Background on Issues of Concern Mapping Methodology

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To aid in project site evaluation and planning, we have developed a quantifiable, mappable metric for each IOC to provide a statewide view of the geographic distribution of individual IOCs and in composite. Mapped data were compiled and integrated to generate one map layer showing 4 category levels: High, High-Medium, Medium-Low and Low levels of vulnerability for each of the eight IOCs. In some cases up to four different data maps were integrated. In other cases, a single metric was chosen to represent that Issue of Concern.

1) **Coastal Ecosystem Degradation and Habitat Loss**

Coastal habitats are not spatially fixed, but rather are continually in spatial flux, responding and shifting to various forcing factors, including sea level rise (SLR). Through the process of vertical accretion of sediment and organic matter, the surface elevation of a salt marsh will rise in relation to sea level, *i.e.*, the marsh can continue to grow 'up' into a rising sea (McKee and Patrick, Jr. 1988; Titus, 1988). When sea level rises faster than the rate of marsh accretion, salt marshes are "drowned" and replaced by tidal mud or sand flats and eventually open water. The concept of elevation capital uses absolute elevations relative to the tidal zone that salt marsh plants require for optimal growth to infer the long-term prognosis of a vegetated salt marsh platform under a regime of rising sea levels (Cahoon and Guntspergen, 2010). If coastal marsh accretion rates are higher than the rate of SLR, then elevation capital is increasing. Conversely, if marsh accretion rates are below the rate of relative sea level rise, then salt marsh elevation capital is decreasing. If any parts of a salt marsh are deemed to not be keeping pace with sea level rise, the years until drowning based on remaining elevation capital can potentially be estimated. The following four our metrics were composited to assess **Coastal Ecosystem Degradation and Habitat Loss.**

<u>UnVegetated to Vegetated Ratio (UVVR) for 1 hectare grid</u>
Marshes that may be suffering from a loss of marsh elevation capital are vulnerable to stress and declining vegetative biomass. Other environmental factors such as eutrophication or inadequate levels of sedimentation may further exacerbate the effects of rising sea levels. One metric that has been advocated for as a useful indicator of salt marsh decline is the loss of vegetation cover and biomass and replacement with bare soil/peat or open water. This metric often takes the form of a ratio of unvegetated to vegetated area or unvegetated to overall marsh area; this metric is positively correlated with degrading marsh condition. The GIS layer for this metric was produced by the Saltmarsh Habitat and Avian Research Program (SHARP). The map layer was derived from the remote sensing of tidal wetlands using NAIP imagery (2015 & 2016) and NED elevation data. For more information, please consult https://www.tidalmarshbirds.org/?page_id=1871.
Also: https://www.sciencebase.gov/catalog/item/57fe81fbe4b0824b2d148389

https://www.nature.com/articles/ncomms14156
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL086703

Marsh Future Change based on SLAMM

To project future marsh change under projected sea level rise (SLR), a marsh change data product provided by the NOAA Office for Coastal Management (https://coast.noaa.gov/digitalcoast/tools/slr.html) was employed by the Rutgers Center for Remote Sensing & Spatial Analysis. The NOAA marsh change product, based on Sea Level Affecting Marshes Model (SLAMM) (US Fish & Wildlife Service, 2011), identifies coastal marsh areas (includes estuarine and brackish marsh areas dominated by *Spartina alterniflora, Spartina patens* and *Phragmites australis)* that may be vulnerable for conversion to either non-vegetated or open water. Three scenarios of sea level rise (1', 2' and 3') out to the Year 2050 were modeled. As the NOAA-predicted marsh change product does not explicitly model marsh shoreline edge erosion, estimated past shoreline erosion rates to project future shoreline location. Shoreline erosion rates were determined by comparing the shoreline position changes between a baseline year during the 1970s and a contemporary year in the 2010s. The 1', 2' and 3' SLR projected 2050 change maps were combined with the marsh shoreline erosion maps to create a composite projected 2050 change map.

Tidally Restricted Marshes

Marsh areas may be subject to restricted tidal flow due to culvert, tide gate or roadway restrictions. This tidal restriction can decrease the flux of water, sediment, and organisms to and from the marsh and thereby impair normal ecological function leading to ecosystem degradation. These data on tidally restricted marshes were provided by the UMASS Landscape Ecology Lab https://gis.usgs.gov/sciencebase2/rest/services/Catalog/5bd89a1fe4b0b3fc5cea20bb/MapServer

Landscape Condition

NJDEP has ranked watersheds by landscape condition to provide a watershed (Huc12) level view of ecological impairment condition.

References:

Cahoon, D.R.; and Guntenspergen, G.R., 2010. Climate change, sea-level rise, and coastal wetlands. *National Wetlands Newsletter*, 32, 8-12.

McKee, K.L., Patrick, W.H. The relationship of smooth cordgrass (*Spartina alterniflora*) to tidal datums: A review. *Estuaries* **11,** 143–151 (1988). https://doi.org/10.2307/1351966

Titus, J.G. 1988. Chapter 1, In: J.G. Titus (Ed.), *Greenhouse effect, sea level rise, and coastal wetlands*. (EPA 230-05-86-013). Washington, D.C.

U.S. Fish & Wildlife Service, 2011. *Science behind the Sea Level Affecting Marshes Model (SLAMM).* http://www.fws.gov/slamm/SLAMM1.pdf

2) Shoreline Erosion

Marsh shorelines and bayshore beaches are subject to the erosive action of storm and boat wake-driven waves. Fagherazzi (2013) suggested that while coastal marshes are relatively stable in the vertical direction if enough sediment is available, they are inherently unstable along the horizontal direction due to lateral erosion. This Shoreline Erosion dataset was generated by Rutgers Center for Remote Sensing & Spatial Analysis. Areas of coastal marsh lost to shoreline erosion were determined by comparing the shoreline position changes between a baseline year during the 1970s and 2010. The baseline marsh/back bay shoreline was defined by the 1977 New Jersey Tidelands Claimed line. The NJDEP Tidelands claims map (http://www.nj.gov/dep/gis/tidelandsshp.html) depicts areas now or formerly flowed at or below mean high tide as of 1977. The “Claimed” and “Unclaimed” tidelands were extracted and the individual map tile boundaries dissolved. The tidelands data were rasterized at a grid size of 10 m to match the New Jersey DEM (provided by NOAA CSC) spatial extent.

To depict the shoreline at 2010, the Mean Tide Level (MTL) water surface layer from NOAA CSC V-Datum water surface layers was differenced against the NOAA CSC NJ DEM (at 10 m grid size). The Tidelands Claimed layer was buffered inland. The resulting buffer distance file was overlaid with the NJ_water_mask to determine those areas where the shoreline eroded (Tidelands Buffer and Water) vs. areas that have accreted (Not Tidelands and Not water) vs. No Change. This erosion rate was then projected out to the year 2050 to map areas vulnerable to future shoreline erosion.

References:
Fagherazzi, S., 2013. The ephemeral life of a salt marsh. *Geology,* 41, 943–944.

3) Coastal Flood Damage

Associated with severe storms are temporarily elevated sea levels, often called storm surges, that may inundate (flood) coastal areas. NOAA has developed the Sea, Lake and Overland Surface from Hurricanes (SLOSH) computer model for coastal inundation risk assessment and the operational prediction of geographic areas that may be exposed to storm surge. The Maximum of the Maximum Envelope of High Water (MEOW), or ***MOM***, provides a worst case snapshot for a particular storm category under "perfect" storm conditions. Each ***MOM*** considers combinations of forward speed, trajectory, and initial tide level. A seamless GIS coverage for the entire New Jersey coastal zone of SLOSH MOM outputs for Category 1, 2, 3 and 4 storms was compiled. The SLOSH data were recoded into depth categories to map those areas potentially subject of to flooding under a Category 1 storm with the higher depth of inundation ranked as higher potential for storm damage:

Rank 4	> 4 ‘
Rank 3	2-4’
Rank 2	0.1 -2’
Rank 1	0’ .

4) Nuisance (High Tide) Flooding

High-tide flooding occurs when local sea level temporarily rises above an identified threshold height for flooding, in the absence of storm surge or riverine flooding. This type of extreme high tide or ‘nuisance’ flooding can inundate developed areas blocking roads, and flooding yards. Areas mapped as subject to Nuisance flooding were ranked with a Vulnerability Score of 4.

Maps of High Tide flooding have been developed (https://toolkit.climate.gov/topics/coastal-flood-risk/shallow-coastal-flooding-nuisance-flooding and included on the NOAA Coastal Flood Exposure Viewer https://coast.noaa.gov/digitalcoast/tools/flood-exposure.html). We have downloaded this data layer to map this metric. The flood thresholds used in this map are derived national flood thresholds from NOAA Technical Report NOS CO-OPS 086: Patterns and Projections of High Tide Flooding along the U.S. Coastline Using a Common Impact Threshold. The derived thresholds used here provide a national definition of coastal flooding and impacts for quantifying and communicating risk. These thresholds may deviate from National Weather Service (NWS) impact thresholds, which take into account local flood risk and are used to issue NWS coastal flood watches, warnings, and advisories.

5) Coastal Storm Damage

Severe storms can inflict a lot of damage to residential and commercial properties through a combination of flooding, wave action and high winds. The Federal Emergency Management Agency (FEMA) through its National Flood Insurance Program (NFIP) compiles data on coastal storm damage. These data are then synthesized and distributed on the basis of municipalities or US Census tracts. The NFIP flood damage claim payout data (https://www.fema.gov/data-visualization-floods-data-visualization) are only available at the municipal scale. There are two main metrics: NFIP Total Losses (Sum Total of all National Flood Insurance Program claims since 1978); and, Total Payments (Total payments ($) made through the National Flood Insurance Program since 1978).

In addition, FEMA also provides data on their Individuals and Households Program (IHP) Flood Damage, Public Assistance Applicants and Hazard Mitigation Assistance Projects. These data are provided for several different geographic units, namely, state, county and in some cases municipality and zip code. The following data sets were spatially identified by zip code and so were compiled for inclusion in our IOC analysis:

--Individual and Household – Valid Registrations and Total IHP $ awards. IHP is intended to meet basic needs and supplement disaster recovery efforts. The IHP is not intended to return disaster-damaged property to its pre-disaster condition. IHP is intended to help with critical expenses that cannot be covered in other ways. The IHP is not intended to return all homes or belongings to their pre-disaster condition. In some cases, IHP may only provide enough money, up to the program limits, for residents to return an item to service. Secondary or vacation residencies do not qualify. (https://www.fema.gov/openfema-data-page/individuals-and-households-program-valid-registrations-v1).

---Housing Assistance – Valid Registrations and Total Damage $ awards. Housing Assistance under FEMA's Individuals and Households Program (IHP) can provide financial help and direct services after a disaster. The program assists with housing needs not covered by insurance or provided by any other source. Housing Assistance includes the following: lodging expense reimbursement for short-term stays in hotels or motels, rental assistance for temporary housing; money to help repair or replace your primary home; or permanent housing construction.
https://www.fema.gov/api/open/v2/HousingAssistanceOwners

---Hazard Mitigation Assistance (HMA) and Public Assistance (PA) are FEMA grant programs for communities. HMA is for actions taken to reduce or eliminate long term risk to people and property from natural disasters. Hazard mitigation planning reduces loss of life and property by minimizing the impact of disasters. It involves state, tribal and local governments identifying natural disaster risks and vulnerabilities that are common in their area. Public Assistance (PA) is FEMA's largest grant program providing funds to assist communities responding to and recovering from major declared disasters or emergencies. The Hazard Mitigation and Public Assistance Projects are spatially identified by state and county only and so were not further analyzed (https://www.fema.gov/openfema-data-page/public-assistance-applicants-v1; https://www.fema.gov/openfema-data-page/hazard-mitigation-assistance-projects-v2)

The above mapped data layers were combined into a single index of storm damage using Principal Components Analysis. The 1st Principal Component had an eigenvalue of nearly 100% and thus captured most of the information in the following input data layers: NFIP Total Losses Total Payments; Individual and Household Assistance– Valid Registrations and Total IHP $ awards; and Housing Assistance – Valid Registrations and Total

Damage $ awards. The 1st PC was subsequently used as a composite index to represent Storm Damage at a municipal/zip code scale.

6) Water Quality Degradation

Salt marshes and other coastal habitats can be negatively affected by degraded water quality such as nutrient over-enrichment or petrochemical/toxic chemical pollution. We have selected the **NJDEP Integrated Water Quality Assessment Units not supporting aquatic life or shellfish use** as our primary metric of water quality degradation. This metric was mapped at a HUC12 watershed basin level of geographic resolution.

7) Loss of CO2 Sequestration

Coastal salt marshes remove from the atmosphere and store (sequester) large amounts of carbon in their peaty sediments. The loss of this carbon store and potential release to the water column and atmosphere is one of the IOCs. The vulnerability of a salt marsh to the loss of sequestration depends on a number of factors including salinity, tidal restrictions and the ability of the marsh to vertically accrete under accelerating rates of sea level rise.

Salt Marsh Blue Carbon

The methodology developed by NJDEP to assess NJ's Blue Carbon potential identifies 18 ppt salinity as a key threshold (Personal communication: Metthea Yepsen and David Dumont). Coastal marshes above 18 ppt have higher carbon sequestration potential. Using CRSSA's existing salinity GIS layer we classified NJ's existing marshes accordingly to provide present day sequestration potential, not under future sea level rise. Marshes where tidal influx is restricted increase the vulnerability of a marsh to potential losses in carbon sequestration. The Tidal Restriction data layer was generated by McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017 for the North Atlantic Conservation Cooperative, US Fish and Wildlife Service, Northeast Region. Higher values represent a higher degree of tidal restriction. A threshold of 0.25 was selected as most Atlantic Coast back-bay fringing marshes were below this threshold. Marshes that were behind some sort of human barrier (i.e., a causeway) were above this 0.25 threshold. All other factors held equal, a marsh with a greater tidal restriction was rated as having a higher potential loss. The Marsh Future Change map was included as an additional factor affecting future sequestration with areas expected to convert at a Sea Level Rise of 1' by 2050 rated with a higher loss potential than those expected to convert at 2 and 3' of SLR.

Future Marsh Retreat Zones

In addition to accreting vertically, salt marshes can also retreat landward through a process of 'creative destruction' (Titus et al., 2009). If there is only a gradual rise in elevation, the adjacent uplands will be periodically flooded by rising tidal inundation. The more sensitive upland vegetation will be stressed by the flooding and higher salinity and be replaced by emergent marsh vegetation. However, in some areas, the slope above the coastal marsh is steeper than the marsh surface itself restricting the landward migration process. Development or other ‘hard’ obstructions (i.e. levees or bulkheads, roadways, causeways, fill) in the upland fringe adjacent to coastal wetlands will also impinge on the landward retreat process, effectively squeezing out the marshes. These future marsh retreat zones should be high priority for purchase and preservation to ensure role of salt marshes in our coastal zone is sustained over the coming decades. Using geospatial analysis software, future marsh retreat zones for three scenarios of sea level rise (1’, 2’ and 3’) out to the Year 2050 were modeled by Rutgers CRSSA. Those portions of New Jersey’s coastal wetland complex that are free to retreat inland as part of the natural landward migration process were mapped and labeled as **unimpeded marsh retreat zones**. Areas where future tidal marsh retreat are blocked by developed uplands, other coastal protection structures or roads were mapped and labeled as **impeded marsh retreat zones**.

Similarly, the prioritization of restoration and/or protection efforts may vary by these above factors. These two priorities were mapped into 15 distinct categories (Table 1: Detailed Carbon Sequestration Layer). These 15 categories were then reclassed to match criteria established by the NJDEP (Personal Communication: Metthea Yepsen and David Dumont) (Table 1: Summarized Carbon Sequestration).

Table 1. Criteria as defined by NJDEP and the Class categories as mapped.

Row	Class_Names	Legend for Detailed Carbon Sequestration layer	Legend for main Summarized Carbon Sequestration IOC layer
0			
1	MC:Hi, Sal>=18	High edge erosion, salinity >=18 PPT	Highest
2	MC:Hi, Sal >5 <=18	High edge erosion, salinity 5-18 PPT	High
3	MC:Hi, Sal <5	High edge erosion, salinity <5 PPT	Moderate
4	MC:Mod, TR:Lo, Sal >=18	Conversion likely by 2050 with 1 ft SLR, not tidally restricted, salinity >=18 PPT	High
5	MC:Mod, TR:Lo, Sal >5 <=18	Conversion likely by 2050 with 1 ft SLR, not tidally restricted, salinity 5-18 PPT	Moderate
6	MC:Mod, TR:Lo, Sal <5	Conversion likely by 2050 with 1 ft SLR, not tidally restricted, salinity <5 PPT	Low

7	MC:Mod, TR:Hi, Sal >=18	Conversion likely by 2050 with 1 ft SLR, tidally restricted, salinity >=18 PPT	Highest
8	MC:Mod, TR:Hi, Sal >5 <=18	Conversion likely by 2050 with 1 ft SLR, tidally restricted, salinity >=18 PPT	High
9	MC:Mod, TR:Hi, Sal <5	Conversion likely by 2050 with 1 ft SLR, tidally restricted, salinity <5 PPT	Low
10	MC:Low, TR:Lo, Sal >= 18 PPT	Not likely to convert by 2050 with less than 2 ft SLR, not tidally restricted, salinity >=18 PPT	Moderate
11	MC:Low, TR:Lo, Sal >5 <=18	Not likely to convert by 2050 with less than 2 ft SLR, not tidally restricted, salinity 5 to 18 PPT	Low
12	MC:Low, TR:Lo, Sal < 5 PPT	Not likely to convert by 2050 with less than 2 ft SLR, not tidally restricted, salinity <5 PPT	Low
13	MC:Low, TR:Hi, Sal >= 18 PPT	Not likely to convert by 2050 with less than 2 ft SLR, tidally restricted, salinity >=18 PPT	Highest
14	MC:Low, TR:Hi, Sal >5 <=18	Not likely to convert by 2050 with less than 2 ft SLR, tidally restricted, salinity 5 to 18 PPT	High
15	MC:Low, TR:Hi, Sal < 5 PPT	Not likely to convert by 2050 with less than 2 ft SLR, tidally restricted, salinity <5 PPT	Low
18	MC:MR, TR:Hi, Sal >=18 PPT	Marsh migration zone, tidally restricted, salinity >= 18 PPT	MR Tidally Restricted
19	MC:MR, TR:Low, Sal >=18 PPT	Marsh migration zone, not tidally restricted, salinity >= 18 PPT	MR Not Tidally Restricted
20	MC:MR, TR:Hi, Sal >5 <=18 PPT	Marsh migration zone, tidally restricted, salinity 5 to 18 PPT	MR Tidally Restricted
21	MC:MR, TR:Low, Sal >5 <=18 PPT	Marsh migration zone, not tidally restricted, salinity 5 to 18 PPT	MR Not Tidally Restricted
22	MC:MR, TR:HI, Sal <=5 PPT	Marsh migration zone, tidally restricted, salinity < 5 PPT	MR Tidally Restricted

23	MC:MR, Sal <=5 PPT	Marsh migration zone, not tidally restricted, salinity < 5 PPT	MR Not Tidally Restricted
24	Uplands		
25	Water		

References:
Titus, J.G.; and Anderson, K.E., 2009. *Coastal sensitivity to sea-level rise: a focus on the mid-Atlantic region* (Vol. 4). Government Printing Office.

8) Social Vulnerability

The vulnerability of adjacent coastal communities and their populations to the impacts of storms and flooding is a major issue of concern that applies directly to human welfare. New Jersey recently passed the Environmental Justice Law, N.J.S.A. 13:1D-157, (Law) which requires the New Jersey Department of Environmental Protection (NJDEP) to evaluate the contributions of certain facilities to existing environmental and public health stressors in overburdened communities when reviewing certain permit applications. The law also directed the NJDEP to map overburdened communities and provide notice to the 331 municipalities in which those communities are located. An **Overburdened Community (OBC)**, as defined, is any census block group, as determined in accordance with the most recent United States Census, in which:

- at least 35 percent of the households qualify as low-income households (at or below twice the poverty threshold as determined by the United States Census Bureau);
- at least 40 percent of the residents identify as minority or as members of a State recognized tribal community; or
- at least 40 percent of the households have limited English proficiency (without an adult that speaks English "very well" according to the United States Census Bureau).

In addition, the Center for Disease Control (CDC) Social Vulnerability indices (SVI) maps the location of a community's most vulnerable people. The CDC Overall SVI combines percentile rankings of US Census American Community Survey (ACS) 2014-2018 variables, for the state, at the census tract level. This composite SVI can be further divided into sub-metrics: Socio-Economic, Household Composition, Race/Ethnicity/Language and Housing/Transportation.

We combined the above two data layers, the NJDEP delineated Overburdened Communities and the CDC SVI, into a single composite with the following attribute categories (Table 2).

Table 2. The composite Overburdened Communities - Social Vulnerability map coding schema.

Class	Score
OBC & SVI 1st Quartile	1
OBC & SVI 2nd Quartile	2
OBC & SVI 3rd Quartile	3
OBC & SVI 4th Quartile	4

9) IOC Composite of Number of IOCs that Qualify as High Vulnerability

The eight IOC layers were composited to develop a general overview of what areas of New Jersey's coastal zone might be at highest vulnerability as it relates to these eight IOCs.
The 8 IOCs were composited in two different ways:

1. Each IOC was ranked on a scale of 1-4 (with 4 representing the highest vulnerability). The 8 IOC gridded maps were summed for each grid cell, thus a max value of 32 was possible. This composite was then binned into 6 classes.
2. Composite of Number of IOCs that Qualify as High Vulnerability. The 8 IOC gridded maps were combined into a single composite recording the number of IOCs that were ranked as highly vulnerable for that grid cell location. For example, if 6 out of the 8 IOCs were ranked as High for a specific grid cell location, that grid cell was given a code of 6.

   Please note that these are gridded rasters, with the grid cells 10 feet in size on a side.