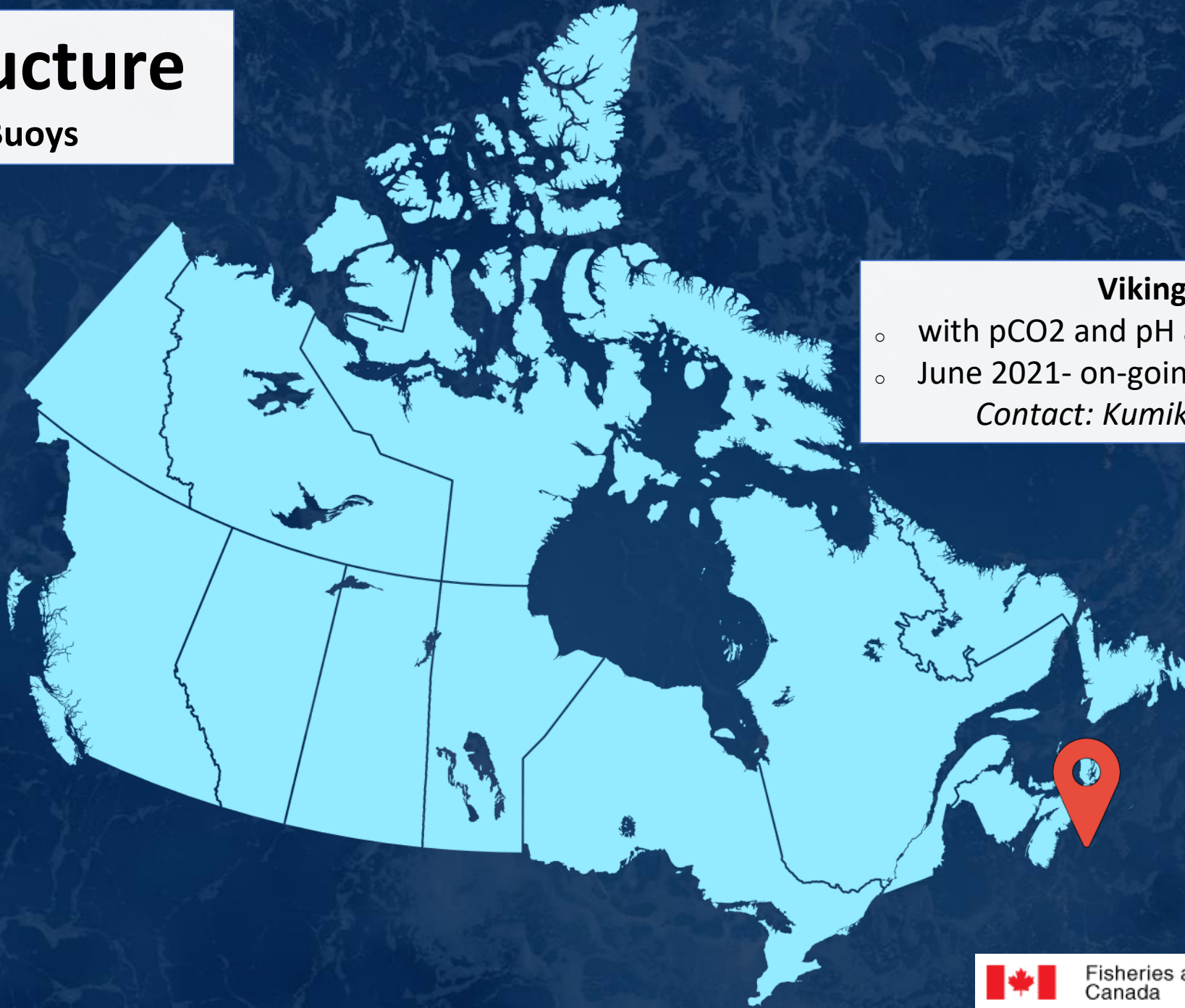


Hakai
Science on the Coastal Margin

 **seaspan**

Infrastructure

Atlantic Buoys



Viking Buoy

- with pCO₂ and pH at HL-2
- June 2021- on-going

Contact: Kumiko Azetsu-Scott



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Pêches et Océans
Canada

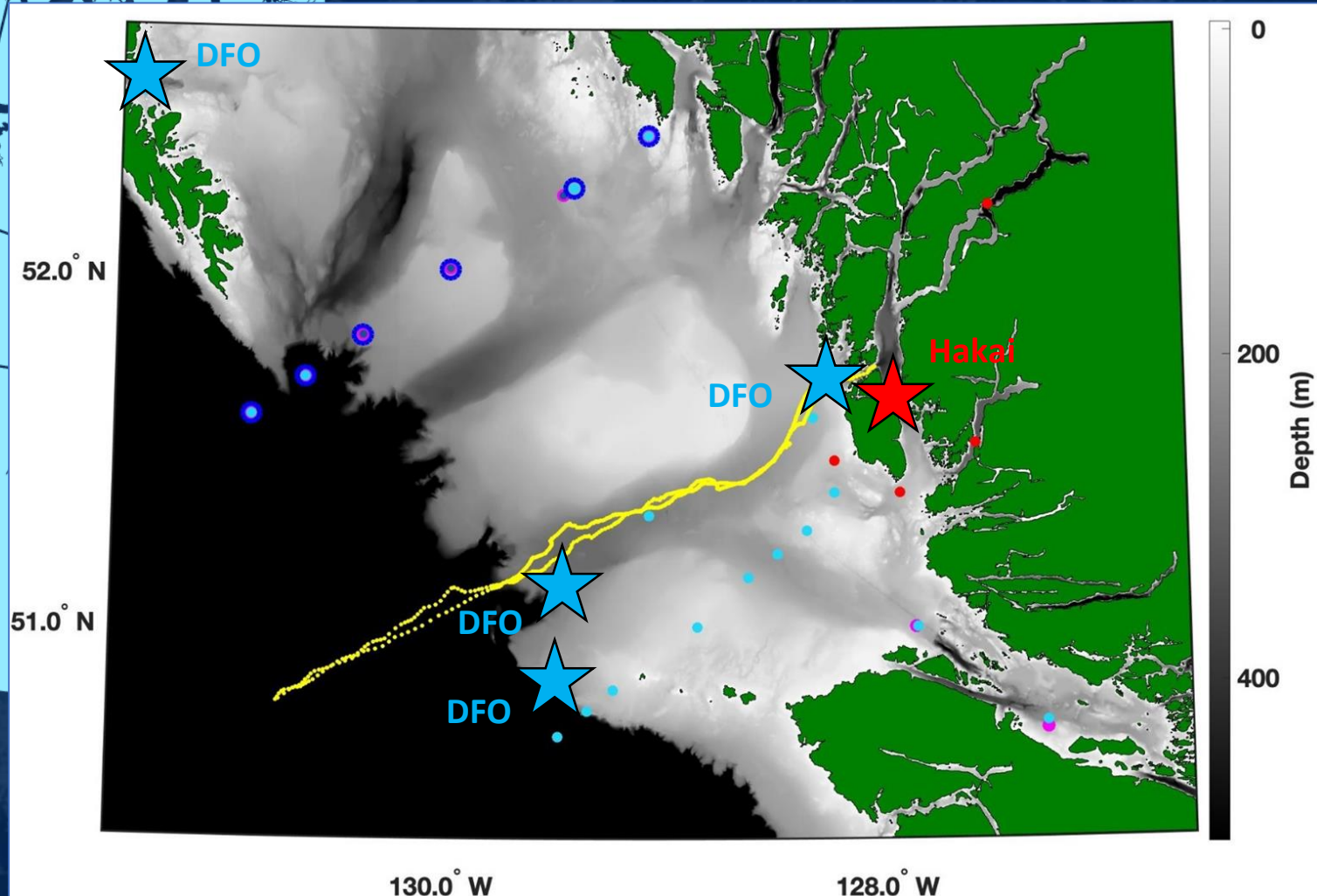
Infrastructure

Queen Charlotte Sound Moorings

DFO Moorings

- Subsurface moorings with pH
- **KC Buoy (Hakai)**
- Continued monthly sampling (high-resolution surface observations)

Contact: Wiley Evans



Hakai
Science on the Coastal Margin



Fisheries and Oceans
Canada

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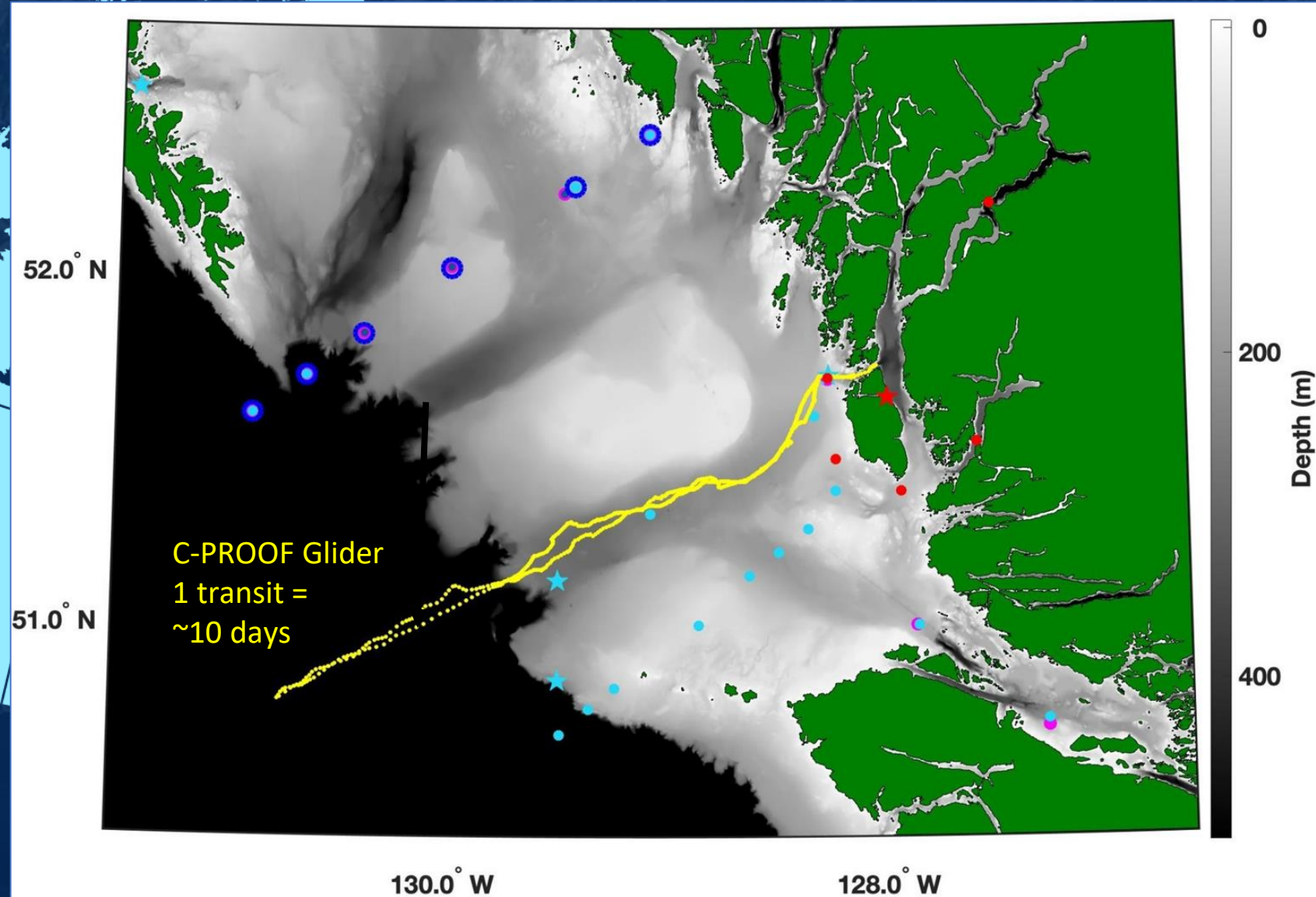
Infrastructure

Queen Charlotte Sound Glider

C-PROOF Glider

- Proxy-based assessment (mooring and glider)

Contact: Wiley Evans



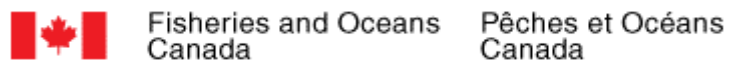
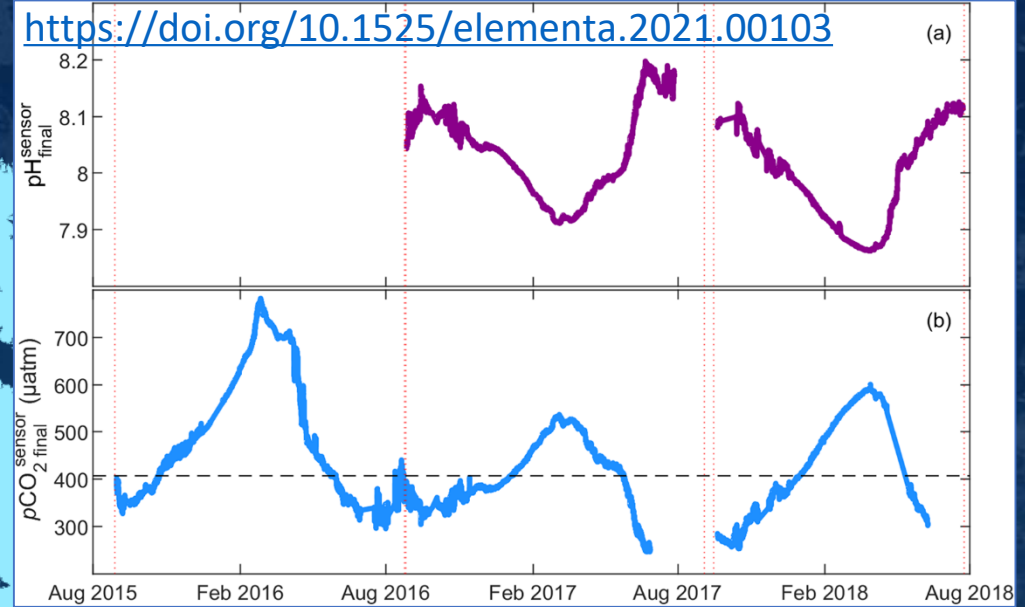
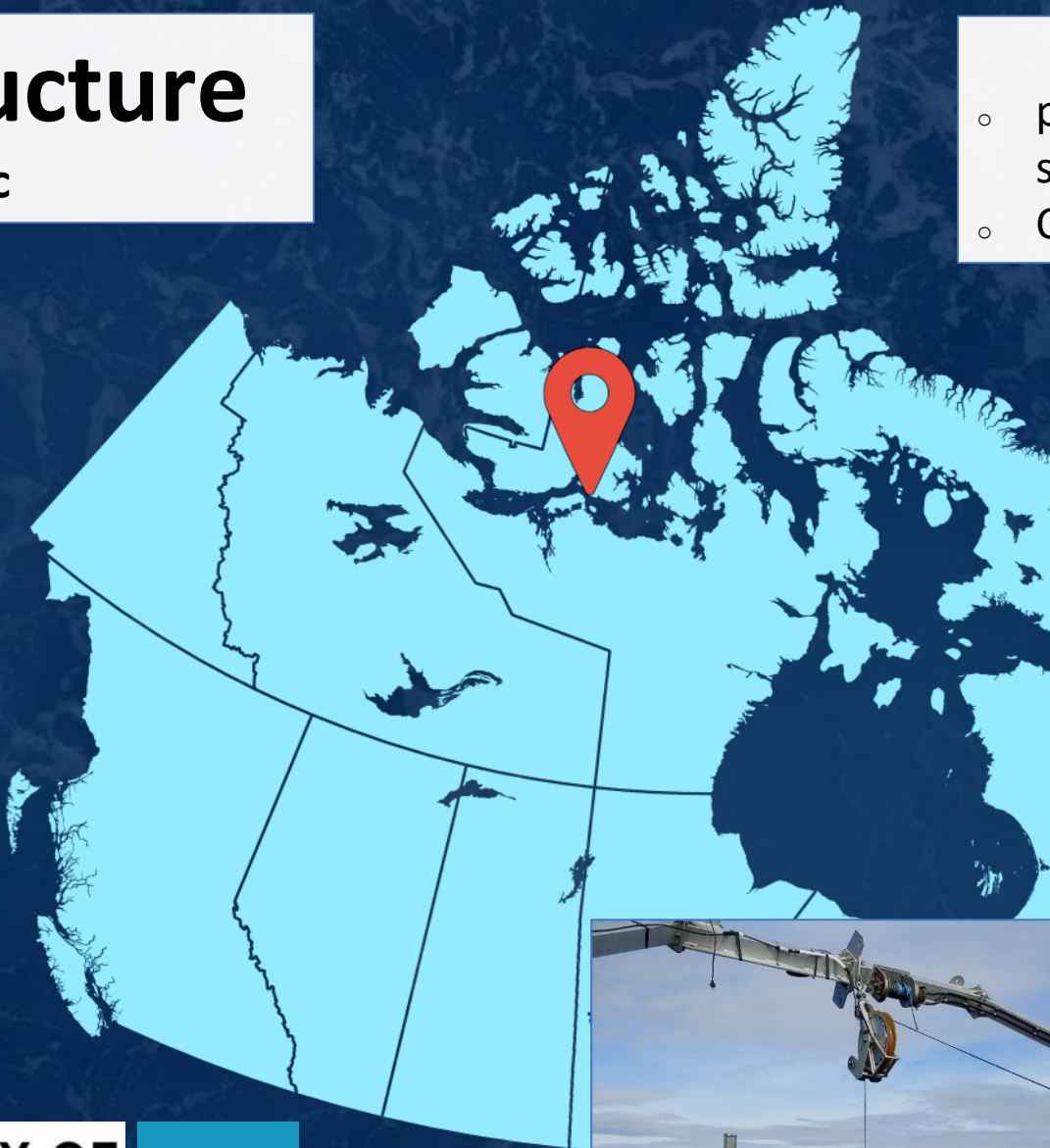
  **University of Victoria** 

 Fisheries and Oceans Canada  Pêches et Océans Canada

Infrastructure

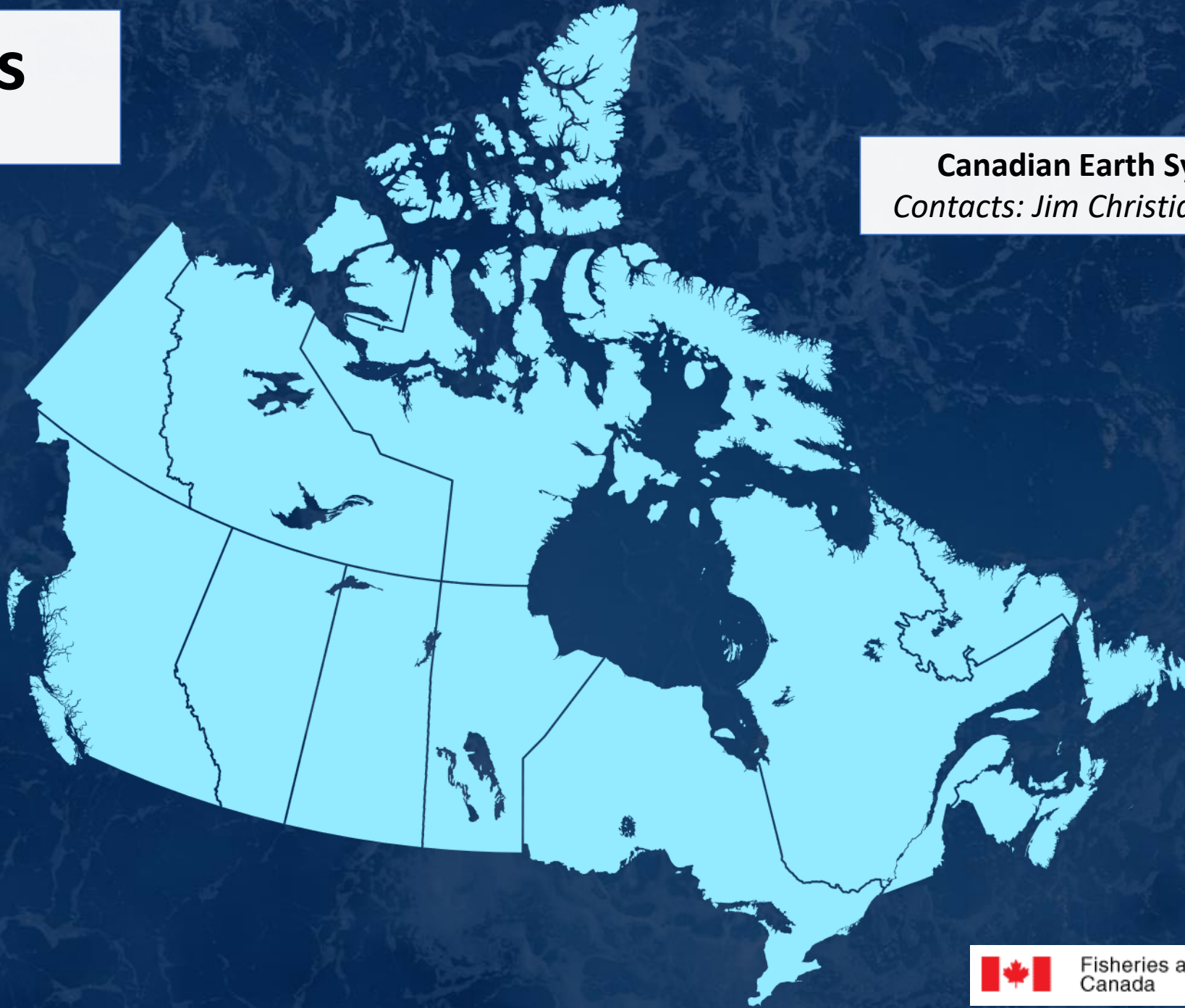
Arctic

- ## Cambridge Bay Observatory
- pH (Seabird), pCO₂ (Pro Oceanus), seawater sample collection
 - Contact: Brent Else, Richard Dewey



Models

Global



Canadian Earth System Model v. 5
Contacts: Jim Christian, Neil Swart (ECCC)



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Canada

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Canada

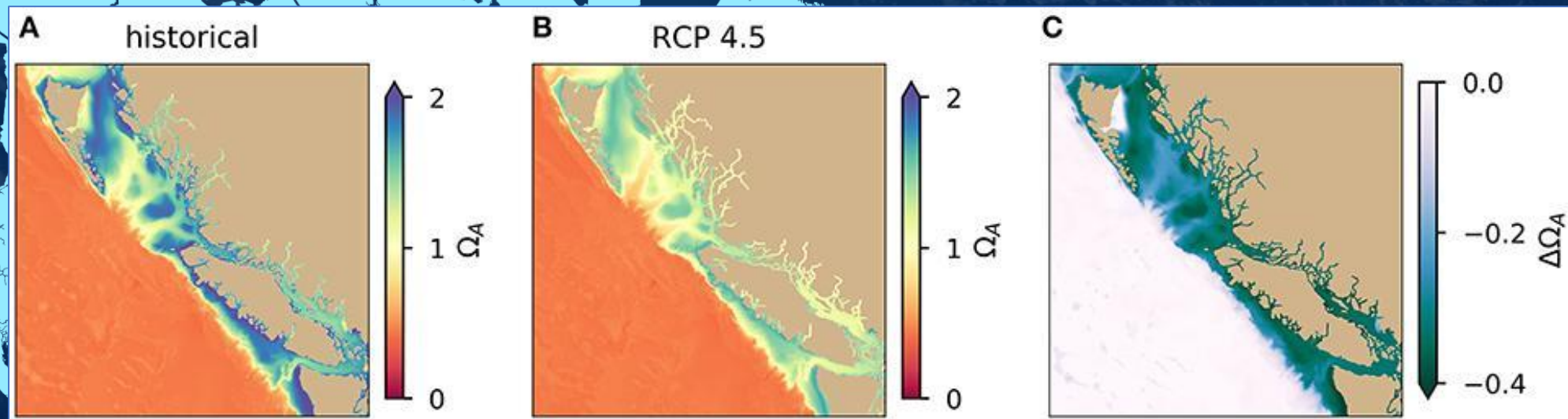
Models

NE Pacific

Northeast Pacific regional ocean
biogeochemical model

Contacts: Jim Christian, Amber Holdsworth

Fig. 7 Holdworth et al., 2021



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Observational Studies

Arctic



1) Coastal-offshore acidification conditions in Baffin Bay

- KEBABB (Knowledge, Ecosystem Based Approach in Baffin Bay)

2) Variability & trends in acidification conditions in the Canadian Arctic Archipelago

- KEBABS (Knowledge, Ecosystem Based Approach in Barrow Strait)

3) Risks and impacts of OA in the Canadian Beaufort Sea

- CBS-MEA (Canadian Beaufort Sea – Marine Ecosystem Assessment)

4) OA in the presence of sea ice in the High Arctic, MAP-Last Ice

- BIOTA (Biological Impact of Trends in the Arctic), Multidisciplinary Arctic Program – Last Ice

Collaborators: Pickard (WHOI), Feely (NOAA); Bednarsek (SCCWRP)

Contacts: Christine Michel, Clark Richards, Andrea Niemi



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Observational Studies

Arctic (Community-Based)



5) Tuktoyaktuk community based observation

- COVID – suspended this year

Contact: Kumiko Azetsu-Scott

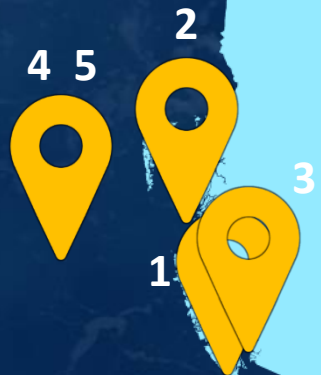


Fisheries and Oceans
Canada

Pêches et Océans
Canada

Observational Studies

Pacific



1) Ocean Networks Canada workshop on *in situ* sensors for OA research

- Collaborators: Bresnahan, Murphy

Contacts: James Christian, Akash Sastri

2) Marine CO₂ System Variability and Dynamics in Queen Charlotte Sound

Contacts: Ben O'Connor, Stephanie Waterman, Wiley Evans, Jen Jackson

3) First-hand knowledge of ocean change: Identifying emerging challenges for shellfish aquaculture in the NE Pacific

Contacts: Evie Morin, Karen Kohfeld, Debby Ianson

4) Rapid deep ocean deoxygenation and acidification threaten life on NE Pacific seamounts

Contacts: Debby Ianson, Tetjana Ross, Cherisse Du Preez

5) Anthropogenic and climatic contributions to observed carbon system trends in the NE Pacific

Contacts: Ana C. Franco, Debby Ianson

OCEAN NETWORKS CANADA



Hakai
Science on the Coastal Margin



SFU

SIMON FRASER UNIVERSITY



Fisheries and Oceans Canada

Pêches et Océans Canada

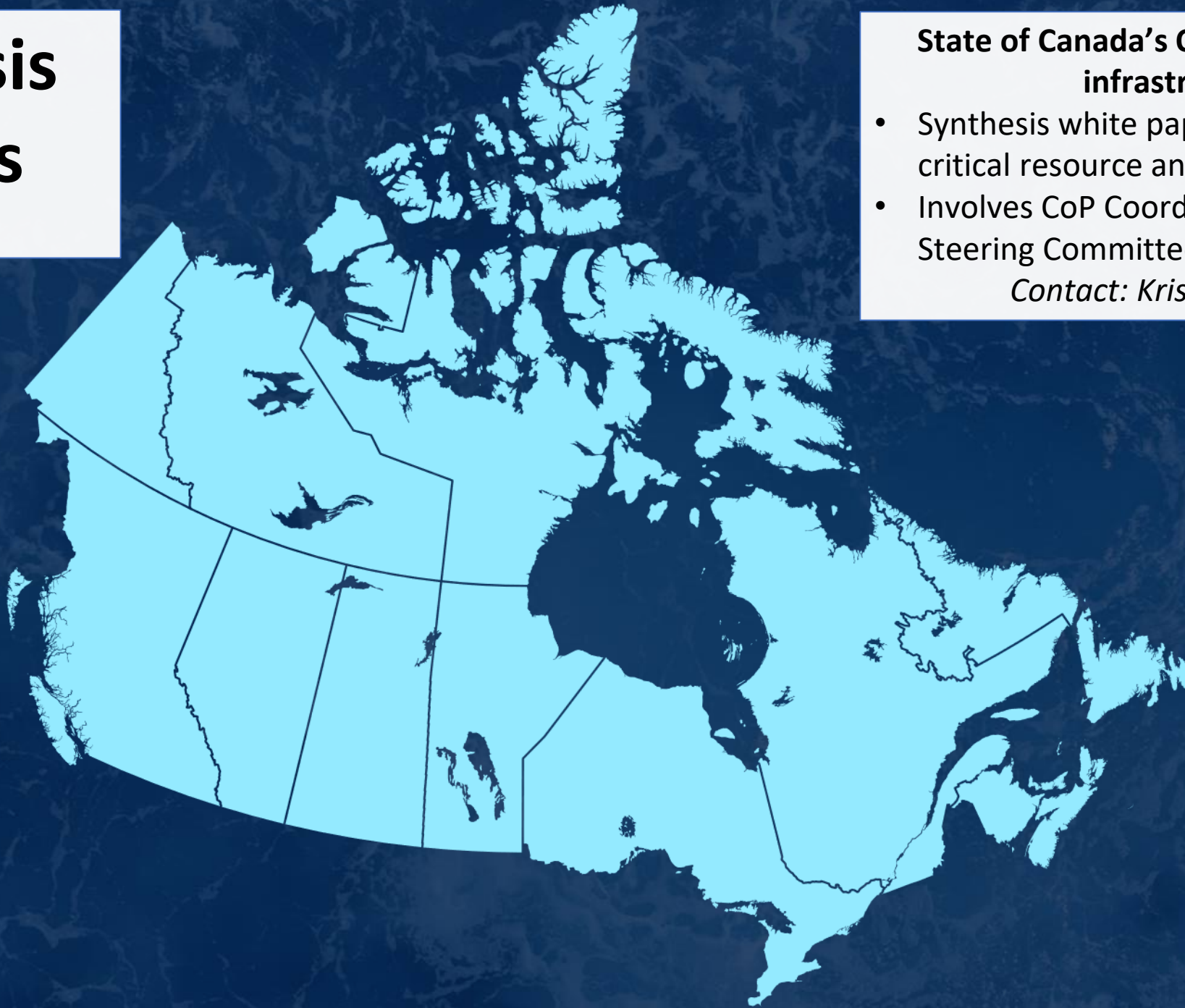
Synthesis Studies

National

State of Canada's OA knowledge and infrastructure

- Synthesis white paper *in prep*, identify critical resource and knowledge needs
- Involves CoP Coordinator, co-Leads, and Steering Committee

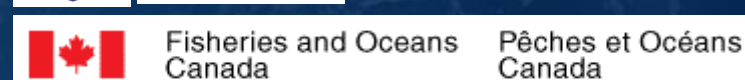
Contact: Kristina Barclay



Synthesis Studies

Pacific

- 1) PICES North Pacific OA synthesis report**
 - Collaborators: Alin, Bednarsek, Feely, Hernandez Ayon
 - Contacts: James Christian, Sonia Batten*
- 2) A Submesoscale Modelling Approach to the Past, Present, and Future Carbonate Chemistry Balance of the Salish Sea**
 - Contacts: Tereza Jarníková, Debby Ianson, Susan Allen*
- 3) Using Endmember Models to Estimate Seasonal Carbonate Chemistry and Acidification in Temperate Estuaries; (Integrated Coastal Acidification Program)**
 - Contacts: Ellie Simpson, Karen Kohfeld, Debby Ianson*
- 4) Estimating the NE Pacific Ocean CO₂ Flux using a Neural Network Approach**
 - Contacts: Patrick Duke, Roberta Hamme, Debby Ianson*



Biological Studies

Atlantic



Fisheries and Oceans
Canada

Pêches et Océans
Canada

1) Impacts of coastal acidification and climate change stressors on the Atlantic sea scallop

- Collaborators: Shannon Meseck (NOAA)

Contacts: Helen Gurney-Smith, Kumiko Azetsu-Scott

2) DFO-NOAA Atlantic sea scallop technical report and collaborative study

- US members: Shannon Meseck, Chris Chambers

Contact: Helen Gurney-Smith

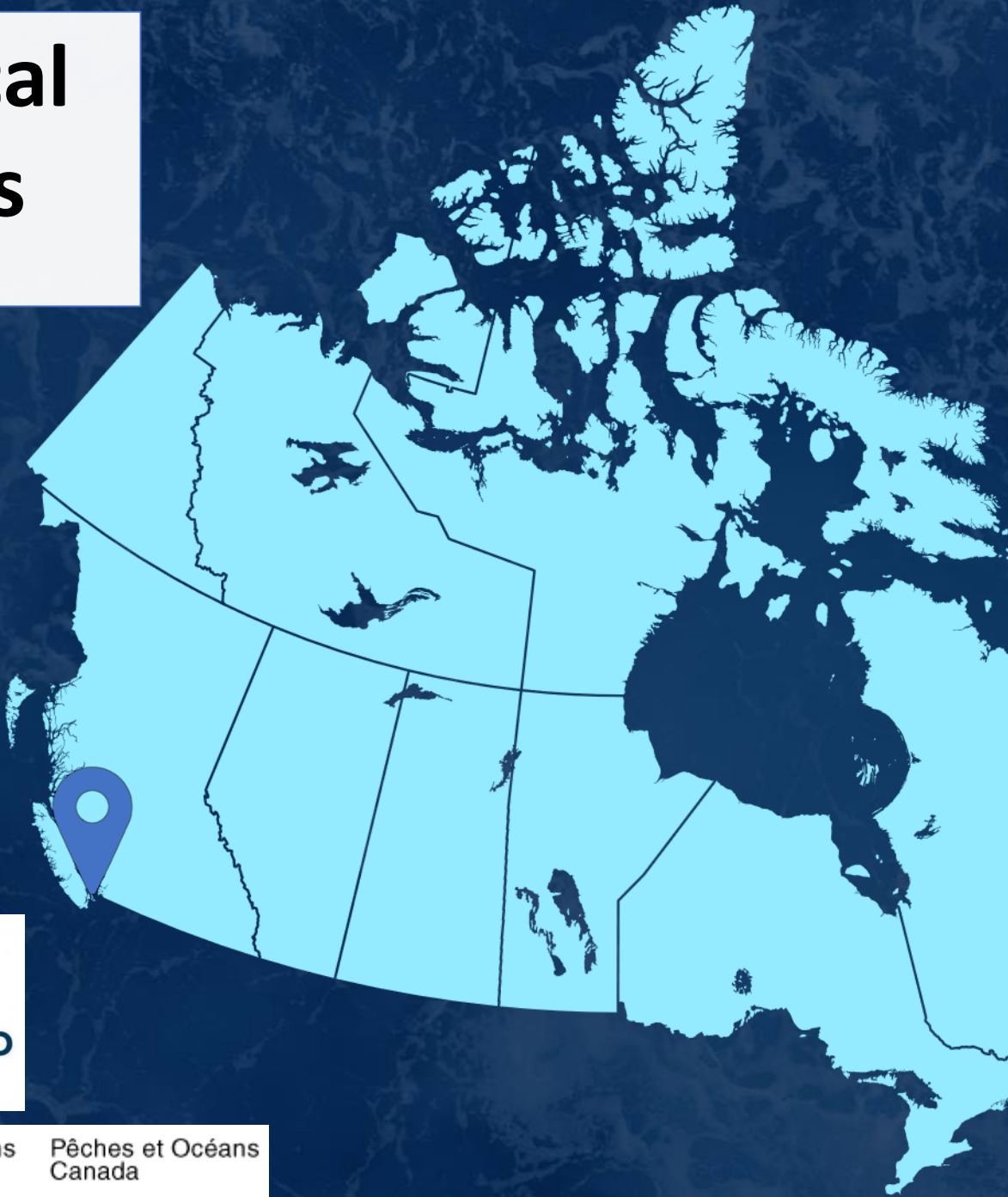
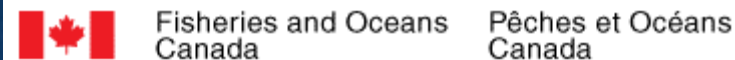
3) Lobster climate vulnerability assessment

- US members: Samantha Siedlecki, Charlie Stock, Kathy Mills, Chris Chambers

Contact: Helen Gurney-Smith

Biological Studies

Pacific



1) Selective breeding of Pacific oysters to improve resistance to summer mortality syndrome

Contacts: Chris Pearce (DFO), Tim Green (VIU)

2) Examining climate-change impacts on US and Canadian commercial shellfish species and potential biomitigation techniques

Contacts: Chris Pearce, Clara Mackenzie (DFO)

3) The role of environment in shaping resilience of Pacific oysters to summer mortality syndrome: A comparison of intertidal and deep-water culture sites

Contacts: Chris Pearce (DFO), Clara Mackenzie (DFO), Tim Green (VIU)

4) Investigating the impact of ocean acidification on pteropods in the NE Pacific: A multi-method approach

Contacts: Matt Miller, Debby Ianson, John Dower

Biological Studies

5) An *in situ* pairing of chemical oceanography and OA physiological responses

Contacts: Helen Gurney-Smith, Brenna Collicutt

6) Pacific oyster spat growth and transcriptomics response under future ocean conditions

Contacts: Jan Finke, Brenna Collicutt

7) Climate change effects on marine shellfish - Elucidating transgenerational mechanisms of sensitivity and resiliency under realistic environmental conditions

Contacts: Brenna Collicutt, Iria Gimenez

8) Climate change effects on marine shellfish - Investigating carbonate chemistry parameters driving larval sensitivity

Contacts: Iria Gimenez, Brenna Collicutt

Hakai
Science on the Coastal Margin



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Community Resources



OA CoP Resources

- 1) Map of Canada's OA resources
- 2) COAST to Coast OA Sensor Package
- 3) Database of Canadian OA research outputs and experts
- 4) OA CoP Communication Plan

oceanacidification.ca

Contacts: Kristina Barclay, Brent Else, Helen Gurney-Smith

DFO Resources

Aquatic Climate Change Adaptation Services Program (ACCASP)

Contacts: Emily Smits, Denise Joy

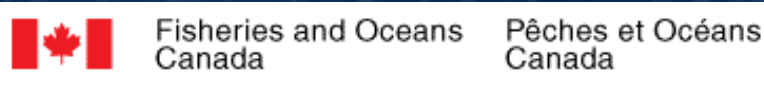


Fisheries and Oceans
Canada

Pêches et Océans
Canada

Partnerships

Many collaborations between institutions, governments, and NGOs



Summary

- **Planned Cruises (2021) = 9 total**
 - 4 Atlantic
 - 2 Arctic
 - 3 Pacific
- **Moorings = 6 total**
 - 1 Atlantic
 - 5 Pacific
- **Gliders = 1 total (Pacific)**
- **Underway = 1 total (Pacific)**
- **Models = 2 total**
 - 1 Global
 - 1 NE Pacific
- **Observational Studies = 10 Total**
 - 5 Arctic
 - 5 Pacific
- **Synthesis Studies = 5 total**
 - 1 National
 - 4 Pacific
- **Biological Studies = 9 total**
 - 1 Atlantic
 - 8 Pacific
- **Community Resources = 5 total**
 - 4 OA CoP
 - 1 DFO
- **And more!!**

Join us!

[OceanAcidification.ca](https://oceanacidification.ca)

Membership form: oceanacidification.ca/join-us

Join Team Canada on the OA Info Exchange (oainfoexchange.org)

Have an idea? Want to contribute?

Blog posts!

Resource map!

We're always looking for new content!

Email: [**coordinator@oceanacidification.ca**](mailto:coordinator@oceanacidification.ca)



@meoparoacop



@meopar_oacop



@meopar_oacop

Canadian OA Project Updates

GOA-ON North American Hub Meeting

May 20, 2021

DFO Partnerships and Funding

DFO/NOAA joint OA Working Groups

- Project duration (dates/years): 2016 – Ongoing
- Location in Canada: National
- Collaborators: NOAA
- Main contact person(s): Denise Joy, Emily Smits

Aquatic Climate Change Adaptation Services Program (ACCASP) Ocean Chemistry Funding

- Project duration (dates/years): Ongoing
- Location in Canada: National
- Collaborators: n/a
- Main contact person(s): Denise Joy, Emily Smits

SDG 14.3.1 Reporting

Sustainable Development Goal 14.3.1 Reporting

- Project duration (dates/years): 2019 - Ongoing
- Location in Canada: National (representative sites in Atlantic, Arctic, and Pacific oceans)
- Collaborators: International effort through IOC-UNESCO
- Main contact person(s): Denise Joy, Emily Smits

Planned Cruises

Atlantic

AZOMP

- The Labrador Sea, GO-SHIP line
- UN SDG 14.3.1 data site,
- Annual, on-going
 - Recent: July-August, 2020
 - Sample analysis completed and data submitted to the data shop.
 - Planned: May-June, 2021
- DFO, funded
- Main contact person(s): Kumiko Azetsu-Scott

AZMP

- 2/ year (Spring and Fall), ongoing
 - Recent: Scotian Shelf, September-October, 2020
 - Sample analyzed, using the secondary in-house standards, data submitted to the program coordinator,

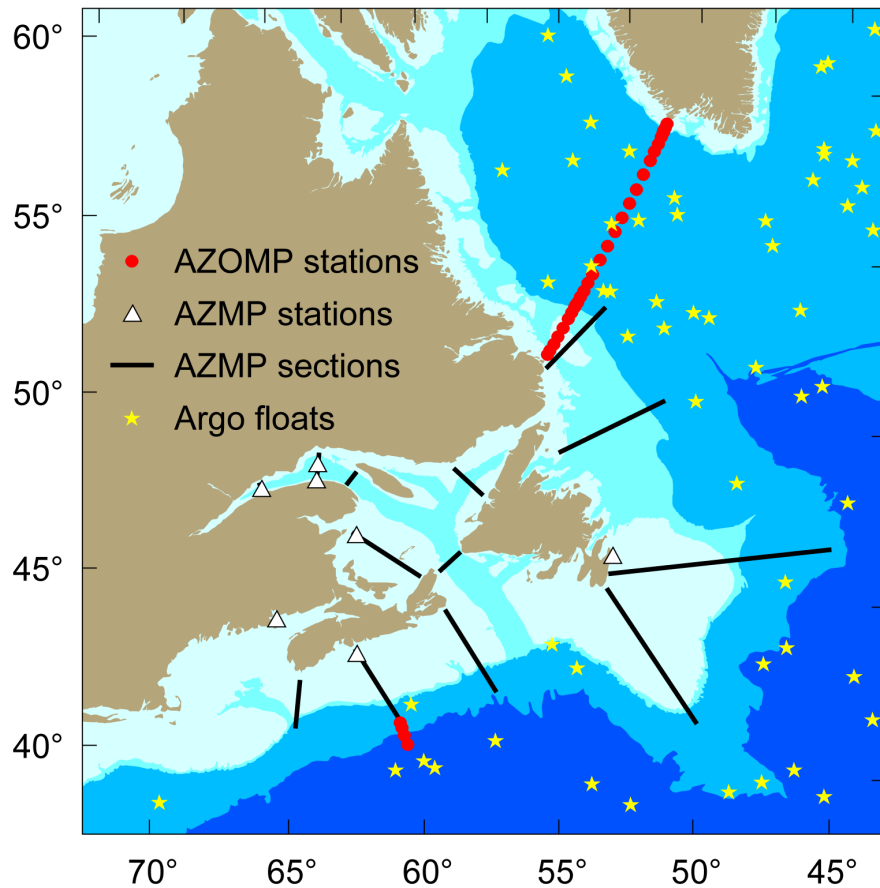
- Planned: May, 2021 and Sep—Oct, 2021
- DFO, funded
- Main contact person(s): Kumiko Azetsu-Scott

AZMP-Bedford Basin

- A bay in Nova Scotia, Canada
- Ongoing (weekly monitoring)
 - Resumed in October, 2020
- DFO, Funded.
- Main contact person(s): Kumiko Azetsu-Scott

Eastern Shore Islands Area of Interest

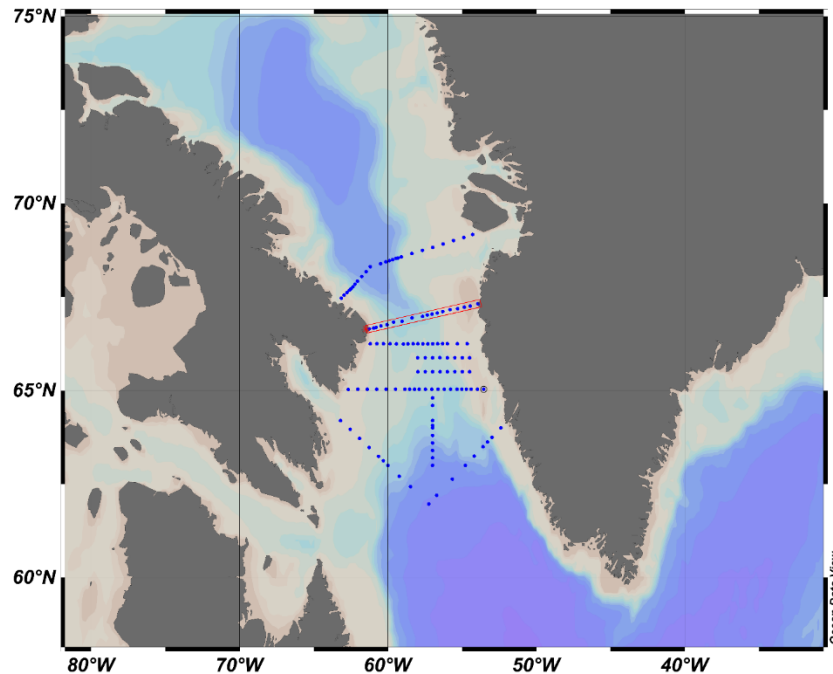
- OA baseline survey for Area of Interest (Marine Protected Area)
- Nova Scotia coastal region,
- Planned: Aug, 2021 (2021 – 2024)
- DFO, funded
- Main contact person(s): Kumiko Azetsu-Scott



Arctic

Davis Strait

- GO-SHIP line, SAS line,
- Annual
 - Previous: 2014-2011, 2013, 2015, completed in Aug. – Sept., 2020.
 - Samples were collected, but not analyzed due to a lack of Certified Reference Materials (CRMs)
- Planned Aug 2021, annual (2020-2025)
- Collaborators: Craig Lee (UW, USA), Colin Stedmon and Marja Koski (DTU, Denmark) and Thomas Juul Pedersen (GINR, Greenland)
- NSF, DFO, ECOTIP funded
- Main contact person(s): Kumiko Azetsu-Scott



Amundsen Science

- Baffin Bay, Northwest Passage, Beaufort Sea
- Ongoing
- Planned Aug. – Nov., 2021
- University of Calgary, ArcticNet funded
- Main contact person(s): Brent Else

Pacific

DFO La Perouse Cruise

- Queen Charlotte Sound
- Planned: late May, 2021

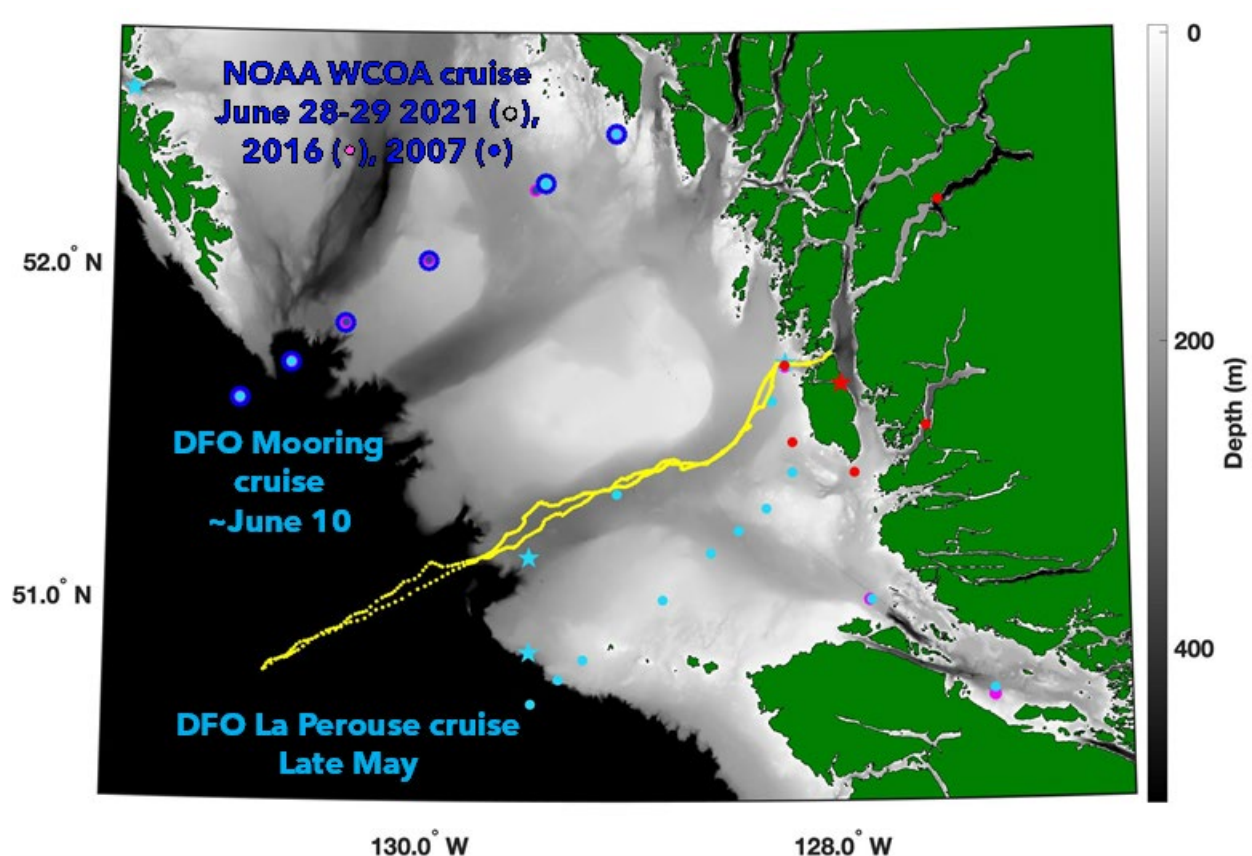
- Collaborators: DFO, Hakai
- Main contact person(s): Wiley Evans

DFO Mooring Cruise

- Queen Charlotte Sound
- Planned: June 10, 2021
- Collaborators: DFO, Hakai
- Main contact person(s): Wiley Evans

NOAA WCOA Cruise

- Queen Charlotte Sound
- Ongoing
 - Previous: 2007, 2016
- Planned: June 28 - 29, 2021
- Additional sampling by Hakai
- Collaborators: NOAA, DFO, Hakai
- Main contact person(s): Wiley Evans

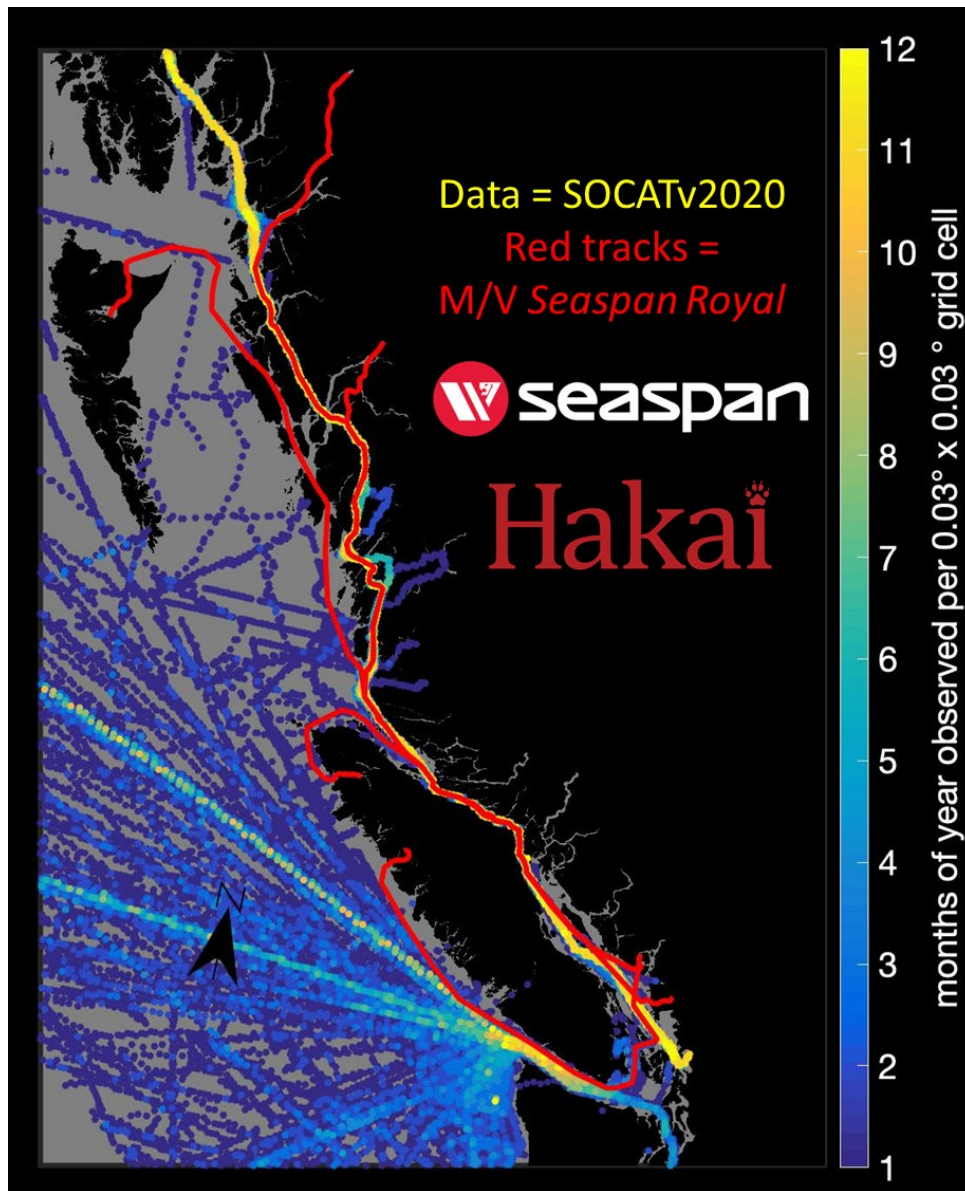


Underway

Pacific

M/V *Seaspan Royal* Underway

- Underway surface ocean and marine boundary layer measurements
- Data = SOCATv2020
- Beginning August 2021
- Collaborators: Seaspan and Hakai Institute
- Main contact person(s): Wiley Evans



Infrastructure/Moorings

Atlantic

Viking Buoy

- pCO₂ and pH at HL-2
- Project duration (dates/years): June 2021- on-going
- Location in Canada: Atlantic Canada (Scotian Shelf)
- Collaborators: n/a
- DFO, funded
- Main contact person(s): Kumiko Azetsu-Scott

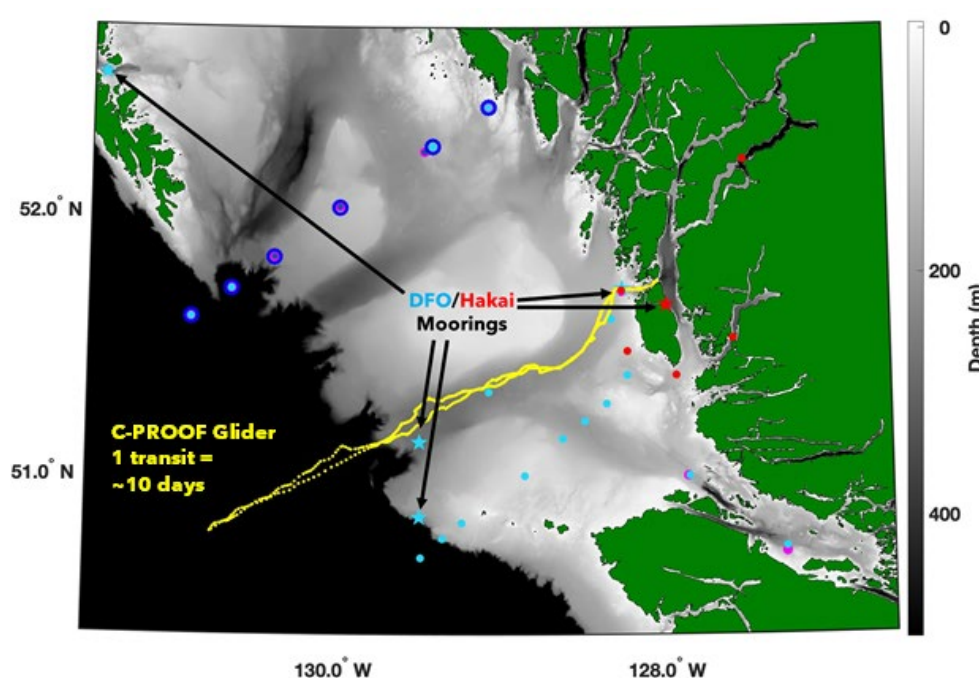
Pacific

DFO Moorings

- 4 moorings in Queen Charlotte Sound
- Sub-surface moorings with pH
- Collaborators: DFO, Hakai
- Proxy-based assessment from mooring and C-PROOF glider observations
- Main contact person(s): Wiley Evans

KC Buoy (Hakai Institute)

- Queen Charlotte Sound
- Continued monthly sampling at KC10
- Continued high-resolution surface ocean and marine boundary layer observations
- Proxy-based assessment from mooring and C-PROOF glider observations
- Main contact person(s): Wiley Evans



C-Proof Glider

- Queen Charlotte Sound
- Proxy-based assessment from mooring and glider observations
- 1 transit = 10 days
- Many different partners including: DFO, Hakai, UBC, UVic, C-PROOF
- Main contact person(s): Wiley Evans

Arctic

Cambridge Bay Observatory

- pH (Seabird), pCO₂ (ProOceanus), seawater sample collection
- (Duke et al., 2021), Elementa
 - <https://doi.org/10.1525/elementa.2021.00103>
- Collaborators: Arctic Research Foundation, MEOPAR, University of Calgary, Ocean Networks Canada, DFO
- Main contact person(s): Brent Else, Richard Dewey

Models

Global

Canadian Earth System Model v. 5

- Project duration (dates/years): Ongoing
- Location in Canada: n/a (global)
- Variables included: T, S, DIC, TA, air-sea CO₂ flux, O₂, pH, Omega_A
- Collaborators: n/a
- (Swart et al., 2019) Geoscientific Model Development
 - <https://doi.org/10.5194/gmd-12-4823-2019>
- (Kwiatkowski et al., 2020) Biogeosciences
 - <https://doi.org/10.5194/bg-17-3439-2020>
- (Arora et al., 2020) Biogeosciences
 - <https://doi.org/https://doi.org/10.5194/bg-17-4173-2020>
- (Séférián et al., 2020) Current Climate Change Reports
 - <https://doi.org/10.1007/s40641-020-00160-0>
- Main contact person(s): James Christian, Neil Swart (ECCC)

Pacific

Northeast Pacific regional ocean biogeochemical model

- Project duration (dates/years): Ongoing
- Location in Canada: British Columbia coast
- Variables included: T, S, DIC, TA, air-sea CO₂ flux, O₂, pH, Omega_A
- Data and more info: <https://open.canada.ca/data/en/dataset/a203a06d-9c1f-4bb1-a908-fe52912ff658>
- Collaborators: n/a

- (Holdsworth et al., 2021) Front. Mar. Sci.
 - <https://doi.org/10.3389/fmars.2021.602991>
- Main contact person(s): James Christian, Amber Holdsworth

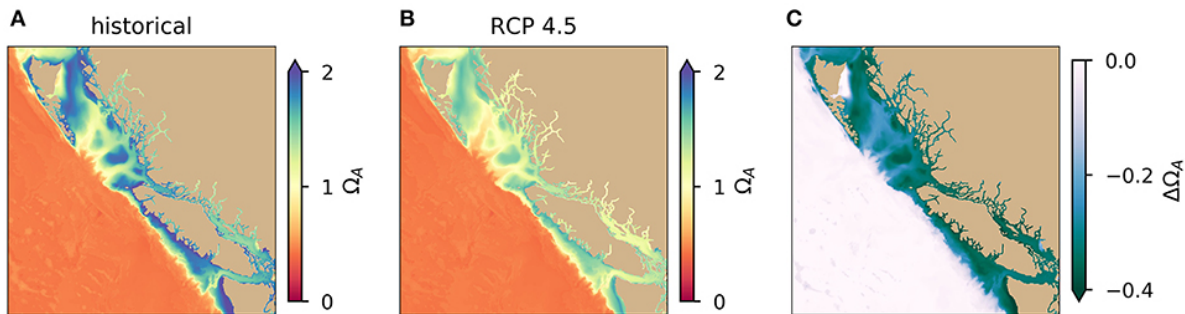


Figure 7 Holdsworth et al., 2021

Observational Studies

Arctic

Coastal-offshore acidification conditions in Baffin Bay/ KEBABB (Knowledge and Ecosystem Based Approach in Baffin Bay)

- Project duration (dates/years): 2019-on-going (no sampling in 2020 due to COVID pandemic)
- Location in Canada: Arctic/Baffin Bay
- Collaborators: Robert Pickard, USA (WHOI)
- Main contact person(s): Christine Michel

Variability & trends in acidification conditions in the Canadian Arctic Archipelago/ KEBABS (Knowledge and Ecosystem Based Approach in Barrow Strait)

- Project duration (dates/years): 2021-2023
- Location in Canada: Canadian Arctic/Barrow Strait
- Collaborators: n/a
- Main contact person(s): Christine Michel, Clark Richards

Risks and impacts of ocean acidification in the Canadian Beaufort Sea/ CBS-MEA (Canadian Beaufort Sea – Marine Ecosystem Assessment)

- Project duration (dates/years): 2017-on-going (no sampling in 2020 due to COVID pandemic)
- Location in Canada: Arctic/Canadian Beaufort Sea
- Collaborators: Richard Feely, USA (NOAA); Nina Bednarsek, USA (SCCWRP)
- (Niemi et al., 2021) Front. Mar. Sci.
 - <https://doi.org/10.3389/fmars.2021.600184>
- Main contact person(s): Christine Michel, Andrea Niemi

Ocean acidification in the presence of sea ice in the High Arctic / BIOTA (Biological Impact of Trends in the Arctic), MAP-Last Ice (Multidisciplinary Arctic Program – Last Ice)

- Project duration (dates/years): 2017-on-going (no sampling in 2020-2021 due to COVID pandemic)
- Location in Canada: Canadian High Arctic, Lincoln Sea
- Collaborators: n/a
- Main contact person(s): Christine Michel

Tuktoyaktuk community based observation

- Project duration (dates/years): March 2020 - ongoing (DFO, suspended this year due to no access to the community)
- Location in Canada: mouth of Mackenzie River, Beaufort Sea coast
- Collaborators: n/a
- Main contact person(s): Kumiko Azetsu-Scott

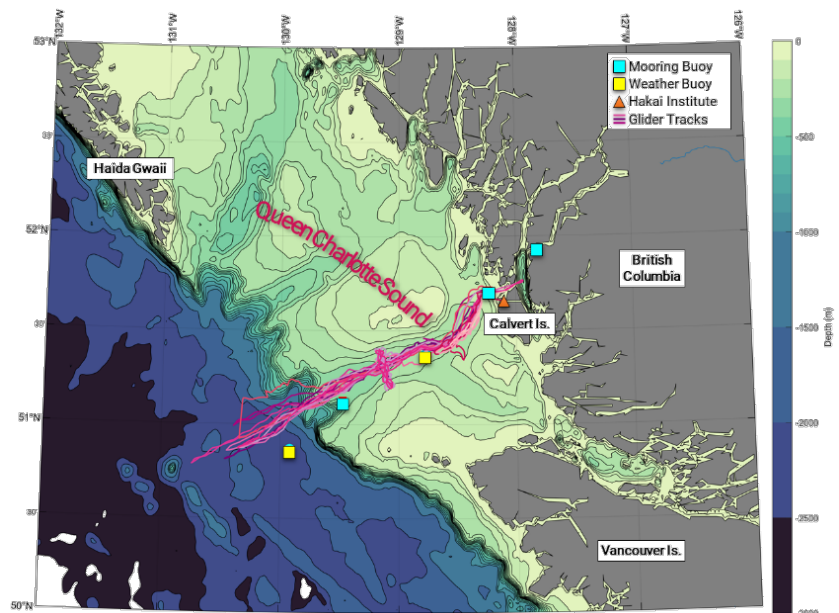
Pacific

Ocean Networks Canada workshop on in situ sensors for ocean acidification research

- Project duration (dates/years): completed 2019
- Location in Canada: Victoria
- Collaborators: P. Bresnahan, D. Murphy
- (Sastri et al., 2019) Front. Mar. Sci.
 - <https://doi.org/10.3389/fmars.2019.00653>
- Main contact person(s): James Christian, Akash Sastri

Marine CO₂ System Variability and Dynamics in Queen Charlotte Sound

- Project Duration: 2018-2023
- Location: Pacific Canada
- Data:
 - Mooring Buoys (DFO, Hakai Institute)
 - Ocean Gliders (C-PROOF)
 - Cruises (DFO, Hakai Institute, NOAA)
- Areas of Interest:
 - Mechanisms of CO₂ system variability in coastal British Columbia



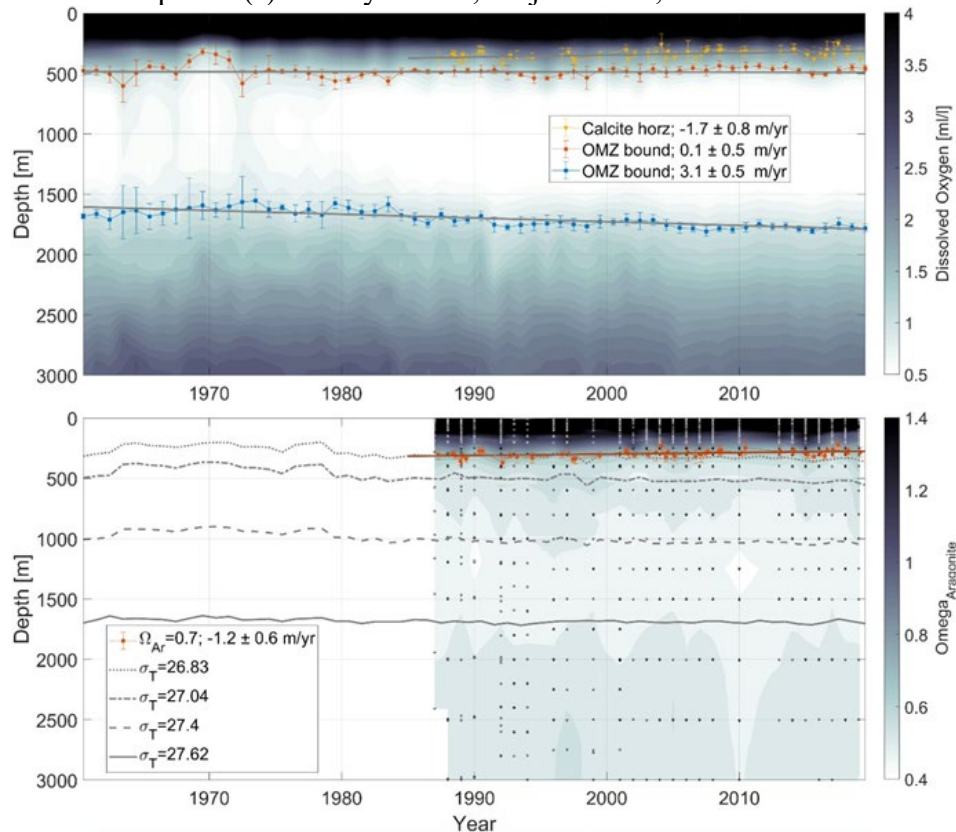
- Open ocean and continental shelf exchange
- Affects of upwelling/downwelling on Ω_{ar} horizon
- Application of multiple linear regression (MLR) algorithms for estimates of CO₂ system parameters using measurements of T, S, & O₂.
- Collaborators: DFO, NOAA, Hakai, UBC, UVic, C-Proof
- Main contact person(s): Ben O'Connor (UBC), Stephanie Waterman (UBC), Wiley Evans (Hakai), Jen Jackson (Hakai)

First-hand knowledge of ocean change: Identifying emerging challenges for shellfish aquaculture in the Northeast Pacific

- Project duration (dates/years): 2018-2021
- Location in Canada: Pacific Canada
- Collaborators: SFU, DFO, NSERC, MEOPAR
- Main contact person(s): Evie Morin, Karen Kohfeld, Debby Ianson

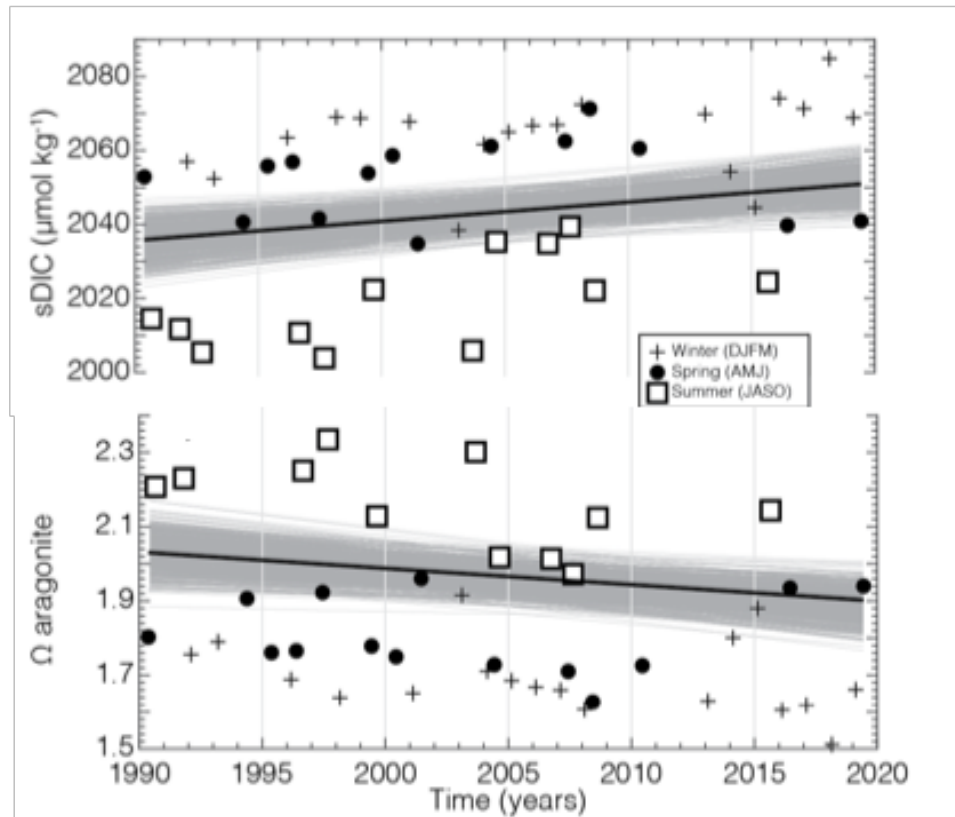
Rapid deep ocean deoxygenation and acidification threaten life on Northeast Pacific seamounts

- Project duration (dates/years): 2018-2020
- Location in Canada: Pacific Canada
- Collaborators: DFO
- (Ross et al., 2020), 2020 Global Change Biology
 - <https://doi.org/10.1111/gcb.15307>
- Main contact person(s): Debby Ianson, Tetjana Ross, Cherisse Du Preez



Anthropogenic and climatic contributions to observed carbon system trends in the Northeast Pacific

- Project duration (dates/years): 2018-2021
- Location in Canada: Pacific Canada
- Collaborators: UBC, DFO, MEOPAR
- Franco et al., in review, GBC
- Main contact person(s): Ana C. Franco, Debby Ianson



Synthesis Studies

National

State of Canada's OA knowledge and infrastructure

- Project duration (dates/years): ongoing
- Location in Canada: national
- Collaborators: OA Community of Practice
- Goals: identify knowledge gaps and critical resources/infrastructure including monitoring datasets, modeling outputs, species responses, possibly socio-economic indicators
- Main contact person(s): Kristina Barclay

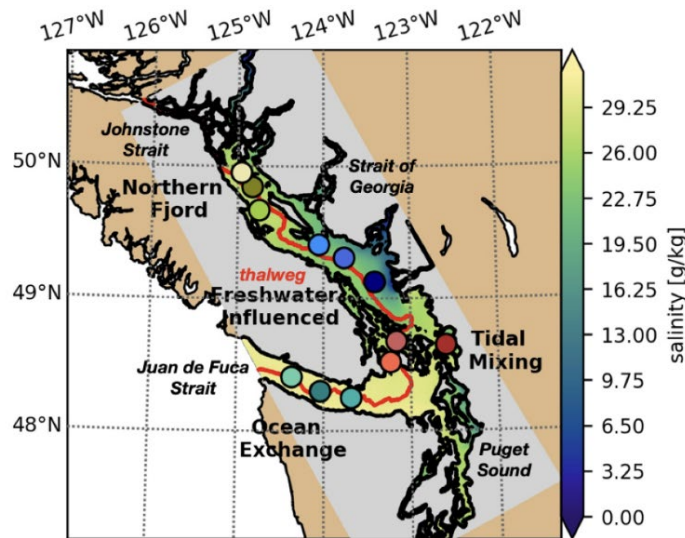
Pacific

PICES North Pacific ocean acidification synthesis report

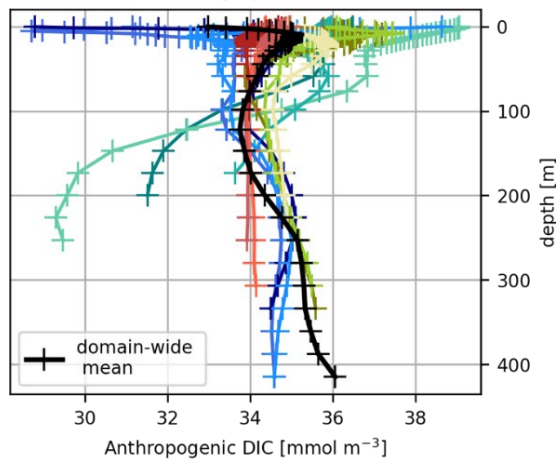
- Project duration (dates/years): completed 2019
- Location in Canada: North Pacific Ocean, British Columbia coast
- Collaborators: Simone Alin, Nina Bednarsek, Richard Feely, J. Martin Hernandez Ayon
- Report (Christian and Ono, 2019), https://meetings.pices.int/publications/special-publications/Special-Report%205-Ocean_Acidification.pdf
- Main contact person(s): James Christian, Sonia Batten (PICES Executive Secretary)

A Submesoscale Modelling Approach to the Past, Present, and Future Carbonate Chemistry Balance of the Salish Sea

- Project duration (dates/years): 2016-2021
- Location in Canada: Pacific Canada
- Collaborators: UBC, DFO, MEOPAR
- Jarnikova et al., in review, GBC
- Main contact person(s): Tereza Jarníková, Debby Ianson, Susan Allen

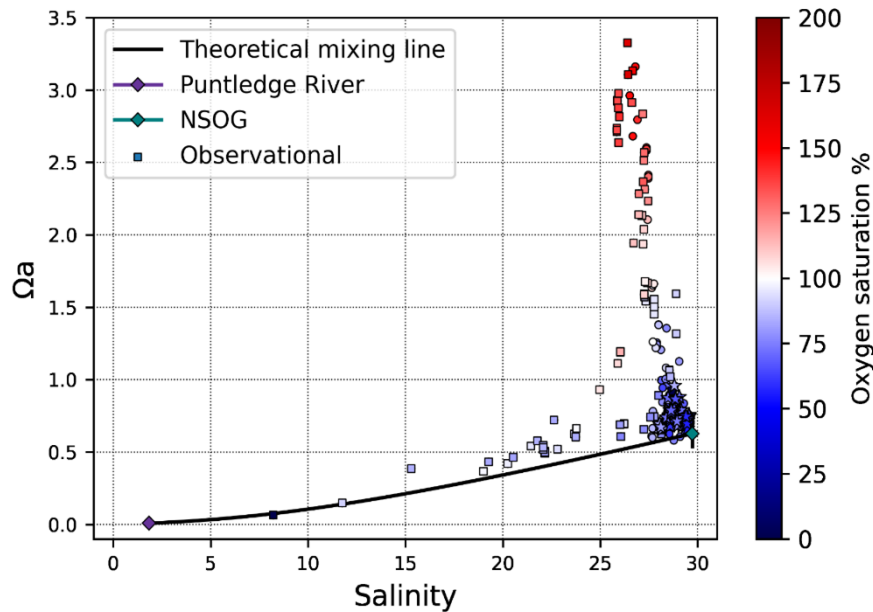


Mean extra DIC by depth
(present-day - preindustrial)



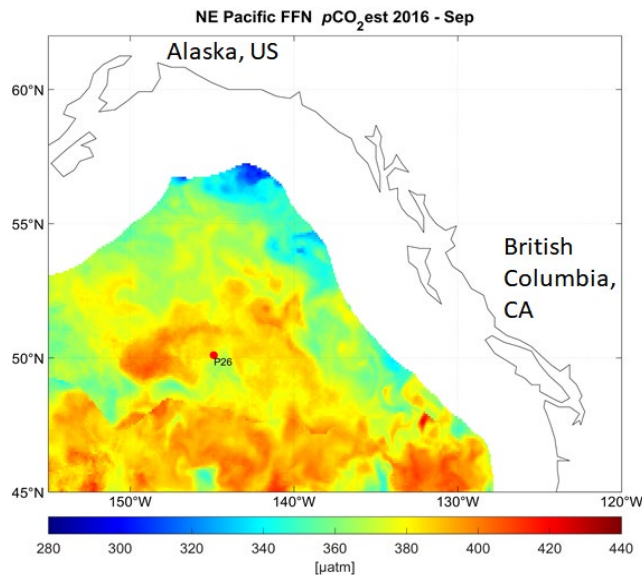
Using Endmember Models to Estimate Seasonal Carbonate Chemistry and Acidification in Temperate Estuaries; (Integrated Coastal Acidification Program)

- Project duration (dates/years): 2015-2021
- Location in Canada: Pacific Canada
- Collaborators: SFU, DFO, MEOPAR
- Simpson et al., in prep
- Main contact person(s): Ellie Simpson, Karen Kohfeld, Debby Ianson



Estimating the NE Pacific Ocean CO₂ Flux using a Neural Network Approach

- Project duration (dates/years): 2019-2023
- Location in Canada: Pacific Canada
- Collaborators: UVic, Canada's Marine Carbon Sink Project, NSERC
- Main contact person(s): Patrick Duke, Roberta Hamme, Debby Ianson



Biological Studies

Atlantic

Impacts of coastal acidification and climate change stressors on the Atlantic sea scallop

- Project duration (dates/years): 2021-2023
- Location in Canada: Atlantic Canada
- Collaborators: Shannon Meseck (NOAA, USA)
- Main contact person(s): Helen Gurney-Smith, Kumiko Azetsu-Scott

Pacific

Selective breeding of Pacific oysters to improve resistance to summer mortality syndrome

- Project duration (dates/years): 2019-2022
- Location in Canada: Vancouver Island (Pacific Region, Canada)
- Collaborators: DFO, VIU
- **OA focus/relevance:**
 - Examining genetic basis for OA resilience: Larvae arising from breeding program applied to OA challenge experiments; “OA-resilient” and “OA-susceptible” larval lineages tested under OA conditions
 - Investigating impacts of OA seawater buffering on the larval oyster microbiome and repercussions for later life stages (i.e. susceptibility to summer mortality)
- Main contact person(s): Chris Pearce (DFO), Tim Green (Vancouver Island University (VIU))

Examining climate-change impacts on US and Canadian commercial shellfish species and potential biomitigation techniques

- Project duration (dates/years): 2021-2023
- Location in Canada: Vancouver Island (Pacific Region, Canada)
- Collaborators: n/a
- **OA focus/relevance:**
 - Investigating impacts of coinciding OA and temperature stressors (regionally-relevant conditions) on juvenile shellfish
 - Examining static and variable stressor conditions
- Main contact person(s): Chris Pearce (DFO), Clara Mackenzie (DFO)

The role of environment in shaping resilience of Pacific oysters to summer mortality syndrome: A comparison of intertidal and deep-water culture sites

- Project duration (dates/years): 2021-2023
- Location in Canada: Vancouver Island (Pacific Region, Canada)
- Collaborators: DFO, VIU
- **OA focus/relevance:**
 - Investigating how physical conditions (including pH and aragonite saturation) may influence summer mortality across different locations (farms) and sites (deep-water vs intertidal culture)

- Interested in how time in the intertidal zone may improve resilience to summer mortality and/or act as a refuge for deep-water cultured oysters during the summer months
- Trialing OA biomitigation strategies (co-culture with macroalgae/sea cucumbers)
- Main contact person(s): Chris Pearce (DFO), Clara Mackenzie (DFO), Tim Green (VIU)

Investigating the impact of ocean acidification on pteropods in the NE Pacific: A multi-method approach

- Project duration (dates/years): 2017-2022
- Location in Canada: Pacific Canada
- Collaborators: UVic, DFO, NSERC
- Main contact person(s): Matt Miller, Debby Ianson, John Dower

An *in situ* pairing of chemical oceanography and ocean acidification physiological responses

- Project duration (dates/years): 2015-present
- Location in Canada: Quadra Island, BC (Hakai Institute)
- Variables included: temperature, salinity, pCO₂ and TCO₂, and then calculating total alkalinity, pH, aragonite and calcite saturation
- Collaborators: n/a
- Summary + current status: This project started in 2015 with goals of examining the physiological response of shellfish to ocean acidification *in situ*. Various shellfish species were outplanted to a raft offshore of the Hakai Institute on Quadra Island, BC and transcriptomics samples were taken at various times of the year alongside detailed continuous carbonate chemistry monitoring. Data is currently being sequenced and analyzed.
- Main contact person(s): Helen Gurney-Smith (DFO), Brenna Collicutt (Hakai Institute)

Pacific oyster spat growth and transcriptomics response under future ocean conditions

- Project duration (dates/years): July/August 2019
- Location in Canada: Quadra Island, BC (Hakai Institute)
- Variables included: temperature, salinity, pCO₂ and TCO₂, and then calculating total alkalinity, pH, aragonite and calcite saturation
- Collaborators: n/a
- Summary + current status: In 2019 a controlled experiment was conducted in Hakai's Marna Wet Lab looking at Pacific oyster spat response to future ocean conditions. Treatments included ambient and high temperatures as well as ambient, mid and high pCO₂ conditions. Oyster spat were measured for growth and sampled to examine transcriptomic responses over three weeks. This study is currently being written up for publication.
- Main contact person(s): Jan Finke, Brenna Collicutt (Hakai Institute)

Climate change effects on marine shellfish - Elucidating transgenerational mechanisms of sensitivity and resiliency under realistic environmental conditions

- Project duration (dates/years): 2020-2021
- Location in Canada: Quadra Island, BC (Hakai Institute)
- Variables included: temperature, salinity, pCO₂ and TCO₂, and then calculating total alkalinity, pH, aragonite and calcite saturation
- Collaborators: n/a
- Summary + current status: Three separate experiments have been conducted to examine the potential for transgenerational plasticity in Pacific oysters and Bay mussels in response to future climate change scenarios. Static as well as dynamic pCO₂ treatments were explored to better represent the natural environment. Experiments have been completed and sample processing and data analysis is underway.
- Main contact person(s): Brenna Collicutt, Iria Gimenez (Hakai Institute)

Climate change effects on marine shellfish - Investigating carbonate chemistry parameters driving larval sensitivity

- Project duration (dates/years): 2020-2022
- Location in Canada: Quadra Island, BC (Hakai Institute)
- Variables included: temperature, salinity, pCO₂ and TCO₂, and then calculating total alkalinity, pH, aragonite and calcite saturation
- Collaborators: n/a
- Summary + current status: Pilot experiments have been conducted to test and fine-tune a novel experimental system capable of decoupling key carbonate chemistry parameters including pH, saturation state and PCO₂. Production of stable dynamic treatments responding to near real-time environmental changing conditions has also been developed and tested.
- Main contact person(s): Iria Gimenez, Brenna Collicutt

Community Resources

OA CoP Resources

Map of Canada's OA resources

- Project duration (dates/years): Jan. 2021 – ongoing
- Location in Canada: National
- Collaborators: OA CoP
- Goal: provide updated, accessible overview of projects and resources
- Not a formal inventory, instead focusing on updates and accessibility
- Please contact us with items to include – coordinator@oceanacidification.ca
- oceanacidification.ca/map-of-canadas-oa-resources
- Main contact person(s): Kristina Barclay

COAST to Coast OA Sensor Package

- Project duration (dates/years): ongoing, seeking funding and collaborators
- Location in Canada: National
- Collaborators: seeking Canadian partners (science and industry)
- Goals: partner aquaculture (shellfish) and mariculture (macroalgae), determine and predict OA impacts, assess low-cost sensors
- Main contact person(s): Brent Else, Helen Gurney-Smith, Kristina Barclay

Database of Canadian OA research outputs and experts

- Project duration (dates/years): ongoing
- Location in Canada: National
- Collaborators: n/a
- Main contact person(s): Kristina Barclay

Outreach/communication plan (new 2020)

- Project duration (dates/years): December 2020 – ongoing
- Location in Canada: national
- Collaborators: n/a
- Goals: increase membership, awareness, and engagement
- Outputs: blog posts, social media posts, new membership list, revamping website
 - **Website: oceanacidification.ca**
- Main contact person(s): Kristina Barclay

DFO Resources

Aquatic Climate Change Adaptation Services Program (ACCASP) Ocean Acidification social media campaign, animated video, etc.

- Project duration (dates/years): 2016 – Ongoing
- Location in Canada: National
- Collaborators: n/a
- Main contact person(s): Denise Joy, Emily Smits

Publications

- Arora, V.K., Katavouta, A., Williams, R.G., Jones, C.D., Brovkin, V., Friedlingstein, P., Schwinger, J., Bopp, L., Boucher, O., Cadule, P., Chamberlain, M.A., 2020. Carbon – concentration and carbon – climate feedbacks in CMIP6 models and their comparison to CMIP5 models. *Biogeosciences* 17, 4173–4222. [https://doi.org/https://doi.org/10.5194/bg-17-4173-2020](https://doi.org/10.5194/bg-17-4173-2020)
- Christian, J.R., Ono, T., 2019. Ocean Acidification and Deoxygenation in the North Pacific Ocean. *PICES Spec. Publ.* 5, 116.
- Duke, P.J., Else, B.G.T., Jones, S.F., Marriot, S., Ahmed, M.M.M., Nandan, V., Butterworth, B., Gonski, S.F., Dewey, R., Sastri, A., Miller, L.A., Simpson, K.G., Thomas, H., 2021. Seasonal marine carbon system processes in an Arctic coastal landfast sea ice environment observed with an innovative underwater sensor platform. *Elem. Sci. Anthr.* 9, 1–21. <https://doi.org/10.1525/elementa.2021.00103>

- Holdsworth, A.M., Zhai, L., Lu, Y., Christian, J.R., 2021. Future Changes in Oceanography and Biogeochemistry Along the Canadian Pacific Continental Margin. *Front. Mar. Sci.* 8, 1–20. <https://doi.org/10.3389/fmars.2021.602991>
- Kwiatkowski, L., Torres, O., Bopp, L., Aumont, O., Chamberlain, M., R. Christian, J., P. Dunne, J., Gehlen, M., Ilyina, T., G. John, J., Lenton, A., Li, H., S. Lovenduski, N., C. Orr, J., Palmieri, J., Santana-Falcón, Y., Schwinger, J., Séférian, R., A. Stock, C., Tagliabue, A., Takano, Y., Tjiputra, J., Toyama, K., Tsujino, H., Watanabe, M., Yamamoto, A., Yool, A., Ziehn, T., 2020. Twenty-first century ocean warming, acidification, deoxygenation, and upper-ocean nutrient and primary production decline from CMIP6 model projections. *Biogeosciences* 17, 3439–3470. <https://doi.org/10.5194/bg-17-3439-2020>
- Niemi, A., Bednaršek, N., Michel, C., Feely, R.A., Williams, W., Azetsu-Scott, K., Walkusz, W., Reist, J.D., 2021. Biological Impact of Ocean Acidification in the Canadian Arctic: Widespread Severe Pteropod Shell Dissolution in Amundsen Gulf. *Front. Mar. Sci.* 8, 1–16. <https://doi.org/10.3389/fmars.2021.600184>
- Ross, T., Du Preez, C., Ianson, D., 2020. Rapid deep ocean deoxygenation and acidification threaten life on Northeast Pacific seamounts. *Glob. Chang. Biol.* 26, 6424–6444. <https://doi.org/10.1111/gcb.15307>
- Sastri, A.R., Christian, J.R., Achterberg, E.P., Atamanchuk, D., Buck, J.J.H., Bresnahan, P., Duke, P.J., Evans, W., Gonski, S.F., Johnson, B., Juniper, S.K., Mihaly, S., Miller, L.A., Morley, M., Murphy, D., Nakaoka, S., Ono, T., Parker, G., Simpson, K., Tsunoda, T., 2019. Perspectives on in situ sensors for ocean acidification research. *Front. Mar. Sci.* <https://doi.org/10.3389/fmars.2019.00653>
- Séférian, R., Berthet, S., Yool, A., Palmiéri, J., Bopp, L., Tagliabue, A., Kwiatkowski, L., Aumont, O., Christian, J., Dunne, J., Gehlen, M., Ilyina, T., John, J.G., Li, H., Long, M.C., Luo, J.Y., Nakano, H., Romanou, A., Schwinger, J., Stock, C., Santana-Falcón, Y., Takano, Y., Tjiputra, J., Tsujino, H., Watanabe, M., Wu, T., Wu, F., Yamamoto, A., 2020. Tracking Improvement in Simulated Marine Biogeochemistry Between CMIP5 and CMIP6. *Curr. Clim. Chang. Reports* 6, 95–119. <https://doi.org/10.1007/s40641-020-00160-0>
- Swart, N.C., Cole, J.N.S., Kharin, V. V., Lazare, M., Scinocca, J.F., Gillett, N.P., Anstey, J., Arora, V., Christian, J.R., Hanna, S., Jiao, Y., Lee, W.G., Majaess, F., Saenko, O.A., Seiler, C., Seinen, C., Shao, A., Sigmond, M., Solheim, L., Von Salzen, K., Yang, D., Winter, B., 2019. The Canadian Earth System Model version 5 (CanESM5.0.3). *Geosci. Model Dev.* 12, 4823–4873. <https://doi.org/10.5194/gmd-12-4823-2019>



Global Ocean Acidification
Observing Network



Ocean Acidification
International
Coordination Centre

OA-ICC

Update OA Mexico 2021

J. Martín Hernández Ayón



Universidad Autónoma
de Baja California,
Ensenada, México



Regional action plan on ocean acidification for Latin America and the Caribbean (2019)



http://www.goa-on.org/documents/resources/oa-regional_action_plan-la_carib-fren_eng.pdf

For managing and adapting to the challenge of ocean acidification needs:

- better understand and **quantify the changes** now happening in the ocean;
- **understand the consequences** of those changes **on ecosystems and society**;
- better and **rapidly communicate** that information to those who need to know; and
- ensure politicians, decision-makers and **policy-makers are armed** with the latest facts to help make the best and boldest decisions in light of these increasingly serious conditions.

In Mexico where we are?

- better understand and **quantify the changes** now happening in the ocean: **“Major Effort”**
- **understand the consequences** of those changes on **ecosystems and society**: **“Efforts”**
- better and **rapidly communicate** that information to those who need to know: **“We are working on”**
- ensure politicians, decision-makers and **policy-makers are armed** with the latest facts to help make the best and boldest decisions in light of these increasingly serious conditions: **“Some progress”**

Overview of Mexico OA

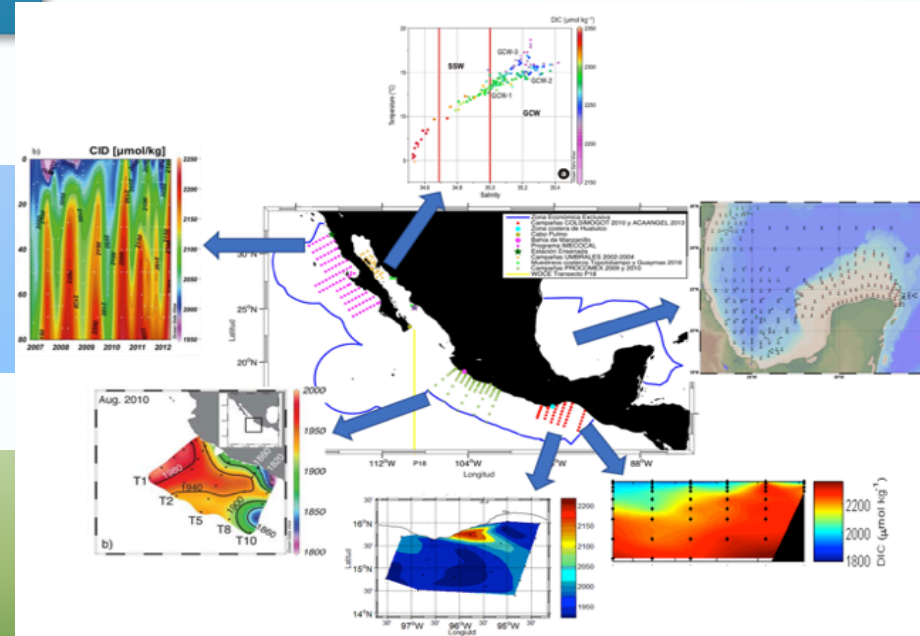
is across different ecosystems

Monitoring coastal areas:
Major Efforts

Setup instrument to study pH or pCO₂ changes & responses:
Some work

Ecosystem responses?
Good Progress

Biogeochemistry Models:
Models for the GoM



Monitoring coastal areas:

Dra. Leticia Espinosa
IPN-CIIDIR Sinaloa



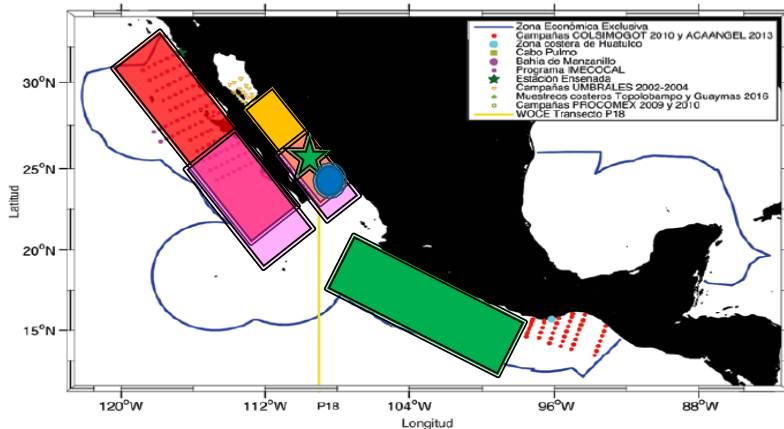
Dr. Gilberto Gaxiola C.



ICMyL



INAPESCA
INSTITUTO NACIONAL DE PESCA
Y ACUICULTURA



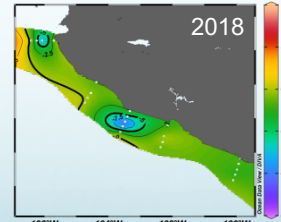
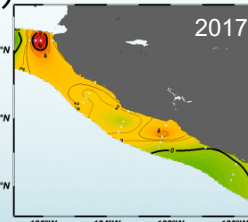
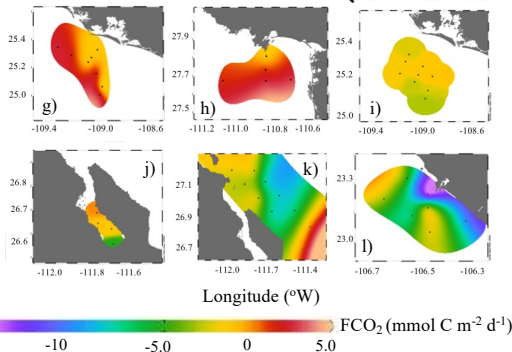
In collaborations with SEMAR, UNAM-ICML and INAPESCA, we are monitoring:

- 2016-2018 the Gulf of California
- 2017-2019 the Pacific Tropical Mexican
- 2019 Baja California Sur and Gulf of California
- 2020 Baja California, Baja California Sur and Gulf of California
- 2017 Sinaloa buoy
- 2021 El Elefante reef

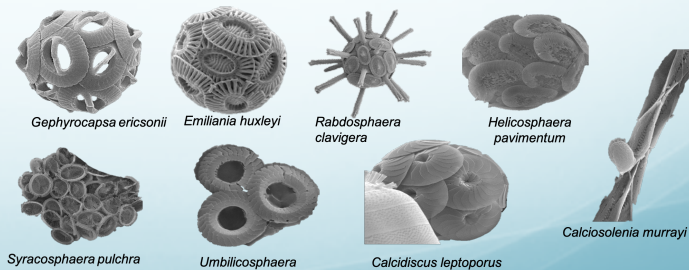
FCO₂ (mmol C m⁻² d⁻¹)

Gulf of California (2016-2017)

Pacific Tropical Mexican



Baja California 2020, coccolithophori



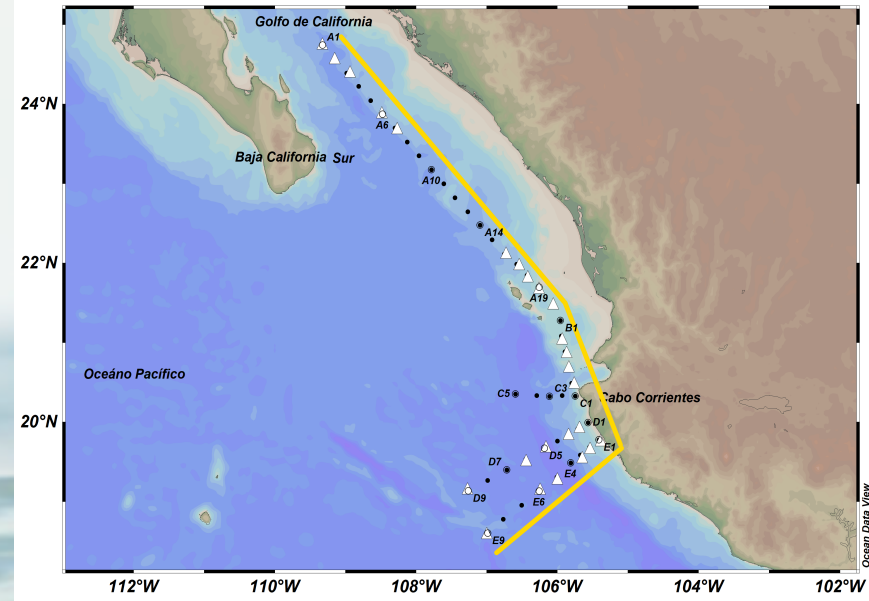
Students: Pedro Morales, Lorena Flores, Itahi de la Cruz, Lizbeth Guzmán, Yamili Covarrubias, Madeline Molina, Perla Silva



Universidad Autónoma de Baja California
Facultad de Ciencias Marinas
Instituto de Investigaciones Oceanológicas



Ocean-atmosphere carbon fluxes in the oxygen minimum zone of the Mexican Tropical Pacific

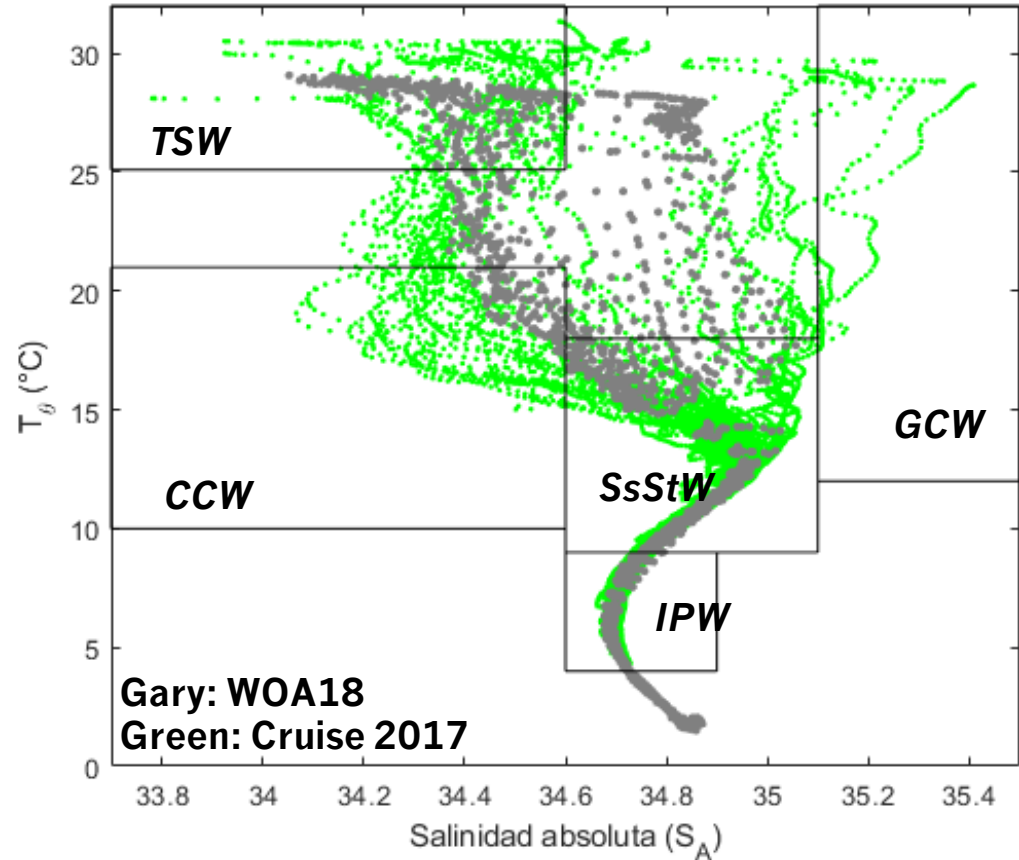
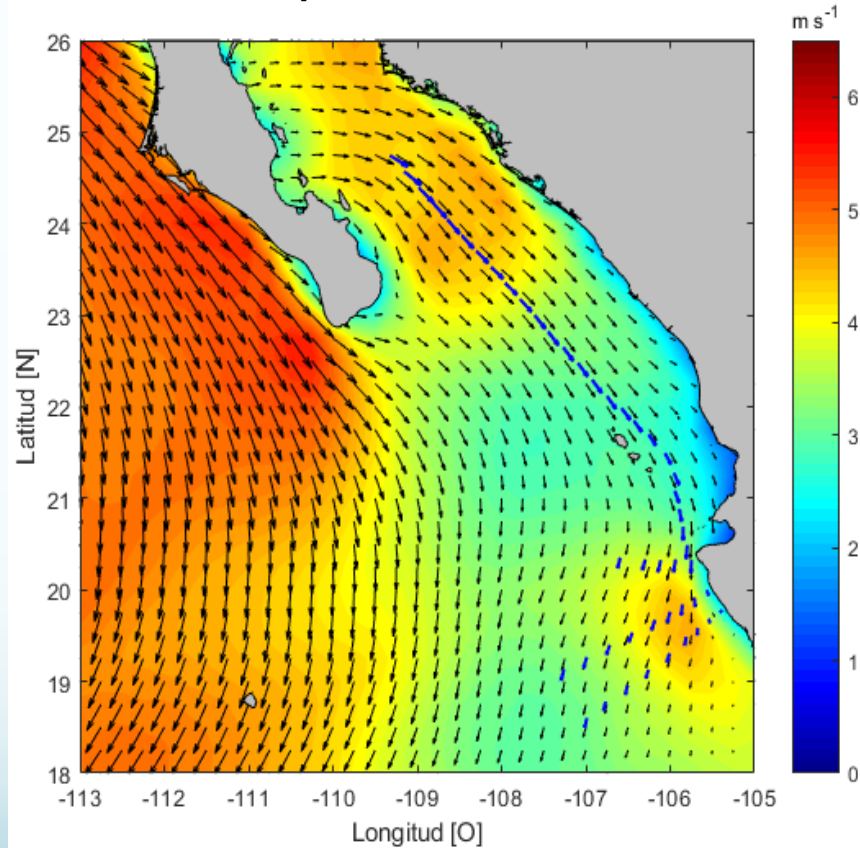


09 de octubre del 2020, Ensenada, B.C

Cupul et al., (In Prep).

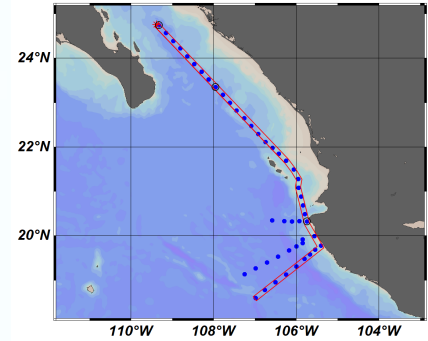
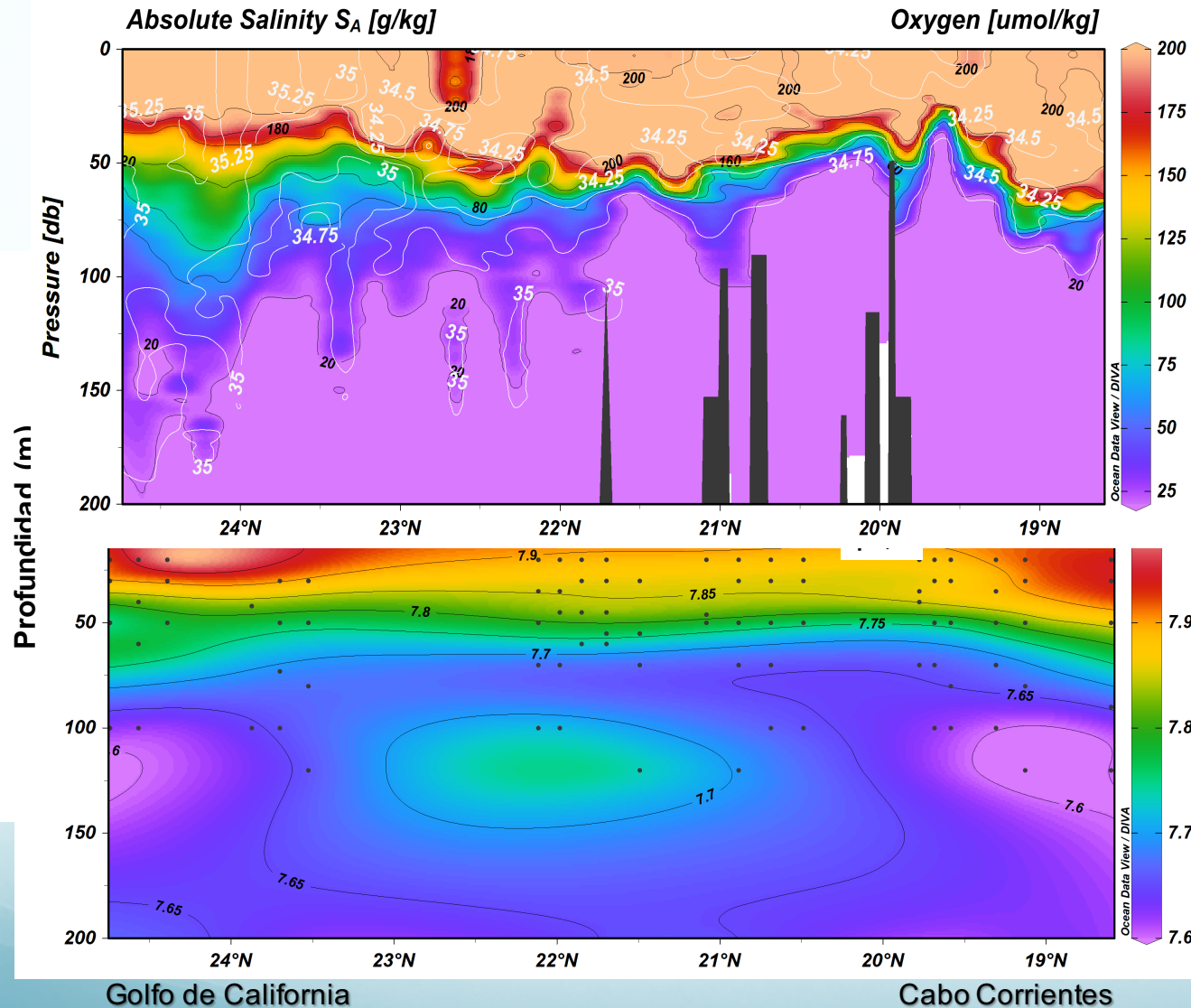
La Niña Condition 2017

Speed Winds



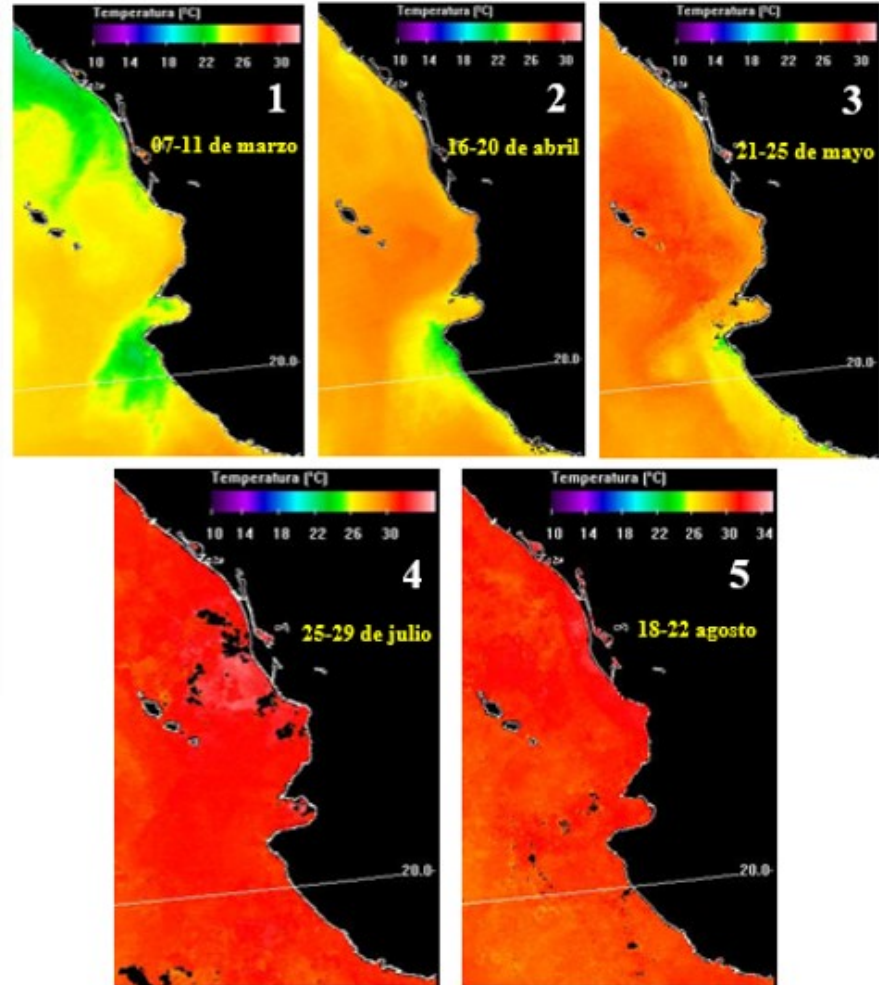
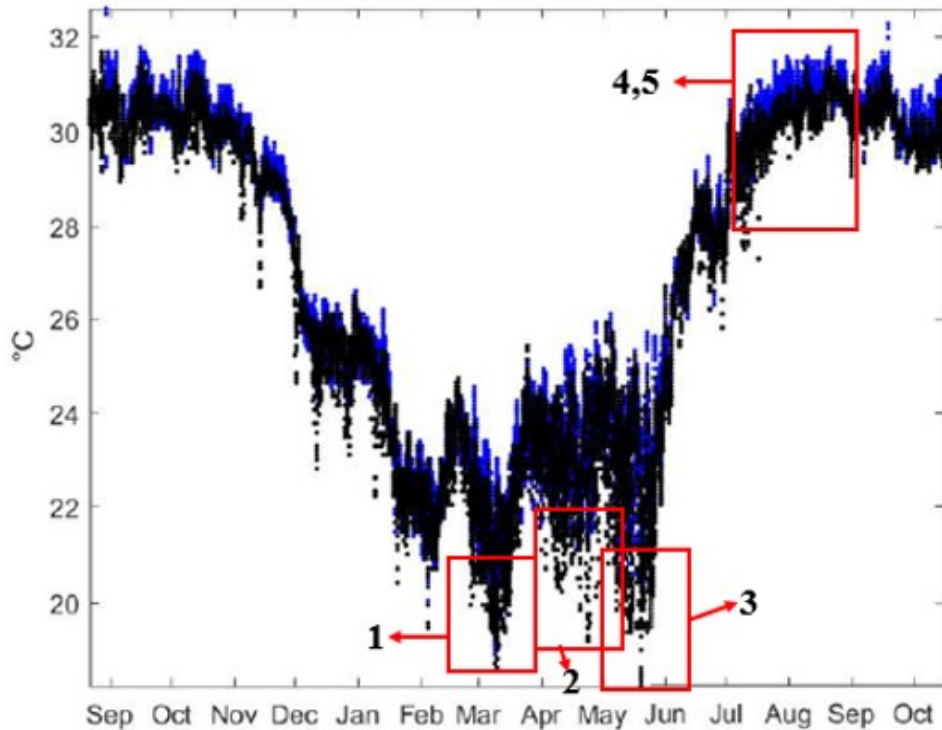
During the cruise in october 2017, the circulation changed as spring-summer

Oxygen and pH_T



More oxygen and high pH
Because anomaly
output flow of
California surface
water

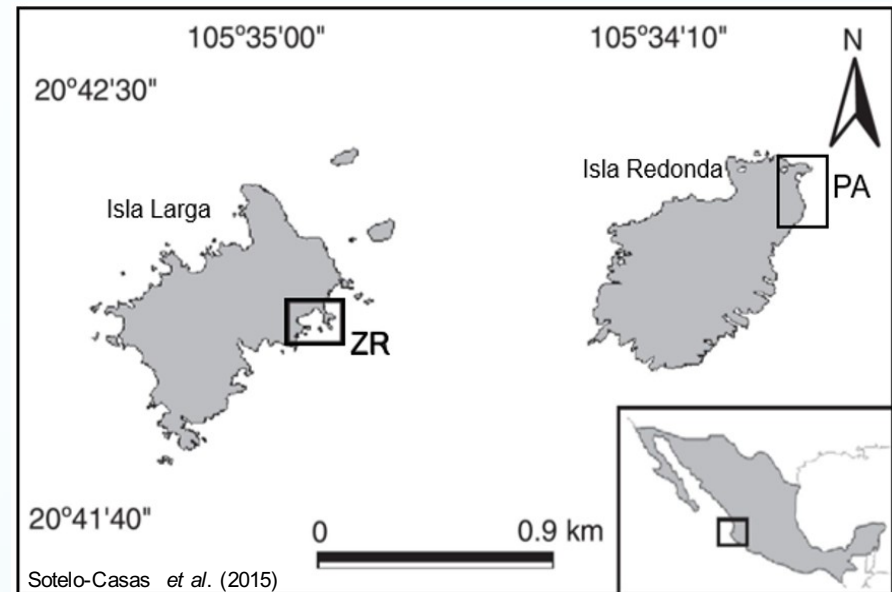
Upwelling in Cabo Corrientes

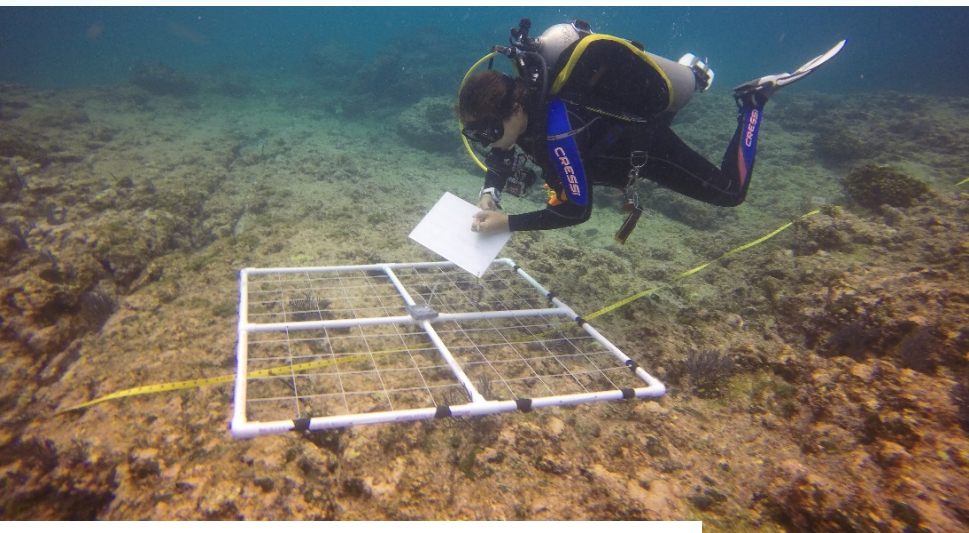
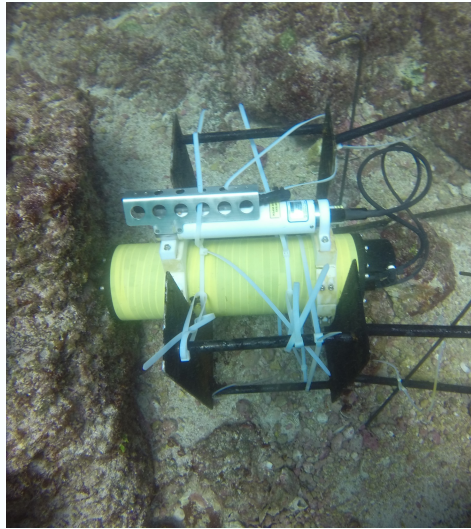


Cupul M. et al (In prep)

Parque Nacional Islas Marietas

- ✓ Since 2005 by CONANP
- ✓ One of the most important reef systems in the Mexican Pacific.
- ✓ Fringing reef composed of patches of the genus *Pocillopora* spp., *Porites* spp. and *Pavona* spp.





Evaluation and monitoring of the effect of Climate Change on the coral communities of the Central Mexican Pacific

- Evaluate the effect of positive and negative thermal anomalies events on the coral communities
- Understand, from the organism level to the ecosystem level, the effect of the thermal variations observed in the reefs and coral communities of the Central Mexican Pacific.
- Integrate the effect of ocean acidification on the coral community in order to evaluate the possible present and future scenarios of global climate change.

Naturally acidified coastal environments: A window into the future to assess the effects of OA on calcifying organisms

Question:

Coral calcification response to OA vary regard acclimatation regimes

Methods Approach:

Two coral communities inhabiting distinct pH regimes (non vs. naturally acidified)

Searching low-pH stress indicators on calcification
Sclerochronology

Measuring stressors' variability

(°C, pH, $\Omega_{\text{aragonite}}$)

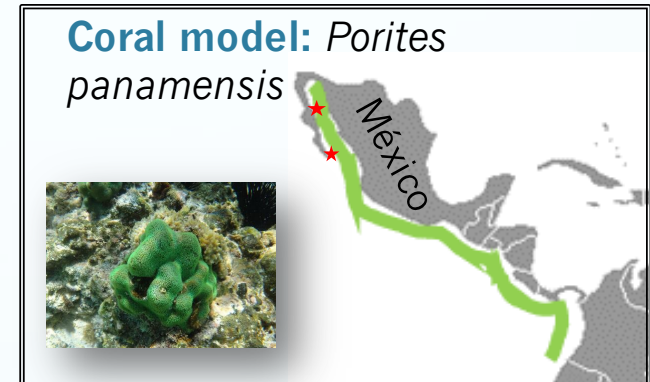
Diurnal to Seasonal

Defining thresholds

Coral response to OA

OA scenarios experiments

(Physiology proxies: calcification, respiration, etc.)

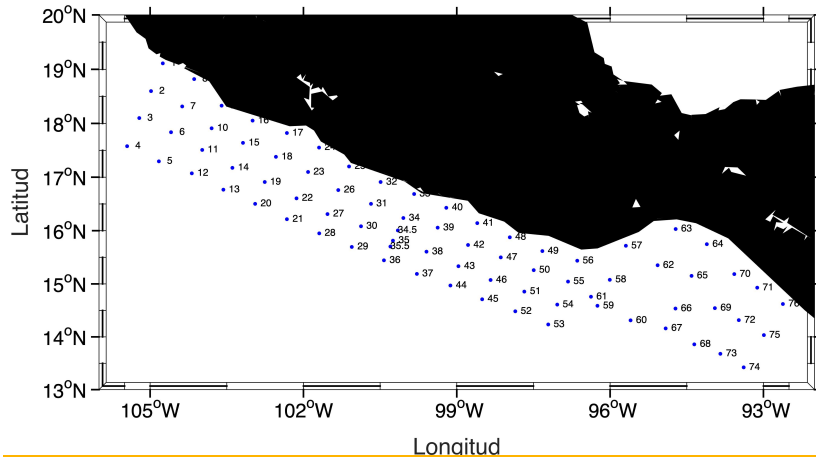


Expected Outcomes:

Coral physiology response(s) to OA
Synergistic effects and potential feedbacks

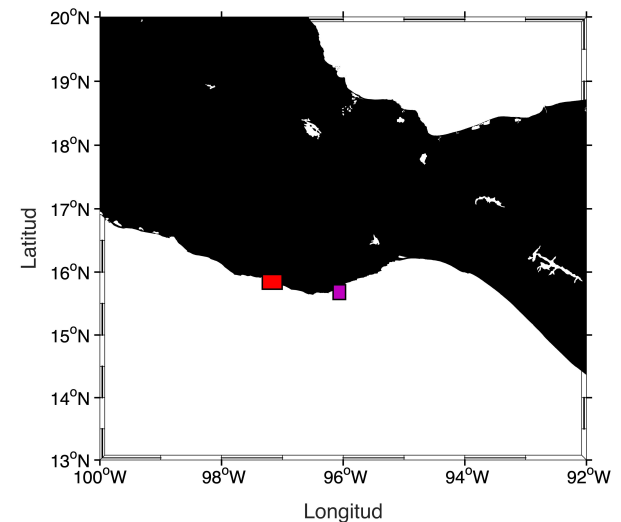
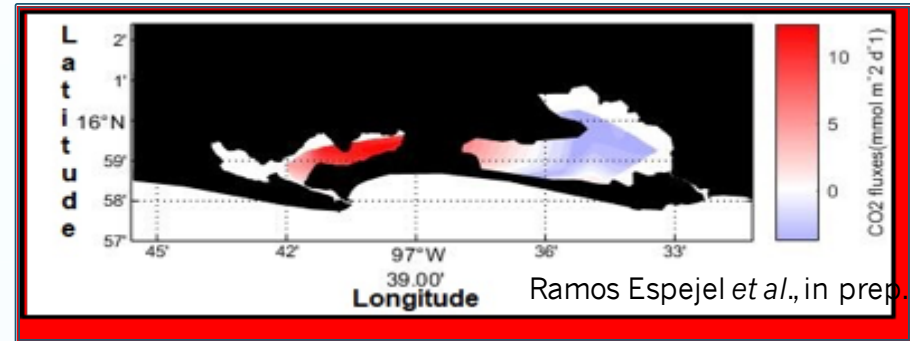
Huatulco Coast, February, 2020

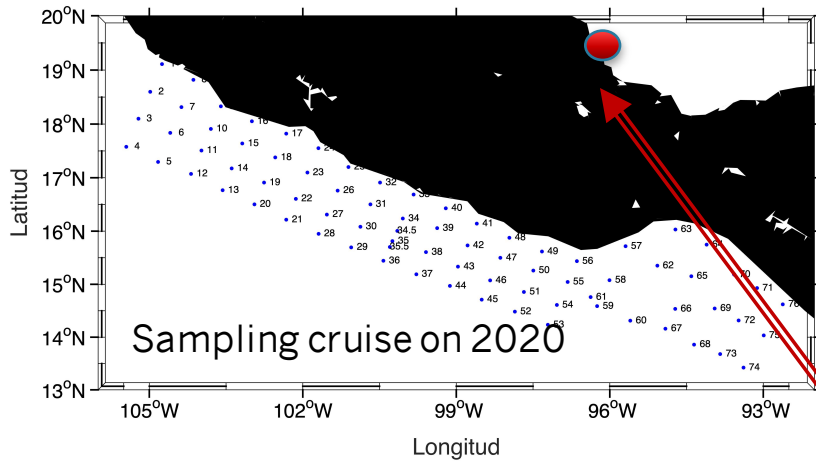
DIC-rich water reaches the coast
(>2km from the shoreline) at 20-30m
depth.



New research projects:
Spatio-temporal variability of the
biogeochemical processes in the
Coastal zone of the Gulf of
Tehuantepec and its relationship
with zooplankton.

Chacahua Lagoon National Park CO₂ fluxes
ranging from -3.8-12.43 mmol m²d⁻² during
the dry season



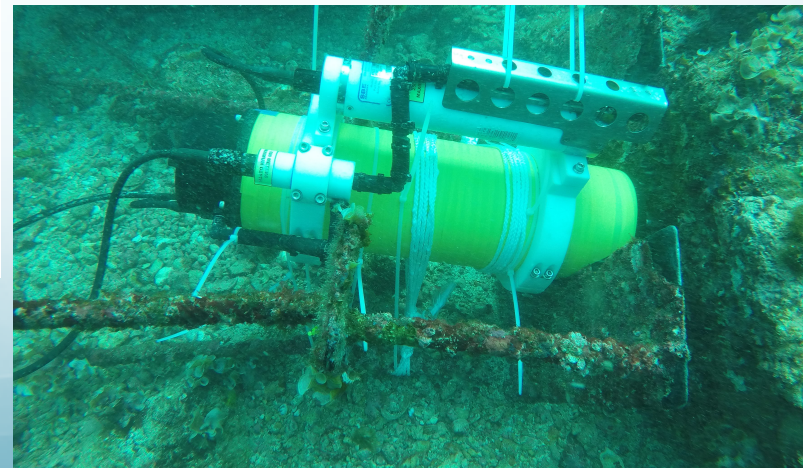
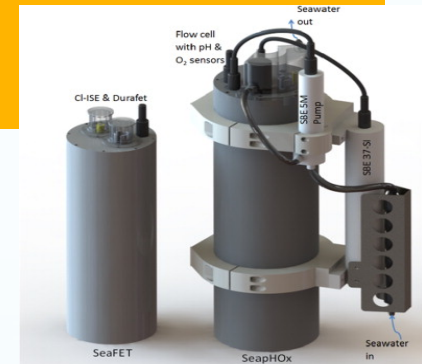
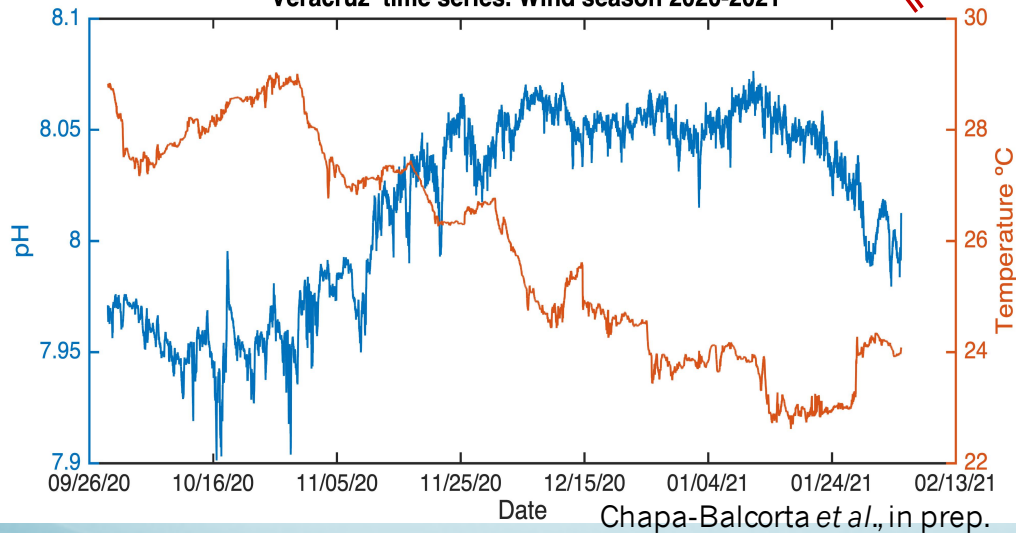


Veracruz coastal moored SeapHox

pH Variability larger than expected

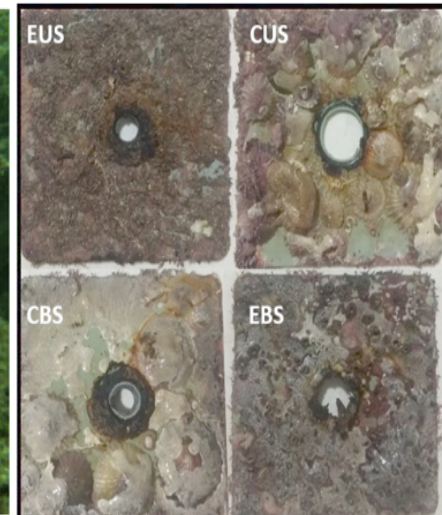
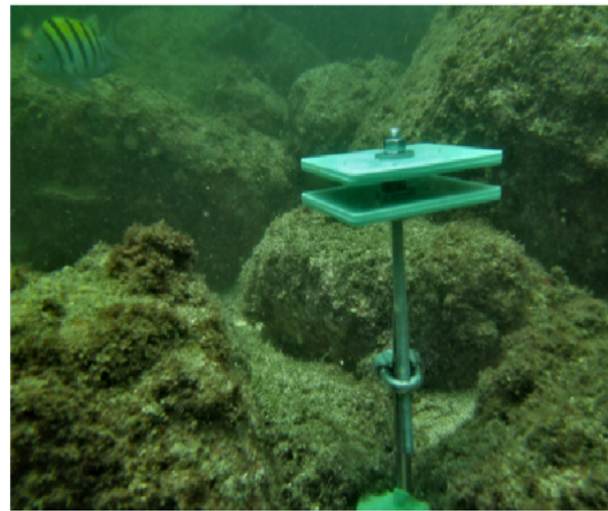
Marked diel variations

Veracruz time series. Wind season 2020-2021



Effects of OA on sclerobionts of the eastern tropical Pacific

Aim: To estimate calcification rate of encrusting organisms under different environments



Study site (left), artificial fouling structure in situ (middle) and four micro-habitat tiles colonized by encrusting calcifiers after six months (right).



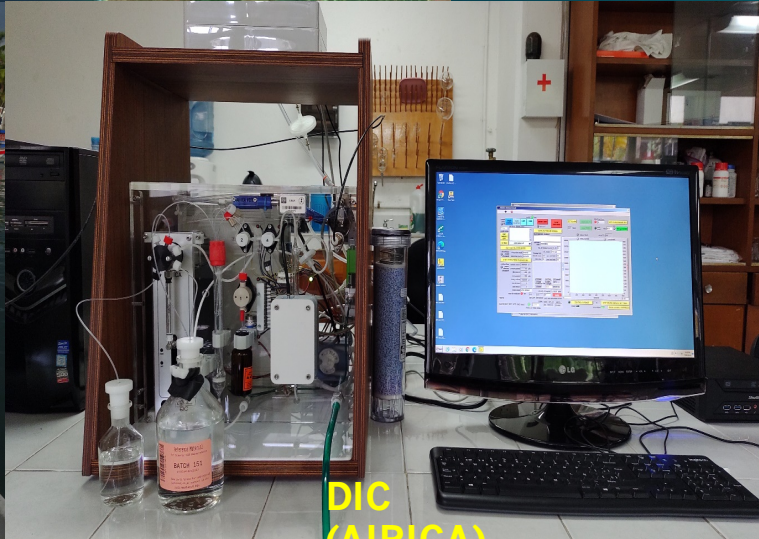
Coastal observatory
of global change.
Mazatlan, NE Pacific)



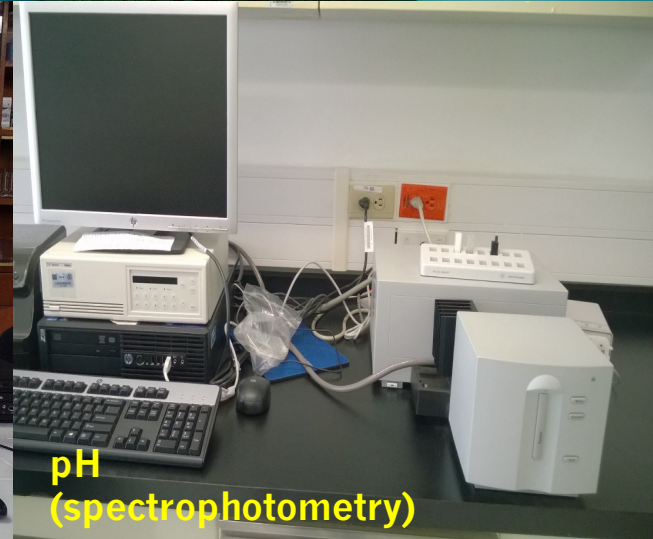
Coral records
(Caribbean Sea)



~Monthly
sampling



DIC
(AIRICA)



pH
(spectrophotometry)

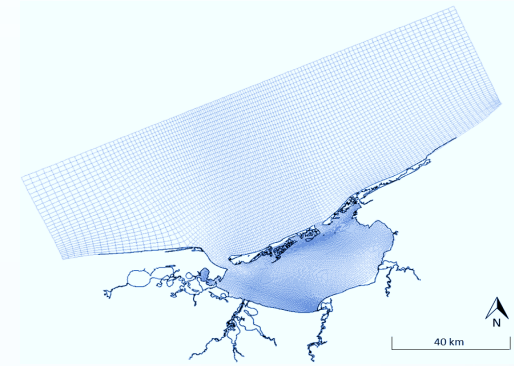
Coastal acidification in a tropical lagoon



Instituto de Ciencias del Mar y Limnología

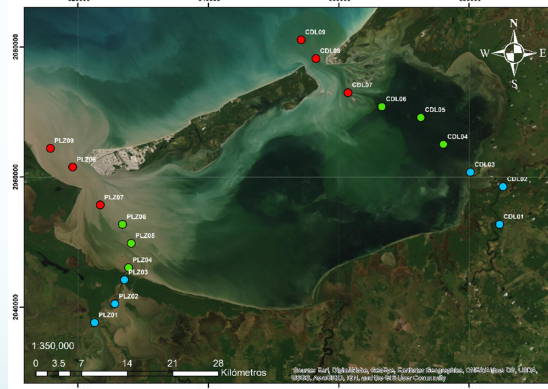
Ecological modelling laboratory.
Dr. José Gilberto Cardoso Mohedano

Model

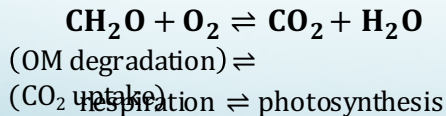
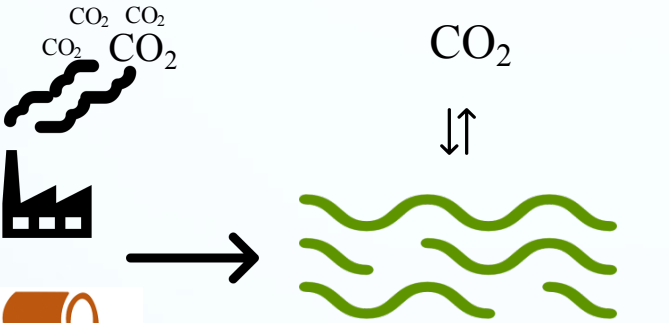


- ✓ Hydrogeochemical 3D model with DELFT 3D software.
- ✓ Study of river influences: Palizada and Candelaria.
- ✓ Modelling of: pH, alkalinity, CO₂, DIC and dissolved carbonate species

Determination of TIC,
Alkalinity and pH.



Términos Lagoon, Campeche, México



Organic Matter
Nutrients
(Eutrophication)

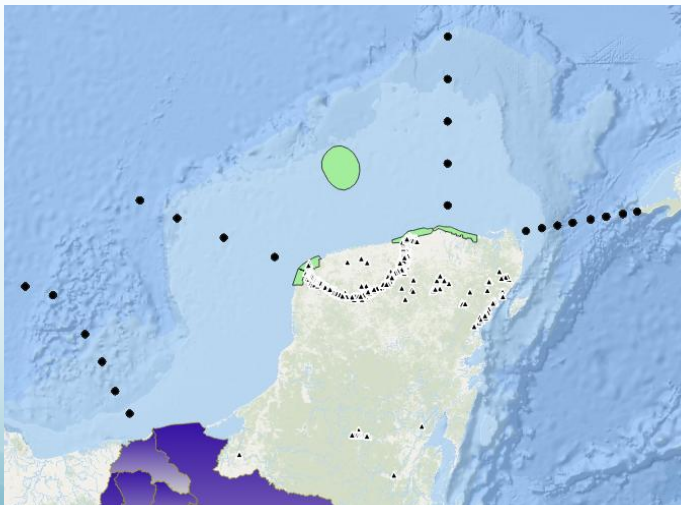
BIOMARCCA: Marine biodiversity and climate change lab

Ongoing research

The role of groundwater flow of the carbonate system from karstic environments.

Potential impacts of pH and $\Omega_{\text{aragonita}}$ on the distribution and diversity patterns of pteropods from the Gulf of Mexico. ECOSUR-CICESE-NOAA

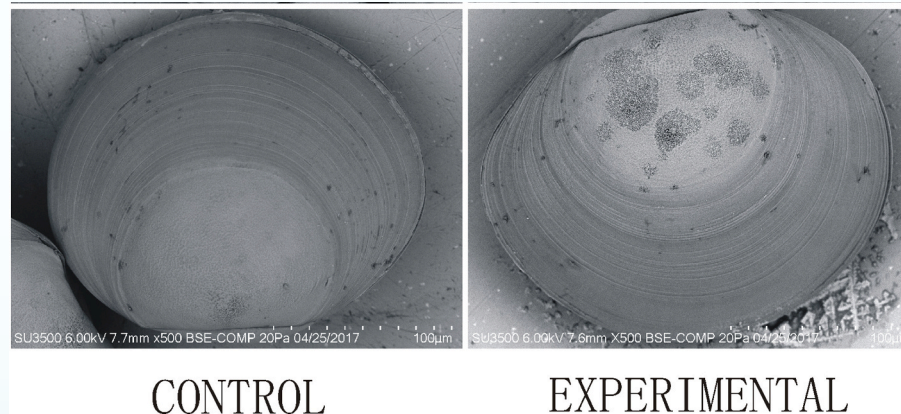
Biochemistry of the carbonate system in the Yucatan continental Shelf. IIO – UABC, CIGoM



Tomada de <https://www.xenotes.com/es/que-son-los-cenotes/>

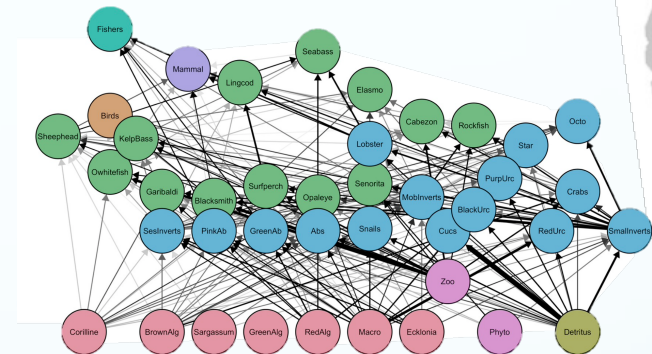
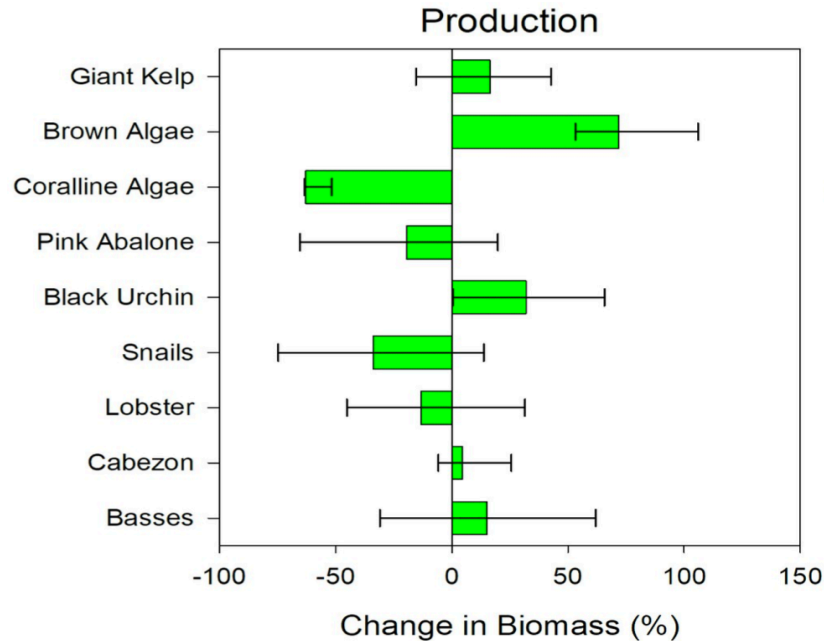
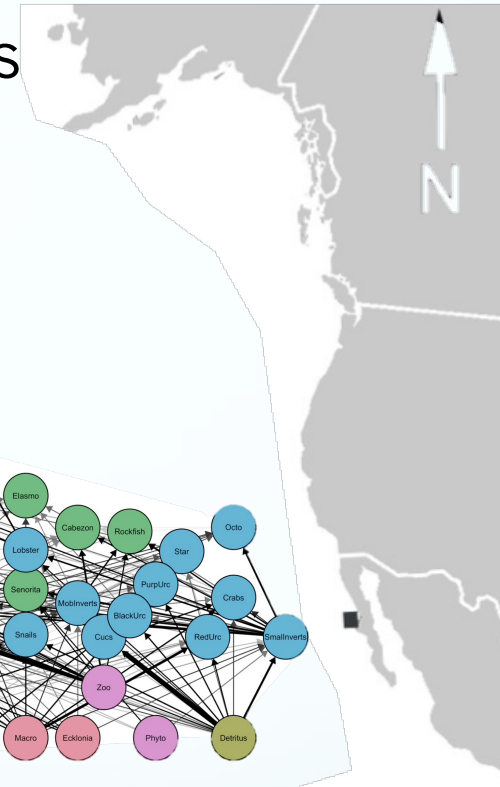


Acidification stress effect on umbonate veliger larval development in *Panopea globosa*



The gene expression analyses reported high expression values for nicotinamide adenine dinucleotide (NADH) dehydrogenase and Perlucin in larvae at pH 7.5, suggesting a higher energetic cost in this larval group to maintain homeostasis.

Forecasting ocean acidification in Kelp forests

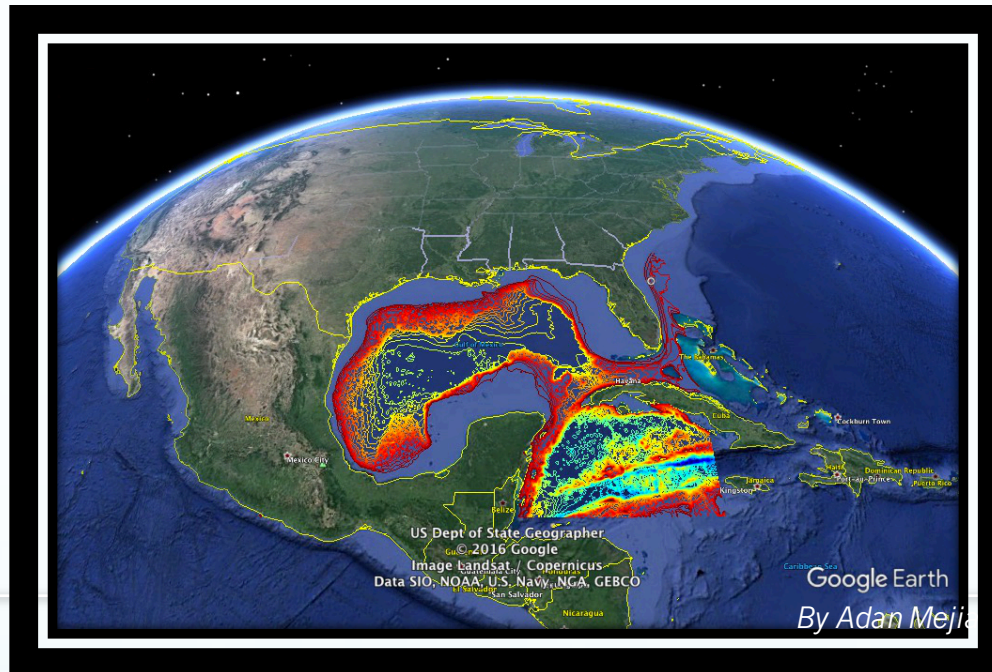


Schlenger et al., 2021 PlosOne

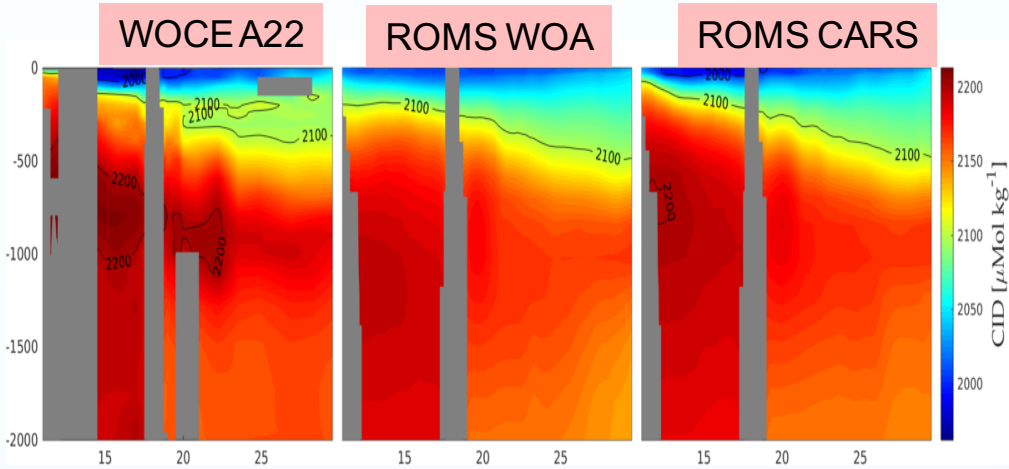
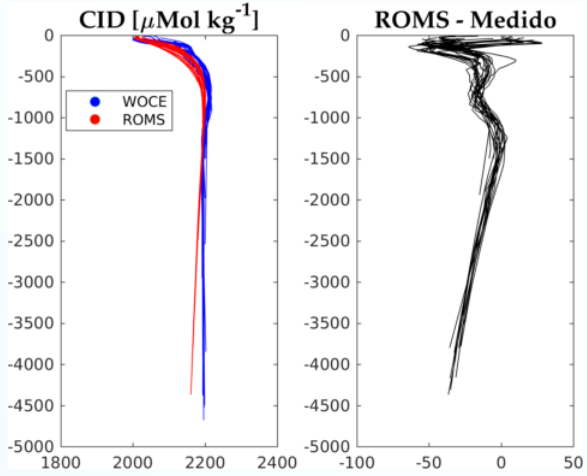
Simulations of the effect that have a decrease of 0.5pH in 50 years in a trophic web of submarine forests in the Californias. There is good news for some species and super bad news for others. The results of these simulations suggest that these ecosystems will maintain their productivity in a more acidic ocean. Unfortunately, they will be completely different systems.

J.Martin Hernández-Ayón, Ivonne Montes, Joel Sudre,
Sorayda Tanahara, Alberto Zirino, Victor Camacho y Giovani Durante

BIOEBUS Model



Transects of the DIC from North Atlantic section: Comparison of simulations of the BioEbus Model vs International Bases of Word Ocean Experiment (WOCE)



Vertical section of Dissolved Inorganic Carbon (DIC) differences between ROMS and WOCE.

Red shows the CID for ROMS (October Average), and Blue shows data from WOCE (October, 2013) and CARS (October Average).

Better and **rapidly communicate** that information to those who need to know



INTERNATIONAL CARBON
SYMPOSIUM IN MÉXICO
MONTERREY, NUEVO LEÓN

First Call

Monterrey, Nuevo León
October **13** to **15**, 2021

Main topic:
Natural Climate Solutions and Carbon Markets:
towards an effective carbon neutrality

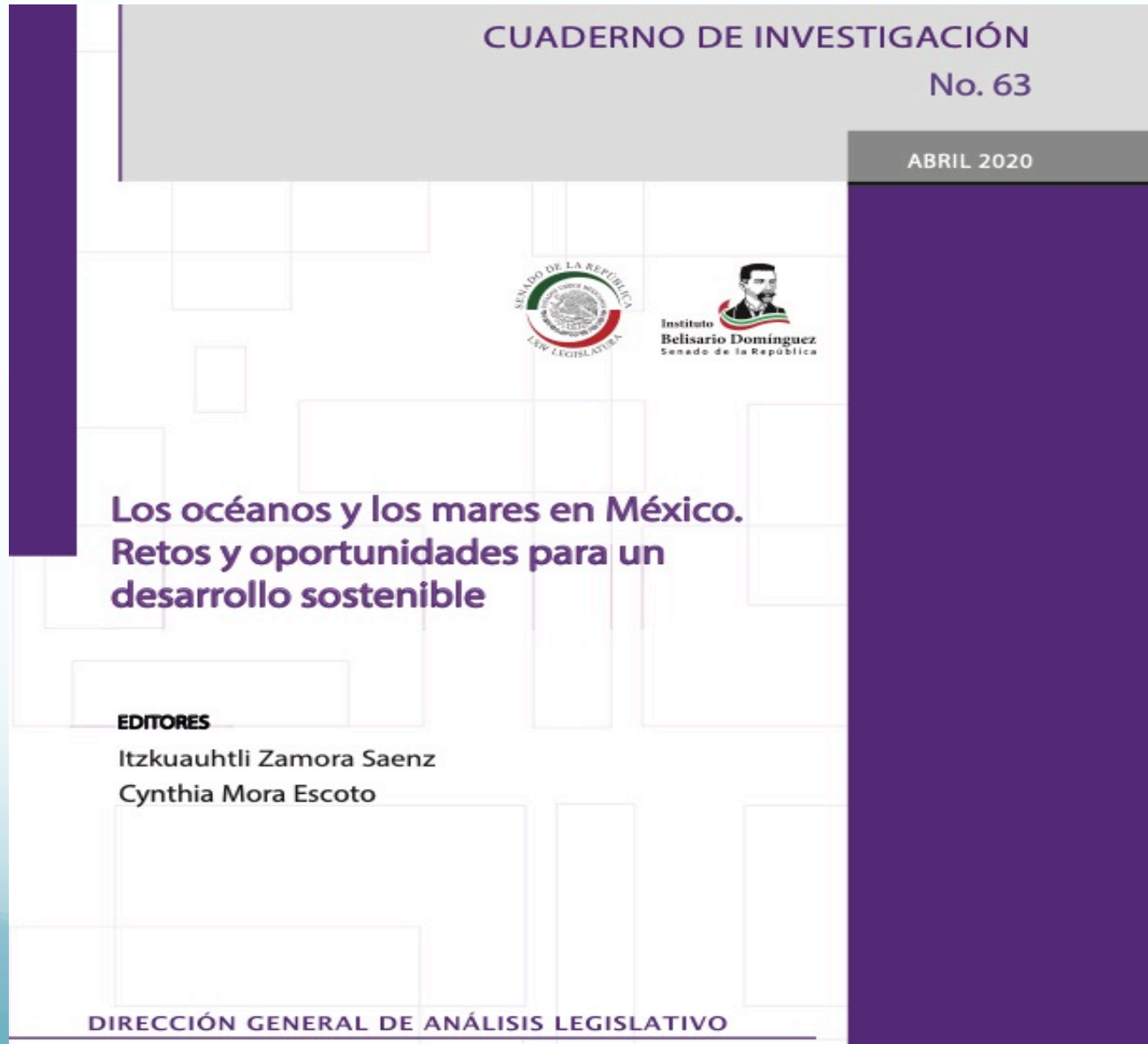


VIRTUAL EVENT

PMC
Programa Mexicano del Carbono
RED TEMÁTICA DEL CONACYT

May 21

“Ensure politicians, decision-makers and **policy- makers are armed** with the latest facts to help make the best and boldest decisions in light of these increasingly serious conditions”



Overview of Mexico OA

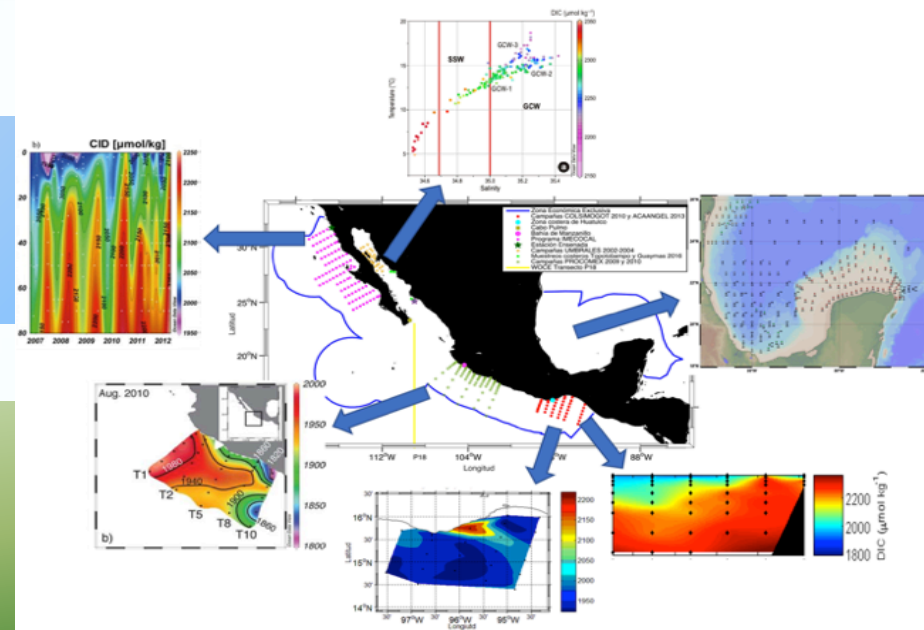
is across different ecosystems

Monitoring coastal areas:
Major Efforts

Setup instrument to study pH or pCO₂ changes & responses:
Some work

Ecosystem responses?
Good Progress

Biogeochemistry Models:
Models for the GoM



Ocean Acidification in the Gulf of Mexico: Drivers, Impacts, and Unknowns

Emily Osborne¹, Xiping Hu², Emily R. Hall³, Melissa R. McCutcheon², Michael Acquafredda⁴, Martin Hernandez Ayon⁵, Leticia Barbero^{1,6}, Cecilia Chapa-Balcorta⁷, Casey Galvin⁸, Dwight Gledhill⁴, Fabian Gomez¹, Tacey Hicks⁹, Alain Munoz¹⁰, Orion Norzagaray⁵, Hauke Kite-Powell⁸, Katie Shamberger⁹, Jennifer Vreeland-Dawson⁹, Yuan-Yuan Xu⁶, and Kimberly Yates¹⁰

¹Atlantic Oceanographic and Meteorological Laboratory, National Oceanographic and Atmospheric Administration, Miami, FL, USA ²Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, USA ³Mote Marine Laboratory, Sarasota, FL, USA ⁴Ocean Acidification Program, National Oceanographic and Atmospheric Administration, Silver Spring, MD, USA ⁵Autonomous University of Baja California, Mexico ⁶Cooperative Institute for Marine and Atmospheric Studies, Rosenstiel School for Marine and Atmospheric Science, University of Miami, Miami, FL, USA ⁷Instituto de Recursos, Universidad del Mar. Puerto Angel, Oaxaca, Mexico ⁸Woods Hole Oceanographic Institution, Marine Policy Center, Woods Hole, Massachusetts, USA ⁹Department of Oceanography, Texas A&M University, College Station, TX, USA ¹⁰Center for Environmental Studies in Cienfuegos, Cuba ¹¹US Geological Survey, St. Petersburg, FL, USA



Created by Barbara Ambrose

COASTAL ACIDIFICATION NETWORKS



C-CAN
California Current
Acidification
Network

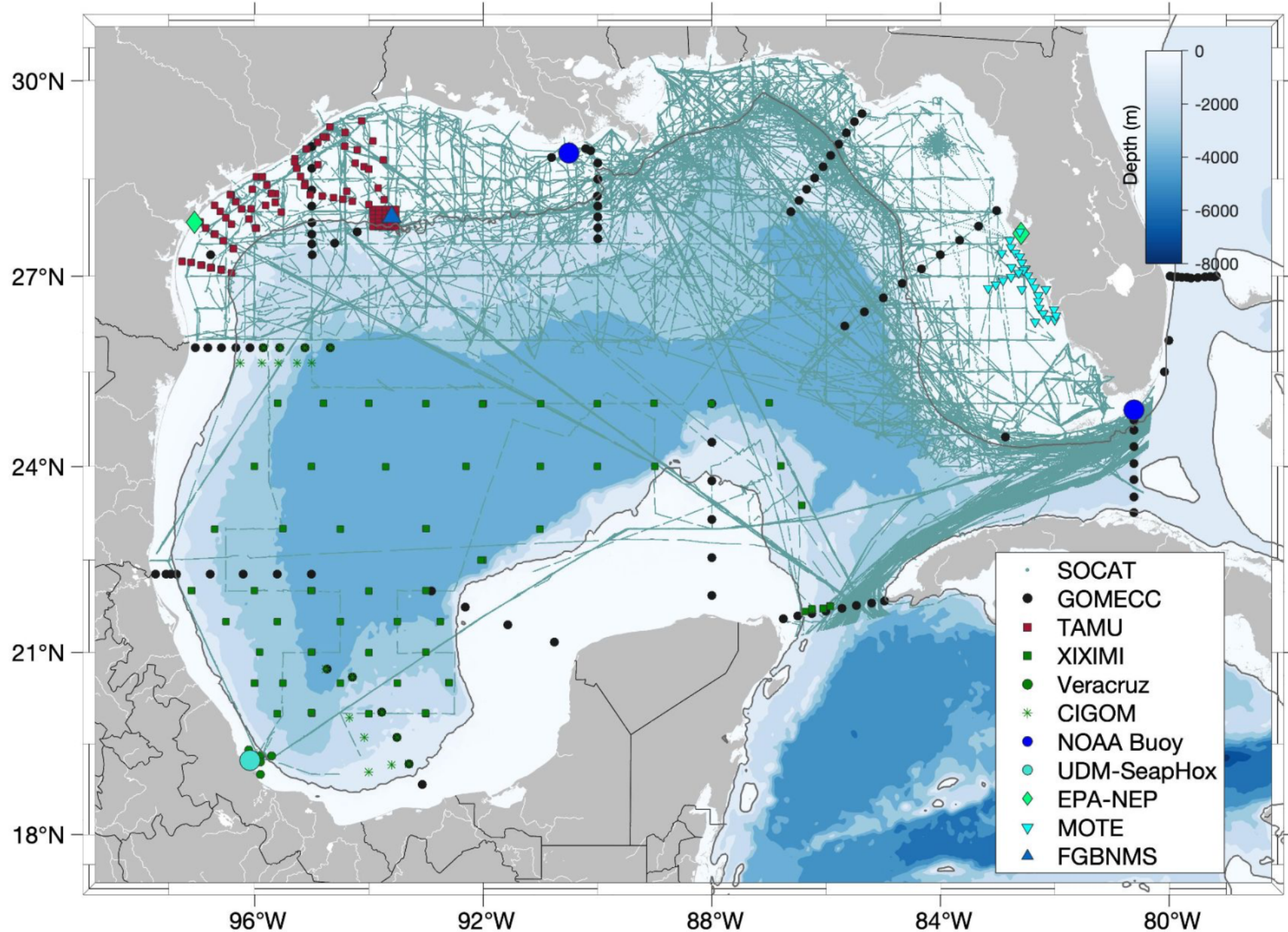
**GULF OF MEXICO
COASTAL
ACIDIFICATION
NETWORK**



SOCAN
Southeast Ocean and Coastal
Acidification Network

**NORTHEAST
COASTAL ACIDIFICATION
NETWORK**

OA Monitoring in the Gulf of Mexico



**Physical & Chemical
Drivers of
Gulf of Mexico
Acidification**

Air-Sea CO₂
Exchange

Ocean
Circulation

SLR & Coastal
Inundation

Episodic
Storm Events

Freshwater
Influx

Eutrophication
and Hypoxia

Ocean
Warming

Submarine
groundwater
discharge

Oil Spills and
Seeps

Biological Impacts of Gulf of Mexico Acidification

Essential Ecosystem Services

Coral Reefs

Oyster Reefs

Mangroves

Seagrass Beds

Salt Marshes

Microbe Communities

Phytoplankton

Ecologically* Important Species *Low Trophic

Harmful Algae

Crustose Coralline Algae

Economically Important Species

Gulf Shrimp

Coral Reefs

Finfish

Stone Crab

Spiny Lobster

Sponges

Sea Urchin

Blue Crab

Queen Conch

Bay Scallop

Oysters

Hard Clam

Gulf of Mexico Ocean Acidification
RESEARCH AND MONITORING PRIORITIES

Build out **sustained acidification observing capabilities** to fill major observing gaps in both **coastal zone and open ocean.**

Improve **estuarine acidification observing capabilities**, particularly within **commercially and recreationally important regions.**

Gulf of Mexico Ocean Acidification
RESEARCH AND MONITORING PRIORITIES

Improve regional acidification **predictive capabilities** on near- and long-term time-scales

Gulf of Mexico Ocean Acidification
RESEARCH AND MONITORING PRIORITIES

Monitor and research how acidification **impacts ecosystems that provide essential services.**

Conduct research to understand **impacts to ecologically and economically important species and ecosystem productivity and function.**

GCAN's Next Steps: Socioeconomic and Vulnerability Assessment for OA in the Gulf of Mexico



