North American Updates on Blue Carbon Science, Conservation and Collaboration

Workshop report

April 2021

Commission for Environmental Cooperation

cec.org

Please cite as:

CEC. 2021. *North American Updates in Blue Carbon Science, Conservation and Collaboration*. Montreal, Canada: Commission for Environmental Cooperation. 18 pp.

This publication was prepared by the Mexican Carbon Program (*Programa Mexicano del Carbono*) for the Secretariat of the Commission for Environmental Cooperation. The information contained herein does not necessarily reflect the views of the CEC, or the governments of Canada, Mexico or the United States of America.

ISBN: 978-2-89700-295-4

Legal deposit – Library and Archives Canada, 2021

Publication Details

Document category: Project publication

Publication date: May 2021

Original language: English

Review and quality assurance procedures:

Final Party review: May 2021

QAxx.xx

Project:

Operational Plan 2019–2020 / Strengthening Adaptation Capacity in Marine Protected Areas

For more information:

Commission for Environmental Cooperation
700 de la Gauchetière St. West, suite 1620
Montreal (Quebec)
H3B 5M2 Canada
t 514.350.4300 f 514.350.4314
info@cec.org / www.cec.org

Table of Contents

List of Abbreviations and Acronyms

CEC	Commission for Environmental Cooperation
Cinvestav	*Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional* (Center for Research and Advanced Studies of the National Polytechnic Institute)
Conabio	*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad* (National Commission for the Knowledge and Use of Biodiversity)
Conanp	*Comisión Nacional de Áreas Naturales Protegidas* (National Commission of Natural Protected Areas)
DFO	Fisheries and Ocean Canada
GHG	Greenhouse gases
INECC	*Instituto Nacional de Ecología y Cambio Climático* (National Institute of Environment and Climate Change of Mexico)
IPCC	Intergovernmental Panel on Climate Change
MPA	Marine Protected Area
NAMPAN	North American Marine Protected Areas Network
NDC	National Determined Contribution
NOAA	National Oceanic and Atmospheric Administration
PMC	*Programa Mexicano del Carbono* (Mexican Carbon Program)
SEEA	UN System of Environmental Economic Accounting
Semarnat	*Secretaría de Medio Ambiente y Recursos Naturales* (Ministry of Environment and Natural Resources)
TNC	The Nature Conservancy
UNEP	United Nations Environment Programme
USGS	United States Geological Survey

Executive Summary

In 2020, the Commission for Environmental Cooperation (CEC) organized a series of activities on blue carbon as part of its 2019–2020 project, "Strengthening Adaptation Capacity in Marine Protected Areas," as summarized in this report. Building upon previous efforts on blue carbon, the CEC worked to convene a meeting of North American blue carbon practitioners, update its map of North American blue carbon habitats, and explore opportunities for the three countries to collaborate to advance blue carbon science, conservation and restoration.

The North American Workshop on Blue Carbon Science, Conservation and Collaboration was held virtually on 3 December 2020, and was preceded by a series of national workshops organized by each country to discuss national advances and updates on blue carbon, in preparation for the trinational discussion.

The workshops allowed blue carbon experts and marine protected area (MPA) practitioners from Canada, Mexico and the United States to exchange knowledge on blue carbon conservation and science and to identify key opportunities that would advance the integration of blue carbon into marine and coastal protected area management and planning, supporting the development of national and regional strategies for climate adaptation, carbon mitigation, disaster risk reduction and coastal restoration. The workshops helped the experts identify data and review progress made to update and expand the CEC's North American Blue Carbon map layer, as well as propose possible next steps for collaboration for the North America blue carbon community of practice. Overall, the meetings also provided the opportunity for experts and practitioners to meet and share information with their peers on respective challenges and opportunities.

Experts discussed blue carbon topics from different angles: science, policy, management, finance and communication. They agreed on the need for better science, data, and tools to support blue carbon management. Capacity and research needs include improving understanding of credit schemes, as well as lateral and vertical greenhouse gas (GHG) fluxes and addressing uncertainty in scientific data and projections. Historical data and projection of blue carbon habitats are needed to identify conservation and restoration priorities. Remote sensing and other advanced techniques are needed to make maps more dynamic and useful. Standard methodologies and tools for carbon assessment, mapping, and accounting would facilitate the comparison of results internationally. During the workshops, experts recommended organizing trinational trainings on finance and markets, and creating a portfolio of successful projects from across the region that would enable lessons learned to be shared. Experts also recognized the value of increasing opportunities at the trinational level to interact, exchange and learn from each other.

Acknowledgments

The CEC Secretariat acknowledges the many individuals who contributed their valuable time and knowledge to the success of this effort, including:

Project Steering Committee: Chantal Vis and Marlow Pellatt (Parks Canada); Fernando Camacho Rico, Maria del Pilar Jacobo and Veronica Mendieta Siordia (*Comisión Nacional de Áreas Naturales Protegidas*—Conanp); and Lauren Wenzel and Gonzalo Cid (US National Oceanic and Atmospheric Administration, Marine Protected Area Center).

Consultants: Elisa López García and Rosalía Andrade Medina (Programa Mexicano del Carbono, PMC) and Ricardo Llamas (GIS Consultant).

Blue Carbon Experts and MPA practitioners*:

- From Canada: Zeba Ali, Jessica Andrews, Kumiko Azetsu-Scott, Hasini Basnayake, Deborah Carlson, Gail Chmura, Matt Christensen, Angela Danyluk, Angela Douglas, Ronnie Drever, Robert Gregory, Margot Hessing-Lewis, Sophie Johannessen, Brianne Kelly, Karen Kohfeld, Ron Lyen, Mary O'Connor, Emily Smits, Jason Stow, Jennie Wang, Melissa Wong.
- From Mexico: Joanna Acosta Velázquez, Armando Alanís, Zuelclady M. F. Araujo Gutiérrez, Roberto Aviña Carlín, Anayeli Cabrera, Andrea Camacho, Margarita Caso, Beatriz Carolina Corral Osuna, Rosa Román Cuesta, Gloria Cuevas Guillaumin, Luisa Alejandra Domínguez, Mónica Franco, Tannia Frausto, Margarita Gallegos, Miguel Ángel García, José Arturo González González, María Alejandra González Gutiérrez Marco Heredia, Isabel Hernández, Jorge Herrera Silveira, Eder Larios, María Teresa Maldonado, Vanessa Maldonado Montero, Rafael Mayorga, Dilia Meza, César Moreno, Patricia Moreno Casasola, Iván Muñoz, Claudia Octaviano, Armando Efraín Olachea, Mary Paz Ortiz, Yves Paiz, Jorge López Portillo Guzmán, Fabiola Ramírez, Rainer Ressler, Lilia Rico, Isaura Rivera, María Teresa Rodríguez, Minerva Rosette, Zulia Mayari Sánchez Mejia, Claudia Teutli Hernandez, Genoveva Trejo, María de los Ángeles Soriano Luna, Carlos Troche Souza, Aseneth Ureña, Bárbara Urtaza, Sergio Armando Villela Gaytán, Juan Carlos Zamora Cunningham
- From the United States: Omar I. Abdul-Aziz, Maria Brown, Zac Cannizzo, Alex Clayton, Philip Colarusso, Stephen Crooks, Carolyn Currin, Laura Cussen, Katie Darr, Jenny Davis, Mimi D'iorio, Meagan Eagle, Steve Emmett-Mattox, Chandra Giri, Jill Hamilton, Janine Harris, Nate Herold, Anna Hilting, Sara Hutto, Melanie Jackson, Jessie Jarvis, Cathy Johnson, Gabrielle Johnson, Tahzay Jones, Chris Kinkade, Kevin Kroeger, Emily Landis, Laura Lorenzoni, Morgan McCue, Emily Owen, Emily Pidgeon, Ann Robertson, Hilary Stevens, Maxine Sugarman, Tonna Marie Surgeon-Rogers, Ariana Sutton-Grier, Tiffany Troxler, Katie Warnell, Lisamarie Windham-Myers, Eric Ward, Tom Wirth, Metthea Yepsen, Zhiliang Zhu.

**experts who participated in national preparatory workshops and/or North American Workshop on Blue Carbon Science, Conservation and Collaboration.*

1 Background and CEC Project Context

"Blue carbon" refers to the carbon captured by coastal ecosystems, such as mangroves, salt marshes and seagrass. Over the past decade, scientists and policy-makers have increasingly focused on the impressive ability of these coastal marine ecosystems to sequester, store, and, when disturbed, even emit carbon.[1] Coastal ecosystem carbon was first grouped under the term "blue carbon" in a 2009 report of the United Nations Environment Programme (UNEP). There is now a wide array of blue carbon projects across North America, contributing to our understanding and management of these ecosystems and supporting their inclusion in national and regional carbon accounting. Reporting standards have already been developed by the Intergovernmental Panel on Climate Change (IPCC) for some blue carbon ecosystems, and carbon markets globally are beginning to incorporate blue carbon projects or initiatives into carbon credit schemes.

The Commission for Environmental Cooperation (CEC) is an international organization jointly established by the governments of Canada, Mexico and the United States, and operating in accordance with the Environmental Cooperation Agreement.[2] The CEC facilitates effective cooperation and public participation to conserve, protect and enhance the North American environment in support of sustainable development for the benefit of present and future generations.

In addition to longstanding work on marine and coastal conservation, the CEC implemented two blue carbon projects from 2013–2017 to improve blue carbon data, mapping, and our approaches to reducing emissions and protecting current blue carbon sequestration and storage across the continent. These two projects also created an ad hoc North American community of practice on blue carbon through regular workshops, meetings, and the exchange of information. Project activities have included: mapping coastal blue carbon distribution at selected sites, establishing criteria and developing GHG offset methodology for the conservation of tidal wetlands, and supporting ten research projects in the three countries aimed at improving estimates of carbon storage, sequestration and flux/emissions (including the impacts of natural and human-caused disturbances and restoration).

As part of its 2019–2020 Operational Plan, the CEC is continuing to work on coastal ecosystems through its "Strengthening Adaptation Capacity in Marine Protected Areas" project, which aims to improve the capacity of MPA practitioners to manage the impacts of global and regional changes, so that MPAs remain resilient. The project is being implemented with Parks Canada, Mexico's National Commission of Natural Protected Areas (*Comisión Nacional de Áreas Naturales Protegidas*—Conanp) and the US National Oceanic and Atmospheric Administration (NOAA) as lead national agencies. The project will aid coastal and marine practitioners in integrating blue carbon into coastal ecosystem planning and management and supporting national and regional carbon mitigation strategies, disaster risk reduction and coastal restoration.

As part of this project, the CEC involved the North American community of practice on blue carbon in discussions of advances in science and conservation and identifying pathways for MPA practitioners to better integrate blue carbon into climate change-related planning and decision-making. As a first step in this reactivation, three national workshops were held for blue carbon experts and practitioners to discuss the state of blue carbon in their respective countries, in preparation for the trinational workshop. In parallel, the project also aims to update the CEC's 2017

[1] CEC. 2017. *North America's Blue Carbon* (2015-2016 project accomplishments). Montreal: Commission for Environmental Cooperation. http://www.cec.org/files/documents/project_resources/project-accomplishments_2015-2016/blue-carbon-description-en.pdf

[2] See http://www.cec.org/about/agreement-on-environmental-cooperation/

North America Blue Carbon map layer. Together, the trinational workshop report and updated map layer will provide up-to-date knowledge on blue carbon in the region and help inform trilateral collaboration. The results could also contribute to North American environmental cooperation goals as well as each country's international commitments, such as the Nationally Determined Contributions (NDC) under the Paris Agreement.

2 North American Blue Carbon Map Layer Update

The North American Blue Carbon map layer is part of the North American Environmental Atlas managed by the CEC,[3] and shows the distribution of selected salt marsh, mangrove, and seagrass habitats in North America. The North American Blue Carbon map was initially compiled in 2015 and updated in 2017, based on data compiled from international, national, state and provincial sources, as well as from individual researchers.

Following up on the 2017 map update, the consultants interviewed researchers from the three countries to help identify potential data sources. A total of 76 sources of spatial information were initially identified: 31 sources recovered from the CEC's 2017 map, and 45 new sources, including detailed localized datasets. From these sources, three levels of information were compiled: a) global scale, from international data sources, b) regional scale, from public national sources, and c) local scale, from data provided mainly by universities and provincial/state research centers.

The national workshops and the North American workshop, summarized in the following sections of this report, allowed a draft version of the updated map to be made available on ArcGIS and presented to the participants of each workshop. This draft map was prepared to give experts an overview of the data sources identified as well as some of data integration challenges that had surfaced (e.g., overlap).

Following a review by the CEC's GIS team of the available new or updated datasets, 20 data sources were integrated in the draft version of the seagrass layer, and two data sources were used to generate the draft version of the mangrove and salt marsh habitat layers. The remaining data sources were not integrated, as they did not provide enough spatial information or showed spatial information already included from other sources. The general attributes obtained from most of the identified layers were defined and a collective attribute table was generated, in which the final characteristics of the mangrove, seagrass and salt marsh layers are described (each data source and corresponding credits will be included in the metadata of the final map). The preliminary list of data sources considered for integration in the draft map layer (as of September 2020) is presented in Appendix II.

During each workshop, experts discussed different strategies for spatial integration and prioritization of data sources. A survey disseminated to gather more detailed feedback from each group of experts yielded 11 survey responses, which helped to provide guidance on the data features to prioritize (e.g., the level of metadata detail, its reported accuracy and spatial resolution, dates, and whether the data originated from independent research or from national or international institutions). The comments provided through the surveys also helped the CEC identify additional sources of seagrass, salt marsh and mangrove spatial information which could improve the final map layer.

Based on the surveys and discussions held during the national workshops, the three key criteria to prioritize datasets selected for integration in the draft map were: (i) datasets with the most complete metadata; (ii) datasets with a high reporting accuracy; and (iii) datasets with a fine spatial resolution.

[3] The North American Environmental Atlas combines and harmonizes geospatial data from Canada, Mexico and the United States to allow for a continental and regional perspective on environmental issues that cross boundaries. See http://www.cec.org/north-american-environmental-atlas/.

To accurately integrate the final version of the map, experts gave preponderance of consideration to layers of information generated in local or regional studies over layers of information from studies at the national or global level. In the areas where there was an overlap, it was suggested to preserve the details obtained from the local datasets over the areas also covered by global datasets.

Overall, this consultative process helped to identify additional data sources, resolve challenges, and work towards a more comprehensive, harmonized map. The final updated map is expected to be published by the CEC in 2021.

3 Summary of National Blue Carbon Workshops

3.1 Canada[4]

Canada's national blue carbon expert workshop was held on 25 September 2020, under the leadership of Parks Canada and in collaboration with the CEC. The workshop had a total participation of 21 experts from academia, government and nongovernmental organizations.

Under the Paris Agreement, Canada committed to reducing its GHG emissions by 30% of 2005 levels by 2030, and to reach net-zero by 2050. This goal includes using nature-based solutions for climate change mitigation. The Government is also committed to protecting 25% of its land and oceans by 2025. The marine and terrestrial area protected in Canada has increased significantly during the last 25 years. At the end of 2019, Canada had 12.1% of its terrestrial area (land and freshwater) conserved, including 11.4% in protected areas, and 13.8% of its marine territory conserved, including 8.9% in protected areas. In this context, blue carbon is relevant for MPA designation and management in Canada, presenting an opportunity to further understand blue carbon systems and develop mechanisms to conserve carbon stocks and enhance sequestration through ecological restoration/reclamation. Blue carbon also plays a part in "green" coastal management and engineering projects such as soft shores and living dikes, and in biodiversity conservation and protected area establishment approaches that integrate GHG mitigation (or at least reduce carbon mobilization) as a co-benefit. With an increased interest at all levels of government to position blue carbon as a nature-based solution to climate change, there are growing opportunities to strengthen the policy and management of blue carbon ecosystems. Municipalities are already regarding restoration efforts as essential for future development (e.g., the West Coast Environmental Law Living Dike Project).

Nevertheless, significant data gaps still exist at the national level and a better understanding of GHG fluxes, stocks, and accumulation rates is needed to determine the importance of blue carbon in Canada's coastal and marine ecosystems. The lack of standardized carbon measurement protocols for determining carbon stocks, accumulation rates and GHG flux; the lack of knowledge about stressors affecting carbon sequestration; and uncertainty about the effect of sea-level rise and climate change on blue carbon dynamics are important challenges to integrate blue carbon in coastal and marine management in Canada. It highlights the need for national mapping and monitoring efforts for both seagrasses and salt marshes, as well as using updated technologies and standardized methodologies.

Another important challenge is the need for improved communication, such as information campaigns about blue carbon and the benefits, services and inherent value of blue carbon ecosystems. There is also a need to raise awareness and promote dialogue among the different levels of government

[4] For the full report of Canada's national workshop (available in English and French), please contact Chantal Vis (Parks Canada) at: Chantal.vis@canada.ca.

(federal, provincial, local and Indigenous peoples) as well as with stakeholders, using both bottom-up and top-down approaches to aid recognition of each other as allies. Furthermore, coastal and marine ecosystem management need to be understood in a broader context that includes the spillover effects of MPAs, blue carbon integration in existing management and policy priorities (regarding fishing, biodiversity, climate change, etc.), co-benefits and trade-offs between services, ecosystem service accounting, nationally determined contributions (NDCs) under the Paris climate agreement, and voluntary carbon markets.

Blue carbon stakeholders in Canada could benefit from more national and trinational collaboration opportunities, like those offered by the CEC or the UN System of Environmental Economic Accounting (SEEA) or through events such as the Salish Sea Ecosystem Conference and Coastal Zone Canada, in order to increase blue carbon research and monitoring, training opportunities and funding.

Some valuable initiatives and ongoing work were presented: a research project undertaken by a team from the University of British Columbia and the Department of Fisheries and Oceans (DFO), aiming to quantify blue carbon storage potential of Canada's eelgrass beds; eelgrass monitoring work undertaken by the Southern Gulf of St. Lawrence Coalition on Sustainability with funding from DFO's National Eelgrass Taskforce (NETForce); continued and ongoing work at McGill University on carbon dynamics in salt marshes throughout Quebec, the Atlantic Provinces, and Canada's coasts; work carried out by the Hakai Institute on blue carbon in eelgrass systems in British Columbia, as well as a research project on marine nature-based climate solutions led by Nature United; research examining blue carbon dynamics on the west coast of Vancouver Island and in Boundary Bay by Parks Canada and Simon Fraser University; and a pan-Canadian census initiative on salt marshes for Parks Canada's coastal National Parks and national Marine Conservation Areas. Spatial information generated through these initiatives, when available, was shared and reviewed for integration into the updated CEC map of North American blue carbon habitats.

Discussions held during the workshop also highlighted the following two elements: (1) the opportunity that the workshop offers to initiate a national blue carbon community of practice in Canada, to identify knowledge gaps and strategies to tackle the challenges discussed and the integration of blue carbon into national programs and objectives, and (2) the need to better understand carbon credits and accounting, namely which activities and ecosystems are accounted for in voluntary carbon markets. For example, should wetlands within MPAs be included? Will Canada be able to include wetland restoration and conservation activities in national carbon inventories and in its report on blue carbon to the IPCC? What is the extent of information needed to do so?

3.2 Mexico[5]

Mexico's national blue carbon expert workshop was held on 22 October 2020. This workshop was a joint initiative led by Mexico's Ministry of Environment and Natural Resources (*Secretaría de Medio Ambiente y Recursos Naturales*, SEMARNAT), CONANP and the National Institute of Ecology and Climate Change (*Instituto Nacional de Ecología y Cambio Climático*, INECC), in collaboration with the CEC. The workshop included 57 experts from academia, government and nongovernmental organizations.

Through protected areas and other area-based conservation measures, Mexico has established protection of 13.25% of its land surface (continental and insular areas) and 22.9% of its marine

[5] For the full report of Mexico's national workshop (available in Spanish), please contact Maria del Pilar Jacobo (Conanp) at: pilar.jacobo@conanp.gob.mx

Exclusive Economic Zone, thus exceeding Aichi Target 11 by 12.9% with respect to the 10% commitment for coastal and marine areas. The protected areas administered by CONANP represent a great opportunity for blue carbon projects, since they represent 10.88% of the country's land area and 22.05% of its marine area. These areas preserve 464,620 ha of mangroves, 811,954 ha of hydrophilic vegetation and 5,058,563 ha of water bodies (lakes, lagoons and rivers). Furthermore, the environmental sector of the federal government—Semarnat, Conanp, INECC, the National Commission for the Knowledge and Use of Biodiversity (*Comisión Nacional para el Conocimiento y Uso de la Biodiversidad*, Conabio), and the National Forestry Commission (*Comisión Nacional Forestal*) —understands the opportunity for conservation of national protected areas behind the implementation of carbon projects aligned with sustainable financing strategies.

Regarding science and monitoring challenges, experts from government institutions, academia and civil associations recognize the wealth of information available in Mexico, particularly related to mangrove ecosystems distribution and carbon stocks. Nevertheless, seagrasses and salt marshes have been less studied. Opportunities identified include: (1) facilitating open access to data and information; (2) strengthening existing protected area monitoring systems to include blue carbon ecosystems; (3) standardizing national blue carbon estimation methodologies (this was also highlighted as a relevant trinational opportunity); and (4) improving understanding and knowledge on the current state of blue carbon ecosystems. Blue carbon ecosystems are increasingly affected by the variability of environmental factors all over the country. Some proposals to address the challenges in science and information management were related to building awareness and capacity to implement the IPCC Wetlands Supplement (2013), potentially through training workshops. This could help increase the effort devoted to studying the current state of blue carbon ecosystems and carbon quantification, and to monitoring these ecosystems. Mexico has been developing maps of seagrass habitat distribution and carbon stocks in the Gulf of Mexico and the Caribbean, which could advance the integration of blue carbon in national policy.

From a policy and management perspective, it was discussed that Mexico has the scientific information, legal framework and capacity needed to incorporate blue carbon in national and international policies, instruments and decisions. Relevant regulatory instruments include existing forestry programs, working groups of the Inter-ministerial Climate Change Commission (*Comisión Intersecretarial de Cambio Climático*), and environmental sector programs, among others. However, compliance with laws for the protection of blue carbon ecosystems could be enhanced by creating relevant Official Mexican Standards (*Norma Oficial Mexicana*). This was highlighted as an opportunity to advance conservation, management and restoration.

Mexico’s current climate change legal framework does not specifically cover blue carbon. Thus experts suggested that instruments such as the General Law for Climate Change (*Ley General de Cambio Climático*) be strengthened and aligned with state, municipal and territorial management programs, and the focus on ecosystem goods and services related to INECC’s 2020 National Atlas of Vulnerability to Climate Change (*Atlas Nacional de Vulnerabilidad al Cambio Climático*) be similarly strengthened and linked to the Ramsar Fact Sheets. In terms of national policy developments, it is expected that Mexico’s revised NDC will integrate blue carbon as a fundamental component. The NDC, along with other international commitments, is a promising opportunity to strengthen land planning and management instruments to improve protection for these ecosystems, especially inside protected areas. The design of protocols and restoration projects, based on guidelines, maritime zoning plans, and Basin Management Action Plans (*Plan de Acción de Manejo Integral de Cuenca*), should be considered.

Incorporating nature-based solutions for action at the level of national programs and integrating blue carbon in protected area management plans were both highly recommended. It would also be important to strengthen work at Ramsar sites and on the federal level legal and regulatory framework, more generally. At state and municipal levels of government, establishing clear mechanisms and the

space to facilitate public and multi-stakeholder participation in blue carbon-relevant decision-making will be important in aligning public policies with the conservation and restoration of these ecosystems.

Regarding funding, opportunities in land management schemes and collaboration with the private sector were discussed. New sources of funding, such as co-benefit-based Payments for Ecosystem Services, the regulated and voluntary markets, as well as REDD+, should be explored to ensure fair, equitable, and community-oriented benefit-sharing. Likewise, opportunities for compensation from conservation could be explored.

Finally, experts identified the following opportunities for regional collaboration: (1) exchanging knowledge on methodologies and tools; (2) advancing our understanding of the existing funding options for protected areas in the region; (3) improving regional geographic information; (4) developing a repository of information through a new or existing platform to share knowledge, information, and experiences regionally, and to help develop a portfolio of regional projects; and 5) enhancing communication on blue carbon ecosystems and building awareness in local communities. Experts noted that joint projects involving participants from across North America would allow experiences, success stories, and methodologies to be shared and exchanged; there are also opportunities to share project budgets and portfolios trinationally, since some international funding agencies allow for resource optimization.

3.3 United States[6]

The United States' national blue carbon expert workshop was held on 19 October 2020, under the leadership of NOAA's Marine Protected Areas Center, in collaboration with the CEC. A total of 56 experts participated in the workshop, including blue carbon scientists and MPA practitioners, Congressional staff experts, and observers from Canada, Mexico and Chile.

With President-elect Biden having committed to rejoin the Paris Agreement on the first day of his administration, there is a renewed commitment and interest in climate issues in the United States. Blue carbon is an opportunity to link two high-priority crises: biodiversity and climate. The United States is currently protecting 26% of its waters through MPAs.

From a scientific perspective, additional blue carbon research and monitoring is needed to understand variation in carbon sequestration rates, fluxes and dynamics, including the impacts of environmental conditions and management actions. There is also a need to establish common definitions of blue carbon ecosystems (coastal versus marine). More research is needed in other potential blue carbon systems, like kelp and other macroalgae. Pilot studies should also focus on the whole suite of ecosystem services and co-benefits that blue carbon systems provide.

From a policy perspective, experts recommended emphasizing co-benefits in order to garner broader public and political support. It was mentioned that people tend to understand the fish and wildlife benefits provided by these systems more than carbon services. The experts also discussed the challenges of addressing the long-term horizon (50 to100 years) within a generally time-bound political and legal system. The challenges mentioned include providing rights for carbon credits, building a policy framework for dynamic systems that are changing with temperature or sea level, as well as the policy and legal issues related to committing to activities for carbon storage within that broad timeframe.

[6] For the full report of the United States' national workshop, please contact Lauren Wenzel (NOAA MPA Center) at: Lauren.Wenzel@noaa.gov.

From the MPA management perspective, experts agreed on the critical nature of stakeholder relationships and on the need to put a strong focus on blue carbon outreach and education, including developing common messages about blue carbon and its co-benefits. They recommended enhancing collaboration among the three countries to address common challenges inherent in the protection of marine biodiversity and jointly prioritizing conservation actions through existing platforms like the North American Marine Protected Areas Network (NAMPAN), which can be used to share knowledge on blue carbon and MPA management in a climate change context.

From the financing perspective, experts discussed international trading standards, such as the Verified Carbon Standard and the American Carbon Registry and their accompanying methodologies, as key tools to fund restoration projects. The major challenges identified to participate in such schemes were costs, land-tenure ownership issues, and the fact that investors want certainty, which is often lacking.

4 Summary of the North American Workshop

The North American Workshop on Blue Carbon Science, Conservation and Collaboration was held on 3 December 2020. A total of 30 experts participated in the workshop (8 from Canada, 11 from Mexico and 11 from the United States), including blue carbon scientists, MPA practitioners, and climate change experts (see Appendix I for the full list of participants).

Lucie Robidoux of the CEC introduced the workshop and its objectives: (i) to exchange on the state of blue carbon conservation in the three countries; (ii) to identify key opportunities for advancing the integration of blue carbon in marine and coastal protected area management and climate adaptation planning in North America; (iii) to present the draft update to the CEC North American Blue Carbon map layer; and (iv) to explore how to build collaboration within the North American blue carbon community of practice.

Marlow Pellatt of Parks Canada, María del Pilar Jacobo of Conanp, and Lauren Wenzel of NOAA's MPA Center welcomed participants and recognized the value of building on previous CEC blue carbon efforts. Each country representative presented a summary of their national workshop and highlighted key priorities for blue carbon at the national level. The process to update the North American Blue Carbon map layer and a draft version of the map were presented by Rosalía Andrade of PMC.

Experts participated in three thematic discussions, with the objectives of identifying opportunities for collaboration on blue carbon and MPAs. The three topics discussed were:

- The state of knowledge on blue carbon science and the remaining knowledge gaps, focusing on information needed to support decision-making and MPA management
- Blue carbon management and restoration approaches, case studies and lessons learned, addressing how MPAs can help catalyze blue carbon as a nature-based solution for adaptation
- Communication, education, and outreach strategies to engage decision-makers and the public for the conservation of blue carbon ecosystems, including communications goals, target audiences, key messages and opportunities for collaboration

4.1 The state of knowledge on blue carbon science, and remaining gaps

The first thematic discussion was focused on the state of blue carbon science and remaining knowledge gaps. Experts were asked to discuss key advances that could help inform other blue carbon science initiatives in the region as well as decision-making for MPA managers planning for

blue carbon projects. Experts were also invited to discuss remaining knowledge gaps and research needs related to blue carbon ecosystems.

The conversation flowed around three main lines of thought:

1. GHG fluxes as a research priority
2. Remote sensing needs and opportunities
3. Opportunities to improve scientific information sharing and collaboration

Several experts agreed that research on lateral and vertical GHG fluxes (CH_4, N_2O and CO_2) in blue carbon ecosystems is a priority for the region. Specifically, experts mentioned they lacked information on the climate, geomorphic, hydrologic and biological condition gradients and the uncertainty around estimated fluxes in existing published data. Reference institutions mentioned include the Center for Research and Advanced Studies of the National Polytechnic Institute (*Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional*—Cinvestav), the Sonora Institute of Technology (*Instituto Tecnológico de Sonora*), the Waquoit Bay National Estuarine Research Reserve, the University of British Colombia and McGill University.

Experts discussed options to expand the focus of conservation priorities from MPAs to also include degraded areas as an opportunity to identify restoration priorities in the region, including how we can improve blue carbon sequestration through improved management. This point opened a discussion on existing knowledge gaps both inside and outside MPAs. It was mentioned that the challenge in identifying degraded areas to prioritize restoration is lack of historical information. Experts identified an opportunity to work collaboratively on remote sensing and other techniques in order to develop wetland cover historical change (30-40 years) data layers into the blue carbon maps, which would make the maps more dynamic and useful to create projections. On the topic of remote sensing, experts said that the United States is preparing two new tools: (a) a Landsat dataset that would go back to the state of coastal wetland land cover in the mid-1980s and be capable of tracking change since that period, and thus able to provide an estimate of loss due to land use and natural causes over nearly 40 years,[7] and (b) a model that works on transitions of coastal wetlands to represent types, storage, long-term potential, emission factors, and also forecast future trends. The model was initially developed for Louisiana but is planned for expansion to cover the entire US coastal zone.[8] Experts also discussed how there is a need for both small- and large-scale information in the region, depending on the conservation goal. Small-scale information is often needed at a project level to address specific concerns such as degraded areas; however, larger scale baselines (such as the CEC North American blue carbon map) are needed to advance national policy discussions, for example on GHG accounting, and to contribute to national carbon reduction goals.

Overall, experts agreed on the need to link conservation efforts to mitigation (the Convention on Biological Diversity's 30x30 proposed target was mentioned as a reference) and to work trinationally on common methods to identify priority conservation areas.

Experts also discussed the importance of addressing coastal squeeze and the landward blocking of coastal wetland migration paths due to hard shoreline structures, such as seawalls or rock revetments. Many comments focused on information gaps to predict where and how coastal wetlands are going to migrate due to sea-level rise and, in those scenarios, how MPAs can still support conservation of the

[7] See Yang, X. et al. 2020. Tracking coastal tidal wetland change using Landsat time series. Advancing Earth and Space Science 2020 Fall Meeting. <https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/706955>

[8] See LaFosse Stagg, C. et al. 2020. A National Assessment of Tidal Wetland Carbon Sequestration and GHG emissions with Implications for Land Management in the United States. Advancing Earth and Space Science 2020 Fall Meeting. <https://agu.confex.com/agu/fm20/meetingapp.cgi/Paper/697688>

areas. Experts mentioned that Canada's laws and regulations are designed to protect current distribution of coastal ecosystems, but do not address future habitat distribution. Canadian experts noted the urgent need to extend inland protection.

Finally, experts discussed regional opportunities to improve scientific information-sharing and collaboration. While myriad methods and datasets are generated in the region, experts agreed that such tools need to be shared and standardized to allow comparison. Specifically, experts suggested:

1. Establishing a network of permanent monitoring sites that make use of similar reporting methods
2. Mirroring other bilateral or trinational initiatives; as an example, the ongoing work on kelp forests in the Gulf of California[9]
3. Holding regional webinar series to present monitoring standards, similar to the Monitoring BC Nearshore Habitats Web Series,[10] and which could feature existing frameworks and methods[11]

4.2 Blue carbon management and restoration approaches

The second thematic discussion focused on blue carbon management and restoration approaches by sharing case studies and lessons learned on blue carbon as a nature-based solution for climate adaptation. The discussion led experts to share recent experiences with the blue carbon voluntary market as well as their success stories on communication and engagement.

The topic raised several questions: What approaches could help maximize carbon sequestration benefits while ensuring coastal adaptation in a changing climate? What market-based experiences exist in the region? How can MPA managers learn from and use the lessons learned in their own work? Are there adaptation-based experiences in the region that make use of benefit-sharing schemes?

Regarding the voluntary market for blue carbon credits, US experts shared experience from Virginia, working with The Nature Conservancy (TNC), and from the Pacific Northwest, working with Silvestrum. The blue carbon offset project in the Virginia Coast Reserve, implemented in collaboration with the Virginia Institute of Marine Sciences, the University of Virginia, TerraCarbon, and the State Government of Virginia, is a TNC initiative to quantify the carbon storage benefits of a 10-year restoration project involving eelgrass. Technical challenges involve proving additionality for the restoration actions, mapping at a fine scale, having legal authority for carbon credits, and the reporting methodology involved. The project is using drones for mapping and complements efforts from the university to assess fluxes. In sum, the project provides an interesting opportunity for long-term monitoring and demonstrates the feasibility of cases where there are high-quality data available, along with government support and land tenure clarity[12] (and also acknowledges the very real technical, legal and financial challenges encountered in such projects). Silvestrum has been successful

[9] This work involves the University of California Davis, the University of California Los Angeles, the Center for Scientific Research and Higher Education at Ensenada (*Centro de Investigación Científica y de Educación Superior de Ensenada*), and the Autonomous University of Baja California Sur (*Universidad Autónoma de Baja California Sur).*

[10] https://quadracentre.org/meetings/bc-habitat-workshop-series

[11] https://www.frontiersin.org/articles/10.3389/fmars.2018.00211/full

[12] https://www.nature.org/en-us/about-us/where-we-work/united-states/virginia/stories-in-virginia/vcr-marine-restoration/

in developing feasibility assessments in several areas and in diverse ecosystems in the United States (macroalgae, peatlands, seagrasses and mangroves, among others), but acknowledged the financial and methodological challenges, particularly for those cases where other sorts of funding are involved to cover restoration and conservation of wetlands. Canadian experts also shared two interesting market experiences: the Darkwoods Forest Carbon Project, also implemented by TNC,[13] and the Atmospheric Benefit-sharing Agreements implemented by the Province of British Colombia.[14]

Tonna Marie Sturgeon-Rogers, Waquoit Bay National Estuarine Research Reserve Manager, explained the importance of educating stakeholders and decision-makers on climate benefits and the other services provided.[15] She noted that the potential for marketing carbon credits can engage and educate the public, though the process is complex. Experts from Mexico also shared experiences where training on linking restoration activities with the sustainable exploitation of the areas had allowed managers to open dialogue with local communities and thus raise awareness of the value of the services provided by wetlands. These comments allowed discussion to flow into the following thematic discussion on communication and engagement.

In closing the discussion on management and restoration approaches, experts noted the relevance of organizing trinational training on finance and markets, as well as on the creation and sharing of a portfolio of maps of successful projects from the region.

4.3 Communication, education and outreach

The third thematic discussion centered on communication, education, and outreach to decision-makers and the public. It aimed to identify goals, target audiences and key messages to achieve successful implementation of a blue carbon initiative based on MPAs, and opportunities for collaboration.

In general, this discussion highlighted many opportunities for collaboration. Only two challenges were shared: one related to the difficulty of communicating uncertainty, especially in a data deficiency context, and another linked to the use of the term “blue carbon” as a new and not yet widely understood concept. Regarding the proposed messages, participants had different views on targets and approaches, though all agreed on the opportunity for communicating the co-benefits of blue carbon for fish and wildlife habitat, human health, coastal protection, and poverty reduction. Specific ideas shared by the experts included:

- the creation of a communication toolkit for working with different groups of stakeholders
- the importance in inter-institutional communication efforts of incorporating blue carbon co-benefits in development plans
- the opportunity to engage global stakeholders by linking biodiversity and climate targets with the Sustainable Development Goals (SDGs)
- the importance of sharing success stories and case studies related to blue carbon conservation and restoration.

Experts agreed on the opportunity for greater communication and engagement at the local level, including through bottom-up approaches. As coastal and marine ecosystems change and migrate due

[13] https://www.natureconservancy.ca/en/where-we-work/british-columbia/featured-projects/west-kootenay/darkwoods/dw-carbon.html

[14] https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-first-nations/first-nations-negotiations/atmospheric-benefit-sharing-agreements

[15] http://waquoitbayreserve.org/

to climate impacts, there will be an urgent need to help communities understand the connection between environmental health and human wellbeing. Blue carbon can be a tool for sharing the value of MPAs with communities. Experts highlighted the need to include and engage with communication experts in their work, and to involve and engage with new blue carbon researchers in the North American region to exchange information and methodologies and collaborate.

5 Pathways for Blue Carbon Collaboration in North America

- **Blue carbon as a nature-based response to climate, biodiversity and sustainable development national commitments**

The three countries have committed themselves to ambitious international goals to face the most urgent global crises. The conservation, restoration and sustainable use of blue carbon ecosystems offers an opportunity to make cost-effective contributions to these goals. Advances in this direction could be exemplified by the proposed target under the Convention on Biological Diversity of conserving 30% of the world's lands and oceans by 2030. But how to maximize blue carbon sequestration while addressing other goals? How to find those priority areas where all the targets can be achieved? What methodologies and standards could countries use to report advances toward those goals? How to integrate local variabilities in national accounting?

- **Identify ways to integrate dynamic systems in static laws and management instruments**

Experts agree that mangroves, salt marshes and seagrass beds are dynamic systems that will migrate with climate change. This fact transforms blue carbon ecosystem management into a three-dimensional paradigm, where the history of an area must be understood in order to project future changes. Armed with this information, managers will be more successful in their conservation efforts. But there remain challenges to identifying priority areas based on predictions, as well as in communicating the benefits of long-term protection to the current users of the land.

- **Innovative financing schemes based on the services provided by blue carbon ecosystems to support their conservation and restoration within MPAs**

The three countries shared blue carbon financing schemes along a gradient of success. From payments for ecosystem services to regulatory markets, experts recognized the differing regulatory and market contexts within the three countries. Probably the most comprehensive take-home message is the need to minimize the financial costs associated with market schemes and maximize the engagement and support for ecosystem conservation outcomes. Some ways to minimize costs are to choose an area with available, trustworthy data and land-tenure clarity. Emphasizing co-benefits to engage multisector stakeholders is important to generate support.

- **"Blue is the new green," and other opportunities to communicate and share**

Experts agreed that working together will lead to more effective and efficient blue carbon strategies, both nationally and locally. The construction of a community of practice, the gathering of a portfolio of success stories, a series of technical webinars, and a platform to share information were proposed. Opportunities to share and manage information among the region were discussed and agreed upon. Some questions that arose are: how to share information with other sectors involved? How to translate blue carbon scientific data into MPA value? How to communicate the importance of blue carbon ecosystems to those who aren't aware? How to educate decision-makers to secure support for actions with long-term benefits that may be fully realized only over decades or centuries? Experts can share local experiences, but the fact remains that there are as many messages and channels as stakeholders to be involved.

Appendix I: Participants - North American Workshop on Blue Carbon Science, Conservation and Collaboration

CANADA

Deborah Carlson
Staff Counsel
Green Communities Program
West Coast Environmental Law
dcarlson@wcel.org

Gail Chmura
Professor
McGill University
gail.chmura@mcgill.ca

Margot Hessing-Lewis
Research Scientist
Hakai Institute
margot@hakai.org

Brianne Kelly
Senior Specialist, Marine Ecosystems and Fisheries
WWF Canada
bkelly@wwfcanada.org

Karen Kohfeld
Professor
Simon Fraser University
kohfeld@sfu.ca

Marlow Pellatt
Acting Manager
(Ecosystem Scientist)
National Ecosystem Science Lab,
Office of the Chief Ecosystem Scientist
Parks Canada
marlow.pellatt@canada.ca

Chantal Vis
Marine Ecosystem Specialist
Parks Canada
Chantal.vis@canada.ca

Melissa Wong
Research Scientist
Fisheries and Oceans Canada
melisa.wong@dfo-mpo.gc.ca

MEXICO

Joanna Acosta Velázquez
Consultant
The Nature Conservancy (TNC)
joanna.acosta@gmail.com

Gloria Cuevas Guillaumin
Director of Environmental Analysis,
General Directorate for Climate Change Policy
Semarnat
gloria.cuevas@semarnat.gob.mx

Luisa Alejandra Domínguez
Deputy Director of Species and Habitat Conservation for Adaptation to Climate Change
INECC
luisa.dominguez@inecc.gob.mx

José Arturo González González
Director of the West Coast National Park of Isla Mujeres Punta Cancun and Punta Nizuc and Mangroves of Nichupte (Area of Flora and Fauna Protection)
Conanp
arturo.gonzalez@conanp.gob.mx

Jorge Alfredo Herrera
Researcher
Cinvestav / PMC
jorge.herrera@cinvestav.mx

María del Pilar Jacobo Enciso
Director
Conanp
pilar.jacobo@conanp.gob.mx

Vanessa Maldonado Montero
Coordinator, Climate Change Adaptation and Mitigation Initiatives
Conanp
vanessa.maldonado@sinergiaplus.org

Verónica Mendieta Siordia
Analyst, Climate Change Strategies
Conanp
veronica.mendieta@sinergiaplus.org

Rainer Ressler
Director
Conabio
rressl@conabio.gob.mx

Zulia Mayari Sánchez
Professor-Researcher
Sonora Institute of Technology
zulia.sanchez@itson.edu.mx

Carlos Troche Souza
Remote Sensing Specialist
Conabio
ctroche@conabio.gob.mx

UNITED STATES

Stephen Crooks
Wetland scientist / Geomorphologist
Silvestrum Climate Associates LLC
steve.crooks@silvestrum.com

Kevin Kroeger
Research Chemist
Woods Hole Coastal and
Marine Science Center
kkroeger@usgs.gov

Emily Landis
Coastal Wetlands Strategy Lead
The Nature Conservancy (TNC)
elandis@TNC.org

Hilary Stevens
Coastal Resilience Manager
Restore America's Estuaries
hstevens@estuaries.org

Tonna Marie Surgeon-Rogers
Manager & Acting Coastal
Training Program Coordinator
Waquoit Bay National Estuarine
Research Reserve
tonna-marie.surgeon-rogers@mass.gov

Tiffany Troxler
Professor
Florida International University
ttroxler@fiu.edu

Lauren Wenzel
Director
NOAA Marine Protected Areas Center
lauren.wenzel@noaa.gov

Lisamarie Windham-Myers
Research Ecologist
National Research Program,
Water Resources Division
United States Geological Survey
lwindham-myers@usgs.gov

Zhiliang Zhu
Physical Scientist
United States Geological Survey
zzhu@usgs.gov

Gonzalo Cid
International Coordinator
NOAA Marine Protected Areas Center
Gonzalo.Cid@noaa.gov

Eric Ward
Research Ecologist
US Geological Survey
eward@usgs.gov

CEC

Simonetta Ferrante
Assistant, Ecosystems
sferrante@cec.org

Lucie Robidoux
Head of Unit, Ecosystems
lrobidouz@cec.org

Julie Roy
Project Lead, Ecosystems
jroy@cec.org

CONSULTANTS

Rosalía Andrade Medina
Consultant
Programa Mexicano del Carbono
r.andrademedina@gmail.com

Elisa López García
Consultant
Programa Mexicano del Carbono
elislopez84@gmail.com

Appendix II: Preliminary List of Identified Mapping Data Sources as of September 2020, Based on Interviews with Blue Carbon Experts

In August and September 2020, consultants from PMC interviewed over 50 blue carbon experts and researchers and compiled the following list of potential data sources for the update of the CEC blue carbon map. This preliminary list of sources was presented and used at as starting point for discussion in the three national workshops held respectively on 25 September, 19 October and 22 October 2020.

It should be noted that this list does not reflect datasets selected for integration in the final map by the CEC. The CEC's GIS team will thoroughly review each dataset identified through expert interviews, national workshops and surveys. Data sources will be clearly indicated in relevant metadata.

International

- Bunting, P. et al. 2018. *The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent*. Remote Sensing 10(10): 1669. Paper DOI: https://doi.org/10.3390/rs10101669 (
- Mcowen, C. et al. (2017). A global map of saltmarshes. *Biodiversity Data Journal* 5: e11764. Data DOI: https://doi.org/10.34892/07vk-ws51. (updated, global)
- UNEP World Conservation Monitoring Centre, Short, F. T. 2018. Global distribution of seagrasses (version 6.0). Sixth update to the data layer used in Green and Short (2003). Cambridge (UK): UN Environment World Conservation Monitoring Centre. Data DOI: https://doi.org/10.34892/x6r3-d211 (updated, global)

Canada

- Government of Nova Scotia. 2020. *Forest Inventory*. Nova Scotia (Canada): Department of Lands and Forestry. https://data.novascotia.ca/Lands-Forests-and-Wildlife/Forest-Inventory/c8ai-fjbt (new, regional, seagrass)
- Government of British Columbia, Ministry of Forests, Lands, Natural Resource Operations and Rural Development – GeoBC. 2011. Eelgrasses. British Columbia (Canada): Coastal Resource Information Management System. https://catalogue.data.gov.bc.ca/dataset/d507dc35-396c-4bb2-aa9b-815e2da0ccd5 (new, regional, seagrass)
- Reshitnyk, L. Y. et al. 2016. Extrapolated eelgrass extent for British Columbia. Version 1.0. Cambell River, British Colombia (Canada): Hakai Institute. https://doi.org/10.21966/1ty5-e654 (new, local, seagrass)
- Sampaio De Araujo, C. A./Université du Québec à Rimouski, for seagrass data along the St. Lawrence Estuary and the north coast of the Gulf. Contact: CarlosAlberto.SampaioDeAraujo@uqar.ca (new, local, seagrass)

Mexico

- Benítez-Valenzuela, L. I. et al. 2020. Turbulent fluxes and tide measurements from a coastal lagoon in the Gulf of California. PANGAEA. DOI: https://doi.org/10.1594/PANGAEA.918686 (new, local, seagrass)
- Cecropia. Contact: Agustín Escobar López agustin@cecropia.org (new, local, mangrove)
- Cinvestav-Unidad Mérida. 2019. Contact: Javier Ramírez javier.ramirez@cinvestav.mx (new, local, mangrove)
- Cinvestav-Unidad Mérida. 2016. Contact: Juan Mendoza Martínez juan.mendoza@cinvestav.mx (new, local, seagrass)

- Conabio. 2016. Distribución de los manglares en México en 2015. Escala 1:50000. Edición 1. Mexico City (Mexico): CONABIO - Sistema de Monitoreo de los Manglares de México. Accessed on CONABIO Geoportal. (updated, regional, mangrove)
- Costa Salvaje (Sinaloa and California Sur). 2016-18. (new, local, mangrove)
- Encinas-Lara, M.S. and L. A. Mendez-Barroso. 2019. UAV-derived orthomosaic over a small intertidal coastal strip within "El Soldado" Estuary in Guaymas, Sonora, Mexico. PANGAEA. DOI: https://doi.org/10.1594/PANGAEA.902726 (new, local, seagrass)
- Gallegos Martínez M., G. Hernández Cárdenas and I. Pérez- Espinosa. 2018. Comunidades de vegetación acuática sumergida del Golfo de México. Escala 1: 25000. Edición 2. Mexico City (Mexico): Universidad Autónoma Metropolitana Unidad Iztapalapa, INECC and Consorcio de Investigación del Golfo de México. Accessed on CONABIO Geoportal. (new, regional, seagrass)
- Gallegos-Martínez, M., G. Hernández-Cárdenas and I. Pérez-Espinosa. 2018. Pastos marinos del Estado de Veracruz, México. Escala 1:1. Edición 1. Mexico City (Mexico): Universidad Autónoma Metropolitana Unidad Iztapalapa and INECC. Accessed on CONABIO Geoportal. (new, regional, seagrass)
- Herrera-Silveira, J.A. et al. 2018. Evaluación y monitoreo de los pastos marinos en el contexto del proyecto de ampliación del Puerto de Veracruz-Fase I. API-GI-CS-62601-066-17. PMC-Cinvestav-Unidad Mérida. (new, local, seagrass)
- Herrera-Silveira, J.A. et al. 2018. Almacenes de carbono en manglar y pastos marinos del área de protección de flora y fauna reserva de Yum Balam. Informe Técnico Final. PMC, Cinvestav and Centro Mexicano de Derecho Ambiental. (new, local, mangrove and seagrass)
- INECC and United Nations Development Programme Mexico. 2017. *Estudio para la identificación, caracterización y evaluación del balance entre las emisiones de GEIs y las zonas de captura y almacenamiento de carbono en zonas de ecosistemas costero/marinos del Pacífico, Golfo de México y la Península de Yucatán (Carbono azul)*. Project 85488 "Sexta Comunicación Nacional de México ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático". Mexico City (Mexico): Programa Mexicano del Carbono, 430 pp. (new, local, mangrove and seagrass)
- Mendoza-Martínez, J. E. et al. 2019. Almacenes de carbono en biomasa de pastos marinos de una laguna arrecifal y su relación con variables ambientales. In Paz, F., A. Velázquez and M. Rojo, ed., *Estado Actual del Conocimiento del Ciclo del Carbono y sus Interacciones en México: Síntesis a 2019*. Serie Síntesis Nacionales. Texcoco, Mexico (Mexico), 544 pp. (new, local, seagrass)
- Mendoza-Martínez, J. E., J. A. Herrera-Silveira and M. A. Liceaga-Correa. 2018. Almacenes de Carbono en Biomasa de Pastos Marinos Costeros Tropicales de Regiones Cársticas. In Paz, F., A. Velázquez and M. Rojo, ed., *Estado Actual del Conocimiento del Ciclo del Carbono y sus Interacciones en México: Síntesis a 2018.* Serie Síntesis Nacionales. Texcoco, Mexico (Mexico). ISBN pending. 686 p. (new, local, seagrass)
- Palafox Juárez, E. B. and M. A. Liceaga Correa. 2013. Vegetación acuática sumergida de la Región Centro - Poniente del estado de Yucatán e]. Escala 1: 450,000. Edición 1. Merida, Yucatan (Mexico): Cinvestav - Unidad Mérida. Accessed on Conabio Geoportal. (new, regional, seagrass)
- Pérez-Espinosa, I. et al. 2020. Distribución espacial de los pastos marinos y las macroalgas en la zona costera Este del estado de Yucatán. Escala 1: 20000. Edición 1. Mexico City (Mexico): Universidad Autónoma Metropolitana Unidad Iztapalapa. Accessed on Conabio GeoPortal. (new, regional, seagrass)
- Pérez-Espinosa, I. et al. 2019. Distribución espacial de los pastos marinos y la vegetación acuática sumergida en los Petenes, Campeche. Escala 1: 350000. Edición: 1. Mexico City

(Mexico): Universidad Autónoma Metropolitana Unidad Iztapalapa. Accessed on Conabio GeoPortal. (new, local, seagrass)
- Sandoval Gil, J. M. 2020. Contact: jmsandovalgil@gmail.com (new, local, seagrass)
- Santiago-Molina, L. A. 2018. *Estimación del potencial de captura de carbono (C) del bosque de manglar de Tumilco de Tuxpan, Veracruz, México*. Tesis de Posgrado. Maestría en Manejo de Ecosistemas Marinos y Costeros. México: Universidad Veracruzana, 92 p. (new, local, mangrove)
- Torres, J. R./Tecnológico Nacional de México and Instituto Tecnológico del Valle del Yaqui. 2018-19. Contact: jtorres.velazquez@itvy.edu.mx (new, local, mangrove)

United States

- Connecticut Department of Energy and Environmental Protection. 2019. Long Island Sound Blue Plan map layers. http://cteco.uconn.edu/projects/blueplan/index.htm (new, local, seagrass, mangrove)
- Kauffman, J.B. et al. 2020. Total ecosystem carbon stocks at the marine-terrestrial interface: Blue carbon of the Pacific Northwest Coast, United States. Global Change Biology 2020; 2: 5679– 5692. https://doi.org/10.1111/gcb.15248 (new, local, seagrass)
- NOAA Coastal Services Center. 2007. Coastal Bend Texas Benthic Habitat Mapping Patchy Raster Map. http://www.csc.noaa.gov/benthic/data/gulf/bend.htm (new, local, seagrass)
- NOAA Office for Coastal Management. 2016. Coastal Change Analysis Program (C-CAP) 2016 Regional Land Cover Data - Coastal United States. https://www.fisheries.noaa.gov/inport/item/48336 (new, regional, mangrove)
- Northeast Regional Ocean Council. 2017. Eelgrass Beds – Northeast United States. Accessed on Northeast Ocean Data Portal. (new, regional, seagrass)
- Prentice, C. et al. 2020. A synthesis of blue carbon stocks, sources, and accumulation rates in eelgrass (Zostera marina) meadows in the Northeast Pacific. Global Biogeochemical Cycles, 34, e2019GB006345. https://doi.org/10.1029/2019GB006345 (new, regional, seagrass)
- Texas Parks and Wildlife. 2015 and 2020. TPWD Coastal Fisheries Habitat Assessment. https://tpwd.texas.gov/landwater/water/habitats/seagrass/ (new, local, seagrass).
- US Environmental Protection Agency. 2016. National Greenhouse Gas Inventory of US Coastal Wetlands. Assembled datasets. Smithsonian Institute. https://github.com/Smithsonian/Coastal-Wetland-NGGI-Data-Public (new, regional, mangrove, seagrass, salt marsh).
- Washington Department of Natural Resources. 2019. Submerged Vegetation Monitoring Program. Olympia, WA: DNR Nearshore Habitat Program. https://www.dnr.wa.gov/programs-and-services/aquatics/aquatic-science/nearshore-habitat-eelgrass-monitoring (updated + new datasets, local, seagrass)