CORE CMECS GIS PROCESSING METHODS OREGON ESTUARY PROJECT OF SPECIAL MERIT PHASE II

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The Oregon Estuary Project of Special Merit is a multi-phase project to produce estuary and shorelands habitat information, using the federally adopted Coastal and Marine Ecological Classification Standard (CMECS) version 4.0 (FGDC, 2012). For Phase II, updated and site-specific geospatial information was synthesized to enhance the CMECS habitat products developed in Phase I. This document describes the methods used by the Phase II project team to enhance and update the existing Oregon estuary CMECS habitat products.

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Table of Contents

Background 2
Project Partners and Data Providers 2
Guiding Principles and Methods 2
Aquatic Setting (AS) 7
Biotic Component (BC) 12
Substrate Component (SC) 7
Modifiers 15
Anthropogenic Impact Modifiers 16
References 17

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Background

The Oregon Estuary Project of Special Merit is a multi-phase project to produce estuary and shorelands habitat information, using the federally adopted Coastal and Marine Ecological Classification Standard (CMECS) version 4.0 (FGDC, 2012). For Phase II, updated and site-specific geospatial information was synthesized to enhance the CMECS habitat products developed in Phase I. This document describes the methods used by the Phase II project team to enhance and update the existing Oregon estuary CMECS habitat products. This work was done within a computerized mapping system, also known as a Geographic Information System (GIS).

Phase I of this project, completed in 2014, resulted in a consistent and comprehensive coastwide data set delineating estuarine habitats in Oregon (OCMP, 2014). The objective of Phase II was to increase the level of detail and currentness of the maps in areas where high quality, site-specific habitat information was available. Data developed in Phase II was integrated into the existing geospatial and classification framework from Phase I to create an updated version of the CMECS estuarine habitat data.

Project Partners and Data Providers

The Phase II project relied upon data generated by project partners and other data providers. Our project partners were South Slough National Estuarine Research Reserve (SSNERR), and Oregon Department of Fish and Wildlife's (ODFW) Shellfish and Estuarine Assessment of Coastal Oregon (SEACOR) project. The Phase II project team worked closely with the partners to review available data sets, assess their suitability for inclusion in CMECS estuarine habitat maps, and consult on appropriate methods for converting the source data into a geospatial format that was compatible with overall mapping protocols and quality criteria.

The estuarine habitat types integrated into the final Phase II product varied by data provider. Specific data sources used to update or enhance existing CMECS data layers are described in the relevant CMECS Settings and Components section of this document.

The geographic extent of data from project partners and other data providers varied depending on the source. Data from SEACOR were used to update areas in Tillamook Bay, Netarts Bay, Siletz Bay, Yaquina Bay, and Alsea Bay. Data from SSNERR were used to update areas in Coos Bay. Additional bathymetry data from the US Army Corps of Engineers were used to update areas in Tillamook Bay and Coos Bay. Seagrass data created by EPA were used to update areas in Nehalem River, Tillamook Bay, Netarts Bay, Sand Lake, Nestucca Bay, Salmon River, Siletz Bay, Yaquina Bay, Alsea Bay, Siuslaw River, Umpqua River, Coos Bay, Coquille River.

Guiding Principles and Methods

The project team used a set of guiding principles to assure the Phase II updates would result in a consistent and high quality data product. Those principles were used in the determination of operational procedures which the team followed when working in the GIS, and are listed and explained below.

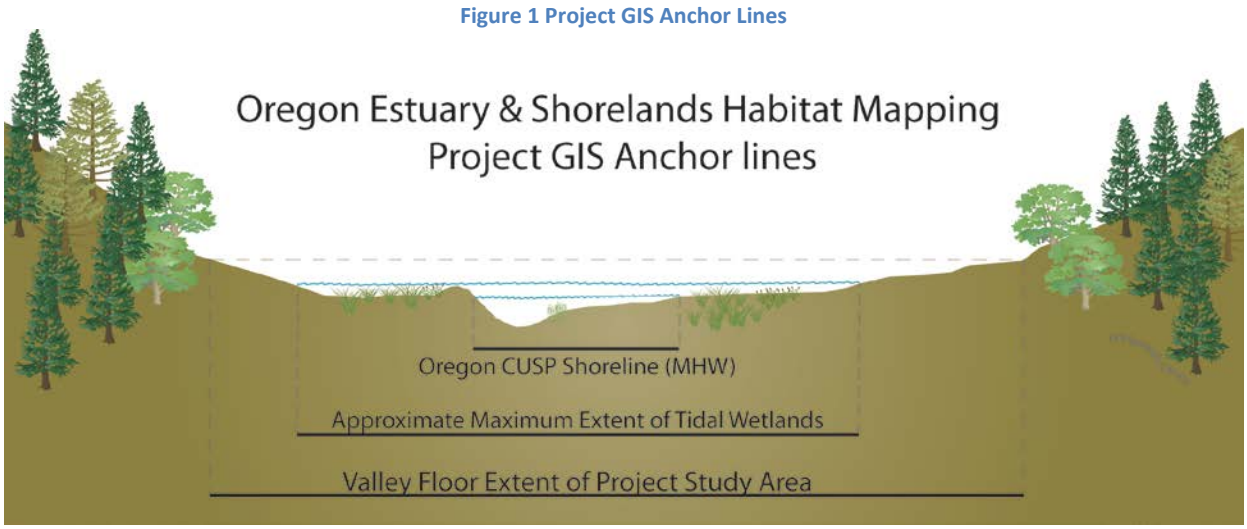
Following the explanation of the project's guiding principles, the methods used to generate GIS products for each component and setting are described.

Operational Procedure #1 – Vector Polygons: A vector-based data file type approach was used. While we may have used raster GIS information in the development of our information products, all products generated from our work are in the vector data format. Specifically, all data included in the final product are polygon geometry.

Operational Procedure #2 – Source Data Screening: Source data from partners and other data providers were evaluated for quality, consistency, and spatial extent to assess suitability for inclusion and to determine appropriate data synthesis approach(es). For example, if the source data were collected as point locations, the data could be interpolated into a surface that would become a set of polygons depicting the extent of the resource of interest. If the source data points did not have enough spatial coverage to create a high quality surface, the source data would not be integrated into the final map layers.

Operational Procedure #3 - Anchor Layers: The project Anchor Layers are GIS layers which form the boundaries of the project analysis layers and are carried through all subsequent GIS processing steps. They enforce key geometry features within the layers (components) for the estuary project. These lines are often used in multiple instances in the CMECS hierarchy. The figure below shows a schematic profile of how the Anchor Layers relate to one another in the estuarine landscape. These layers were developed in Phase I and are explained in detail in the Phase I methods report (Lanier, et. al. 2014).

Figure 1 Project GIS Anchor Lines



The Anchor Layers were not modified during Phase II. However, if the boundaries of a new data set did not align with an Anchor Layer (for example, the shoreline), but were expected to align, the Anchor Layer boundary was given priority and used to constrain the new data set's boundary.

Operational Procedure #4 – Retain Source Geometry: The original source geometry was used for component layer transformations (from the source data into CMECS). Source geometries were only altered when polygons with identical attributes were merged.

Operational Procedure #5 – Cartographic Smoothing: Data that was vectorized from raster surfaces was smoothed before being integrated into existing surrounding data, for cartographic and computational reasons.

Operational Procedure #6 – Maximum Extent: For biological data sets that may cover a range of time periods, the team had to decide how to handle data covering a range of time periods. Considering the needs of the primary users, planners, thought it was best to show maximum extent that has been mapped because that would show at least potential habitat for a particular resource (for example, seagrass). The inclusion of all detected beds through the inclusion of EPB, NWI and C-CAP data provides an approximation of the maximum extent of this CMECS class. As seagrass beds are spatially and temporally dynamic, this layer that shows areas suitable for development of aquatic bed habitats – even if they are not currently occupied.

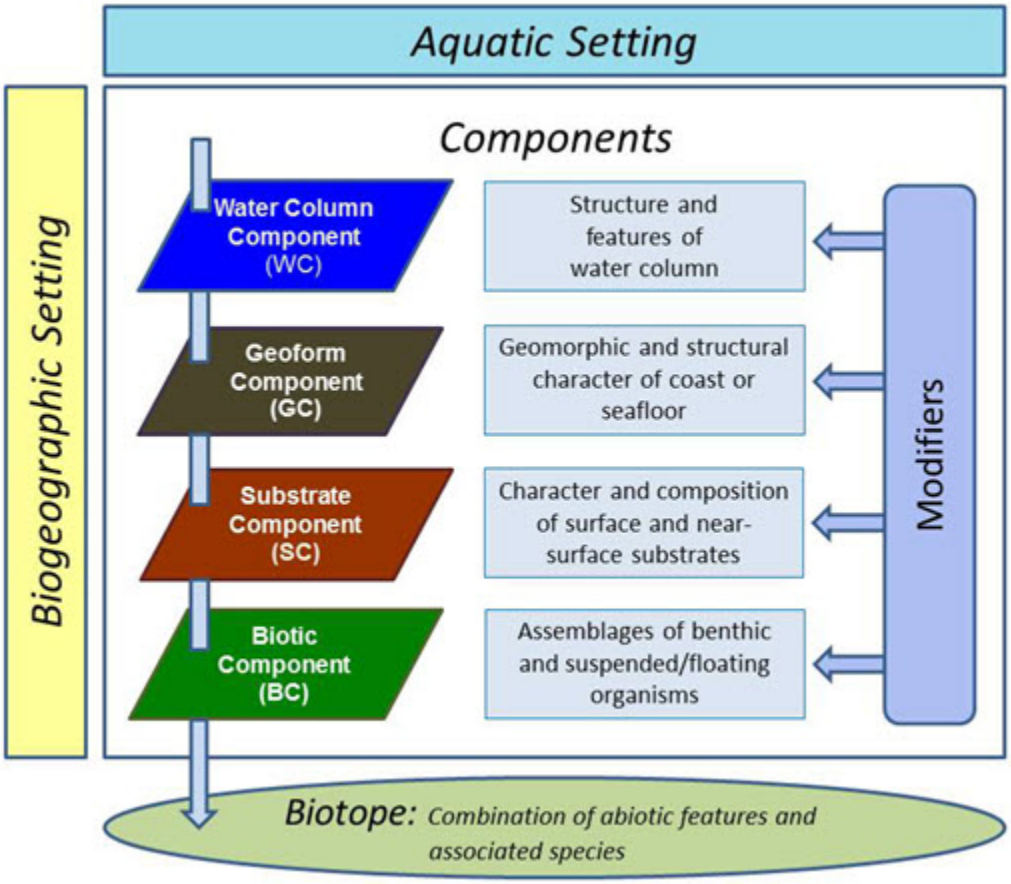
CMECS Settings and Components

CMECS characterizes marine and coastal environments in terms of two settings and four components (See Figure 1 below). Settings offer alternate but complementary approaches for partitioning the marine and coastal world. Components provide specific tools for describing observation (sampling) sites. Settings are applicable to all components.

The data produced in Phase I were as comprehensive as possible and sought to provide information products for all settings and components, to the highest levels of classification within each setting or component that could be determined based upon the availability of information in the input data sources. The only major thematic area of CMECS for which we were not able to produce information products was the Water Column Component.

For Phase II, the updates were site-specific and detailed, rather than comprehensive. The team and project partners focused on incorporating high quality source data sets to provide additional detail for the Biotic, Substrate and Geoform Components, as well as some updates to the Aquatic Setting and associated modifiers.

Figure 1 CMECS System Diagram



The following sections describe the changes that were made during Phase II to specific habitat types within the full CMECS system. This document includes only the parts of CMECS that were updated in Phase II. See the Phase I documentation for explanations of the comprehensive mapping approach and habitat types. Each section lists the data sources used for these updates and enhancements, as well as the estuaries where these changes were made. Note that the descriptions of the CMECS elements are taken directly or slightly paraphrased from the CMECS classification document.

Geoform Component

Updates to the Geoform Component are primarily at the attribute level. Only one estuary (Coos) received Geometry updates. The attribute edits that were performed were primarily global in nature for the geoform component. The need for global edits came about because it was discovered that there were some geoform attribute code value changes in the online CMECS Catalog code-list since our CMECS phase I project concluded in 2014.

The code lists for CMECS codes are available online in a couple of different formats:

- MS Excel: https://www.cmecscatalog.org/cmecs/documents/Cmecs_Excel.xlsx
- MS Access: https://www.cmecscatalog.org/cmecs/documents/cmecs4.accdb

In the select cases where a Geoform code dating from pre-2014 was found to have changed in the CMECS code list of 2017-2018, the corresponding code change was made in the geoform component geospatial data and metadata to bring the data set back into compliance with the modern codes. None of these attribute edits were intended to, or constituted, a change in geoform type.

For the estuary that had geometry updates, the improvements were made possible by one of the new data sources that was available in Phase II: improved bathymetry information. These data were from the following sources:

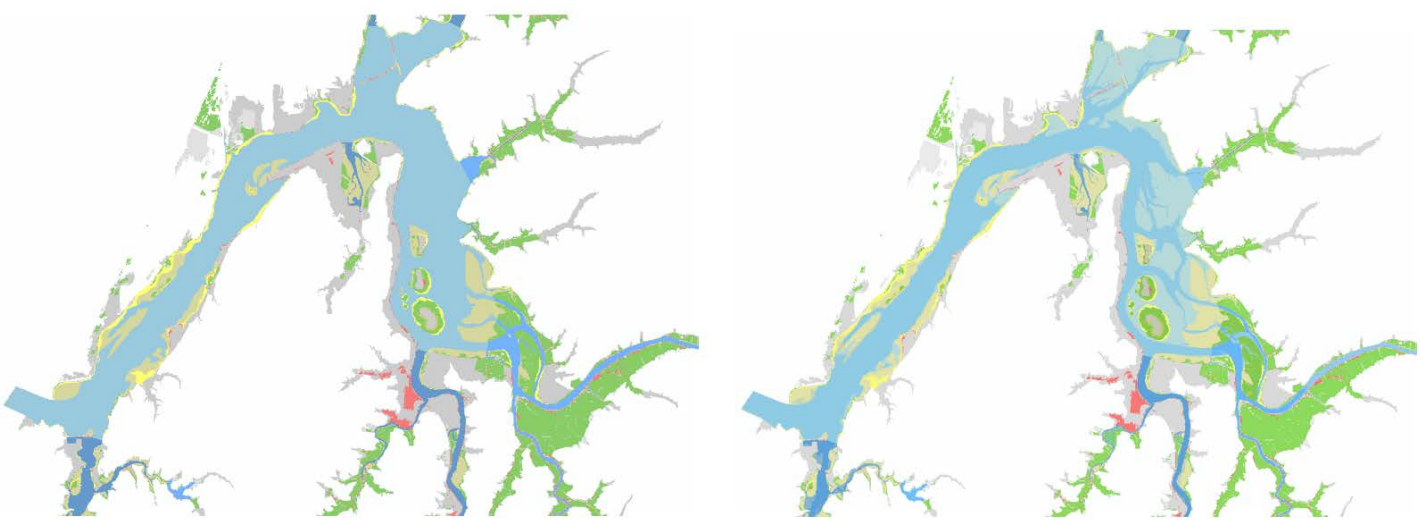
- 2014 USACE NWP Topobathy Lidar: Coos Bay (OR) https://inport.nmfs.noaa.gov/inport/item/49941
- A "best of" compilation by Ted Conroy & David Sutherland of University of Oregon, provided by SSNERR

Geoform | Geologic | Flat |Tidal Flat

An extensive, nearly horizontal, barren (or sparsely vegetated) tract of land that is alternately covered and uncovered by the tide. Tidal flats consist of unconsolidated sediment (mostly clays, silts and/or sand, and organic materials).

https://www.cmecscatalog.org/cmecs/classification/unit/99.html

The improved elevation data was good enough to allow for better (or in some cases entirely new) delineation of tidal flats. This was done by mapping the Mean Lower Low water (MLLW) line and combining it with the Mean High Water (MHW) line to create the polygon topology for the tidal flats. These polygons were then merged into the geoform component. Example of the improvement made in the Coos bay estuary:



Before **After**

The above example makes clear how a single new high quality data input can result in a large improvement to the CMECS data product. We hope to repeat this kind of success by pursuing more high resolution bathymetry data that can be incorporated in other estuaries.

In addition to the attribute and geometry changes laid out above, a smattering of minor edits and topology corrections were captured in this release. For a more detailed list of those issues addressed see: http://bit.ly/GeoformChanges2018

Substrate Component (SC)

Updates to the Substrate Component are more comprehensive than those made to the Geoform component. In all, sixteen estuaries had substrate geometry updates, from two primary sources:

- The Oregon Estuary Plan Book, 1987 (EPB)
- Oregon Fish and Wildlife SEACOR Program, 2011-2015 (SEACOR)

Estuaries that received updates from these sources included:

- EPB (16 estuaries) - Necanicum, Nehalem, Tillamook, Netarts, Sand Lake, Nestucca, Salmon, Siletz, Yaquina, Alsea, Siuslaw, Umpqua, Coos, Coquille, Rogue, Chetco
- SEACOR (5 estuaries) – Tillamook, Netarts, Siletz, Yaquina, Alsea

Data from the EPB is obviously the older of these two sources, but was chosen for inclusion because it could provide improved substrate class information for substrate classes across 16 estuaries. Substrate data from the EPB originated from ODFW field sampling in the 1970's, and classes available were cross-walked to CMECS according to the table below:

EPB Code	EPB Class	CMECS Substrate Code	CMECS Class	Polygons
1.2.8	Bedrock	1.1.1	Bedrock	28
1.1.6	Cobble/Gravel	1.2.1.1	Gravel	60
1.2.7	Boulder	1.2.1.1.1	Boulder	30
1.1.2	Sand / Mud (mixed)	1.2.2	Fine Unconsolidated Substrate	136
1.1.1	Sand	1.2.2.2	Sand	154
1.1.3	Mud	1.2.2.5	Mud	137
2.1.5	Wood debris / Organic	2.3.1.2	Woody Debris	10
1.1.4	Shell	2.5	Shell Substrate	6

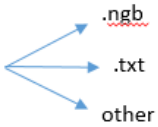
Due to the age of the EPB data set, and the lack of specificity of the grain sizes used in the EPB, the

polygons from this source were only used to improve classifications in locations where no other more modern and specific data was available. In the future, when more modern data is available in an area covered by EPB data, the newer data is expected to replace the EPB sourced classifications.

Data from the SEACOR project was processed by ODFW from raw field sampling data points into polygons using a method outlined as follows:

SEACOR Sediment to CMECS Data Processing Methodology

(Steps provided by Tony D'Andrea of ODFW)

Tool	Step
	1. Field Data Collection
	2. Lab Particle Size Analysis (PSA) 
	3. Data Compatibility
	4. Pre-processing (see coding walkthrough) a) Use the access database to download field data for the AOI b) Access PSA pre-processed data c) Run the R-code (GS_R_script) to create the master excel sheet
	5. Set up coding environment a) Import necessary extensions b) Set up the workspace c) Add study area or shoreline d) Add raw sediment data shapefile created from the master excel sheet a) Clip sediment data to shoreline polygon b) Double check proper formatting and verify with user if required c) Create a mud column from clay and silt d) Double check the accuracy of the mud column with 'additup2' column
	6. Run inverse distance weighted interpolation

a) Interpolate chosen fields based on the standard SEACOR naming convention
b) Run IDW interpolation
c) Save interpolations as raster files

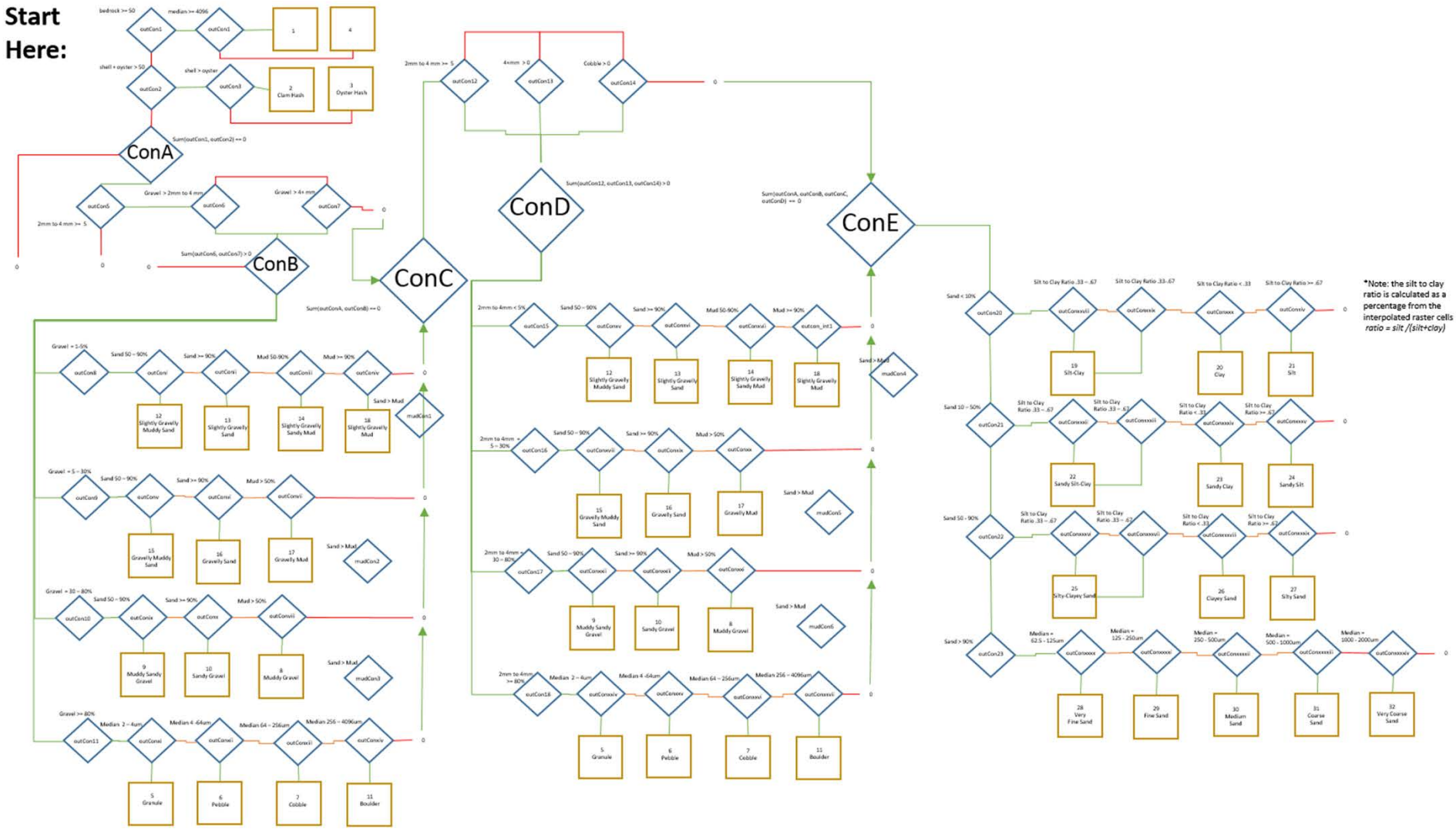
7. Create a single output layer using conditional statements

a) Create a silt to clay ratio layer and save it as an additional raster
b) Create a directory for intermediary results of conditional statements. All of them will be save for troubleshooting
c) For a complete list of conditional statement architecture see the “sediment decision tree” on following page

8. Finalize CMECS Layer

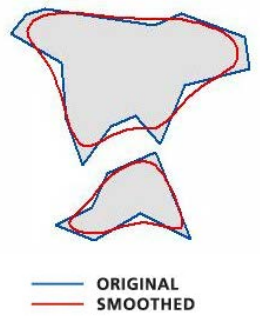
a) Clip mutually exclusive result of conditional statements to the study area
b) Convert from raster to polygon
c) Specify English name and CMECS code for each substrate
d) Add study area to the final shapefile
e) Add and calculate shape_area and shape_length fields

ODFW Sediment Decision Tree



The ODFW process outlined above resulted in an individual substrate polygon layer for each of the five estuaries where ODFW had done field work. These deliverables were then further processed by OCMP in order to integrate them into the substrate component. The processing steps for the substrate deliverables were:

a) **Reprojection** to match the project working projection of statewide Oregon lambert
b) **Smoothing** to round off corners created as a result of vectorizing the interpolated raster surface
c) **Merging** of the new polygons with the existing data for the relevant estuary



Since the SEACOR data was considered the best source available for the areas surveyed, the merging step for the SEACOR substrate information gave the SEACOR polygons and attributes the highest priority and effectively replaced and previous data from other sources.

A representative graphic showing areas of updated CMECS substrate classes is shown below, to illustrate the relative contributions of the SEACOR and EPB sources to the latest release of the data.

The vast majority of classification changes are from CMECS substrate code 1.2 “Unconsolidated Mineral Substrate”, to more detailed subclasses of “Fine Unconsolidated Substrate”. In some cases, there were also additions of sub-classes of “Coarse Unconsolidated Substrate”, and of “Biogenic Substrate”.

In addition to the attribute and geometry changes laid out above, a smattering of minor edits and topology corrections were captured in this release. For a more detailed list of those issues addressed see: http://bit.ly/SubstrateChanges2018

Biotic Component (BC)

Updates to the Biotic Component were by far the most comprehensive of edits made to any of the CMECS component data sets during this release cycle. The major changes made largely reflect the focus areas of the phase II project, which were faunal and vegetative aquatic beds. As with the substrate component, there were just a few major contributors of new information, but the information contributed made significant improvements in the most glaringly unclassified portions of the estuaries affected.

New sources incorporated into the biotic component included:

- The Oregon Estuary Plan Book, 1987 (EPB)
- Oregon Fish and Wildlife SEACOR Program, 2011-2015 (SEACOR)
- Seagrass delineations By Pat Clinton, 2004-2007 (EPA)
- Seagrass delineations by Quantum Spatial, 2016 (QSI)

Estuaries that received updates from these sources included:

- EPB (16 estuaries) - Necanicum, Nehalem, Tillamook, Netarts, Sand Lake, Nestucca, Salmon, Siletz, Yaquina, Alsea, Siuslaw, Umpqua, Coos, Coquille, Rogue, Chetco
- SEACOR (5 estuaries) – Tillamook, Netarts, Siletz, Yaquina, Alsea
- EPA (7 estuaries) – Tillamook, Nestucca, Salmon, Yaquina, Alsea, Umpqua, Coos
- QSI (1 estuary) - Coos

Data from the EPB is obviously the oldest of these sources, but was chosen for inclusion because it could provide the earliest spatial aquatic bed information available across 16 estuaries. Habitat data such as the aquatic bed areas from the EPB originated from ODFW field sampling in the 1970's, and classes available were cross-walked to CMECS according to the table below:

EPB Code	EPB Class	CMECS Biotic Codes	CMECS Class	Polygons
1.3	Aquatic Bed	2.5	Aquatic Bed	81
1.3.10	Algal Bed	2.5.1	Benthic Macroalgae	171
1.3.9	Seagrasses	2.5.2	Aquatic Vascular Vegetation	270

Due to the age of the EPB data set, the polygons from this source were only used to improve classifications in locations where no other more modern and specific data was available. In the future, when more modern data is available in an area covered by EPB data, the newer data is expected to replace the EPB sourced classifications.

Data from the SEACOR project was processed by ODFW from raw field sampling data points into polygons using methods similar to those outlined for substrate types, and were processed on an estuary by estuary basis. Each estuary set of deliverables included one polygon layer per biotic community

characterized. There were five SEACOR estuaries in the current data update, and each had different numbers of biotic deliverables, depending on what was present in the system. The breakout of numbers of species per estuary was as follows:

- Tillamook – 12 clam, 2 shrimp, 2 eelgrass, 4 algae
- Netarts – 11 clam, 2 shrimp, 2 eelgrass, 4 algae
- Siletz – 4 clam, 2 shrimp, 2 eelgrass, 4 algae
- Yaquina – 10 clam, 2 shrimp, 2 eelgrass, 4 algae
- Alsea – 8 clam, 2 shrimp, 2 eelgrass, 4 algae

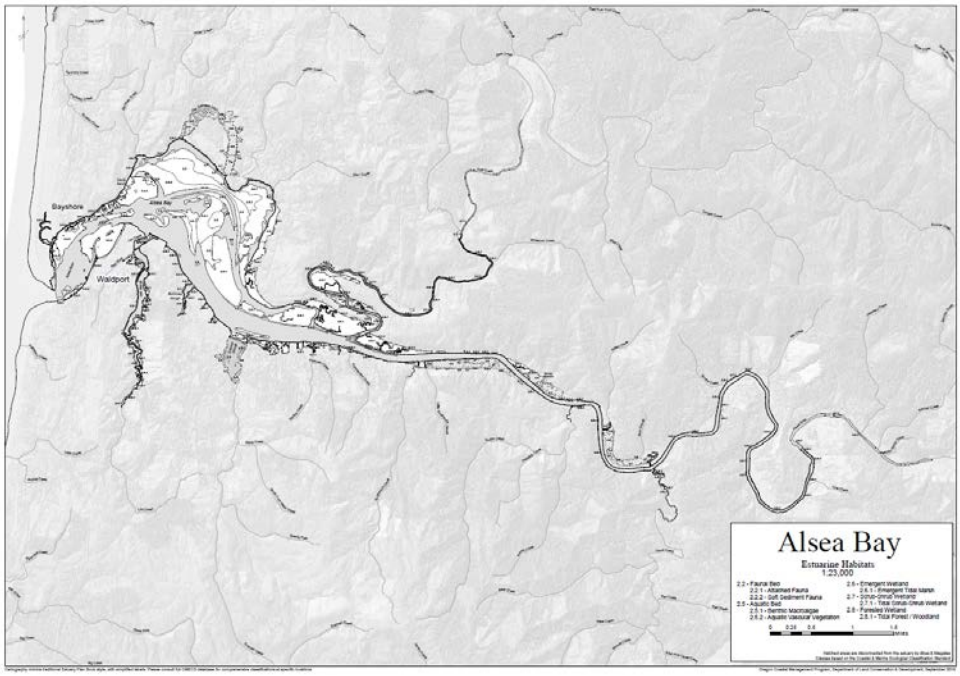
The ODFW deliverables to OCMP were processed in a similar manner to the related substrate deliverables. The steps differed only in that the biotic layers for each group of biotic communities were processed and merged together before being smoothed and integrated with existing Biotic data in the estuary. For each biotic community, the processing steps for the biotic deliverables were:

a) **Reprojection** to match the project working projection of statewide Oregon lambert
b) **Unioning** of related layers (all clams, all shrimp, all eelgrass, all algae)
c) **Smoothing** to round of corners created as a result of vectorizing the interpolated raster surface
d) **Merging** of the new polygons with the existing data for the relevant estuary

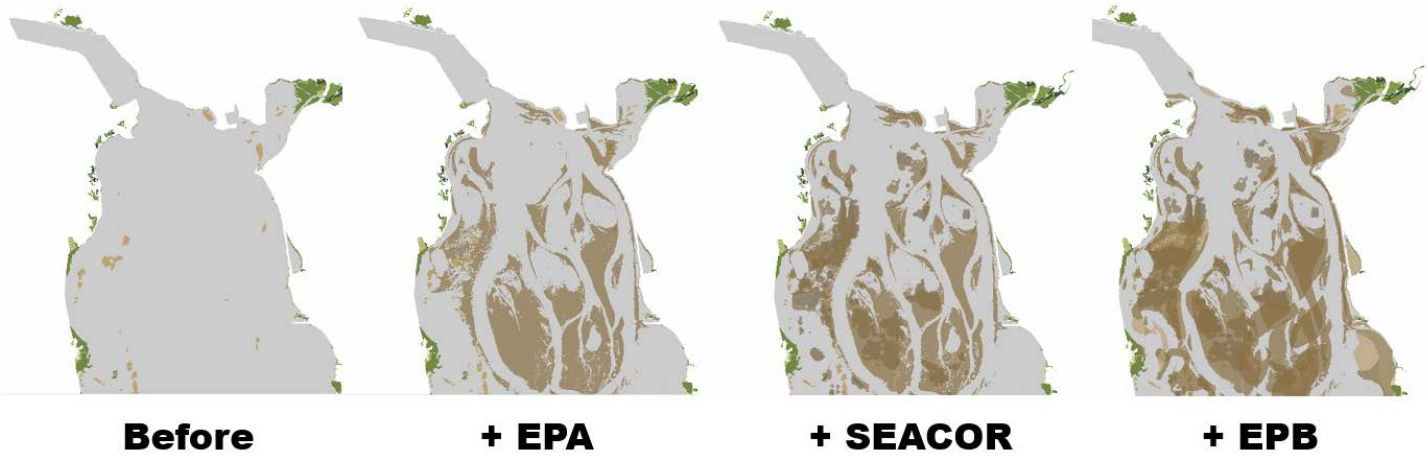
Since the SEACOR data was considered the best source available for the areas surveyed, the merging step for the SEACOR biotic information gave the SEACOR polygons and attributes the highest priority and effectively replaced and previous data from other sources. However, when SEACOR data overlapped, decisions had to be made as to how to capture these co-occurrences. The CMECS classification allows for summarizing data at any hierarchical level, and so one choice would have been to “roll-up” to the nearest common class. However, when this option was presented to the Technical Advisory Committee (TAC), this approach was not favored, as it was felt that this would obscure too much information from future users. Instead, a decision was taken to provide all possible classification levels of the hierarchy in the Biotic component data table. This would allow any future user to query the data set at any location to see what classes occurred at each location. In addition a cartography column was calculated for users who wanted a simplified overview of the biotic communities. The classes in this column represented a very small set of high-level biotic communities, and leave out all the messy details of individual species. The classes included in this simplified cartography column are as follows:

2.2 - Faunal Bed
    2.2.1 - Attached Fauna
    2.2.2 - Soft Sediment Fauna
2.5 - Aquatic Bed
    2.5.1 - Benthic Macroalgae
    2.5.2 - Aquatic Vascular Vegetation
2.6 - Emergent Wetland
    2.6.1 - Emergent Tidal Marsh
2.7 - Scrub-Shrub Wetland
    2.7.1 - Tidal Scrub-Shrub Wetland
2.8 - Forested Wetland
    2.8.1 - Tidal Forest / Woodland

The simplified classes were chosen in part to provide an easy way to recreate habitat maps of the approximate equivalent cartographic information density as the original estuary habitat maps of the Oregon Estuary Plan Book. An example of such a map is included below:



A representative graphic showing to illustrate the relative contributions of the EPA, SEACOR and EPB sources to the latest release of the data:



The vast majority of classification changes are from “Unclassified”, to “Faunal bed” and its sub-classes, and “Aquatic bed” and its subclasses.

In addition to the attribute and geometry changes laid out above, a smattering of minor edits and topology corrections were captured in this release. For a more detailed list of those issues addressed see: http://bit.ly/BioticChangez2018

Aquatic Setting (AS)

Updates to the Aquatic Setting for this release were primarily related to improvements that were made possible by the improved bathymetry information for Coos Bay and Tillamook Bay available for phase II. These data were from the following sources:

- 2014 USACE NWP Topobathy Lidar: Coos Bay (OR) https://inport.nmfs.noaa.gov/inport/item/49941
- 2015 USACE NCMP Topobathy Lidar: Tillamook Bay (OR) https://inport.nmfs.noaa.gov/inport/item/49948

The primary improvement enabled by these new data was the improved delineation of the -4m MLLW line that is necessary to define the edge of the "Estuarine Coastal" aquatic setting. Areas of updated CMECS aquatic setting are shown below:

Aquatic Setting edits to areas in the higher elevation portions of the estuarine tidal system (especially any related to the diked modifier) have been held back until the winter 2019 release due to the need to coordinate edits with the Biotic component.

In addition to the attribute and geometry changes laid out above, a smattering of minor edits and topology corrections were captured in this release. For a more detailed list of those issues addressed see: http://bit.ly/AquaticChanges2018

Modifiers

Modifiers are physicochemical, spatial, geological, biological, anthropogenic, and temporal variables with defined categorical values and ranges that are used to describe CMECS units. Modifiers can be applied when additional information is needed to further characterize an identified unit for individual applications. Modifiers provide additional environmental, structural, or biological information about the ecosystem; modifiers are useful for description and application—but they are not required for classification according to the CMECS schema. Modifiers are a dynamic component of the CMECS in the sense that users are free to apply additional local modifiers for their project needs as long as these are reported and do not conflict with the established definition of modifiers in the CMECS document.

Anthropogenic Impact Modifiers

Impounded/diverted (diked areas): Areas where artificial construction impedes, redirects, or retains hydrological flow by building or placing barriers (e.g., dams, levees, dikes, berms, seawalls, or piers); these structures are designed to either retain water or to prevent inundation. To identify areas affected by dikes and other artificial barriers, we used a GIS layer of diked areas provided by Ducks Unlimited (DU).

The DU diked areas layer was generated in two steps (Kevin Petrik, personal communication, April 2014). In the first step, vector lines of dikes from the Levees Inventory (Mattison, 2011) were combined with the LIDAR DEM. Using Python code, the LiDAR elevation was sampled at intervals along the dike lines and a mean elevation was calculated for each levee. This elevation was transferred to the land on the upslope side by a GIS technician to designate the land protected by the levee. The resulting base data was combined with NWI data and used as input into SLAMM (Sea Level Affecting Marshes Model). The model initial conditions were examined for new areas of flooding. If new areas were expected to flood, further analysis was performed of aerial imagery to confirm new levee protected areas, which were added to the mapping.

In our project, we intersected the DU diked areas layer with maps for the CMECS Aquatic Setting. Wetlands classified as diked by DU were assigned the Anthropogenic Impact modifier "Impounded/diverted" (which includes diked areas). The results were reviewed by our Estuary Habitat Specialist and Technical Advisory Committee, and revisions to diked status were made based on their input.

Dredged: Landscape that is mechanically altered by the removal of sediments or other materials (e.g., shell) in order to deepen or widen channels (e.g., for navigation or alteration to hydrology). Dredged channels were found by locating "Sidecast of Significance" in the Levees Inventory (Mattison, 2011). Scranton's adjacent "Water" polygons that appeared to be sources for the sidecast material were then selected to create a separate layer. As the existence of sidecast material suggests, these polygons represent those channels that have been dredged. They were then classified as "Channels" in the Geologic Geoform Component with a modifier of "dredged".

References

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