

North America Blue Carbon Maps Cartographic Integration Process

Commission for Environmental Cooperation

North America Saltmarshes Map update process

This document describes the processes conducted to update the North America Saltmarshes distribution map published by the Commission for Environmental Cooperation (CEC) in 2015. The overall process comprises data search of new or updated mapping sources describing the spatial distribution of Saltmarshes across North America, data review, data selection and cartographic integration of the selected data.

An initial review of the datasets used in the 2015 North America Saltmarshes distribution map and an exhaustive search for data updates or new datasets available was conducted by the Mexican Carbon Program, that reviewed 12 saltmarshes datasets ranging from global to regional scale. Three new layers were delivered as result of the search, and 9 layers used in the 2015 North America Saltmarshes distribution map were restored from the CEC archives (Table 1).

Table 1. Initial saltmarshes datasets collected and reviewed.

Dataset	Geometry	Source
1 WCMC Saltmarshes Distribution Map	Polygon	World Conservation Monitoring Center-United Nations Environment Programme
2 USA Saltmarshes distribution from the National Wetlands Inventory	Polygon	U.S. Fish and Wildlife Service
3 Louisiana saltmarshes distribution	Polygon	United States Geological Survey
4 British Columbia saltmarshes distribution	Polygon	British Columbia ShoreZone - GeoBC
5 St. Lawrence river saltmarshes distribution	Polygon	Environment Canada
6 Gulf of St. Lawrence saltmarshes distribution	Polygon	Coastal and epipelagic habitats of the St. Lawrence Estuary and Gulf - Database (Fisheries and Oceans Canada)
7 New Brunswick saltmarshes distribution	Polygon	Service New Brunswick
8 Prince Edward Island saltmarshes distribution	Polygon	PEI Department of Energy 2000 Wetlands Inventory
9 Nova Scotia saltmarshes distribution	Polygon	Nova Scotia Wetland Inventory
10 Baja California saltmarshes distribution	Polygon	Frederick T. Short (University of New Hampshire)
11 North Pacific coast seagrass locations	Point	Kauffman, J. B., Giovanonni, L., Kelly, J., Dunstan, N., Borde, A., Diefenderfer, H., ... & Brophy, L. (2020). Total

		ecosystem carbon stocks at the marine-terrestrial interface: Blue carbon of the Pacific Northwest Coast, United States. Global Change Biology.
12	USA Saltmarshes distribution from the National Greenhouse Gases Inventory	Point USA Environmental Protection Agency

In a second review of the saltmarshes datasets, each of them was evaluated and identified for suitability in the update process. Based on this second review, a final list of saltmarshes datasets was defined to be used in the mapping integration process representing the spatial distribution of saltmarsh ecosystems across North America. The following list offers a summary of the second review of saltmarshes datasets.

1. WCMC Saltmarshes Distribution Map

This dataset offers updated information of the global saltmarshes distribution used in the 2015 North America Saltmarshes distribution map.

2. USA Saltmarshes distribution from the National Wetlands Inventory

This dataset offers updated information of the saltmarshes distribution across the conterminous United States and Alaska used in the 2015 North America Saltmarshes distribution map.

3. Louisiana saltmarshes distribution

This layer will not be used, as the updated version of the National Wetlands Inventory (NWI) offers updated data for Louisiana, the Louisiana reference map used in the 2015 North America Saltmarshes distribution map is from 2013 while the updated NWI is 2020.

4. British Columbia saltmarshes distribution

The original dataset used in the 2015 North America Saltmarshes distribution map corresponds to British Columbia ShoreZone 2014. There is an updated version of this dataset reported in 2018.

5. St. Lawrence river saltmarshes distribution

The datasets used to generate this layer of spatial information were requested to Guy Letourneau from Environment Canada. Based on his comments, a new delineation of the St. Lawrence river estuarine region must be conducted prior integrating this dataset in the new North America Saltmarshes distribution map.

6. Gulf of St. Lawrence saltmarshes distribution

This dataset will not be used in the new North America Saltmarshes distribution map as it represents a grid of cells with saltmarsh information in the Gulf of St. Lawrence that is already present in the Nova Scotia, Prince Edward Island and New Brunswick updated datasets.

7. New Brunswick saltmarshes distribution

There is an update of this layer (2019 version). However, based on email communication with Bernie Connors (Land Information Infrastructure Secretariat Unit, Service New Brunswick); the database that contains saltmarsh information is the New Brunswick Hydrographic Network.

8. Prince Edward Island saltmarshes distribution

This dataset is the same as used in the 2015 North America Saltmarshes distribution map, it still provides information that complements the spatial data in the updated version of the WCMC Saltmarshes Distribution Map.

9. Nova Scotia saltmarshes distribution

There is an updated version that provides Saltmarshes distribution data within the Nova Scotia Forest Inventory by counties.

10. Baja California saltmarshes distribution

The region concerning this dataset is covered in the most recent map of the global distribution of saltmarshes produced by WCMC.

11. North Pacific coast seagrass locations

This dataset contains updated point locations of saltmarshes distribution across the north pacific coast of the United States.

12. USA Saltmarshes distribution from the National Greenhouse Gasses Inventory

This dataset contains updated point locations of saltmarshes distribution across the United States.

Derived from the second review of the initially identified and reviewed saltmarshes datasets covering the North American region. A final list of datasets was defined to be used as main inputs in the new North America Saltmarshes distribution map. The selected datasets are described in Table 2.

Table 2. Final datasets for the North America Saltmarshes Map update.

	CODE	Name	Version	Resolution/ Scale	Spatial Reference	Year of Origin	Last Update	Coverage	Source
Polygons	SM_01	WCMC Saltmarshes Distribution Map	6	1:10,000 – 1:4,000	WGS 1984	2017	2019	Global	UN World Conservation Monitoring Centre
	SM_02	National Wetlands Inventory	2	1:24,000 and 1:25,000	Albers (NAD83)	2016	2020	USA	U.S. Fish and Wildlife Service
	SM_03	C-CAP Saltmarshes USA Northeast	NA	0.5 meters	WGS 1984	2012 - 2013	2019 - 2020	Regional	NOAA Coastal Change Analysis Program (C-CAP)
	SM_04	PEI 2000 Wetlands Inventory	1	1:17,500	Double Stereographic (NAD83)	2005	2010	Regional	Conservation and Management, Department of Environment, Energy, and Forestry (PEI)
	SM_05	New Brunswick Hydrographic Network (NBHN)	1	Not reported	Double Stereographic (NAD83)	2018	2018	Regional	GeoNB, Province of New Brunswick's gateway to geographic information
	SM_06	Nova Scotia Forest Inventory	1	1:10,000 – 1:12,500	UTM 20N (NAD83)	2020	2020	Regional	Nova Scotia, Department of Lands and Forestry Home

SM_07	BC ShoreZone Observed Habitat Polygons	NA	NA	Albers (NAD83)	2011	2018	Regional	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
SM_08	St. Lawrence wetlands classification	NA	NA	UTM 19N (WGS84)	2005	2005	Regional	Environment Canada

Preprocessing by dataset

SM_01. WCMC Saltmarshes Distribution Map

The original dataset was acquired from the World Conservation Monitoring Centre (WCMC) that integrates two vector layers: polygons and points.

A “selection by attributes process” was performed to isolate all saltmarshes polygons corresponding to Canada, the United States and Mexico territories. All polygons located in the USA territories over the Pacific Ocean as well as Puerto Rico were deselected. A final saltmarshes layer was exported from the remaining polygons selection.

SM_02. National Wetlands Inventory, Version 2

Based on Cowardin Classification (<http://www.fws.gov/wetlands/Documents/Wetlands-and-Deepwater-Habitats-Classification-chart.pdf>) used to delineate salt marshes in the 2015 CEC North America Blue Carbon Map, a SQL selection was set up to isolate saltmarshes in the 2020 USA National Wetlands Inventory.

USA National Wetlands Inventory (NWI) Code Definitions table was downloaded from the US Fish and Wildlife Service (<https://www.fws.gov/wetlands/data/wetland-codes.html>) and used to join all polygon features descriptions to the state-level wetlands shapefiles available through the NWI.

The SQL expression selected all polygons defined as “Estuarine – Intertidal – Emergent – Persistent – Saltwater Tidal”

```
WHERE "SYSTEM_NAME" == Estuarine AND "SUBSYSTEM_NAME" == Intertidal AND
"CLASS_NAME" == Emergent OR "SUBCLASS_NAME" == Persistent AND
"WATER_REGIME_SUBGROUP" == Saltwater Tidal
```

All saltmarshes polygons identified at state-level based on the predefined SQL selection were finally merged into a national saltmarshes distribution file (Alaska and CONUS).

SM_03. C-CAP Saltmarshes USA Northeast

Polygons describing classes related to salt marsh habitats in both New Hampshire and Rhode Island files were selected and exported to new spatial layers. Classes selected were: Brackish Marsh, Dieoff Depression, High Marsh; J.gerardii, High Marsh; Mix, High Marsh; S.alterniflora, High Marsh; S.patens-D.spicata, Low Marsh, Panne, Salicornia spp., Salt Shrub, Short form S. alterniflora, Terrestrial border, Wrack.

New layers were merged in a new spatial layer combining salt marshes polygons from Rhode Island and New Hampshire and names were standardized to avoid different spelling refereeing to identical classes.

SM_04. PEI 2000 Wetlands Inventory

This layer contains different types of wetland areas across Prince Edward Island, including “salt or brackish marshes”. A “select by attributes” tool was used to select all “salt or brackish marshes” within the WETL_TYPE (Wetland Type) attribute. A final layer of saltmarshes of PEI was generated from the selected features.

SM_05. New Brunswick Hydrographic Network (NBHN)

This layer was indicated by Bernie Connors (Land Information Infrastructure Secretariat Unit, Service New Brunswick) as the one that contains more specific information on the wetland types, including coastal marsh attribute. The codes for the attribute description are in a “xlsx” files delivered by Bernie Connors (DNR_DataDictionary.xlsx).

According to the reference xlsx spreadsheet, CM (Coastal Marsh) = wetlands dominated by rooted herbaceous plants that drain directly into coastal waters and have the potential to be at least partially inundated with salt or brackish water

As a first processing step, the wetlands layer within the Hydrographic Network set of files was selected (NBHN_0000_03_wl.shp). The WC attribute describes “wetland class”, all “Coastal Marsh” polygons were selected and exported to a new feature dataset.

SM_06. Nova Scotia Forest Inventory

This layer is a combination of county-level forest inventories of Nova Scotia, all the layers were merged to generate a province-level forestry inventory layer. Saltmarshes are described in the “wetland type” (WC_TYPE) field, code for saltmarsh = S.

Individual files were acquired for Annapolis, Antigonish, Cape Breton, Colchester, Cumberland, Digby, Guysborough, Halifax East, Halifax West, Hants, Inverness, Kings, Lunenburg, Pictou, Queens, Richmond, Shelburne, St. Marys, Victoria, and Yarmouth.

Saltmarshes were extracted from all forest inventories by individual files, that created a collection of individual files of saltmarshes. Those individual files by section were then integrated in a single file of saltmarshes for Nova Scotia.

SM_07. BC ShoreZone Observed Habitat Polygons

This is an updated layer from the BC_ShoreZone dataset used in the CEC 2015 Blue Carbon Map (BC_ShoreZone 2014). The data was downloaded from the BC Geographic Warehouse Custom Download. By means of a selection by attributes, all polygons with SPECIES_NM equal to “marsh grasses and sedges” and “Salicornia virginica” were exported to a final BC saltmarshes layer.

SM_08. St. Lawrence wetlands classification

The layers used to generate the St. Lawrence saltmarshes distribution were delivered by Environment and Climate Change Canada. The shapefiles used to generate this layer correspond

to the estuarine section of the St. Lawrence river. Based on feedback from Guy Letourneau (Environment and Climate Change Canada), some of the shapefiles of the sections used in the 2015 Blue Carbon Map should be omitted as they are not considered as part of estuarine region of the St. Lawrence river. Sections of Quebec, Cap Tourmente, Montmangy, and Orleans that were included in the previous Blue Carbon Map of North America are omitted in this updated version.

Different years in the shapefiles correspond to different mapping efforts based on the date when the source orthoimages were taken. Due to geometry problems reported by Environment and Climate Change Canada, files from 2000 were not used when there were files from 2002 for each section of the River. The process to prepare the final layer of the salt marshes in the St. Lawrence river is described below.

1. A new attribute field describing the year of origin of each polygon was added to each shapefile of the preselected river sections.
2. Merge of 12 shapefiles that encompass the estuarine section of the St. Lawrence river.
3. Dissolve all polygons based on their legend description.
4. Selection by attributes of polygons containing the text string “marsh” and export to a final St. Lawrence saltmarshes layer.

2021 North America Saltmarshes Distribution Map, Cartographic Integration Process

1. All preprocessed polygon spatial layers (SM_01 - SM_08) were reprojected from their original Coordinate Reference System (CRS) to the standard North American Atlas CRS (Table 3).

Table 3. North American Atlas, Coordinate reference System

Projection	Lambert Azimuthal Equal Area
Linear Unit	Meters (1.0)
False Easting	0.0
False Northing	0.0
Central Meridian	-100.0
Latitude of Origin	45.0
Datum	D Sphere ARC INFO
Spheroid	Sphere ARC INFO
Semimajor Axis	6370997.0
Semiminor Axis	6370997.0
Inverse Flattening	0.0

2. Definition of standard attribute fields that describe common information recorded in most of the input datasets (Table 4).

Table 4. Standard attribute fields defined for the North America Saltmarshes polygons Map update.

Field Name	Definition	Data Type	Description
COUNTRY	Country	Text	Country of location of each polygon (CAN: Canada, USA: United States of America, MEX: Mexico)

STATEABB	State or Province	Text	State or province code defining the location of each polygon (two letters country code + two letters state/province code)
NAME	Reported Name	Text	Name of the features described by each polygon, as reported by the source of each dataset
INPT_SRCE	Input Source	Text	Description of the original dataset used to acquire each polygon
YEAR_PUB	Year of Publication	Long	Year of the publication of the last update of the dataset used as input
RESP_PARTY	Responsible Party	Text	Name of the entity responsible on providing each dataset
YEAR_ORGN	Year of Origin	Text	Year of origin of data reported by the source of each dataset (this can be year when data was taken or when the data was originally published by the source)
SURVEY_MET	Survey Method	Text	Reported method of data acquisition as reported by the source of each dataset
SCAL_RPRTD	Scale Reported	Text	Scale of the input data used in each polygon or general dataset as reported by the source
RESL_RPRTD	Resolution Reported	Text	Resolution of the input data used in each polygon or general dataset as reported by the source
SOURCE_DES	Source Description	Text	General description of the source dataset used to derive each polygon
CITATION	Citation	Text	Full citation of the used data source
SOURCE_ID	Source ID	Text	Identification code of the datasets reported in the data sources full description document
AREA_SQMT	Area in m2	Float	Area calculated using the map CRS

3. GIS steps to integrate selected and preprocessed saltmarshes datasets.

As some of the datasets show spatial overlaps, some criteria were defined to deal with overlapping polygons from different data sources and keep as much spatial information as possible.

In order to define the criteria to prioritize sources datasets on areas where information overlaps, the Mexican Carbon Program conducted a series of three national workshops with experts from Canada, the United States and Mexico.

Experts were asked to rank the sources datasets features that should be considered when selecting the sources of information that must prevail over areas with overlapping polygons. Six quality features were evaluated by the experts, comprising:

- Most updated datasets
- Fine spatial resolution over coarse spatial resolution
- Datasets reporting accuracy
- National or regional datasets over global datasets
- Independent research studies over institutional datasets
- Most complete metadata

A group of eleven experts participated in a survey to rank the criteria (Table 5).

Table 5. Group of Blue Carbon experts from Canada, the United States and Mexico.

	Name	Country	Institution	Email
1	Nate Herold	United States	NOAA	nate.herold@noaa.gov
2	Margot Hessing-Lewis	Canada	Hakai Institute	margot@hakai.org

3	Gail Chmura	Canada	McGill University	gail.chmura@mcgill.ca
4	Dan Mulrooney	Canada	Parks Canada	dan.mulrooney@canada.ca
5	Anna Hilting	United States	NOAA	anna.hilting@noaa.gov
6	María Teresa Rodríguez Zúñiga	Mexico	CONABIO	mrodrig@conabio.gob.mx
7	Joanna Acosta Velázquez	Mexico	Aura: manglares y costas, S. C.	joanna.acosta@gmail.com
8	Iliana Pérez Espinosa	Mexico	COANBIO	iperez@conabio.gob.mx
9	Carlos Troche	Mexico	CONABIO	ctroche@conabio.gob.mx
10	Beatriz Carolina Corral Osuna	Mexico	INECC	beatriz.corral@gmail.com
11	Zulia Mayari Sánchez Mejía	Mexico	Instituto Tecnológico de Sonora	zulia.sanchez@itson.edu

Based on the survey results, data features were ranked by the experts from the three countries as shown in the figure below (Figure 1).

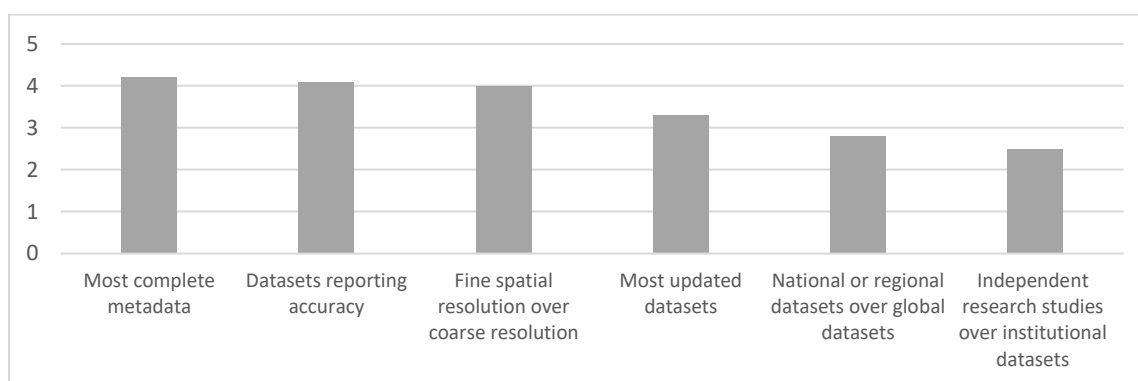


Figure 1. Criteria for spatial layers prioritization defined by the Blue Carbon group of experts.

As a result of the experts-defined criteria and the characteristics of the information provided by each source dataset, we defined each dataset as authoritative over its corresponding region.

All polygons from the most spatially extent dataset (WCMC global saltmarsh distribution map), that intersected areas already mapped by regional or national datasets were omitted in the integration process. In the United States, regional data from NOAA C-CAP in Rhode Island and New Hampshire were prioritized at regional level over the USA National Wetlands Inventory. Polygons from the latest dataset that intersected with regional data from the C-CAP product data were removed.

These criteria were defined as in most of the cases, the data from local or regional data sources refer to a latest date than the sources data reported by WCMC global saltmarsh distribution map, and in some other cases, the local or regional datasets are the same used in the WCMC global saltmarsh distribution map.

All polygons from each local or regional datasets and the remaining polygons from the that do not overlap with already mapped areas were merged in a final North America saltmarshes distribution map.

Step 01

Selection of all polygons from the WCMC global saltmarsh distribution map that do not overlap other input datasets and generation of a new spatial layer.

Output = WCMC_saltmarshes_laea_final.shp

Step 02

All the layers previously prepared and preprocessed with no overlapping areas between source data sets were merged in a new spatial layer.

- WCMC_saltmarshes_laea_final.shp
- CAN_BC_saltmarshes_laea_final.shp
- CAN_NB_saltmarshes_laea_final.shp
- CAN_NS_saltmarshes_laea_final.shp
- CAN_PEI_saltmarshes_laea_final.shp
- CAN_StLawrence_saltmarshes_laea_final.shp
- USA_NWI_saltmarshes_laea_final.shp
- USA_CCAP_saltmarshes_laea_final.shp

Output = NorthAmerica_saltmarshes_layers_merge.shp

Step 03

A process of “Multipart to Single part” was applied to the output layer from the previous step. This way, all polygons are individually accounted as single polygons, which will allow to dissolve spatially connected polygons that share the same values in all the attribute fields.

Output = NorthAmerica_saltmarshes_layers_singlepart.shp

Step 04

A “Dissolve” process was applied to the output layer from the previous step. All individual polygons that are spatially connected and share the same values across the thirteen common attribute fields (except area) will break down into new polygons. This way, the number of polygons and the size of the final spatial layer file is reduced. No multipart features creation is allowed in this step.

Output = NorthAmerica_saltmarshes_polygons_dissolve.shp

Step 05

A new field “AREA_SQMT” is created and the area in squared meters is calculated for this field. The area is calculated based on the map coordinate reference system, 1 decimal point and thousands separated by comas are defined.

Step 06

After a final check of attribute table consistency and data display on different GIS platforms, a spatial data file in ESRI “shp” format is generated to provide the final CEC North America saltmarsh distribution map.

Note that, although there are no overlapping areas from different data sources, overlapping polygons within the same input datasets are preserved. (e.g., WCMC in the Baja California peninsula or Environment Canada in the Saint Lawrence wetlands classification).