LONG ISLAND SOUND STUDY VULNERABILITY ASSESSMENT OUTREACH

Results of outreach for the vulnerability matrices
developed by Battelle (2016)

Long Island Sound Study
LI-00A00156

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SUMMARY:
The purpose of this project was to obtain and summarize feedback from local experts on the scoping reports developed on climate change vulnerabilities for the EPA's National Estuary Programs in the northeast from Maine to New York. The scoping reports and associated vulnerability matrices were developed by Battelle for the EPA following the EPA's workbook steps as described in Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans (EPA 2014).

The purpose of the scoping study is:

> [t]o raise awareness of risks to U.S. EPA goals associated with climate change and indicate where more analysis might be needed. This study reviewed and analyzed existing information to create a risk-based climate change vulnerability assessment to inform those managing coastal watershed in the Northeast Study Area. The vulnerability assessment resulted in consequence/probability (C/P) matrices for four EPA goal areas: pollution control; habitat; fish, wildlife and plants; recreation and public water supplies. C/P matrices were produced for two future time periods, 2050 and 2100, for which climate change projections were available. (Battelle 2016)

Reviewers had numerous comments and additions largely stemming from the wide geographic range (northeast) for which the vulnerability assessment (VA) was conducted and generalized. Many of the comments further refine the matrix impacts for Long Island Sound. There are suggestions to modify the VA for Long Island Sound by incorporating several new habitat matrices including Open Water of Long Island Sound and Bluffs and Escarpments. Soils and climate change impacts should be incorporated into all habitat types.

Climate Change Stressors considered in the Vulnerability Assessment:

- Warmer summers
- Warmer winters
- Warmer water
- Increasing drought
- Increasing storminess
- Sea level rise
- Ocean acidification

The four areas associated with climate change risks to EPA goals in Long Island Sound are:

- Pollution Control
- Habitat
- Fish, Wildlife and Plants
- Recreation and Public Water Supplies

Eight matrices were developed for these topical areas (4 areas, two time periods: 2050, 2100)

Habitats in the northeast region where further examined for vulnerability to climate change risks. Habitat types for the Scoping Report were based on an understanding of habitat type consistent with the North Atlantic Coast Comprehensive Study (NACCS) (USACE 2014) within the NE Study Area. Habitats considered in this Vulnerability Assessment are:

- Ocean Beach and Dune Ecosystem
- Coastal Wetlands

- Submerged Aquatic Vegetation
- Oyster Reefs,
- Rock Reefs/Rocky Shorelines
- Shallow Bay Habitat/Bay Islands
- Terrestrial Upland
- Floodplains/Riparian.

Sixteen matrices were developed for the Habitat types (8 habitats, two time periods: 2050, 2100).

Who reviewed the Matrices?
Comments were obtained from 150+ individuals (likely many more as many people/groups participated on conference calls).
Groups surveyed included: LISS STAC Committee; LISS Habitat Restoration and Stewardship Work Groups, LISS Climate Change and Sentinel Monitoring Work Group, LISS Water Quality Monitoring Work Group, NRCS, USFWS, NOAA, Audubon, TNC, NYDEC, CT DEEP, individual scientists/researchers from various universities, particularly as recommended by various work groups members.

How to use this document:
Comments and feedback are included either as general comments or specific to a matrix entry.
General comments are subdivided as follows:

- Comments on the overall assessment
- Comments on stressors
- Comments on the EPA goal matrices
- Comments on the Habitat matrices.

Comments **specific** to any **matrix entries** (either EPA goal matrices or Habitat matrices) were incorporated into that matrix entry or entries were moved within the matrix as suggested by reviewers.

Section A: General comments on the Vulnerability Assessment
Section B: General comments on the Stressors
Section C: General comments on the eight matrices developed for EPA goals (Pollution Control, Habitat, Fish, Wildlife and Plants, and Recreation and Public Water Supplies).
  Appendix A: Modified EPA goals matrices incorporating comments and edits.
  Appendix B: Original EPA goals matrices showing comments and edits
Section D: General comments on the sixteen Habitat matrices
  Appendix C: Modified Habitat Matrices incorporating comments and edits
  Appendix D: Original matrices showing comments and edits
Section E: Recommendations for next steps
  Appendix E: Preliminary Descriptions/Information for the Vulnerability Assessment Stressors

SECTION A. General Comments for the LIS Vulnerability Assessment:

- There are too many conditional clauses, including "may" in places where they should use "will". For example, "Some fish reproduction may require cold temperatures…" This has been studied and there is an answer one way or the other - no need to equivocate. Similarly, "Warmer Water - Dissolved oxygen capacity of water may drop." This is not debatable - the solubility of oxygen decreases as temperature of seawater increases. This is a comment that was echoed by numerous reviewers.
- Along these same lines, we have the projections for many of the stressors, and we know for example, the lethal temperature limit for oysters, we should use known science; Change may actually be good for some organisms in the short term. This is part of managing expectations; the positive or negative aspect of the impacts is missing.
- In general, the tables and color coding are difficult to read. Perhaps the color choices in matrices should be changed; Things in red are not necessarily bad.
- Hopefully, the "consulting firm only" expert input [on matrix developed] has not biased the report.
- It would be helpful to identify the level of connectedness among the categories and impacts of climate change. For example, climate change = increased rain events = more pollution in water = impact on wetlands.
- It is unclear how the likelihood scores were assigned (beyond the explanation provided). Many of the results don't match with expectations. For example, it is not intuitive that: it is more likely that "loss of melting snow may reduce spring and summer flow volume and raise pollutant concentration," than it is that increased storminess will result in more frequent urban flooding. The latter is already occurring, while the former will need analysis on a decadal scale to really understand variability in snowfall, etc.
- Matrices need to highlight and include human responses to stressors. Often it is the human responses to climate change that are the real problem, not the climate changes directly. Perhaps human responses should be explicitly called out. Are greater demand for air conditioning and greater greenhouse gas emissions beyond the scope of this assessment?
- There is no synergy of impacts.
- Human responses could have a huge impact on this VA; need more on this.
- Need to consider transitions; transitions are not fully considered in terms of regime changes
- May want to highlight impacts in the matrices that are already happening. [This relates back to the comment on use of conditional clauses.]
- What is path forward? What are truly viable management options?

SECTION B. Stressors

No explanation of the seven stressors is provided in the Battelle report. For this report and for future vulnerability assessment purposes, J. Barrett developed preliminary descriptions and references for these stressors for the Long Island Sound area using information in the National Climate Assessment (2018 and 2014) and other reports applicable to the Long Island Sound area. These descriptions are provided in Appendix E.

Stressors for Long Island Sound:

- Warmer summers
- Warmer winters
- Warmer water
- Increasing drought
- Increasing storminess
- Sea level rise
- Ocean acidification

General Comments on the Stressors:

- There were concerns expressed as to how the stressors were chosen and based on what information. Also, there is great variability within the Northeast region for some of these stressors and this does not appear to have been taken into account.
- Concerns were expressed about the limited numbers of stressors examined and the applicability of Northeast Regional climate assessments to more local environments (downscaling). Another comment, however, thought that the chosen stressors covered all the major impacts.
- There were numerous comments/confusion on the Increasing Storminess stressor:
    - The references listed in the VA report used for the changes in rainfall lump all of New England together and concludes that rainfall will increase. This might be true, but there is no evidence that CT and New York will respond the same way as Maine and New Hampshire. Analyses show that rainfall in southern New England is different.
    - Does this include an increase in extreme precipitation events?
      It is unclear if "Increasing Storminess" includes increased precipitation and increased intense precipitation events. If not, these impacts are missing.
    - Need to tease apart increased storm events versus changes in precipitation.
- Throughout matrices, Ocean Acidification is often put in the low risk categories but this is based on a small (short term) data set.
- The increased drought projection is questionable.
- Sea Level Rise impacts:
    - SLR may vary within estuaries
    - The response of groundwater to SLR does not seem to be captured in the impacts.
- Warmer Water: repeated references to "loss of protective ice" - not sure that we consistently have a protective ice layer in our habitats, usually more episodic periods of patchy ice
- Warmer winter temperatures may promote the northern migration of southern species – important to note that this is already happening. E.g., Kelp being replaced by Sargassum
- Shallow Bay matrix states that increased drought may result in warmer waters leading to areas of hypoxia. It is unclear how increased drought leads to an increase in water temperature. Tidal flushing from LIS impacts water temperatures. Could be sunnier days causing warmer waters but unclear.

SECTION C. Vulnerability Assessment for EPA GOALS (Pollution Control, Habitat, Fish, Wildlife and Plants, and Recreation and Public Water Supplies)

- Long Island has a sole source aquifer; perhaps VA should be done separately for Long Island. Or divide LIS into segments for further analysis. NY has several major issues with septic systems and sole source aquifer.
- Water pollution is the number one problem with shellfish propagation.
- There are not many kelp beds along the Connecticut shoreline due to habitat conditions. Kelp mainly occurs in the Eastern Sound, but is not well mapped.
- There will be loss of associated wildlife and plants as individual sites no longer support reproduction.
- Concerns on Long Island: lack of groundwater recharge; inundation of wells by sea level rise and flooding; loss of water table aquifer if inundation occurs.
- Water Supply in NYC: there is concern with disinfection byproducts; byproducts are due to more naturally occurring pollutants leading to increased chlorine use leading to increased byproducts. (NYC does not filter water) So with increase byproducts, treatment plants may need to do more.
- Recreation can include use of beaches/water and shellfishing. It would be helpful to define recreational uses.
- All other comments are associated with individual matrices.

SECTION D. Habitats

Habitats considered in this Vulnerability Assessment are:

- Ocean Beach and Dune Ecosystem
- Coastal Wetlands
- Submerged Aquatic Vegetation
- Oyster Reefs
- Rock Reefs/Rocky Shorelines
- Shallow Bay Habitat/Bay Islands
- Terrestrial Upland
- Floodplains/Riparian

Because the vulnerability analysis of these habitat types is generalized for the northeast, it is not surprising that local reviewers had numerous comments and suggestions refining the matrices for the Long Island Sound region. General comments are found below while habitat specific comments are included in each habitat matrices.

General Comments/Recommendations for the Habitat Matrices:

- Habitat matrices do not include any references to ecosystem functions and services. This should be included. For example, there will be changes in ecosystem services related to amounts of high and low marsh (e.g. carbon sequestration will change); this is not addressed in matrices.
- In most habitats, rate of changes will affect which species migrate.
- Connecticut's coastal habitats are fragmented so species movement will be highly variable and rates of migration will also be highly variable.
- Invasive species are likely to migrate successfully.
- Invaders are a crap shoot - depends on where they are coming from; We need a map of invasive species distributions to help assess ecological impact.

- Very few interactions are mentioned and more should be included. (as in: Increased water temperatures may affect the spawning of oysters which in turn may result in asynchrony between larval development and food supply.)

OCEAN BEACH/DUNE HABITAT:

- Comment from numerous reviewers: Overwash and breaching are not negative and are part of the natural process of beach/dune/barrier island systems. The Assessment needs to ensure that natural processes (breaching and overwash) are not presented as threats.
- There is a lot of redundancy in this matrix. Is there an advantage to separating out risks versus clumping them?
- It would be helpful to know where the beach/dune migration areas are. Also need to examine hydric soils, subaqueous soil mapping, marine sediments over till, etc.
- Many concerns with the sediment supply: Increased vulnerability to increased storminess if up-current source of sediment has been eliminated by erosion control structures - e.g. Griswold Point. This is probably more important than frequency of storms. We can point to many cases of beach loss from interrupting /eliminating the sediment source. Likewise, hard structures are the biggest risk to barrier beaches as they interrupt the sediment supply.
- We may lose coastal forest with increasing storminess, but will gain more maritime forest with increasing storminess. The coastal barrier and its vegetation are dependent upon storms to increase their height and width so that vegetation can continue to exist - there are vegetation losses but they are usually of a temporary nature and part of the barrier dynamics.
- Beach and dunes will try to migrate landward in urban areas, but will not necessarily be successful. Either they will migrate or hard structures will stop them. There may be habitat loss, but they will migrate.
- Beach strands are not a bad thing if they occur. Likewise, inundation of bay front marshes and new inlets are not negative impacts.
- Bluffs and Escarpments – should have an individual matrix
- Soils are a critical component of many of these habitats (from subaqueous to upland) and should be more systematically included. Subaqueous soils may need their own matrix.

SHELLFISH REEFS (formerly Oyster Reefs)

- Oyster Reefs – should be Shellfish Reefs
- There are many other animals beside shellfish; birds are a big part of systems and not mentioned; horseshoe crabs/crabs should be mentioned as a critical food web component and impacts of changing salinity and temperature on crabs.
- Impact of warmer winters is not limited to oysters and other shellfish; fish, crabs, eelgrass etc. are all impacted as well.
- Pollution control is the number one problem with shellfish propagation. We can look at stressors to habitat, but if propagation is the main concern, we need to worry about pollution control. Pollution and climate are linked: increased precipitation (intense precipitation events) leads to bed closures and possibly seaweed area closures.

COASTAL WETLANDS

- Need to make clear that storm surge not a threat to marshes, but higher energy waves hitting marsh edges can cause erosion issues.
- Unclear how the salt wedge moving up the Hudson River further with sea level rise will be mitigated/impacted by changes in precipitation projections.
- Need to emphasize the impact that increased nutrient loads from both surface and groundwater flow and flooding will increase the vulnerability of tidal marshes, along with sea level rise.
- For coastal wetlands, the greatest impact is noted to be an increase in hardened shorelines. It would be worthwhile to add a sentence as to why this is bad for vegetated wetlands as this is not generally understood by the public. Also, another reviewer noted that the greatest impact may actually not be hardened shorelines but the lack of sediment supply to keep pace with sea level rise which is due in part to many anthropogenic influences. In addition, it should be noted that marshes in the western Sound have more sediment supply than those in the eastern Sound.
- In tidal wetlands, changes in temperatures and seasons could impact respiration and biogeochemical rates. (also raised with regard to soils, in general)
- The conversion from low marsh to mudflat has been occurring in central and western LIS for over a century - we still do not know why. Ditching may be contributing.
- With regard to sea level rise and tidal wetlands, we do not see marshes migrating seaward.
- Coastal wetlands – impacts should be informed by the recent SLAMM analysis.
- Even though this region does not have “protective ice,” ice chunks pushed into marshes during winter can provide sediment.
- With sea level rise, tidal flats also likely to become sub-tidal. It is extremely unlikely that intertidal flats may become vegetated. All changes seen to date, have been the reverse of this description.

TERRESTRIAL UPLANDS

- Soils will react faster than the vegetation in terrestrial upland habitats.
- Increase in vernal pool habitat is possible.
- Changes in terrestrial upland soils could increase nutrients used by farmers to maintain productivity.
- There is the potential for a shift in vegetation to purely salt tolerant species, including many invasive species, in certain terrestrial upland areas.
- For both terrestrial uplands and floodplain/riparian areas: Some movement of maritime/coastal forests is natural. How can changes be differentiated from climate impacts?
- Somewhat poorly drained soils may turn into seeps with changing impacts.

SUBMERGED AQUATIC VEGETATION

- There is a lack of information on SAV in brackish and fresh waters.
- Water quality is of high importance in maintaining SAV beds so any factors that impact water quality will impact SAV beds, reducing resilience of SAV to all other impacts. The same is true for increasing water temperatures (once temperature thresholds exceeded.)

- Light intensity is increasing, warming shallow waters more and putting stress on SAV.
- Ocean acidification is good for seagrasses as is higher salinities but these benefits are minor compared to impacts from increasing water temperatures (good until temperature tolerance is exceeded)
- Breaching of barrier beaches can change SAV populations.
- With change in kelp forest habitat, mitigation could be kelp aquaculture, same for blue mussel – but both could be gone by 2050.

FLOODPLAIN-RIPARIAN HABITATS

- Floodplain-Riparian Systems: Could use cold water fish as an impacted species example as oysters are used in other matrices.

ROCK REEFS/SHORELINE

- We are already seeing shifts in suspension feeding organisms due to shifts in plankton sizes in rocky reef communities. (See comment that matrices should include current impacts.)

SHALLOW BAY HABITAT/BAY ISLANDS

- Islands should be separated out into their own category; NY has many islands that are critical bird and seal habitat.
- Shallow bay habitat is more applicable to Rhode Island than Long Island Sound.
- For Shallow bay habitat, changes in the timing of peak flow events will impact salinity, runoff, flushing and nutrient dynamics.
- Bay islands impacted by sea level rise may result in the loss of nesting habitat for coastal waterbirds (entire population of NW Atlantic Roseate Tern (Fed - E) nests in this geographic area)
- Shallow Bay Habitats: Ocean acidification may cause changes in delivery of silica into embayments – need information on this.
- Open Water Habitat – while touched upon in the Shallow Bay Habitat, the open water habitat of Long Island Sound should have an individual matrix
- Shallow Bay Habitats: Increasing storminess may increase runoff from the surrounding watershed which may lead to increased loading of nitrogen and phosphorous to inland bays resulting in eutrophication. This is true for events, but not necessarily over the long term. With storms there is a pulse of organic nitrogen; on average statement is true, but more to it.

SECTION E.
Recommendations for Next Steps:

- Matrices should be reviewed and updated every 5 years
- Over next 5 years, consider implementing changes/modifications as suggested by reviewers. Changes/Modifications that could be implemented over the next 5 years (some are short term and others are longer term)
    - Define stressors with specific reference to the Long Island Sound geographic area. (J. Barrett provides information in Appendix E. The stressors could be reviewed and edited by CCSM work group). Once definitions are agreed upon, review matrices to ensure that all risks/vulnerabilities are included.

- Define habitats so audiences understand what is or is not included within each habitat type. This should be based on LIS habitat restoration and stewardship work group definitions where applicable. Review matrices based on habitat definitions to ensure that risk and vulnerabilities are still applicable.
- Develop a habitat matrix for the open waters of Long Island Sound OR determine the most significant impacts for this habitat instead of a full matrix.
- Develop a habitat matrix for bluffs and escarpments OR determine the most significant impacts for this habitat instead of a full matrix.
- Conduct Vulnerability Assessment and develop matrices for Long Island, NY with respect to Pollution Control and Recreation and Public Water Supply goals, recognizing that Long Island is a sole source aquifer OR determine the most significant impacts for Long Island with regard to these goals instead of a full matrix.
- Consider changing language in matrices from "may" to "is" in situations where impacts of stressors are known for Long Island Sound.
- Based on USDA NRCS input, while soils are mentioned in habitat matrices, a better understanding of impacts of climate change stressors on soils (from subaqueous to upland) should be developed.
- Develop matrix of climate impacts to ecosystem functions or include this in existing matrices.
- As better data for Ocean Acidification become available, review all matrices that include this stressor.
- Habitat matrices do not include any references to ecosystem functions and services. This should be developed for the habitat matrices.
- For coastal wetlands, the greatest impact is noted to be an increase in hardened shorelines. Provide information on why hard structures have negative impacts on coastal environments for the public.

* Develop a report appropriate for all audiences on Climate Change in Long Island Sound based on EPA priority goals. This could mirror the overall matrix found in the New York/New Jersey Harbor and Estuary Program Climate Report. https://www.hudsonriver.org/NYNJHEPClimateVulnerability.pdf
* Correlate risks and vulnerabilities outlined in matrices to LISS CCMP (2015) strategies and actions. Consider management actions to alleviate risks and vulnerabilities.
* Use Vulnerability Assessment matrices to guide research needs pertaining to climate change in Long Island Sound.
* Consider human impacts and interactions moving forward with the Vulnerability Assessment.

APPENDICES:

APPENDIX A: Modified EPA Clean Water Act goal matrices incorporating all comments and edits. (PDF)
APPENDIX B: Original EPA Clean Water Act goal matrices showing comments and edits (Excel file with tabs)
APPENDIX C: Modified Habitat Matrices incorporating all comments and edits (PDF)
APPENDIX D: Original Habitat Matrices showing comments and edits (Excel file with tabs)
APPENDIX E: Preliminary Descriptions/Information for the Vulnerability Assessment Stressors (PDF)

APPENDIX A: Modified EPA Clean Water Act goal matrices incorporating all comments and edits. (PDF)

Long Island Sound: Pollution Control 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH	1. Warmer Winters - Longer growing season can lead to more lawn maintenance with fertilizers and pesticides.	1. Increasing Storminess - Flood control facilities (e.g. detention basins, manure management) may be inadequate. 2. Warmer Water - Greater algae growth may occur 3. Warmer Water - Water may hold less dissolved oxygen 4. Warmer Winters - Loss of melting winter snows may reduce spring or summer flow volume and raise pollutant concentrations in receiving waters	1. Increased Storminess - Increased storminess will lead to increased risks to public health due to sewage/septic outfalls into nearshore beaches 2. Increased Storminess - Increased storminess will lead to negative impacts and closure of shellfish beds. 3. Increased Storminess - Increased storminess will impact human health on nearshore beaches.
	MEDIUM	1. Increasing Storminess - Streams may see greater erosion and scour 2. Increasing Storminess - Urban areas may be subject to more floods 3. Sea Level Rise - Sewer pipes may have more inflow (floods) or infiltration (higher water table) 4. Warmer Water - Warmer temperatures may increase toxicity of pollutants	1. Increasing Drought - Critical-low-flow criteria for discharging may not be met 2. Increasing Drought - Pollutant concentrations may increase if sources stay the same and flow diminishes 3. Increasing Drought - Pollution sources may build up on land, followed by high-intensity flushes 4. Increasing Storminess - Combined sewer overflows may increase; same is true for separate sanitary sewers. 5. Increasing Storminess - High rainfall may cause septic systems to fail 6. Increasing Storminess - Treatment plants may go offline during intense floods 7. Ocean Acidification - Decomposing organic matter releases carbon dioxide, which may exacerbate the ocean acidification problem in coastal waters 8. Sea Level Rise - Contaminated sites may flood or have shoreline erosion 9. Sea Level Rise - Sewage may mix with seawater in combined sewer systems 10. Sea Level Rise - Tidal flooding may extend to new areas, leading to additional sources of pollution 11. Sea Level Rise - Treatment infrastructure may be susceptible to flooding 12. Sea Level Rise - Treatment plants may not be able to discharge via gravity at higher water levels 13. Warmer Summers - Wildfires may lead to soil erosion 14. Warmer Water - Higher solubility may lead to higher concentrations of pollutants 15. Warmer Water - Higher surface temperatures may lead to stratification 16. Warmer Water - Parasites, bacteria may have greater survival or transmission. 17. Warmer Water - Temperature criteria for discharges may be exceeded (thermal pollution) 18. Increased storminess - Intense rainfall events will impact animal (particularly shellfish) and human health at beaches. 19. Sea Level Rise - sea level rise will impact septic systems (inability to treat overflows) and sanitary sewers 20. Warmer Water - Warmer water may cause an increase in pathogen and viral growth. 21. Warmer Water - Warmer water may cause a shift in timing of algal growth and type(s) of species. 22. Sea Level Rise: Sea level rise will raise coastal groundwater tables and put groundwater in contact with more onsite wastewater sources.	
	LOW			

LONG ISLAND SOUND: POLLUTION CONTROL 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH	1. Sea Level Rise - Sewer pipes may have more inflow (floods) or infiltration (higher water table) 2. Warmer Winters - Longer growing season can lead to more lawn maintenance with fertilizers and pesticides	1. Increasing Drought - Critical-low-flow criteria for discharging may not be met 2. Sea Level Rise - Sewage may mix with seawater in combined sewer systems 3. Sea Level Rise - Tidal flooding may extend to new areas, leading to additional sources of pollution 4. Warmer Water - Greater algae growth may occur 5. Warmer Winters - Loss of melting winter snows may reduce spring or summer flow volume and raise pollutant concentration in receiving waters 6. Warmer Water - Warmer water may cause an increase in pathogen and viral growth. 7. Warmer Water - Warmer water may cause a shift in timing of algal growth and type(s) of species. 8. Warmer Water - Water may hold less dissolved oxygen	1. Increasing Storminess - Flood control facilities (e.g. detention basins, manure management) may be inadequate 2. Sea Level Rise - Treatment infrastructure may be susceptible to flooding 3. Sea Level Rise - Treatment plants may not be able to discharge via gravity at higher water levels 4. Increase storminess - Intense rainfall events will impact animals (particularly shellfish) and human health at beaches. 5. Increased Storminess - Increased storminess will lead to increased risks to public health due to sewage/septic outfalls into nearshore beaches 6. Increased Storminess - Increased storminess will lead to negative impacts and closure of shellfish beds. 7. Sea level rise - sea level rise will impact septic systems (inability to treat overflows) and sanitary sewers 8. Sea Level Rise: Sea level rise will raise coastal groundwater tables and put groundwater in contact with more onsite wastewater sources. 9. Increased Storminess - Increased storminess will impact human health on nearshore beaches.
	MEDIUM	1. Increasing Storminess - Streams may see greater erosion and scour	1. Increasing Drought - Pollutant concentrations may increase if sources stay the same and flow diminishes 2. Increasing Drought - Pollution sources may build up on land, followed by high-intensity flushes 3. Increasing Storminess - High rainfall may cause septic systems to fail 4. Increasing Storminess - Urban areas may be subject to more floods 5. Ocean acidifcation - Decomposing organic matter releases carbon dioxide, which may exacerbate the ocean acidification problem in coastal waters 6. Sea level Rise - Contaminated sites may flood or have shoreline erosion 7. Warmer Summers - Wildfires may lead to soil erosion 8. Warmer Water - Higher solubility may lead to higher concentrations of pollutants 9. Warmer Water - Higher surface temperatures may lead to stratification 10. Warmer Water - Temperature criteria for discharges may be exceeded (thermal pollution) 11. Warmer Water - Warmer temperatures may increase toxicity of pollutants	1. Increasing Storminess - Combined sewer overflows may increase; same is true for separate sanitary sewers. 2. Increasing Storminess - Treatment plants may go offline during intense floods 3. Warmer Water - Parasites, bacteria may have greater survival or transmission
	LOW			

LONG ISLAND SOUND: HABITAT 2050

		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Stream erosion may lead to high turbidity and greater sedimentation	1. Increasing Storminess - Coastal overwash or island breaching may occur
			2. Sea Level Rise - Bulkheads, sea walls and revetments may become more widespread	2. Sea Level Rise - Higher salinity may kill targeted species
			3. Sea Level Rise - Saline water may move farther upstream and freshwater habitat may become brackish	3. Sea Level Rise - Shoreline erosion may lead to loss of beaches, wetlands, islands and salt marshes.
			4. Sea Level Rise - Tidal influence may move farther upstream	4. Warmer Water - Warmer water may promote invasive species or disease
	MEDIUM	1. Increasing Storminess - Lower pH for NPS pollution may affect target species	1. Increasing Storminess - Turbidity of surface waters may increase	1. Increasing Drought - An increase in long-term and seasonal short term drought may decrease base flows in streams
		2. Ocean Acidification - Fish may be adversely affected during development stages	2. Warmer Summers - Warmer summers are expected to result in higher temperatures which may lead to greater evaporation and lower groundwater tables	2. Increasing Drought - An increase in long-term and seasonal short term drought may cause groundwater tables to drop
			3. Warmer Water - Desired fish may no longer be present	3. Increasing Drought - Stream water may become warmer
			4. Warmer Water - Warmer water is likely to lead to greater likelihood of stratification	4. Increasing Storminess - Stronger storms may cause more intense flooding and runoff
			5. Warmer winters may cause forests to be more nitrogen limited which in turn may lead to regime shifts.	5. Increasing Storminess - The number of storms reaching an intensity that causes problems are expected to increase
			6. Warmer Water - Warmer water may lead to changes in larvel transport.	6. Warmer Winters - Less snow, more rain may change the runoff/infiltration balance; base flow in streams may change
	LOW	1. Increasing Drought - Increased human use of groundwater during drought may reduce stream baseflow	1. Increasing Storminess - Increase intensity of precipitation may yield less infiltration	
		2. Increasing Drought - New water supply reservoirs may affect the integrity of freshwater streams	2. Warmer Summers - Warmer summers may lead to greater electricity demand may affect operation decisions at hydropower dams. Particularly important for the survival and reproductive success of Puritan tiger beetle (Fed T) on the Connecticut River. The entire population in the Northeast nests on this one river (only other popn. in Chesapeake Bay).	
		3. Ocean Acidification - Long term shellfish sustainability may be an open question	3. Warmer Summers - Warmer summers may result in the switching between surface and groundwater sources for public water supplies may affect the integrity of water bodies	
		4. Sea Level Rise - Light may not penetrate through deeper water.	4. Warmer Winters - Rivers may no longer freeze; a spring thaw would be obsolete	
		5. Warmer Winters - A spring runoff pulse may disappear along with the snow		

LONG ISLAND SOUND HABITAT 2100

LIKELIHOOD OF OCCURRENCE	CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
HIGH		1. Increasing Drought - New water supply reservoirs may affect the integrity of freshwater streams 2. Ocean Acidification - Fish may be adversely affected during development stages	1. Increasing Drought - An increase in long-term and seasonal short term drought may decrease base flows in streams 2. Increasing Storminess - Coastal overwash or island breaching may occur 3. Increasing Storminess - Stream erosion may lead to high turbidity and greater sedimentation 4. Sea Level Rise - Bulkheads, sea walls and revetments may become more widespread 5. Sea Level Rise - Higher salinity may kill targeted species 6. Sea Level Rise - Saline water may move farther upstream and freshwater habitat may become brackish 7. Sea Level Rise - Shoreline erosion may lead to loss of beaches, wetlands, islands and salt marshes 8. Sea Level Rise - Tidal influence may move farther upstream 9. Warmer Water - Warmer water may promote invasive species or disease 10. Warmer Water - Warmer water may lead to changes in larval transport.
MEDIUM		1. Increasing Storminess - Lower pH for NPS pollution may affect target species 2. Ocean Acidification - Long term shellfish sustainability may be an open question 3. Warmer Water - Desired fish may no longer be present 4. Warmer Water - Warmer water is likely to lead to greater likelihood of stratification. 5. Warmer Winters - Warmer winters may cause forests to be more nitrogen limited which in turn may lead to regime shifts. 6. Warmer Water - Warmer water may lead to changes in larvel transport.	1. Increasing Drought - An increase in long-term and seasonal short term drought may cause groundwater tables to drop 2. Increasing Drought - Stream water may become warmer 3. Increasing Storminess - Stronger storms may cause more intense flooding and runoff 4. Increasing Storminess - The number of storms reaching an intensity that causes problems are expected to increase 5. Increasing Storminess - Turbidity of surface waters may increase 6. Warmer Summers - Warmer summers are expected to result in higher temperatures which may lead to greater evaporation and lower groundwater tables 7. Warmer Summers - Warmer summers may result in the switching between surface and groundwater sources for public water supplies may affect the integrity of water bodies 8. Warming of water may lead to increased stratification which in turn may affect larval transport 9. Warmer Winters - A spring runoff pulse may disappear along with the snow 10. Warmer Winters - Less snow, more rain may change the runoff/infiltration balance; base flow in streams may change
LOW	1. Sea Level Rise - Light may not penetrate through deeper water	1. Increasing Drought - Increased human use of groundwater during drought may reduce stream baseflow 2. Increasing Storminess - Increased intensity of precipitation may yield less infiltration 3. Warmer Summers - Warmer summers may lead to greater electricity demand may affect operation decisions at hydropower dams. Particularly important for the survival and reproductive success of Puritan tiger beetle (Fed T) on the Connecticut River. The entire population in the Northeast nests on this one river (only other popn. in Chesapeake Bay). 4. Warmer Winters - River may no longer freeze; a spring thaw would be obsolete	

LONG ISLAND SOUND: FISH, WILDLIFE AND PLANTS 2050

CONSEQUENCE OF IMPACT

LIKELIHOOD OF OCCURRENCE	LOW	MEDIUM	HIGH
HIGH		1. Increasing Storminess - Greater soil erosion may increase turbidity and decrease water clarity	1. Increasing Drought -Changing freshwater inputs may affect salinity distribution in estuaries (especially of interest with regard to shellfish habitat)
		2. Increasing Drought - Native habitat may be affected if freshwater flow in streams is diminished or eliminated	2.Sea Level Rise - Greater coastal wetland losses may occur resulting in the loss of wildlife and plants. High marsh is expected to disappear long before the marsh overall - so the habitat will not be suitable for reproduction for obligate nesting birds (i.e. saltmarsh sparrow)
			3. Sea Level Rise - Sea level may push saltier water farther upstream (especially of interest with regard to shellfish habitat).
			4. Warmer Water - Dissolved oxygen capacity of water may drop
			5. Warmer Water - Habitat may become unsuitably warm, for a species or its food. Example: Warmer water will displace forage fish to deeper and / or more offshore waters where they are not available to terns (who can only dive 'so deep' - and can only fly a certain distance from nesting islands when raising chicks) during the breeding season when they need to feed their young. If sand lance are displaced from shallow sandy waters due to temperature they may not reproduce themselves which would have impacts on many species of commercial and recreational fish as well as the birds.
			6. Warmer Water - Newly invasive species may appear
			7. Warmer Water - Parasites and diseases are enhanced by warmer water
			8. Warmer Winters - Invasive species may move into places that used to be too cold
			9. Warmer Winters -Pests may survive winters that used to kill them
			10. Sea Level Rise - Sea level may push saltier water farther upstream. For any fish ladders that occur at head of tide dams, the hydrologic changes may make the fish ladders less efficient at passing fish.
MEDIUM	1. Sea Level Rise - Light may not penetrate through the full depth of deeper water	1. Increasing Drought - Species may not tolerate a new drought regime	1. Warmer Summers - Species that won't tolerate warmer summers may die/migrate; biota at the southern limit of their range may disappear from ecosystems
	2. Warmer Winters - A longer growing season may lead to an extra reproductive cycle	2. Increasing Storminess - Greater soil erosion may increase sediment deposition in estuaries, with consequences for benthic species	2. Warmer Water - Heat may stress immobile biota
		3. Warmer Winters - Some plants may need a "setting" cold temperature	3 Warmer Water - Some fish reproduction may require cold temperatures; other reproductive cycles are tied to water temperature
		4. Warmer Winters - Food supplies and bird migrations may be mistimed	
		5. Warmer Winters - Species that once migrated through may stop and stay	
		6. Warmer Winters - Species that used to migrate away may stay all winter	
		7. Warmer Summers - Essential food sources may die off or disappear, affecting the food web	
LOW	1. Ocean Acidification - Corrosive waters may impact shellfish development		1. Warmer Summers - Species may need to consume more water as temperature rises
	2. Ocean Acidification - Fish may be adversely affected during development stages by changes to water chemistry		
	3. Ocean Acidification - Shellfish predators may not survive the disappearance of shellfish		
	4. Ocean Acidification - The effect of ocean acidification on calcifying plankton may lead to cascading effects in the food chain		
	5. Warmer Summers - Species may be weakened by heat and become out-competed		

LONG ISLAND SOUND: FISH WILDLIFE AND PLANTS 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Drought - Native habitat may be affected if freshwater flow in streams is diminished or eliminated	1. Increasing Drought -Changing freshwater inputs may affect salinity distribution in estuaries (especially of interest with regard to shellfish habitat)
				2. Increasing Storminess - Greater soil erosion may increase turbidity and decrease water clarity
				3. Increasing Storminess - Greater soil erosion may increase sediment deposition in estuaries, with consequences for benthic species
				4.Sea Level Rise - Greater coastal wetland losses may occur resulting in the loss of wildlife and plants. High marsh is expected to disappear long before the marsh overall - so the habitat will not be suitable for reproduction for obligate nesting birds (i.e. saltmarsh sparrow)
				5. Sea Level Rise - Sea level may push saltier water farther upstream (especially of interest with regard to shellfish habitat
				6. Warmer Water - Dissolved oxygen capacity of water may drop
				7. Warmer Water - Habitat may become unsuitably warm, for a species or its food. Example: Warmer water will displace forage fish to deeper and / or more offshore waters where they are not available to terns (who can only dive 'so deep' - and can only fly a certain distance from nesting islands when raising chicks) during the breeding season when they need to feed their young. If sand lance are displaced from shallow sandy waters due to temperature they may not reproduce themselves which would have impacts on many species of commercial and recreational fish as well as the birds.
				8. Warmer Water - Newly invasive species may appear
				9. Warmer Water - Parasites and diseases are enhanced by warmer water
				10. Warmer Winters - Invasive species may move into places that used to be too cold
				11. Warmer Winters -Pests may survive winters that used to kill them
				12. 10. Sea Level Rise - Sea level may push saltier water farther upstream. For any fish ladders that occur at head of tide dams, the hydrologic changes may make the fish ladders less efficient at passing fish.
	MEDIUM	1. Sea Level Rise - Light may not penetrate through the full depth of deeper water	1. Ocean Acidification - Corrosive waters may impact shellfish development	1. Increasing Drought - Species may not tolerate a new drought regime
			2. Ocean Acidification - Fish may be adversely affected during development stages by changes to water chemistry.	2. Warmer Water - Heat may stress immobile biota
			3. Ocean Acidification - Shellfish predators may not survive the disappearance of shellfish.	3. Warmer Summers - Species that won't tolerate warmer summers may die/migrate; biota at the southern limit of their range may disappear from ecosystems.
			4. Ocean Acidification - The effect of ocean acidification on calcifying plankton may lead to cascading effects in the food chain	4. Warmer Summers - Essential food source may die off or disappear, affecting the food web
			5. Warmer Winters - Species that once migrated through may stop and stay	5. Warmer Summers - Species may need to consume more water as temperature rises
			6. Warmer Winters - Species that used to migrate away may stay all winter	6. Warmer Water - Some fish reproduction may require cold temperatures; other reproductive cycles are tied to water temperature
				7. Warmer Winters - A longer growing season may lead to an extra reproductive cycle and may affect the food web.
				8. Warmer Winters - Food supplies and bird migrations may be mistimed
				9. Warmer Winters - Some plants may need a "setting" cold temperature
	LOW		1. Warmer Summers - Species may be weakened by heat and become out-competed	

LONG ISLAND SOUND: RECREATION AND PUBLIC H2O SUPPLIES 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH	1. Increasing Storminess - Flood waters may raise downstream turbidity and affect water quality	1.Increasing Storminess - Water infrastructure may be vulnerable to flooding.	1. Sea Level Rise - Water infrastructure may be vulnerable to inundation or erosion.
		2. Increasing Storminess - More frequent or more intense storms may decrease recreational opportunities	2. Sea Level Rise - Sea level may push salt fronts upstream past water diversion.	
		3. Increasing Storminess - Greater NPS pollution may impair recreation	3. Sea Level Rise - Salt water intrusion into groundwater may be more likely.	
		4. Sea Level Rise - Clearance under bridges may decrease	4. Sea Level Rise - Beaches or public access sites may be lost to coastal erosion or inundation.	
		5. Warmer Summers - Warmer temperatures may drive greater water demand. For example: Dry weather	5. Warmer Water - Desired recreational fish may no longer be present.	
		6. Warmer Summers - Evaporation losses from reservoirs and groundwater may increase		
		7. Warmer Summers - More people using water for recreation may raise the potential for pathogen exposure		
		8. Warmer Water - Changes in treatment processes may be required		
		9. Warmer Water - Increased growth in algae and microbes may affect drinking water quality		
		10. Warmer Water - Harmful algal blooms may be more likely		
		11. Warmer Water - Jellyfish may be more common. We need to consider transitions here: jellyfish may not be an issue; need to consider if they are		
		12. Warmer Water - Fishing seasons and fish may become misaligned		
		13. Warmer Water - Invasive plants may clog creeks and waterways		
		14. Warmer Winters - Summer water supplies that depend on winter snow pack may disappear		
		15. Warmer Winters - Cold places may see more freeze/thaw cycles that can affect infrastructure		
	MEDIUM	1. Increasing Drought - Lower freshwater flows may not keep saltwater downstream of intakes		
		2. Increasing Drought - Groundwater tables may drop		
		3. Increasing Drought - Coastal aquifers may be salinized from insufficient freshwater input		
		4. Increasing Drought - Coastal aquifers may be salinized from higher demand on groundwater		
		5. Increasing Drought - Maintaining passing flows at diversions may be difficult		
		6. Increasing Drought - Freshwater flows in streams may not support recreational uses		
		7. Increasing Drought - Increased estuary salinity may drive away targeted recreational fish		
		8. Ocean Acidification - Eco-tourism resource or attractions (e.g. birding, diving, fishing) may be degraded		
		9. Ocean Acidification - Recreational shellfish harvesting may be lost		
	LOW			

LONG ISLAND SOUND: RECREATION AND PUBLIC H2O SUPPLIES. 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH	1. Warmer Water - Jellyfish may be more common. We need to consider transitions here: jellyfish may not be an issue; need to consider if they are an issue further south.	1. Increasing Storminess - Flood waters may raise downstream turbidity and affect water quality	1.Increasing Storminess - Water infrastructure may be vulnerable to flooding.
		2. Warmer Winters - Cold places may see more freeze/thaw cycles that can affect infrastructure	2. Increasing Storminess - More frequent or more intense storms may decrease recreational opportunities	2. Sea Level Rise - Water infrastructure may be vulnerable to inundation or erosion.
			3. Increasing Storminess - Greater NPS pollution may impair recreation	3. Sea Level Rise - Sea level may push salt fronts upstream past water diversion.
			4. Ocean Acidification - Eco-tourism resource or attractions (e.g. birding, diving, fishing) may be degraded	4. Sea Level Rise - Salt water intrusion into groundwater may be more likely.
			5. Sea Level Rise - Clearance under bridges may decrease.	5. Sea Level Rise - Beaches or public access sites may be lost to coastal erosion or inundation.
			6. Warmer Summers - Warmer temperatures may drive greater water demand. For example: Dry weather and a longer growing season may lead to increased evapotranspiration which will increase lawn watering which will in turn, decrease water availability.	6. Warmer Water - Desired recreational fish may no longer be present.
			7. Warmer Summers - Evaporation losses from reservoirs and groundwater may increase	7. Ocean Acidification - Recreational shellfish harvesting may be lost
			8. Warmer Summers - More people using water for recreation may raise the potential for pathogen exposure	
			9. Warmer Water - Changes in treatment processes may be required. Treatment plants may need to do more.	
			10. Warmer Water - Increased growth in algae and microbes may affect drinking water quality	
			11. Warmer Water - Harmful algal blooms may be more likely	
			12. Warmer Water - Fishing seasons and fish may become misaligned	
			13. Warmer Water - Invasive plants may clog creeks and waterways	
			14. Warmer Winters - Summer water supplies that depend on winter snow pack may disappear	
	MEDIUM	1. Increasing Drought - Lower freshwater flows may not keep saltwater downstream of intakes	1. Increasing Drought - Groundwater tables may drop	
		2. Increasing Drought - Maintaining passing flows at diversions may be difficult	2. Increasing Drought - Coastal aquifers may be salinized from insufficient freshwater input	
		3. Increasing Drought - Increased estuary salinity may drive away targeted recreational fish	3. Increasing Drought - Coastal aquifers may be salinized from higher demand on groundwater	
			4. Increasing Drought - Freshwater flows in streams may not support recreational uses	
	LOW			

APPENDIX C: Modified Habitat Matrices incorporating all comments and edits (PDF)

OCEAN BEACH AND DUNE ECOSYSTEMS 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Intense storms and associated storm surge will increase the likelihood of new temporary or permanent inlet development.	1. Increasing Storminess - An increase in intense storms (i.e.nor'easters and hurricanes) may result in significant beach erosion and the reduction, or loss of coastal dunes with associated habitat loss of plants and wildlife. Dune loss likely to lead to increased sand flats.
			2. Increasing Storminess - Storm surge and the resulting beach and dune erosion will result in lowering of beach elevation.	2. Increased Storminess - High winds and associated storm surge may result in the breaching or over wash of barrier islands.
			3. Increasing Storminess - Coastal overwash or barrier island breaching may lead to migrating beach sand and dunes.	3. Sea Level Rise - Barrier beaches will be more susceptible to erosion and overwash, and in some cases, breaching and inlet formation.
			4. Sea Level Rise - Beaches and barrier islands may be degraded or lost by increased flooding frequency associated with sea level rise.	4. Increased Storminess - Hard structures along the shoreline may increase cutting off sediment supply to barrier beaches and preventing overwash.
				5. Sea Level Rise - Beaches and dunes that currently lie adjacent to developed land will not be able to migrate landward resulting in loss of beach and dune habitat.
	MEDIUM		1. Increasing Storminess - Intense storms may result in significant damage or loss of coastal/maritime forest community of the barrier islands.	1. Increasing Storminess - Erosion of beaches and dunes will leave back-bay wetland habitat vulnerable to inundation from winter storms and high tides.
			2. Warmer Summers - Dune or beach species that cannot tolerate warmer summers may die or migrate. Biota at the southern limit of their range may disappear from beach/dune ecosystem.	
			3. Warmer Summers - Warmer summers may result in the promotion of invasive species and disease.	
	LOW		1. Increasing Drought - Increased drought may result in the potential degradation or loss of habitat to plant and animal species including migratory birds.	
			2. Increasing Drought - Increased drought may result in the potential degradation or loss of dune vegetation as well as adverse impact to maritime forest community on barrier islands. (Dunes are a droughty habitat, so increasing drought unlikely to have a major impact on dune vegetation.)	
			3. Warmer Summers - Essential food sources may die-off or disappear affecting beach and dune ecology.	
			4. Warmer Winters - Species that once migrated through may stop and stay through winter.	

OCEAN BEACH AND DUNE ECOSYSTEMS 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Intense storms and associated storm surge will increase the likelihood of new temporary or permanent inlet development 2. Increasing Storminess - Coastal overwash or barrier island breaching may lead to migrating beach sand and dunes.	1. Increasing Storminess - An increase in intense storms (i.e.nor'easters and hurricanes) may result in significant beach erosion and the reduction, or loss of coastal dunes with associated habitat loss of plants and wildlife. Dune loss likely to lead to increased sand flats. 2. Increasing Storminess - Erosion of beaches and dunes will leave back-bay wetland habitat vulnerable to inundation from winter storms and high tides 3. Increased Storminess - High winds and associated storm surge may result in the breaching or over wash of barrier islands. 4. Increasing Storminess - Storm surge and the resulting beach and dune erosion will result in lowering of beach elevation. 5. Sea Level Rise - Barrier beaches will be more susceptible to erosion and overwash, and in some cases, breaching and inlet formation 6. Sea Level Rise - Beaches and dunes that currently lie adjacent to developed land will not be able to migrate landward resulting in loss of beach and dune habitat. 7. Sea Level Rise - Beaches and barrier islands may be degraded or lost by increased flooding frequency associated with sea level rise. 8. Increased Storminess - Hard structures along the shoreline may increase cutting off sediment supply to barrier beaches and preventing overwash.
	MEDIUM		1. Increasing Storminess - Intense storms may result in significant damage or loss of coastal/maritime forest community of the barrier islands. 2. Warmer Summers - Dune or beach species that cannot tolerate warmer summers may die or migrate. Biota at the southern limit of their range may disappear from beach/dune ecosystem. 3. Warmer Summers - Essential food sources may die-off or disappear affecting beach and dune ecology. 4. Warmer Summers - Warmer summers may result in the promotion of invasive species and disease. 5. Warmer Winters - Species that once migrated through may stop and stay through winter.	
	LOW		1. Increasing Drought - Increased drought may result in the potential degradation or loss of habitat to plant and animal species including migratory birds. 2. Increasing Drought - Increased drought may result in the potential degradation or loss of dune vegetation as well as adverse impact to maritime forest community on barrier islands. (Dunes are a droughty habitat, so increasing drought unlikely to have a major impact on dune vegetation.)	

COASTAL WETLANDS 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Sea Level Rise - An increase in the rate of sea level rise will result in significant loss of coastal salt marsh habitat. 2. Increasing Storminess - Coastal overwash or barrier island breaching may result in a smothering of back-bay marshes by migrating beach sand and dunes. However, overwash is not negative and can lead to roll over of marshes. 3. Increasing storminess - increased frequency and intensity of coastal storms will impair coastal wetlands through wind, wave and surge effects. 4. Increasing Storminess - Increased shoreline erosion may lead to loss of coastal wetlands and marshes. 5. Sea Level Rise - An increase in sea-level will lead to greater susceptibility to storm surge. Shoreline erosion is likely to lead to loss of wetlands and salt marshes. 6. Sea Level Rise - As sea level rises, salinity migration farther up the estuary and tidal tributaries is likely to result in an upstream migration of brackish and fresh water wetlands and will impact adjacent soils. 7. Sea Level Rise - As sea level rises, salt marshes will migrate inland depending on physical landforms and landscapes. The ability to migrate may be affected in location where man-made structures, e.g., bulkheads, interfere with migration. (Should be informed by recent SLAMM analysis) 8. Sea Level Rise - In low energy shores with ample sediment supply, intertidal flats may become vegetated as low marsh encroaches seaward. This may increase low marsh at the expense of tidal flats. 9. Sea Level Rise - In some cases where tidal range increases with increased rates of sea-level rise, there may be an overall increase in the acreage of tidal flats but only where there is a sediment supply. 10. Warmer Water - Warmer water is likely to increase incidence of marine and estuarine disease. 11. Warmer Winters - Warmer winter temperatures may promote the northern migration of southern species. 12. Warmer Summers - Warmer summers are likely to promote the northern migration of southern invasive species. 13. Warmer Water - Depending on the termperature increase, warmer waters may alter species composition of the coastal wetlands due to exceedance of temperature tolerance. 14. Warmer Winters - Warmer winters may facilitate the survival of invasive species, epizootics and disease.	1. Sea Level Rise - Bulkheads, sea walls and revetments are likely to become more widespread. 2. Increased Storminess - Increased wave energy causing loss of ribbed mussel beds in marshes. 3. Sea Level Rise - If the rate of sea level rise increases dramatically, salt marshes may not be able to match the change in vertical elevation and will be lost.
	MEDIUM	1. Warmer Summers - Warmer summers leading to increased temperatures are likely to lead to reduced high marsh moisture and increased salinity because of greater evapotranspiration. 2. Warmer Winters - The alteration in the amplitude and timing of the annual spring freshets may adversely impact freshwater and brackish water wetlands.	1. Warmer Summers - Wetland species that can't tolerate warmer summers may die/migrate; biota at the southern limit of their range may disappear from ecosystems. Need to distinguish plants and animals here as this impact may not apply to plants.	
	LOW	1. Ocean Acidification - Changes in surface water pH may affect the viability of certain marsh species. 2. Increased Drought - A decrease in precipitation events may adversely impact coastal wetlands by reducing the supply of sediment necessary to sustain marsh elevation. 3. Increased Drought - A significant decrease in precipitation is likely to result in decreased marsh productivity. 4. Increased Drought - A decrease in precipitation may lead to the oxidation and formation of highly saline marsh soils. Hypersaline conditions on the high marsh will decrease marsh production and habitat support. Additionally, increased drought will cause more decomposition of marsh peat and increased pH. 5. Increasing Storminess - Increased nutrient loads from both surface and groundwater flow and flooding may increase the vulnerability of tidal marshes. 6. Warmer Waters - Warmer waters may alter the salinity distribution in marshes which may, in turn, alter the species composition due to exceedance of salinity tolerance.		

COASTAL WETLANDS 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Sea Level Rise - An increase in the rate of sea level rise will result in significant loss of coastal salt marsh habitat.	1. Sea Level Rise - Bulkheads, sea walls and revetments are likely to become more widespread.
			2. Increasing Storminess - Coastal overwash or barrier island breaching may result in a smothering of back-bay marshes by migrating beach sand and dunes. However, overwash is not negative and can lead to roll over of marshes.	2. Increased Storminess - Increased wave energy causing loss of ribbed mussel beds in marshes.
			3. Increasing storminess - Increased frequency and intensity of coastal storms will impair coastal wetlands through wind, wave and surge effects.	3. Sea Level Rise - If the rate of sea level rise increases dramatically, salt marshes may not be able to match the change in vertical elevation and will be lost.
			4. Increasing Storminess - Increased shoreline erosion may lead to loss of coastal wetlands and marshes.	
			5. Sea Level Rise - An increase in sea-level will lead to greater susceptibility to storm surge. Shoreline erosion is likely to lead to loss of wetlands and salt marshes.	
			6. Sea Level Rise - As sea level rises, salinity migration farther up the estuary and tidal tributaries is likely to result in an upstream migration of brackish and fresh water wetlands and will impact adjacent soils.	
			7. Sea Level Rise - As sea level rises, salt marshes will migrate inland depending on physical landforms and landscapes. The ability to migrate may be affected in locations where man-made structures, e.g., bulkheads, interfere with migration.	
			8. Sea Level Rise - In low energy shores with ample sediment supply, intertidal flats may become vegetated as low marsh encroaches seaward. This may increase low marsh at the expense of tidal flats.	
			9. Sea Level Rise - In some cases where tidal range increases with increased rates of sea-level rise, there may be an overall increase in the acreage of tidal flats but only where there	
			10. Warmer Water - Warmer water is likely to increase incidence of marine and estuarine disease.	
			11. Warmer Winters - Warmer winter temperatures may promote the northern migration of southern species. (This is already happening: Kelp being replaced by Sargassum)	
			12. Warmer Summers - Warmer summers are likely to promote the northern migration of southern invasive species.	
			13. Warmer Summers - Wetland species that can't tolerate warmer summers may die/migrate; biota at the southern limit of their range may disappear from ecosystems. Need to distinguish plants and animals here	
			14. Warmer Water - Depending on the temperature increase, warmer waters may alter species composition of the coastal wetlands due to exceedance of temperature tolerance.	
			15. Warmer Winters - Warmer winters may facilitate the survival of invasive species, epizootics, and disease.	
	MEDIUM	1. Warmer Summers - Warmer summers leading to increased temperatures are likely to lead to reduced high marsh moisture and increased salinity because of greater evapotranspiration.		
		2. Warmer Winters - The alteration in the amplitude and timing of the annual spring freshets may adversely impact freshwater and brackish water wetlands.		
	LOW	1. Ocean Acidification - Changes in surface water pH may affect the viability of certain marsh species.		
		2. Increased Drought - A decrease in precipitation events may adversely impact coastal wetlands by reducing the supply of sediment necessary to sustain marsh elevation.		
		3. Increased Drought - A significant decrease in precipitation is likely to result in decreased marsh productivity.		
		4. Increased Drought - A decrease in precipitation may lead to the oxidation and formation of highly saline marsh soils. Hypersaline conditions on the high marsh will decrease marsh production and habitat support. Additionally, increased drought will cause more decomposition of marsh peat and increased pH.		
		5. Increasing Storminess - Increased nutrient loads from both surface and groundwater flow and flooding may increase the vulnerability of tidal marshes.		
		6. Warmer Waters - Warmer waters may alter the salinity distribution in marshes which may, in turn, alter the species composition due to exceedance of salinity tolerance.		

SUBMERGED AQUATIC VEGETATION 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Greater soil erosion will increase turbidity and decrease water clarity. Turbidity would be an issues iin the spring when plants are just starting to grow. May not be as important later in the growing season or when plants are dormant. Increased storminess may also lead to increased sedimentation of eelgrass beds. (SAV habitats rely on eroding shorelines and other sources of sediment to maintain themselves in the face of sea level rise.)	1. Warmer Summers - Warmer summers may lead to warmer coastal water; possibly exacerbating time during which temperature tolerance is exceeded.
			2. Sea Level Rise - Additionally, hardened shorelines exacerbate the effects of sea level rise on seagrass beds by preventing landward migration and causing scour and decreased availability of suitable habitat.	2. Warmer Summers - Warmer summers may result in the latitudinal expansion of invasive species and disease.
			3. Sea Level Rise - Increased overwash and breaching of barrier island could negatively impact local SAV populations (e.g., eelgrass) by smothering. As sea level rises, however, the inundation of shorelines could create new SAV habitat.	3. Warmer Water - Warmer water is likely to increase incidence of marine and estuarine epizootics and disease (Eelgrass wasting disease).
			4. Sea Level Rise - Shifts in salinity regime will affect the distribution of SAV (other than eelgrass). Brackish and freshwater SAV would be impacted.	4. Warmer Winters - Warmer winters may lead to latitudinal expansion of invasive SAV spp.
			5. Warmer Summers - Warmer summers may lead to latitudinal migration of SAV spp.	
			6. Sea Level Rise - Sea level rise likely to impact human waste water systems/septic systems, which could then cause increased pollution impacting SAV's. Increased pollution could also fuel HAB's which could then shade and smother SAV's.	
	MEDIUM	1. Increasing Storminess - Stronger storms will cause more intense flooding and runoff potentially increasing nutrient loads (nitrogen, phosphorus) resulting in eutrophication.	1. Warmer Winters - Warmer winters may result in asynchrony of vegetative growth and bird migrations.	1. Increasing Storminess - Dependng on depth of bed, increased wave action may severely damage SAV beds.
			2. Sea Level Rise - Sea level rise may pose significant threats to SAV habitat due to potential implications of increased water depth, reduction in light penetration and changes in soil type.	2. Warmer Water - Certain species of SAV are sensitive to large fluctuations in water temperature. Warmer water may exceed tolerance of some SAV species resulting in the loss of SAV habitat.
	LOW	1. Ocean Acidification - Increased acidification may exceed the pH tolerance of some SAV species.	1. Increasing Drought - Potential decrease in freshwater runoff could result in salinity changes that could affect the propogation and growth of SAV.	

SUBMERGED AQUATIC VEGETATION 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Greater soil erosion will increase turbidity and decrease water clarity. Turbidity would be an issues iin the spring when plants are just starting to grow. May not be as important later in the growing season or when plants are dormant. Increased storminess may also lead to increased sedimentation of eelgrass beds. (SAV habitats rely on eroding shorelines and other sources of sediment to maintain themselves in the face of sea level rise.)	1. Increasing Storminess - Dependng on depth of bed, increased wave action may severely damage SAV beds.
			2. Sea Level Rise - Additionally, hardened shorelines exacerbate the effects of sea level rise on seagrass beds by preventing landward migration and causing scour and decreased availability of suitable habitat.	2. Sea Level Rise - Shifts in salinity regime will affect the distribution of SAV, other than eelgrass. Brackish and freshwater SAV would be impacted.
			3. Sea Level Rise - Increased overwash and breaching of barrier island could negatively impact local SAV populations (e.g., eelgrass) by smothering. As sea level rises, however, the inundation of shorelines could create new SAV habitat.	3. Warmer Summers - Warmer summers may result in the latitudinal expansion of invasive species and disease.
			4. Warmer Summers - Warmer summers may lead to latitudinal migration of SAV spp.	4. Warmer Summers - Warmer summers may lead to warmer coastal water; possibly exacerbating time during which temperature tolerance is exceeded.
			5. Sea Level Rise - Sea level rise likely to impact human waste water systems/septic systems, which could then cause increased pollution impacting SAV's. Increased pollution could also fuel HAB's which could then shade and smother SAV's.	5. Warmer Water - Warmer water is likely to increase the incidence of marine and estuarine epizootics and disease (Eelgrass wasting disease).
			6. Warmer Winters - Warmer winters may result in asynchrony of vegetative growth and bird migrations.	6. Warmer Winters - Warmer winters may lead to latitudinal expansion of invasive SAV spp.
	MEDIUM		1. Increasing Drought - Potential decrease in freshwater runoff could result in salinity changes that could affect the propogation and growth of SAV.	1. Warmer Water - Certain species of SAV are sensitive to large flucuations in water temperature. Warmer water may exceed tolerance of some SAV species resulting in the loss of SAV habitat.
			2. Increasing Storminess - Stronger storms will cause more intense flooding and runoff potentially increasing nutrient loads (nitrogen, phosphorus) resulting in eutrophication.	
			3. Sea Level Rise - Sea level rise may pose significant threats to SAV habitat due to potential implications of increased water depth, reduction in light penetration and changes in soil type.	
	LOW	1. Ocean Acidification - Increased acidification may exceed the pH tolerance of some SAV species.		

SHELLFISH REEFS 2050

LIKELIHOOD OF OCCURRENCE	CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
HIGH		1. Warmer Water - Warmer water is likely to lead to an expansion of epizootics (MSX, Dermo) and invasive species.	1. Increased Storminess - More rainfall will lead to increase freshwater input impacting shellfish beds. (Dermo may increase)
			2. Warming summers/winter/water - all interrelated, will mediate species interactions; potential for changes in predation; will affect availability of natural resources and how we manage them.
			3. Increasing Drought - Increase in water temperature and decreased flow during periods of drought may lead to harmful algal blooms some of which may be deleterious to oysters (e.g., cyanobacteria).
			4. Increased storminess - linked to ecologically important shifts in species due to physical and physiological stresses (e.g., more sediment in water); time of year of storms will matter with species life histories
			5. Increased storminess - Increased storminess leading to loss of ribbed mussel beds in tidal wetlands.
MEDIUM	1. Sea Level Rise - Changes in the salinity regime as well as other habitat characteristics are likely to change the distribution of shellfish habitat.	1. Increasing Drought - increase in water temperature leading to an increase in areas of hypoxia.	
	2. Warmer Water - Temperature changes could include changes in predator populations and natural food assemblages which could influence shellfish quality and survival.	2. Increasing Storminess - Greater soil erosion may increase sediment deposition in estuaries, with potential for smothering nascent reefs or shell substrate required for setting.	
		3. Increasing Storminess - Habitat conditions for shellfish could be impacted by strong storms and increased frequency of rain events which can result in increased sedimentation.	
		4. Increasing Storminess - Increased freshwater events can lead to decreases in salinity which could affect the distribution of shellfish.	
		5. Ocean Acidification - Long Term shellfish sustainability is an open question.	
		6. Ocean Acidification - Oysters and other mollusks may be adversely affected during development stages which construct calcareous shells through pH-sensitive calcification processes.	
		7. Sea Level Rise - An increase in salinity would promote the upstream migration of shellfish epizootics and disease.	
		8. Sea Level Rise - Sea level rise could reduce the availability of intertidal habitat thereby limiting the available habitat for some species such as oysters and blue mussels.	
		9. Sea Level Rise - An increase in salinity may affect the growth and propogation of oysters. (This may be a positive effect)	
		10. Warmer Summers - Warm summers will lead to warmer waters that may promote invasive species, epizootics (Dermo, MSX), or disease.	
		11. Warmer Water - Increased water temperature could affect reproduction and growth of oysters and other shellfish.	
		12. Warmer Water - Increased water temperatures may affect the spawning of oysters which in turn may result in asynchrony between larval development and food supply.	
		13. Warmer Water - Warmer water is likel to increase incidence of marine and estuarine disease.	
		14. Increasing Storminess - Increased storminess is exacerbating exposure to pathogens from increased turbidity, runoff and partially treated or untreated sewage overflows from storm events.	
LOW	1. Warmer Water - Increased water temperature may result in dissolved oxygen levels sufficiently low to stress oysters and other shellfish.	1. Increasing Drought - Increase in drought could reduce freshwater inflow and affect the salinity regime which may affect the distribution of shellfish reefs.	
	2. Warmer Winters - Warmer winters may affect the reproduction and growth of oysters and other organisms in the reef.	2. Warmer Summers - Warm summers will lead to warmer waters that may result in temperature stress to oysters and other shellfish.	
		3. Warmer Winters - Invasive species, epizootics, and disease previously killed due to cold water may survive.	

SHELLFISH REEFS 2100

LIKELIHOOD OF OCCURRENCE	CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
HIGH		1. Warmer Water - Warmer water is likely to lead to an expansion of epizootics (MSX, Dermo) and invasive species.	1. Increased Storminess - More rainfall will lead to increased freshwater input impacting shellfish beds. (Dermo may increase)
HIGH			2. Warming summers/winter/water - all interrelated, will mediate species interactions; potential for changes in predation; will affect availability of natural resources and how we manage them.
HIGH			3. Increasing Drought - Increase in water temperature and decreased flow during periods of drought may lead to harmful algal blooms sme of which may be deleterious to oysters (e.g., cyanobacteria).
HIGH			4. Increased storminess - linked to ecologically important shifts in species due to physical and physiological stresses (e.g., more sediment in water); time of year of storms will matter with species life histories
HIGH			5. Increased storminess - Increased storminess leading to loss of ribbed mussel beds in tidal wetlands.
HIGH			6. Increasing Storminess - Increased storminess is exacerbating exposure to pathogens from increased turbidity runoff and partially treated or untreated sewage overflows from storm events
MEDIUM	1. Sea Level Rise - Changes in the salinity regime as well as other habitat characteristics are likely to change the distribution of shellfish habitat.	1. Increasing Drought - increase in water temperature leading to an increase in areas of hypoxia.	
MEDIUM	2. Warmer Water - Temperature changes could include changes in predator populations and natural food assemblages which could influence shellfish quality and survival.	2. Increasing Storminess - Greater soil erosion may increase sediment deposition in estuaries, with potential for smothering nascent reefs or shell substrate required for setting.	
MEDIUM		3. Increasing Storminess - Habitat conditions for shellfish could be impacted by strong storms and increased frequency of rain events which can result in increased sedimentation.	
MEDIUM		4. Increasing Storminess - Increased freshwater events can lead to decreases in salinity which could affect the distribution of shellfish.	
MEDIUM		5. Ocean Acidification - Long Term shellfish sustainability may be an open question.	
MEDIUM		6. Ocean Acidification - Oysters and other mollusks may be adversely affected during development stages which construct calcareous shells through pH-sensitive calcification processes.	
MEDIUM		7. Sea Level Rise - An increase in salinity would promote the upstream migration of shellfish epizootics and disease.	
MEDIUM		8. Sea Level Rise - Sea level rise could reduce the availability of intertidal habitat thereby limiting the available habitat for some species such as oysters and blue mussels.	
MEDIUM		9. Sea Level Rise - An increase in salinity may affect the growth and propogation of oysters. (This may be a positive effect)	
MEDIUM		10. Warmer Summers - Warm summers will lead to warmer waters that may promote invasive species, epizootics (Dermo, MSX), or disease	
MEDIUM		11. Warmer Water - Increased water temperature could affect reproduction and growth of oysters and other shellfish.	
MEDIUM		12. Warmer Water - Increased water temperatures may affect the spawning of oysters which in turn may result in asynchrony between larval development and food supply.	
MEDIUM		13. Warmer Water - Warmer water is likel to increase incidence of marine and estuarine disease.	
LOW	1. Warmer Water - Increased water temperature may result in dissolved oxygen levels sufficiently low to stress oysters and other shellfish.	1. Increasing Drought - Increase in drought could reduce freshwater inflow and affect the salinity regime which may affect the distribution of shellfish reefs.	
LOW	2. Warmer Winters - Warmer winters may affect the reproduction and growth of oysters and other organisms in the reef.	2. Warmer Summers - Warm summers will lead to warmer waters that may result in temperature stress to oysters and other shellfish.	
LOW		3. Warmer Winters - Invasive species, epizootics, and disease previously killed due to cold water may survive.	

ROCK REEFS AND SHORELINES 2050

LIKELIHOOD OF OCCURRENCE	CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
HIGH		1. Sea Level Rise - Littoral zone biota are likely to respond to changing tide heights by shifting vertically where shoreline topography allows it. 2. Sea Level Rise - Loss or compression of intertidal habitat will alter the vertical zonation of the species which utilize this habitat. 3. Sea Level Rise - Rocky shorelines, especially intertidal and shallow water rocky habitat could become totally or partially inundated. Intertidal rock habitat may be lost or compressed and no longer available as intertidal habitat. 4. Warmer Water - Warmer coastal waters may result in a northward shift in rocky intertidal communities of plants and animals at their southern limit. 5. Warmer Water - Warmer waters may result in the colonization of rocky reefs and shorelines by southern species.	1. Warmer waters - Warming water is the principle driver for shifts in rocky reef communities of organisms; Food web and habitat dynamics likely to change. 2. Warmer waters - Warming waters affects large kelp distribution and density; kelp forest habitat will be less dense 3. Warmer Water - Species at the edge of range will likely disappear from LIS. (2 subtidal fish species listed as of CT Special Concern at southern edge of distribution and likely to disappear). Within LIS, there is documented reduction in fish species with cold water centered distribution and an increase in warm water centered distribution fish species. 4. Warmer water -Species interactions based on dominance will shift and will affect management; e.g., winter flounder
MEDIUM	1. Sea Level Rise - Shallow intertidal pools may become entirely submerged and intertidal habitat lost. 2. Warmer Winters - The ecological benefit of ice scour on rocky shorelines would be lost or reduced.	1. Increasing Storminess - An increase in strength and frequency of wave action may adversely affect associated invertebrates upon which multiple wildlife species forage. 2. Increasing Storminess - An increase in strength and frequency of wave action may adversely affect seaweed growing in rocky intertidal zones. 3. Increasing Storminess - In combination with Sea Level Rise, increased frequency and intensity of wave action, will result in erosion of sedimentary rock bluffs. 4. Ocean Acidification - Lowering of pH in adjacent coastal waters would affect the developmental calcification of shells by larval molluscs that might inhabit rocky shorelines i.e., barnacles, mussels, oysters.	
LOW	1. Increasing Drought - Reduced precipitation and increased air temperature may result in stress to upper strata biota. 2. Sea Level Rise - Inundation periods of rock platforms may change altering habitat use. 3. Warmer Summers - Increased air temperatures may affect the survivability of some intertidal species.		

ROCK REEFS AND SHORELINES 2100

LIKELIHOOD OF OCCURRENCE		CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Sea Level Rise - Littoral zone biota are likely to respond to changing tide heights by shifting vertically where shoreline topography allows it. 2. Sea Level Rise - Loss or compression of intertidal habitat will alter the vertical zonation of the species which utilize this habitat. 3. Sea Level Rise - Rocky shorelines, especially intertidal and shallow water rocky habitat could become totally or partially inundated. Intertidal rock habitat may be lost or compressed and no longer available as intertidal habitat. 4. Warmer Water - Warmer coastal waters may result in a northward shift in rocky intertidal communities of plants and animals at their southern limit. 5. Warmer Water - Warmer waters may result in the colonization of rocky reefs and shorelines by southern species.	1. Warmer waters - Warming water is the principle driver for shifts in rocky reef communities of organisms; Food web and habitat dynamics likely to change. 2. Warmer waters - Warming waters affects large kelp distribution and density; kelp forest habitat will be less dense 3. Warmer Water - Species at the edge of range will likely disappear from LIS. (2 subtidal fish species listed as of CT Special Concern at southern edge of distribution and likely to disappear) 4. Warmer water -Species interactions based on dominance will shift and will affect management; e.g., winter flounder
	MEDIUM	1. Sea Level Rise - Shallow intertidal pool may become entirely submerged and intertidal habitat lost. 2. Warmer Winters - The ecological benefit of ice scour on rocky shorelines would be lost or reduced.	1. Increasing Storminess - An increase in strength and frequency of wave action may adversely affect associated invertebrates upon which multiple wildlife species forage. 2. Increasing Storminess - An increase in strength and frequency of wave action may adversely affect seaweed growing in rocky intertidal zones. 3. Increasing Storminess - In combination with Sea Level Rise, increased frequency and intensity of wave action, will result in erosion of sedimentary rock bluffs. 4. Ocean Acidification - Lowering of pH in adjacent coastal waters would affect the developmental calcification of shells by larval molluscs that might inhabit rocky shorelines i.e., barnacles, mussels, oysters.	
	LOW	1. Increasing Drought - Reduced precipitation and increased air temperature may result in stress to upper strata biota. 2. Sea Level Rise - Inundation periods of rock platforms may change altering habitat use. 3. Warmer Summers - Increased air temperatures may affect the survivability of some intertidal species.		

SHALLOW BAY HABITAT/BAY ISLANDS 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Storminess - Increasing overwash and breaching of new inlets could potentially change the physical and environmental characteristics of the bays such as, flushing rates, salinity, light penetration and nutrient dynamics. 2. Increasting Storminess - Increased storminess will result in increased erosion of shallow bay shorelines; increased storminess will also bring more terrestrial materials iinto bays including nutrients, trash, etc. 3. Sea Level Rise - Some bay islands may become completely or almost completely submerged. 4. Sea Level Rise - Depth of waters in shallow bay habitat may be expected to increase as the sea rises potentially affecting coastal bay wetlands and shorelines. 5. Sea Level Rise - Hardening of shorelines with bulkheads, sea walls and revetments may become more widespread resulting in the loss of natural shoreline habitats and decreased water quality. 6. Sea Level Rise - Sea level rise in conjunction with increased tidal amplitude will result in increased erosion of shallow bay shorelines. 7. Sea Level Rise - Sea level rise may change the salinity regime of the inland bays thereby affecting the distribution of salinity-sensitive flora and fauna. 8. Warmer Summers - Increased water temperatures may increase areas of hypoxia in shallow embayments. This, coupled with reduced winds and storms in summer, will exacerbate hypoxia even more. 9. Warmer Summers - Finfish species at the southern end of their distribution may migrate northward. 10. Warmer Water - Desired fish may no longer be present including forage fish for other species. 11. Warmer Water - Warmer water is likely to lead to an expansion of invasive species, epizootics, and disease. 12. Warmer Water - Warmer water is likely to promote the migration of current fish species northward and immigration of fish from southern regions.	
	MEDIUM	1. Warmer water will decrease oxygen solubility possibly resulting in a decrease in oxygen concentrations in bay waters.	1. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease freshwater flow and affect the salinity distribution in the bays. 2. Increasing Drought - increased drought may result in waters sufficiently warm to promote areas of hypoxia. [This impact is questioned, see report] 3. Increasing Drought - Increased drought may result in waters sufficiently warm to promote harmful algal blooms. 4. Increasing Storminess- Increased runoff from the surrounding watershed may lead to increased loading of nitrogen and phosphorous to inland bays resulting in eutrophication. 5. Increasing Storminess - Increased storminess may result in increased turbidity and decrease water clarity. 6. Warmer Water - Warmer water may result in loss of SAV habitat. 7. Warmer Winters - Finfish species that used to migrate may stay all winter.	1. Ocean Acidification - The effect of embayment acidification on calcifying plankton may lead to cascading effects in the food chain. 2. Ocean Acidification - Fish and invertebrates may be adversely affected during developmental stages. 3. Warmer Winters - Invasive species, epizootics, and disease may survive winters that used to kill them. 4. Sea Level Rise - Sea level rise may result in drowning of bay wetlands.
	LOW	1. Warmer Water - Warmer water is likely to lead to greater likelihood of stratifiction. 2. Warmer Winters - Increased foraging of plants and animals.		

SHALLOW BAY HABITAT/BAY ISLANDS 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Sea Level Rise - Some bay islands may become completely or almost completely submerged. 2. Sea Level Rise - Depth of waters in shallow bay habitat may be expected to increase as the sea rises potentially affecting coastal bay wetlands and shorelines. 3. Sea Level Rise - Sea level rise may change the salinity regime of the inland bays thereby affecting the distribution of salinity-sensitive flora and fauna. 4. Warmer Summers - Finfish species at the southern end of their distribution may migrate northward. 5. Warmer Water - Desired fish may no longer be present including forage fish for other species. 6. Warmer Water - Warmer water is likely to lead to an expansion of invasive species, epizootics, and disease. 7. Warmer Winters - Finfish species that used to migrate may stay all winter.	1. Increasing Drought - Increased drought may result in waters sufficiently warm to promote areas of hypoxia. [This impact is questioned, see report] 2. Increased Storminess - Increasing overwash and breaching of new inlets could potentially change the physical and environmental characteristics of the bays such as, flushing rates, salinity, light penetration and nutrient dynamics. 3. Increasing Storminess - Increased storminess will result in increased erosion of shallow bay shorelines; increased storminess will also bring more terrestrial materials iinto bays including nutrients, trash, etc. 4. Sea Level Rise - Hardening of shorelines with bulkheads, sea walls, and revetments may become more widespread resulting in the loss of natural shoreline habitats and decreased water quality. 5. Sea Level Rise - Sea level rise in conjunction with increased tidal amplitude will result in increased erosion of shallow bay shorelines. 6. Warmer Summers - Increased water temperature may increase areas of hypoxia in shallow embayments. This, coupled with reduced winds and storms in summer, will exacerbate hypoxia even more. 7. Warmer Water - Warmer water is likely to promote the migration of current fish species northward and immigration of fish from southern regions. 8. Warmer Winters - Invasive species, epizootics, and disease may survive winters that used to kill them. 9. Sea Level Rise - Sea level rise may result in drowning of bay wetlands.
	MEDIUM	1. Warmer Water - Warmer water is likely to lead to greater likelihood of stratification. 2. Warmer water will decrease oxygen solubility possibly resulting in a decrease in oxygen concentrations in bay waters.	1. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease freshwater flow and affect the salinity distribution in the bays. 2. Increasing Drought - increased drought may result in waters sufficiently warm to promote harmful algal blooms. 3. Increasing Storminess- Increased runoff from the surrounding watershed may lead to increased loading of nitrogen and phosphorous to inland bays resulting in eutrophication. 4. Increasing Storminess - Increased storminess may result in increased turbidity and decrease water clarity.	1. Ocean Acidification - The effect of embayment acidification on calcifying plankton may lead to cascading effects in the food chain. 2. Ocean Acidification - Fish and invertebrates may be adversely affected during developmental stages. 3. Warmer Water - Warmer water may result in the loss of SAV habitat.
	LOW	1. Warmer Winters - Increased foraging of plants and animals.		

TERRESTRIAL UPLANDS 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Warmer Summers - Warmer summers (warmer air temperatures) will lead to increased soil temperatures and will impact soil health. Warmer soils will lead to increased decomposition of soils changing soil types and increasing carbon loss. There will also be increased mobility of nutrients due to increased decomposition. 2. Sea Level Rise - As sea level rises, there will be an encroachment on and flooding of adjacent upland forests and other vegetation types. Soils will also be impacted. 3. Warmer Summers - Species that won't tolerate warmer summers may migrate. Floral and faunal species at the southern limit of their range may disappear. 4. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease recharge and infiltration for groundwater. 5. Warmer Summers - Warmer summers (warmer air temperatures) will lead to increased soil temperatures and will impact soil health. Warmer soils will lead to increased decomposition of soils changing soil types and increasing carbon loss. There will also be increased mobility of nutrients due to increased decomposition.	1. Increasing Storminess - Combined with sea level rise, increased flooding will impact adjacent upland habitat.
	MEDIUM		1. Increasing Storminess - Severe storms may result in significant tree fall or damage. JV - need to define increasing storminess, is it severe storms? 2. Increasing Storminess - The number of storms reaching an intensity that causes problems may increase. JV - too general, applies to everything 3. Warmer Summers - Essential food sources may disappear affecting the food web. 4. Warmer Summers - Some invasive species and disease are expected to expand into the Northeast forests. 5. Warmer Summers - Species may be weakened by heat and become out-competed though ticks and other blood sucking insects are currently having a larger impact (e.g., moose) 6. Warmer Summers - Species may need to consume more water. Impact will depend on expectation for freshwater supply. If drought, impaccts could be exacerbated. 7. Warmer Winters - A longer growing season may lead to an extra reproductive cycle. 8. Warmer Winters - Food supplies and bird migrations may be mistimed. 9. Warmer Winters - Species that used to migrate away may stay all winter. (This is already occurring in LIS region.) 10. Warmer Winters - Invasive species may move into places that used to be too cold. 11. Warmer Summers - Warmer air temperatures may cause an increase in invasive species due to change in soils. 12. Increasing Drought - Stress from excess heat and decreased water may result in increased susceptibility to disease. 13. Increasing Drought - Stress from excess heat and decreased water may result in vegetative die-off.	
	LOW	1. Warmer Summers - Warmer summers will lead to higher humidity which may impact certain species.	1. Increasing Storminess - Increased storm damage will promote and exacerbate the effect of disease.	

TERRESTRIAL UPLANDS 2100		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Warmer Summers - Species that won't tolerate warmer summers may migrate. Floral and faunal species at the southern limit of their range may disappear.	1. Sea Level Rise - As sea level rises, there will be an encroachment on and flooding of adjacent upland forests and other vegetation types. Soils will also be impacted.
			2. Warmer Summers - Species that won't tolerate warmer summers may migrate. Floral and faunal species at the southern limit of their range may disappear.	2. Increasing Storminess - Combined with sea level rise, increased flooding will impact adjacent upland habitat.
			3. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease recharge and infiltration for groundwater.	3. Warmer Summers - Warmer summers (warmer air temperatures) will lead to increased soil temperatures and will impact soil health. Warmer soils will lead to increased decomposition of soils changing soil types and increasing carbon loss. There will also be increased mobility of nutrients due to increased decomposition.
	MEDIUM		1. Increasing Storminess - Severe storms may result in significant tree fall or damage.	
			2. Increasing Storminess - The number of storms reaching an intensity that causes problems may increase.	
			3. Warmer Summers - Essential food sources may disappear affecting the food web.	
			4. Warmer Summers - Some invasive species and disease are expected to expand into the Northeast forests.	
			5. Warmer Summers - Species may be weakened by heat and become out-competed though ticks and other blood sucking insects are currently having a larger impact (e.g., moose)	
			6. Warmer Summers - Species may need to consume more water. Impact will depend on expectation for freshwater supply. If drought, impaccts could be exacerbated.	
			7. Warmer Winters - A longer growing season may lead to an extra reproductive cycle.	
			8. Warmer Winters - Food supplies and bird migration may be mistimed.	
			9. Warmer Winters - Species that used to migrate away may stay all winter. (This is already occurring in LIS region.)	
			10. Warmer Winters - Invasive species may move into places that used to be too cold.	
			11. Warmer Summers - Warmer air temperatures may cause an increase in invasive species due to change in soils.	
			12. Increasing Drought - Stress from excess heat and decreased water may result in increased susceptibiity to disease.	
			13. Increasing Drought - Stress from excess heat and decreased water may result in vegetative die-off.	
	LOW	1. Warmer Summers - Warmer summers will lead to higher humidity which may impact certain species.	1. Increasing Storminess - Increased storm damage will promote and exacerbate the effect of disease.	

FLOODPLAIN_RIPARIAN 2050		CONSEQUENCE OF IMPACT		
		LOW	MEDIUM	HIGH
LIKELIHOOD OF OCCURRENCE	HIGH		1. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease base flows in streams. 2. Increasing Storminess - Increased frequency and intensity of flooding events will result in erosion of floodplains and riparian habitat. This has the potential to adversely impact only breeding sites for Puritan tiger beetle (on CT river). If reproduction cannot happen for two consecutive years the population will not persist. 3. Sea Level Rise - Saline water may move farther upstream and the biological assemblages of floodplain and riparian habitat may change. 4. Warmer Winters - Less snow and more rain may change the runoff/infiltration balance; base flow in streams may change. 5. Sea Level Rise - Bulkheads, sea walls and revetments may become more widespread along floodplains and riparian areas resulting in loss of habitat. 6. Increased Storminess - Floodplain soils will be severely damaged by increased storminess. 7. Increased Storminess - Increased storminess will increase the flashiness of streams. 8. Sea Level Rise - Saline water may mover further upstream and impact freshwater soils. 9. Warmer winters - Spring freshet may change with less snow. This in turn will change the "normal" sedimentation rates of associated marshes. Marshes will get sediment only from increased storminess.	
	MEDIUM	1. Warmer Summers - As with terrestrial and aquatic habitats, warmer summers may result in a latitudinal shift in species.	1. Increasing Drought - Increased human use of groundwater during drought may reduce stream baseflow. 2. Sea Level Rise - May lead to an increase or decrease of floodplains or riparian habitat. 3. Warmer Winters - A spring runoff pulse may disappear along with the snow. 4. Warmer Winters - The absence of snowmelt may lead to a decrease of vernal pool habitat. 5. Warmer Winters - changes in the spring freshet may change sedimendation on floodplains affecting agricultural productivity.	
	LOW	1. Increasing Storminess - Increased frequency and intensity of flooding events may result in the loss of existing floodplains and the formation of new floodplains. 2. Warmer Summers - Species may need to consume more water as temperature rises. 3. Warmer Winters - Rivers may no longer freeze; a spring thaw would be obsolete. JV - spring thaw not from rivers freezing or not, much more from snow melt.		

FLOODPLAIN_RIPARIAN
2100

LIKELIHOOD OF OCCURRENCE	CONSEQUENCE OF IMPACT: LOW	CONSEQUENCE OF IMPACT: MEDIUM	CONSEQUENCE OF IMPACT: HIGH
HIGH		1. Increasing Drought - An increase in long-term and seasonal short-term drought may decrease base flow in streams. 2. Increasing Storminess - Increased frequency and intensity of flooding events will result in erosion of floodplains and riparian habitat. This has the potential to adversely impact only breeding sites for Puritan tiger beetle (on CT river). If reproduction cannot happen for two consecutive years the population will not persist. 3. Sea Level Rise - Saline water may move farther upstream and the biological assemblages of floodplain and riparian habitat may change. 4. Warmer Winters - Less snow and more rain may change the runoff/infiltration balance; base flow in streams may change. 5. Sea Level Rise - Bulkheads, sea walls and revetments may become more widespread along floodplains and riparian areas resulting in loss of habitat. 6. Increased Storminess - Increased storminess will increase the flashiness of streams. 7. Sea Level Rise - Saline water may mover further upstream and impact freshwater soils.	1. Increased Storminess - floodplain soils will be severely damaged by increased storminess. 2. Warmer winters - Spring freshet may change with less snow. This in turn will change the "normal" sedimentation rates of associated marshes. Marshes will get sediment only from increased storminess.
MEDIUM	1. Warmer Summers - As with terrestrial and aquatic habitats, warmer summers may result in a latitudinal shift in species.	1. Increasing Drought - Increased human use of groundwater during drought may reduce stream baseflow. 2. Sea Level Rise - May lead to an increase or decrease of floodplains or riparian habitat. 3. Warmer Winters - A spring runoff pulse may disappear along with the snow. 4. Warmer Winters - The absence of snowmelt may lead to a decrease of vernal pool habitat. 5. Warmer Winters - changes in the spring freshet may change sedimendation on floodplains affecting agricultural productivity.	
LOW	1. Increasing Storminess - Increased frequency and intensity of flooding events may result in the loss of existing floodplains and the formation of new floodplains. 2. Warmer Summers - Species may need to consume more water as temperature rises. 3. Warmer Winters - Rivers may no longer freeze; a spring thaw would be obsolete.		

APPENDIX E: Preliminary Descriptions/Information for the Vulnerability Assessment Stressors (PDF)

APPENDIX E. Preliminary Description and Relevant Information for Stressors in the Long Island Sound Study Vulnerability Assessment

The waters and ecosystems of Long Island Sound are being affected by numerous climate change related environmental conditions. The ecosystems of Long Island Sound provide habitat, feeding grounds and nursery areas for hundreds of species of wildlife, birds, fish and plants. In addition, these systems provide ecosystems services (benefits to humans) including flood protection, wave attenuation, recreational and tourism uses, carbon sequestration, and water filtration – to name just a few. Changes in environmental conditions such as water temperature, air temperature and sea level rise are impacting the ecosystems of Long Island Sound and the ecosystem services they provide. Seven physical parameters that are impacted by the changing climate are explored below. The Vulnerability Assessment conducted by Battelle examines these stressors for the northeast from the Gulf of Maine to Long Island Sound and there is considerable variability in these stressors within this region. Also, no definitions of the stressors are provided. Reviewers of the Vulnerability Assessment were concerned with using these generalized stressors for the Long Island Sound geographic area. For future use, more information on these stressors is provided below.

Climate Change Stressors considered in the Long Island Sound Study Vulnerability Assessment:

- Warmer summers
- Warmer winters
- Warmer water
- Increasing drought
- Increasing storminess
- Sea level rise
- Ocean acidification

AIR TEMPERATURE (warmer summers and warmer winters) –
Air temperatures in the Northeast have increased by almost 2°F between 1895 and 2011 (NCA 2014). Air temperatures for this region are projected to be more than 3.6°F (2°C) warmer on average than preindustrial revolution temperatures by 2035 (NCA 2018) depending on emission scenarios, leading to an increase in the frequency, intensity and duration of heat waves (days over 90°F). Milder winters and earlier spring conditions are already occurring, leading to more frost-free days. Winters in the northeast have warmed three times faster than summers (Thibeault and Seth 2014), with a trend of less early season snow and earlier snow melt (NCA 2018).

Within the Long Island Sound coastal area, mean monthly air temperatures have increased between 2°C and 4°C over the last 200 years; The smaller increase for late spring to summer (April to August) and the larger increases for winter months (November to February) (Coastal Ocean Analytics Report 2016). Similar changes are reported by NYDEC for all regions of New York State with average annual statewide temperature rising about 2.4 °F since 1970 and winter temperature warming greater than 4.4°F (https://www.dec.ny.gov/energy/94702.html)

WARMER WATER:
According to the National Climate Assessment (https://nca2018.globalchange.gov/chapter/18/):

> *Ocean and coastal temperatures along the Northeast Continental Shelf have warmed by 0.06°F (0.033°C) per year over the period 1982–2016 which is three times faster than the 1982–2013 global average rate of 0.018°F (0.01°C) per year. Over the last decade (2007–2016), the regional warming rate has been four times faster than the long-term trend, with temperatures rising 0.25°F (0.14°C) per year.*

Data records recently found and analyzed for eastern Long Island Sound found an increasing trend in water temperature between 1974 and 2016 with an increase of 0.45°C per decade. (Snyder et al. 2019).

Coastal Ocean Analytics (2016) Report explains and illustrates that the annual cycle for water temperature is very large in Long Island Sound as well as the occurrence of great variation in water temperature over short time scales and small geographic areas. The report does find:

> *Over the last century Long Island Sound has warmed at a rate consistent with global averages. The decade of the 1960s was anomalously cool. Warming since then has been faster than that of global trends but not inconsistent with warming that occurred between the 1940s and 1960s.* (COA 2016 p. ES-i)

INCREASING STORMINESS: this stressor can refer to intense precipitation events and/or tropical cyclones. Both are described below.

Intense Precipitation Events:
According to the 2014 National Climate Assessment, the Northeastern United States has had a greater recent increase in extreme precipitation, between 1958 and 2010, than any other United States region. The Northeast had a greater than 70% increase in precipitation falling in very heavy events defined as the heaviest 1% of all daily events. (NCA 2014) By the end of the century (2070 – 2100), monthly precipitation is projected to be approximately 1 inch greater for December – April in the Northeast under the higher emissions scenario. (NCA 2018)
In Connecticut since 1895, annual and summer precipitation vary widely within the State, with both values above average since the 1980's. Since the 1950's, the number of extreme precipitation events has increased, with the most occurring during the last decade. (https://statesummaries.ncics.org/chapter/ct/)
In New York, annual precipitation amounts have been significantly above the long-term average for the last two decades. (CICS-NC and NOAA NCEI) However, this does not necessarily translate to what is happening in the Long Island Sound region.
Significantly, the Coastal Ocean Analytics Report (2016) finds no evidence of rainfall events exceeding more than two inches of rain/day for Long Island and coastal Connecticut. However, it is important to keep in mind the size of the Long Island Sound watershed in CT and NY, and intense rainfall events within the watershed can have a significant impact on LIS water quality, thereby impacting beach and shellfish bed closures.

See also research of Anji Seth and Guiling Wang who spoke at the June 21, 2019 LISS Science and Technical Advisory Meeting

Tropical Cyclones:

Per NOAA's Geophysical Fluid Dynamic Laboratory (July 3, 2019) conclusions on global warming and Atlantic hurricanes (https://www.gfdl.noaa.gov/global-warming-and-hurricanes/):

- *Sea level rise – which very likely has a substantial human contribution to the global mean observed rise according to IPCC AR5 – should be causing higher coastal inundation levels for tropical cyclones that do occur, all else assumed equal.*

- *Tropical cyclone rainfall rates will likely increase in the future due to anthropogenic warming and accompanying increase in atmospheric moisture content. Modeling studies on average project an increase on the order of 10-15% for rainfall rates averaged within about 100 km of the storm for a 2 degree Celsius global warming scenario.*

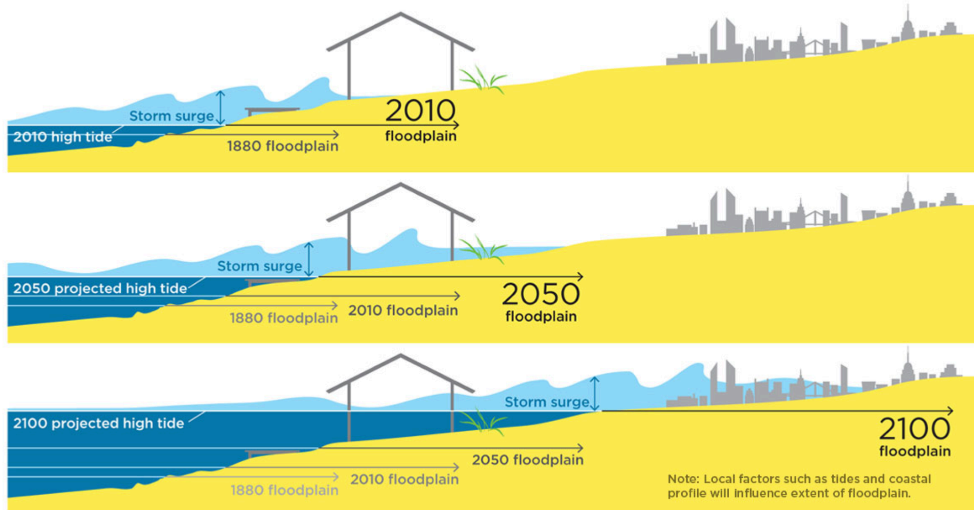
- *Tropical cyclone intensities globally will likely increase on average (by 1 to 10% according to model projections for a 2 degree Celsius global warming). This change would imply an even larger percentage increase in the destructive potential per storm, assuming no reduction in storm size. Storm size responses to anthropogenic warming are uncertain.*

- *The global proportion of tropical cyclones that reach very intense (Category 4 and 5) levels will likely increase due to anthropogenic warming over the 21st century. There is less confidence in future projections of the global number of Category 4 and 5 storms, since most modeling studies project a decrease (or little change) in the global frequency of all tropical cyclones combined.*

- *In terms of detection and attribution, much less is known about hurricane/tropical cyclone activity changes, compared to global temperature. In the northwest Pacific basin, there is emerging evidence for a detectable poleward shift in the latitude of maximum intensity of tropical cyclones, with a tentative link to anthropogenic warming. In the Atlantic, it is premature to conclude with high confidence that human activities–and particularly greenhouse gas emissions that cause global warming–have already had a detectable impact on hurricane activity. A recent study finds that the observed increase in an Atlantic hurricane rapid intensification metric (1982-2009) is highly unusual compared to one climate model's simulation of internal multidecadal climate variability, and is consistent in sign with that model's expected long-term response to anthropogenic forcing. Reduced aerosol forcing since the 1970s probably contributed to the increased Atlantic hurricane activity since then, but the amount of contribution, relative to natural variability, remains uncertain. There is some evidence for a slowing of tropical cyclone propagation speeds over the continental U.S. over the past century, but these observed changes have not yet been confidently linked to anthropogenic climate change. Human activities may have already caused other changes in tropical cyclone activity that are not yet detectable due to the small magnitude of these changes compared to estimated natural variability, or due to observational limitations.*

The Union of Concerned Scientists provides an excellent depiction of the first bullet point on the impacts of sea level rise on storm surge: from https://www.ucsusa.org/global-warming/science-and-impacts/impacts/causes-of-sea-level-rise.html

FIGURE 3. Storm Surge and High Tides Magnify the Risks of Local Sea Level Rise



Sea level sets a baseline for storm surge—the potentially destructive rise in sea height that occurs during a coastal storm. As local sea level rises, so does that baseline, allowing coastal storm surges to penetrate farther inland. With higher global sea levels in 2050 and 2100, areas much farther inland would be at risk of being flooded. The extent of local flooding also depends on factors like tides, natural and artificial barriers, and the contours of coastal land.

INCREASING DROUGHT:

Definition of drought: https://www.ncdc.noaa.gov/monitoring-references/dyk/drought-definition
There are four types of drought per the climate community: 1) meteorological drought, 2) hydrological drought, 3) agricultural drought, and 4) socioeconomic drought.

Per the National Climate Assessment (2014), seasonal drought risk is projected to increase in the summer and fall seasons as higher air temperatures lead to greater evaporation and earlier snow melt. However, this is a projection for the entire northeast and it is unclear what the projections are for the Long Island Sound area. The COA (2016 report) found that while there are no changes in annual precipitation for the Long Island Sound region (records dating to 1900), rainfall along coastal Connecticut and Long Island is slightly decreasing while increasing at inland recording stations. The report also found a slight decrease in the number of snow days on Long Island since 1900.
The US Drought Monitor shows current conditions in the Northeast and in individual states.
https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?Northeast

SEA LEVEL RISE:

Driven by the thermal expansion of water and melting of land-based ice (e.g., glaciers and ice sheets), sea levels are rising at an increasing rate.
There is already a sea level rise trends indicator description on the LISS website.
Sea Level Trends Indicator: http://longislandsoundstudy.net/ecosystem-target-indicators/sea-level-trends-for-kings-point/

Connecticut's legislature has officially adopted the projections of the Connecticut Institute for Resilience and Climate Adaptation of up to 20 inches (50 cm) of sea level rise higher than the national tidal datum in Long Island Sound by 2050.

Report: Sea Level Rise in Connecticut by James O'Donnell:
https://docs.google.com/viewerng/viewer?url=https://circa.uconn.edu/wp-content/uploads/sites/1618/2019/01/Sea-Level-Rise-Connecticut-FinalReportP1.pdf&hl=en

New York State Sea Level Rise website: https://www.dec.ny.gov/energy/45202.html
New York State Sea Level Rise Task Force Report to the Legislature (December 31, 2010) provides the following table of SLR projections for Long Island:

TABLE 1: Projected Sea Level Rise in New York[1]

Lower Hudson Valley & Long Island	**2020s**	**2050s**	**2080s**
Sea level rise[2]	2 to 5 in	7 to 12 in	12 to 23 in
Sea level rise with rapid ice-melt scenario[3]	5 to 10 in	19 to 29 in	41 to 55 in
Mid-Hudson Valley & Capital Region	**2020s**	**2050s**	**2080s**
Sea level rise[2]	1 to 4 in	5 to 9 in	8 to 18 in
Sea level rise with rapid ice-melt scenario[3]	4 to 9 in	17 to 26 in	37 to 50 in

[1] NYSERDA ClimAID Team. 2010. Integrated Assessment for Effective Climate-change Adaptation Strategies in New York State. C. Rosenzweig, W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, P. Grabhorn, Eds. New York State Energy Research and Development Authority, 17 Columbia Circle, Albany, NY 12203.

[2] Shown is the central range (middle 67%) of values from model-based probabilities (16 global climate models by 3 GHG emissions scenarios) rounded to the nearest inch.

[3] The rapid ice-melt scenario is based on acceleration of recent rates of ice melt in the Greenland and west Antarctic ice sheets and paleoclimate studies.

OCEAN ACIDIFICATION:

Ocean acidification (OA) describes the chemical reactions when carbon dioxide is absorbed by seawater creating carbonic acid and hydrogen ions. As more and more carbon dioxide is absorbed, levels of hydrogen ions increase, decreasing the pH, making the ocean waters more acidic. These chemical reactions also lead to decreased carbonate ions in the water, a critical building block for the skeletons and shells of some marine organisms such as oysters, clams and corals.

Since the Industrial Revolution, more and more carbon dioxide has been released into the atmosphere and absorbed by oceans. The pH of the oceans' surface waters has decreased by 0.1pH units, representing about a 30% increase in acidity. (NOAA Ocean Acidification website: https://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F)

Ocean Acidification becomes more complicated for bodies of water near the coast, such as Long Island Sound or the Gulf of Maine. Coastal Ocean Acidification (COA) refers to the processes whereby rivers carry nutrients (among other things) into the oceans. Nutrient loads can promote the excessive growth of algae and phytoplankton. Organisms that feed on the algae and phytoplankton respire (take in oxygen and release carbon dioxide) which increases the amount of carbon dioxide in the water, adding to the decrease in pH of these coastal waters. (NECAN website: http://www.necan.org/overview)

NY DEC and CT DEEP – water quality monitoring includes pH
Chris Gobler research: https://www.somas.stonybrook.edu/people/faculty/christopher-gobler/
Project Oceanology records (1974 to 2016) for eastern Long Island Sound were analyzed by a group of researchers and show a significant decrease in pH (not monotonic).
Reference: Snyder, J.T., M.M. Whitney, H.G. Dam, M.W. Jacobs, H. Baumann. 2019. Citizen science observations reveal rapid, multi-decadal ecosystem changes in eastern Long Island Sound. Marine Environmental Research 146: 80-88. DOI: 10.1016/j.marenvres.2019.03.007

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