Methods Brief

Adding Salinity Modifier to the California Aquatic Resource Inventory (CARI)

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Overview

Introduction

Salinity is a fundamental parameter in estuarine research, serving as a metric for quantifying the concentration of dissolved salts, primarily within water bodies and soils. Within the intricate web of aquatic ecosystems, estuaries are renowned for their dynamic nature, where salinity levels are subject to constant fluctuations. These variations result from a complex interplay of factors, including tidal dynamics, evaporation, precipitation, freshwater influx, and geological attributes. Salinity influences vegetation and wildlife community structure and plays an important role in biogeochemical processes, including carbon sequestration and methane emission rates.

The focus of this effort was to construct a comprehensive and unified dataset that classifies salinity levels across the diverse estuarine environments of California. This dataset is

of particular significance for blue carbon quantification, as it differentiates between saline and brackish salinity categories, which function differently with respect to greenhouse gas (GHG) emissions yet until now have been aggregated in a single “Estuarine” class in statewide wetlands mapping datasets. By systematically applying a decision-tree methodology, we identified and prioritized the most reliable sources of salinity data (or proxy data), aligning them with relevant aquatic features cataloged in the California Aquatic Resource Inventory (CARI; San Francisco Estuary Institute, 2023). This endeavor culminated in an enriched version of CARI, where salinity classes were attributed to aquatic resource polygons where reliable salinity data were available. This augmentation enhances the accuracy and utility of CARI, making it a valuable resource for further estuarine research, environmental management, and conservation efforts.

Target Salinity Classes

We devised a classification scheme aimed at simplifying the complex data into six distinct output salinity classes, as outlined in Table 1. This categorization strategy assigns a single salinity class to a given CARI polygon. Accordingly, the salinity attribute is intended to reflect dominant salinity conditions and does not capture temporal fluctuations in salinity due to factors such as tidal influence, evaporation, and seasonal variations in freshwater inputs. In recognition of the extraordinary variability observed in certain environments, we introduced a "Bar-built (variable)" class, which is designated for bar-built estuaries, where salinity is markedly influenced by their hydrological connection to the ocean, leading to substantial fluctuations. The final "Undefined" class is employed in areas where vegetation mapping is available but does not provide enough information to assign a salinity class. The classification into these six categories serves as a practical means of summarizing and characterizing the prevailing salinity conditions within the habitats under study.

Table 1. Salinity classes and their definitions. Salinity values are in parts per thousand (ppt)

Salinity Class	Range	Description
Fresh	<0.5 ppt	Areas where the water contains minimal dissolved salts, primarily originating from terrestrial freshwater sources such as rivers, streams, and precipitation. These areas may experience fluctuations in salinity due to factors like tidal influence and seasonal variations in freshwater inputs, but they primarily maintain a low-salinity condition.
Oligohaline	0.5 - 5 ppt	Areas with a moderate but relatively low salinity level, typically found at the upper extent of estuaries. Oligohaline habitats support a range of species that can tolerate moderate salinity levels, serving as a transition zone between freshwater

		and more saline estuarine regions.
Mesohaline	5 - 18 ppt	Areas with a moderate to moderately high salt concentration. They are positioned further downstream, nearer to the estuary's mouth, where marine influence becomes more pronounced.
Saline	>18 ppt	Areas with a high salt concentration. These environments are usually found nearer to the estuary's mouth or along the coastal fringe, where seawater dominates and freshwater influence is minimal. This category is equivalent to the IPCC saline category for which methane emissions are assumed to be zero.
Bar-built (Variable)	N/A	Salinity in bar-built estuaries is notable for its variability, influenced by factors like seasonal fluctuations, tidal dynamics, and changes in freshwater inflow. These estuaries can experience elevated salinity levels during low freshwater input or dry seasons and reduced salinity during heavy rainfall and wet seasons. The balance of seawater intrusion during high tides and freshwater dominance during low tides contributes to the salinity dynamics.
Undefined	N/A	Areas where there is inconclusive information available from the vegetation data and water sample measurements to confidently determine the specific salinity level.

Methods

To determine the predominant salinity class in our defined wetland habitats, we used vegetation mapping and published salinity measurements to classify each CARI polygon into one of the six defined salinity classes. Vegetation composition broadly reflects salinity conditions, as the growth and distribution of certain plant species are significantly influenced by their salinity tolerance levels. Where alliance-level vegetation data were available, we crosswalked the dominant vegetation species to the range of salinities it tolerates and the primary salinity in which it is found in California estuaries. (In many cases, vegetation alliances are likely to be found in a range of salinity conditions, in which case the primary salinity class was left undefined.) In cases where comprehensive vegetation data were unavailable or inconclusive with respect to salinity, our effort leveraged published salinity measurements from water samples collected across California estuaries. Although salinity sampling offers a direct measure of point-scale salinity, its constrained temporal and spatial coverage diminishes its reliability as the primary data source for time-integrated statewide salinity mapping. In addition,

most salinity sampling occurs in easily accessible waterways, which may differ in salinity from tidal habitats that exhibit a different frequency of wetting and drying. Pore water salinity measurements, from the interstitial spaces (pores) within sediments, would better reflect conditions within vegetated tidal habitats than open water measurements, but are not commonly collected due to access constraints and sampling difficulty. For this reason, our decision tree methodology was designed to prioritize available vegetation data. When alliance-level vegetation data are absent or inconclusive, interpolated nearby salinity sampling measurements provide an alternative basis for determining the prevailing salinity class. This combined approach ensures a comprehensive assessment of salinity in diverse wetland habitats.

Input Data

Vegetation Data

Vegetation data from across the state were compiled and crosswalked to the salinity classes in Table 1. Vegetation data in this project came from two primary sources: the Vegetation Classification and Mapping Program (VegCAMP; California Department of Fish and Wildlife, 2023) and Pacific Veg Map (Tukman Geospatial, 2023). VegCAMP, is a data product led by the California Department of Fish and Wildlife (CDFW) and is a fine-scale vegetation mapping program completed on a project-level basis across the state. Pacific Veg Map is a collection of land cover and fuels datasets primarily produced by Tukman Geospatial in collaboration with CalFire and other contributing organizations. Recent primary datasets used by this effort include fine-scale vegetation mapping in San Mateo, Santa Clara, Santa Cruz, Marin, and Sonoma counties. These two datasets were combined, and where there was overlap the more recently produced mapping product was selected for use.

Most vegetation data includes a National Vegetation Classification Standard (NVCS; Federal Geographic Data Committee, 2023) alliance/association-level classification value, as described in Figure 1, which was determined to be the most consistent and reliable classification scheme across vegetation datasets. A complete list of alliance/association level classifications was produced by intersecting the compiled vegetation datasets with CARI features. Due to the variability of data sources and years, there are many formatting discrepancies in alliance/association names (e.g., “Atriplex prostrata – Cotula coronopifolia” vs. “Atriplex prostrata - Cotula coronopifolia,” which differ by dash type), requiring us to include all possible naming iterations within the compiled data sources in order to make a comprehensive alliance/association list. See Table 4 in the Appendix for a full list of input vegetation mapping projects.

Vegetation alliances/associations were crosswalked to salinity classes using best professional judgment by staff experts. Each vegetation alliance/association was assigned a salinity range over which the dominant species may be found. Alliances/associates were also assigned a primary salinity class if in California estuaries they are most commonly found at one of the salinity classes within their possible range. (In many cases, primary salinity classes were left undefined, i.e., where vegetation is not a good indicator of a single salinity class.) Sparingly,

a few higher level classifications above the association/alliance level (i.e., group or macrogroup) were used to identify non-saline environments. This includes examples such as Arid West freshwater emergent marsh and Mediterranean California Naturalized Annual and Perennial Grassland. For all areas with vegetation mapping outside the Sacramento-San Joaquin Delta, the primary salinity class was used to designate salinity. Where the primary salinity class was undefined, interpolated salinity measurements were used to select a salinity class within the vegetation's salinity range. (See the Vegetation Attribution section below). For all polygons in the primarily freshwater Sacramento-San Joaquin Delta where vegetation mapping was available, we used the low-salinity end of the salinity range as the designated salinity. See Table 3 in the Appendix for the full vegetation association/alliance-salinity crosswalk.

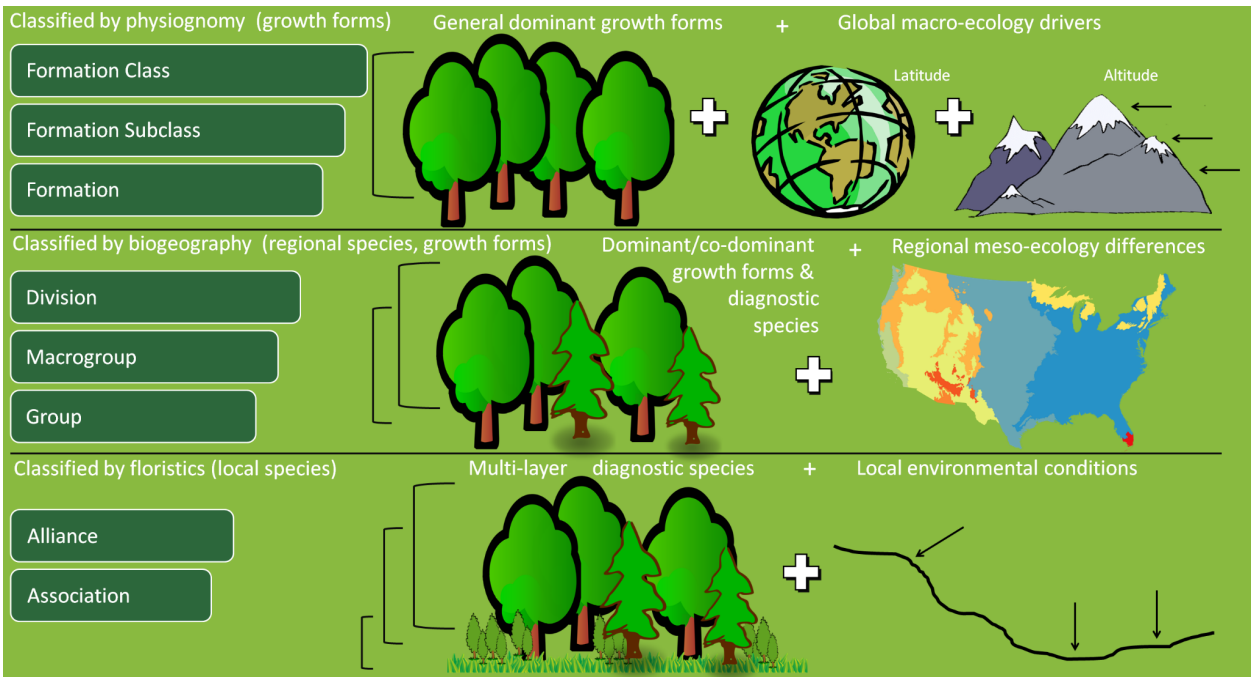

Figure 1. Overview of the United States National Vegetation Classification (Natural Vegetation) illustrating the various classification levels used in most of the vegetation mapping datasets compiled for this effort. If vegetation mapping was not classified to at least the Alliance level, it was not used in our processing except for selected Macrogroup and Group classes for which it was possible to confidently assign a fresh salinity class. (https://usnvc.org/about/plant-communities-and-vegetation-classification/natural-vegetation-classification/)

Salinity Sampling Points

Tabular salinity data spanning 2010 to 2022 was imported from multiple sources, including the Environmental Protection Agency (EPA) Water Quality Portal (which includes USGS National Water Information System (NWIS) data and EPA Storage and Retrieval (STORET) data), California Estuary Marine Protected Area (EMPA) Monitoring Program, National Coastal Condition Assessment (NCCA) / National Wetland Condition Assessment (NWCA), National Estuarine Research Reserve (NERR) System, and California Environmental

Data Exchange Network (CEDEN). For reference dates and associated queries of these salinity point data exports, please consult Table 5 in the Appendix.

Each source dataset underwent independent scripting to ensure proper data ingestion, cleansing, and transformation. This process encompassed appropriate spatial attribution, capturing collection dates, and converting conductivity measurements into salinity estimates. Salinity was determined by applying the Practical Salinity Scale 1978 (PSS-78) algorithm, which takes into account measured conductivity, temperature, and pressure (Intergovernmental Oceanographic Commission (IOC) of UNESCO, 2010). Salinity conversions were made using the “gsw” Python package, which can be accessed at this GitHub repository: https://github.com/TEOS-10/GSW-Python. To convert electrical conductivity measurements to salinity, we assumed a standard temperature of 25°C, a widely adopted default value for conductivity-salinity conversions that falls within the range typical of California estuarine waters (Schemel, 2001). We also assumed a pressure of 0 decibars (dbar) considering most sampling was collected at or near the surface.

All individual point datasets were merged into a single dataset. In cases where points fell within a 50-meter radius of one another, a median salinity value was assigned, a methodology selected to mitigate biases arising from localized salinity spikes that could significantly skew the mean salinity value. After processing, over 17,000 locations across California had assigned salinity values.

Data Analysis

Salinity Sampling Interpolation

The initial phase of processing of the salinity point data involved transforming the data into an interpolated raster format. To align the interpolation with estuarine boundaries, we implemented spatial constraints by incorporating the Pacific Marine and Estuarine Fish Habitat Partnership (PMEP) Estuary Extent dataset and creating a 500-meter buffer around it. To prevent separate estuaries from unintentionally being grouped, some instances required a manual split of the buffered output. Additionally, in the case of the San Francisco Estuary, we further subdivided it using Operational Landscape Units for the San Francisco Bay, while the Delta region was segmented into predefined areas as outlined by the Delta Stewardship Council within the framework of the Delta Adapts program. Estuaries designated as "Bar-built" according to the Central Coast Wetlands Group California Coastal Confluence Inventory were excluded from the analysis. The resulting layer established barriers that allowed the subsequent interpolation to follow natural estuarine boundaries. After these steps, over 2,000 salinity points fell within the bounds of the interpolation regions.

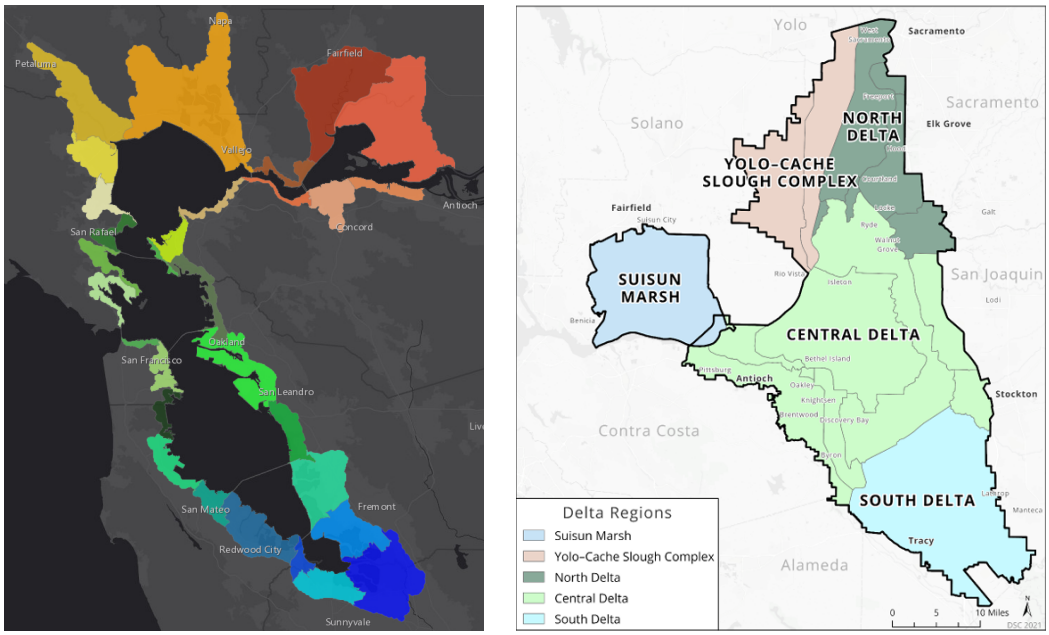

Figure 2. Operational Landscape Units (SFEI) and Delta Regions (Delta Stewardship Council) used to subdivide the San Francisco Estuary for interpolation processing.

Prior to the interpolation, salinity median values were log-transformed to allow for a more normal distribution of values to model. To interpolate salinity values within the study extent, we used the Spline with Barriers ArcGIS tool, a selection made after experimenting with various interpolation methods, including several kriging techniques. The Spline with Barriers tool was selected because its capacity to confine interpolation using barriers yielded the most dependable outcomes of the approaches we tested.

The interpolated surface was mosaicked into a new raster, and the log-transformed values were subsequently converted back to parts per thousand (ppt). Following this conversion, the raster values were classified according to salinity into the respective salinity classes: Fresh, Oligohaline, Mesohaline, or Saline (Table 1). To finalize the procedure, the output raster was transformed into a polygon format, the *Interpolated salinity layer* for use in future processing.

During the testing phase, we identified several high-leverage outliers that skewed the interpolation. Where outliers differed strongly from other nearby values and weren't able to be explained by natural barriers, freshwater inflows, tidal processes, or other hydrologic processes, they were excluded from the analysis. All excluded points were recorded for transparency and documentation. Excluded points can be identified via the "Excluded" column in the salinity point dataset, indicated by a value of "1".

Vegetation Attribution

All vegetation mapping datasets were combined into a single spatial dataset and then joined with the vegetation salinity crosswalk (Table 3). Only vegetation features that were successfully crosswalked were retained, the *Vegetation salinity layer.* Where vegetation datasets overlapped, priority was given to the most recently updated mapping publication. For each vegetation polygon, the primary salinity class from the vegetation crosswalk was used to assign a salinity value. Where the primary salinity class was "Undefined," the *Interpolated salinity layer* was used to select a single salinity class for the vegetation salinity range. If the salinity class in the *Interpolated salinity layer* that had the greatest coverage in the vegetation polygon fell within the salinity range of the *Vegetation salinity layer*, that salinity class was used. If that salinity class fell outside the vegetation salinity range, the nearest class in the vegetation range was chosen, either from a higher class out of range to a lower class or a lower class out of range to a higher class. For example, if the *Interpolated salinity layer* indicated “Saline” but the upper end of the *Vegetation salinity layer* range was “Mesohaline,” then the salinity class was assigned “Mesohaline.” Alternatively, if the Interpolated salinity layer indicated “Fresh” but the lower end of the Vegetation-salinity layer range was “Oligohaline,” then the salinity class was assigned “Oligohaline.” Where “Undefined” vegetation polygons fell outside the PMEP estuary extent buffer and therefore did not have a value from the *Interpolated salinity layer*, they retained the “Undefined” classification. The resolved vegetation polygon dataset was then dissolved by salinity class and intersected with the CARI polygon dataset. The salinity class with the largest overlap was assigned to the CARI polygon for further evaluation in the decision tree framework.

Decision Tree Framework

With the *Interpolated salinity layer* and the *Vegetation salinity layer*, a structured decision tree was employed to select salinity values for CARI polygons based on these inputs. Only CARI polygons that indicated some type of tidal connectivity based on the “Tidal Modifier”, previously classified in CARI development, were assessed for the salinity modifier. This includes tidal wetlands throughout the state as well as managed and nontidal wetlands in Suisun Marsh and the Sacramento-San Joaquin Delta that have an “Unknown” tidal designation in CARI. The order of the steps dictate prioritization of how the salinity modifier is assigned. Moving through the decision tree, once a CARI polygon meets the criteria, the modifier is appropriately assigned and the process iterates to the next CARI polygon. The decision tree initially uses existing CARI polygon attributes, classes or source datasets to classify certain areas as “Saline,” “Bar-built,” or “Fresh,” as described in Steps 1 - 3 in Table 2. For CARI polygons not classified in Steps 1 - 3, the decision tree then assesses whether more than 33% of the polygon overlaps with classified (but not “Undefined”) vegetation data in the *Vegetation salinity layer*, in which case the decision tree assigns the vegetation-based salinity value with the greatest coverage within the polygon. If a CARI polygon is not classified in Steps 1-4 but it has overlap with the *Interpolated salinity layer*, it is assigned the salinity class with the largest overlap. Where no interpolated salinity data are available for a polygon, but has largest overlap with an “Undefined” primary salinity class in the *Vegetation salinity layer*, that polygon retains the “Undefined” salinity designation in the final mapping. Finally all other features that are not classified in steps 1-3 and do not align

with either the *Vegetation salinity layer* or the *Interpolated salinity layer* receive an attribution of "N/A," signifying that no relevant datasets were available for the salinity classification. For a detailed breakdown of the decision tree and the sequential implementation of each decision within the scripts, please consult Table 2.

Table 2. Decision tree used to assign salinity classes to CARI features.

Step	Decision Tree Sequential Queries	Salinity Modifier	Salinity Source
1	CARI Tidal Wetlands Class is “Marine”	Saline	CARI Marine
2	CARI Tidal Wetland Type is “Bar-built”	Bar-built (Variable)	Bar-built
3	CARI Tidal Wetlands source data is from the National Estuarine Research Reserve High Resolution Land Cover dataset, and is previously classified as “Estuarine Non-Saline”	Fresh	National Estuarine Research Reserve High Resolution Land Cover
4	CARI Tidal Wetland feature has more than 33% overlap with a vegetation polygon and greatest overlap with vegetation polygon is not classified as “Undefined”	Vegetation polygon crosswalked salinity value - Fresh, Oligohaline, Mesohaline, or Saline	Association/Alliance Level Vegetation Mapping (*Vegetation salinity layer*) and possibly informed by Salinity Point Sample Interpolation (*Interpolated salinity layer)*
5	CARI Tidal Wetland feature has overlap with interpolated salinity layer	Majority overlap from interpolated salinity points - Fresh, Oligohaline, Mesohaline, or Saline	Salinity Point Sample Interpolation (*Interpolated salinity layer*)
6	CARI Tidal Wetland feature crosswalked to “Undefined” via vegetation attribution	Undefined	Association/Alliance Level Vegetation Mapping (*Vegetation*

			salinity layer)
7	None of the above apply	N/A	N/A

Added Attribute Fields

This process results in the incorporation of three supplementary salinity attributes into the CARI Dataset. The first, the "Salinity_Modifier" field, serves as the classification of salinity, signifying one of the six classes detailed in the classification schema, or "N/A" for features situated outside the realms of our vegetation datasets or estuary extent.

The second attribute, "Salinity_Source," offers a generalized description of the source data used to assign the salinity modifier. This attribute is meant to swiftly convey the basis on which the feature's salinity was determined through the decision-tree framework.

Lastly, the "Salinity_Additional_Information" field offers a greater level of detail about the data used to ascribe the salinity class. For features attributed through vegetation data, it includes a percentage breakdown of the underlying vegetation-based salinity classes and a list of vegetation alliances/associations within each salinity class. In cases where vegetation was initially crosswalked as "Undefined" and then assigned a salinity class through the *Interpolated salinity layer*, an asterisk is added to the name of the vegetation alliances/association. For features ascribed salinity values through the *Interpolated salinity layer*, this attribute includes the average of the median salinity value of the three nearest points and also provides information regarding the data source and the range of collection dates. (Note that the median value, not the mean, was used in the salinity classification.) In other cases, this field delineates the specific step in the decision-tree process that determined the salinity class (steps 1-3 in Table 2).

Dataset Applications and Future Work

The final dataset underwent a thorough internal review process prior to its distribution. This dataset represents estimated, time-integrated salinity conditions for use in statewide or other large-scale blue carbon inventories, assessments of spatial salinity patterns, or other modeling applications. The broad salinity classes are not intended to represent fine-scale spatial salinity variations, and do not capture temporal variability in salinity, which may range widely in many locations.

Future work may build upon and improve this dataset in several ways.

- Future updates to the salinity attribute may integrate up-to-date restoration information, incorporate new salinity measurements, or add new vegetation datasets, either via updates to VegCAMP or Pacific Veg Map or by integrating additional local vegetation mapping.

- Where vegetation alliances/associations have incomplete salinity information, the vegetation-salinity crosswalk may be expanded and improved upon through additional consultation with subject matter experts.
- Certain regions within California estuaries have wide vegetation mapping coverage and extensive salinity sampling, such as the Sacramento-San Joaquin Delta and Suisun Marsh. In these areas, broad salinity patterns can be mapped with relatively high confidence. For other estuaries where vegetation data and/or salinity point measurements are unavailable or limited, a focused local-scale effort to compile and/or collect additional data would improve the coverage and accuracy of the CARI salinity attribute.
- Updated and expanded mapping could improve the representation of areas with variable salinities such as bar-built estuaries and impounded wetlands. The existing Bar-Built modifier is currently based on a single dataset that is not comprehensive across the state. Future work may add to this dataset, for example leveraging the California Coastal Confluence layer (point vector layer) to apply the Bar-built modifier to other appropriate estuarine features in CARI. Additionally, future work should explore data availability to reliably identify impoundments statewide and add detail on the range of salinity conditions in bar-built and impounded wetlands.
- Incorporating up-to-date eelgrass mapping as a vegetation dataset in future updates may improve salinity estimates in open water areas.
- Some open water features differ in salinity class from surrounding and neighboring wetland features due to their lack of crosswalked vegetation data and reliance upon the sampling point interpolation. Future efforts could leverage the salinity classes of the neighboring wetland features where appropriate.

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Appendix

Table 3. NVCS alliance / association to salinity level crosswalk.

NVCS Alliance / Association	**Primary Salinity**	**Salinity Range**
Abronia latifolia	Mesohaline	
Acacia spp. – Grevillea spp. – Leptospermum laevigatum	Fresh	
Acer macrophyllum – Alnus rubra	Fresh	
Acer negundo	Fresh	
Aesculus californica	Fresh	
Agriculture	Fresh	
Ailanthus altissima	Fresh	
Allenrolfea occidentalis	Saline	
Alnus rhombifolia	Fresh	
Alnus rubra	Fresh	
Ammophila arenaria	Mesohaline	Mesohaline to saline
Ammophila arenaria Semi-Natural	Mesohaline	Mesohaline to saline

Arbutus menziesii	Fresh	
Argentina egedii	Saline	
Arid West freshwater emergent marsh	Fresh	
Artemisia californica	Undefined	Fresh to oligohaline
Artemisia californica – (Salvia leucophylla)	Fresh	Fresh to oligohaline
Artemisia pycnocephala Association	Undefined	Fresh to mesohaline
Atriplex lentiformis	Saline	Fresh to saline
Atriplex prostrata - Cotula coronopifolia	Undefined	Fresh to saline
Atriplex prostrata – Cotula coronopifolia Semi-Natural	Undefined	Fresh to saline
Baccharis pilularis	Undefined	Fresh to oligohaline
Baccharis pilularis - Artemisia californica	Undefined	Fresh to oligohaline
Baccharis salicifolia	Undefined	Fresh to oligohaline
Bassia (hyssopifolia, scoparia)	Unknown	
Bolboschoenus maritimus	Mesohaline	Fresh to saline
Cakile (edentula, maritima)	Undefined	Fresh to saline
Calamagrostis nutkaensis	Undefined	Fresh to oligohaline

Californian Annual & Perennial Grassland Macrogroup	Fresh	
Carex	Undefined	
Carex barbarae	Fresh	
Carex obnupta	Unknown	
Ceanothus thyrsiflorus	Fresh	
Centaurea (solstitialis, melitensis)	Undefined	Fresh to saline
Cephalanthus occidentalis	Fresh	
Conium maculatum	Fresh	Fresh to oligohaline
Conium maculatum – Foeniculum vulgare	Fresh	
Conium maculatum – Foeniculum vulgare Semi-Natural	Fresh	
Cornus sericea	Fresh	
Cortaderia (jubata, selloana)	Fresh	Fresh to oligohaline
Cynodon dactylon	Fresh	Fresh to Mesohaline
Delairea odorata Semi-Natural Association	Fresh	Fresh to mesohaline
Deschampsia caespitosa	Mesohaline	Mesohaline to saline
Distichlis spicata	Saline	
Distichlis spicata - Cotula coronopifolia	Saline	

Distichlis spicata - Juncus arcticus var. balticus (J. arcticus var. mexicanus)	Saline	
Distichlis spicata - Sarcocornia pacifica	Saline	
Distichlis spicata - Schoenoplectus americanus	Mesohaline	
Distichlis spicata – Frankenia salina Coastal	Saline	
Distichlis spp. - Salicornia spp.	Saline	
Equisetum (arvense, variegatum, hyemale)	Fresh	
Eriophyllum staechadifolium	Mesohaline	Mesohaline to saline
Eriophyllum staechadifolium – Erigeron glaucus – Eriogonum latifolium	Mesohaline	Mesohaline to saline
Eucalyptus (globulus, camaldulensis)	Fresh	Fresh to oligohaline
Eucalyptus spp.	Fresh	Fresh to oligohaline
Frangula californica ssp. californica – Baccharis pilularis / Scrophularia californica Association	Fresh	
Frankenia salina	Saline	Mesohaline to saline
Frankenia salina - Distichlis	Saline	

Fraxinus latifolia	Fresh	
Gaultheria shallon	Fresh	Fresh to mesohaline
Gaultheria shallon – Rubus (ursinus)	Fresh	Fresh to mesohaline
Grindelia (camporum, stricta)	Undefined	Fresh to saline
Grindelia stricta Provisional Association	Undefined	Fresh to saline
Hesperocyparis macrocarpa	Fresh	Fresh to oligohaline
Hesperocyparis macrocarpa Ruderal Provisional Semi-Natural Association	Fresh	Fresh to oligohaline
Hydrocotyle ranunculoides	Fresh	
Irrigated Hayfield	Fresh	Fresh to mesohaline
Juglans hindsii	Fresh	
Juncus arcticus (var. balticus, mexicanus)	Undefined	Fresh to saline
Juncus arcticus var. balticus	Undefined	Fresh to saline
Juncus lescurii	Undefined	Fresh to saline
Lepidium latifolium	Mesohaline	Fresh to saline
Lepidium latifolium – (Lactuca serriola)	Mesohaline	Fresh to saline
Leymus triticoides	Saline	Fresh to saline
Lupinus arboreus	Fresh	
Lupinus chamissonis – Ericameria ericoides	Fresh	Fresh to oligohaline

Mediterranean California Naturalized Annual and Perennial Grassland	Fresh	
Mesembryanthemum spp.	Undefined	Fresh to saline
Mesembryanthemum spp. – Carpobrotus spp.	Undefined	Fresh to saline
Mesembryanthemum spp. – Carpobrotus spp. Semi-Natural	Undefined	Fresh to saline
Morella californica	Fresh	Fresh to mesohaline
Nassella pulchra	Fresh	Fresh to oligohaline
Non-native grassland Association (preliminary)	Fresh	
Notholithocarpus densiflorus	Fresh	
Phalaris aquatica	Fresh	
Phragmites australis	Undefined	Fresh to mesohaline
Pinus contorta contorta	Fresh	
Pinus muricata	Fresh	
Pinus muricata – Pinus radiata	Fresh	
Pinus radiata	Fresh	
Pinus radiata Plantation Provisional Semi-Natural Association	Fresh	
Platanus racemosa	Fresh	
Polygonum lapathifolium	Fresh	
Polystichum	Oligohaline	

Polystichum munitum	Oligohaline	
Populus fremontii	Fresh	
Populus trichocarpa	Fresh	
Prunus ilicifolia – Heteromeles arbutifolia – Ceanothus spinosus	Fresh	
Pseudotsuga menziesii	Fresh	
Pseudotsuga menziesii – (Notholithocarpus densiflorus – Arbutus menziesii)	Fresh	
Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizenii)	Fresh	
Quercus agrifolia	Fresh	
Quercus douglasii	Fresh	
Quercus garryana	Fresh	
Quercus kelloggii	Fresh	
Quercus lobata	Fresh	
Quercus lobata Riparian	Fresh	
Quercus wislizeni	Fresh	
Rhamnus californicus	Fresh	
Robinia pseudoacacia	Fresh	
Rosa californica	Fresh	
Rubus armeniacus	Fresh	

Rubus armeniacus Semi-Natural Association	Fresh	
Rubus spectabilis	Fresh	
Rubus spectabilis – Morella californica	Fresh	
Rubus ursinus	Fresh	
Salix exigua	Fresh	
Salix gooddingii	Fresh	
Salix gooddingii – Salix laevigata	Fresh	
Salix gooddingii–Quercus lobata / wetland herb	Fresh	
Salix laevigata	Fresh	
Salix lucida	Fresh	
Salix lucida ssp. lasiandra Association	Fresh	
Sambucus nigra	Fresh	
Sarcocornia pacifica	Saline	
Sarcocornia pacifica (Salicornia depressa)	Saline	
Schoenoplectus (acutus, californicus)	Undefined	Fresh to mesohaline
Schoenoplectus acutus	Undefined	Fresh to mesohaline
Schoenoplectus americanus	Undefined	Fresh to mesohaline
Schoenoplectus americanus / Lepidium latifolium	Undefined	
Schoenoplectus californicus	Undefined	Fresh to mesohaline

Schoenoplectus californicus - Schoenoplectus acutus	Undefined	Fresh to mesohaline
Sequoia sempervirens	Fresh	
Sesuvium verrucosum	Unknown	
Spartina foliosa	Saline	
Spergularia marina	Mesohaline	Mesohaline to saline
Stuckenia (pectinata)	Unknown	
Suaeda moquinii	Saline	
Tamarix spp.	Fresh	Fresh to saline
Toxicodendron	Fresh	
Toxicodendron diversilobum	Fresh	
Toxicodendron diversilobum – (Baccharis pilularis) Association	Fresh	
Typha (angustifolia, domingensis, latifolia)	Undefined	Fresh to oligohaline
Typha angustifolia	Undefined	Fresh to oligohaline
Typha latifolia	Undefined	Fresh to oligohaline
Umbellularia californica	Fresh	
Vitis californica	Fresh	
Zostera (marina, pacifica) Pacific Aquatic	Undefined	Mesohaline to saline

Table 4 - VegCAMP and Pacific VegMap projects incorporated into this project.

Vegetation Data Source	**Mapping Project**	**Download Link**
Pacific VegMap	Marin County Vegetation (2021)	Download

Pacific VegMap	San Mateo County (2022)	Download
Pacific VegMap	Santa Cruz and Santa Clara County (2023)	Download
VegCAMP	Sacramento-San Joaquin River Delta (2002)	Download
VegCAMP	Santa Cruz Island (2007)	Download
VegCAMP	Salinas River (2008)	Download
VegCAMP	Liberty Island Remap (2013)	Download
VegCAMP	Palos Verdes (2010)	Download
VegCAMP	Marin County Open Space District (2008)	Download
VegCAMP	Marin Municipal Water District remapping (2006)	Download
VegCAMP	Midpeninsula Regional Open Space District-Peninsula Open Space Trust (2008)	Download
VegCAMP	Suisun Marsh (2012)	Download
VegCAMP	Western Riverside County remap (2015)	Download
VegCAMP	San Nicolas Island (2013)	Download
VegCAMP	Suisun Marsh (2015)	Download
VegCAMP	Sonoma County (2013)	Download
VegCAMP	Mendocino Cypress and Related Vegetation (2018)	Download
VegCAMP	Sacramento-San Joaquin River Delta Remap (2016)	Download
VegCAMP	Napa County Update (2016)	Download
VegCAMP	Santa Lucia Preserve (2013)	Download
VegCAMP	Pismo State Beach and Oceano Dunes State Vehicular Recreation Area (2015)	Download

Table 5. Salinity data sources and source years.

Data Source	Dates	Query	Link
Water Quality Portal	2010 - 2022	State: California; Sample Media: Water; Characteristic Type: Physical (NWIS, STEWARDS, STORET); Result: Physical/Chemical	Link
EMPA	2021-2022	Region: All; Estuary Class: All; MPA Status: All; Estuary Type:	Link

		All; Estuary: All; Water Quality: Data & Metadata	
NWCA / NCCA	2015, 2016	Survey: Wetlands & Coastal; Survey Year; 2015 & 2016; Dataset of Interest: Water Chemistry & Site Information; State of Interest: California	Link
NERR	2017 - 2022	Download Type: Water Quality; National Estuarine Research Reserves: Elkhorn Slough, CA, San Francisco Bay, CA, & Tijuana River, CA; Parameters: Temp, SpCond, & Sal	Link
CEDEN	2017 - 2022	Parameters: SpecificConductivity, Total	Link