

A community-based approach to planning for the effects of climate change on shellfishing in Wellfleet Harbor

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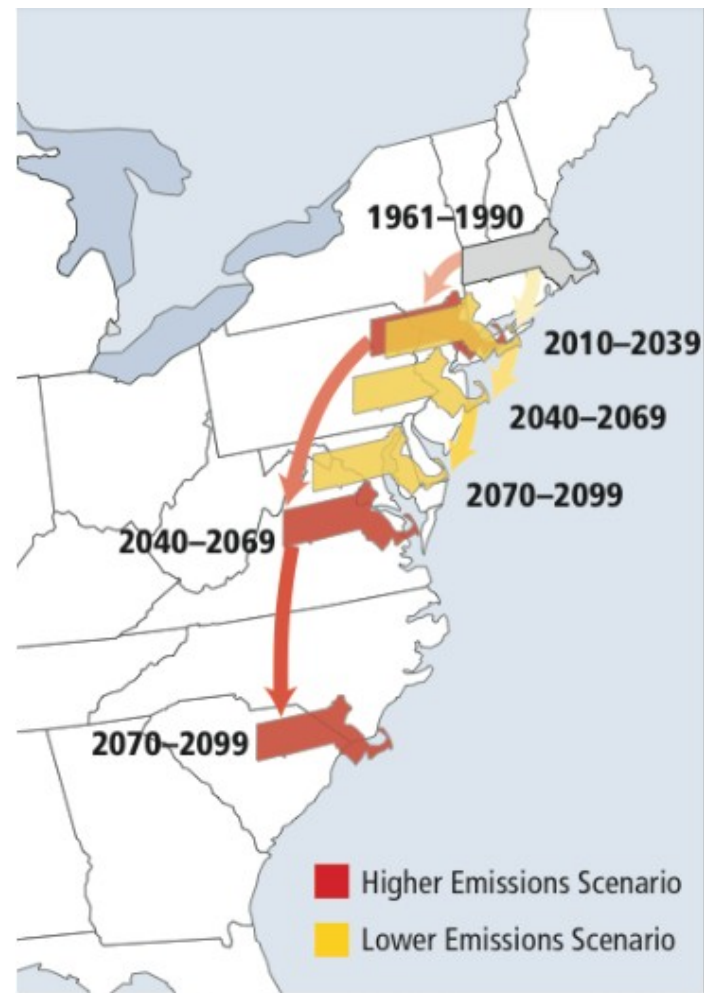
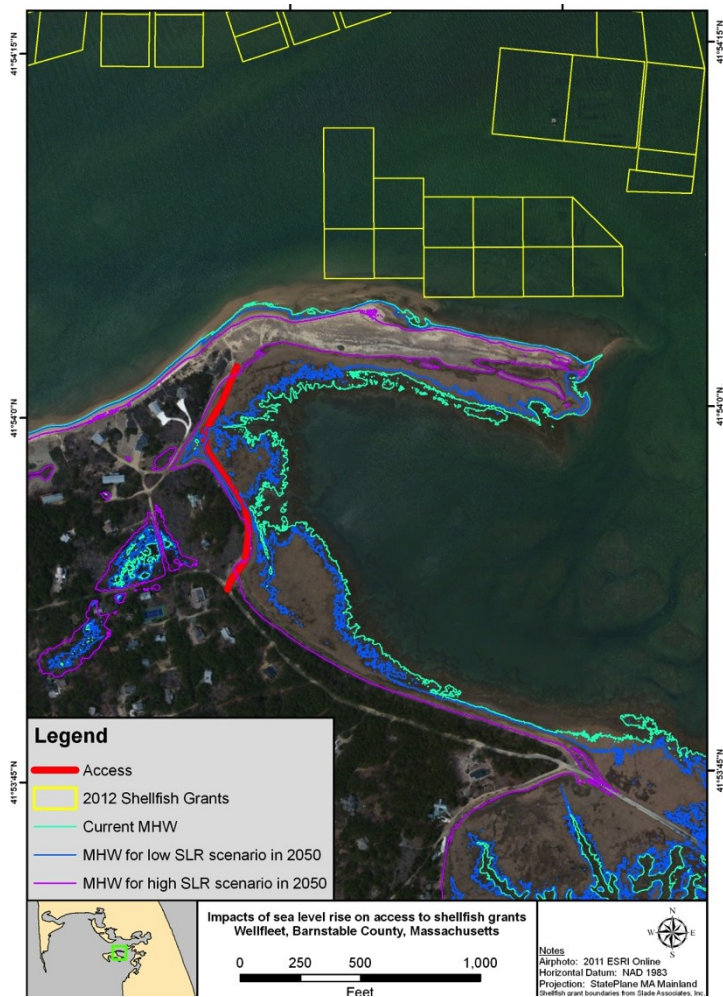
The emerging threat of climate change

SENSITIVITY	Very High			2 shellfish	1 shellfish 1 diadromous
	High			6 groundfish 4 elasmobranchs 4 shellfish	8 shellfish 7 diadromous 3 coastal
	Moderate			5 groundfish 3 elasmobranchs 1 pelagic 2 shellfish	2 diadromous 3 coastal
	Low			8 groundfish 5 elasmobranchs 8 pelagics 1 shellfish	8 coastal
		Low	Moderate	High	Very High
EXPOSURE					

Preliminary results of the National Marine Fisheries Service Fish Stock Climate Vulnerability Assessment for the Northeastern US (From Griffis 2015). Numbers indicated in each cell refer to number of species.

Multiple climate stressors

- Sea level rise
- Increasing frequency and intensity of precipitation
 - Stormwater runoff, storm surge, and wind
- Increasing air and water temperatures
 - Seasonal increases
 - More extreme heat days
- Changing water chemistry
 - Ocean acidification



Working Group on Climate Change Impacts on Shellfishing in Wellfleet Harbor

- Purpose to identify:
 - Threats to shellfishing in Wellfleet Harbor from climate change.
 - The role of shellfish in mitigating impacts from climate change and other environmental hazards in Wellfleet Harbor.
 - Strategies to increase the resilience of Wellfleet and its shellfishery in a time of climate change.

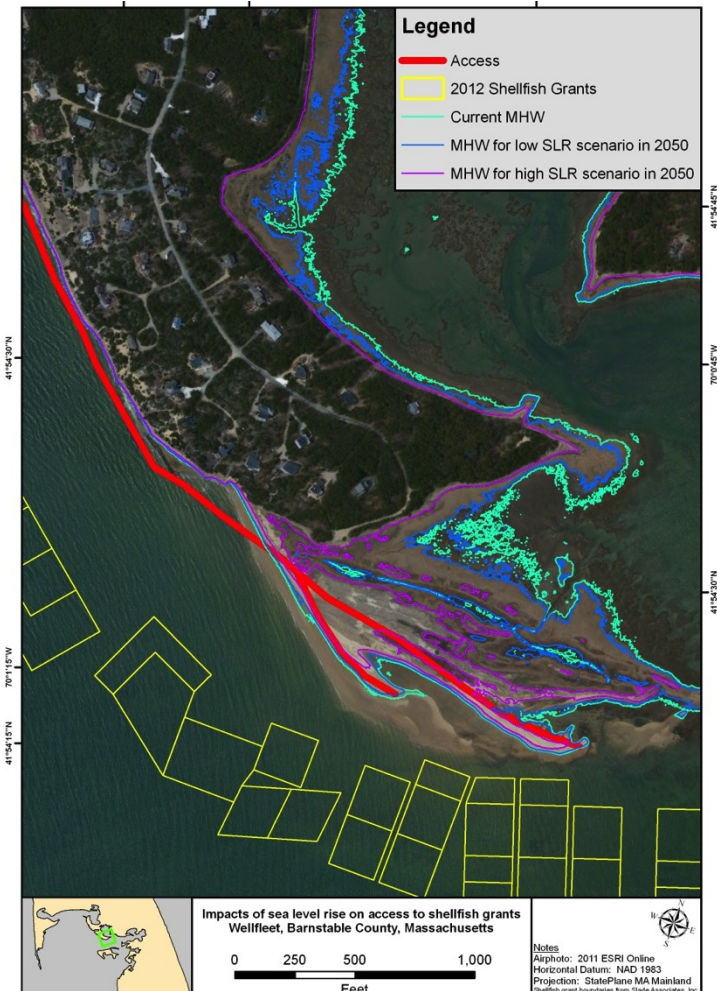
Working Group on Climate Change Impacts on Shellfishing in Wellfleet Harbor

- A community-based group with broad representation from the shellfish industry and the Town (10)
 - Shellfish Advisory Board
 - Wastewater Planning Committee
 - Conservation Commission
 - Board of Health
 - Wellfleet Bay Audubon Sanctuary
 - MA Aquaculture Association
 - Oyster growers
 - Quahog growers
- Additional support from shellfish researchers, coastal/marine scientists

- A structured discussion *and* learning process
 - Summer 2013 - 2015, 6 meetings
 - Vulnerability, Consequences, and Adaptation Planning Scenarios Process (VCAPS)
 - Implemented in 14 coastal communities in Alabama, Maine, Massachusetts, North Carolina, and South Carolina
 - www.vcapsforplanning.org
 - Iteration between state of science presentations and discussion
 - Elaborate scenarios linking local climate stressors, consequences, vulnerabilities, and mitigation adaptation strategies
 - Impacts of sea level rise and storm surge
 - Warming temperatures (vibrio)

Potential impacts from sea level rise

- Change the proportion of inter-tidal and sub-tidal habitat areas.
- Alter species' location and composition, including predators of shellfish.
- Degrade water quality in Wellfleet Harbor.
- Change how shellfish can be grown and harvested.
- Disrupt access to grants and lead to inadequacy of infrastructure.
- Lead to resource use conflicts.



Potential impacts from from changes in precipitation patterns

- Increase diseases and pathogens.
- Degrade water quality in Wellfleet Harbor.
- Disrupt access to grants from coastal erosion.
- Decrease economic revenue due to increased pathogens, shellfish diseases, predation, and harmful algal blooms.
- Alter sediment transport, which can impact the health of shellfish and suitability of grants.

Potential impacts from warming air and water temperatures

- Selectively benefit predator species.
- Increase shellfish mortality due to diseases, predators, and pathogens.
- Increase exposure risks to those who work the shellfish beds.
- Decrease revenue due to increased pathogens, shellfish diseases, and harmful algal blooms.
- Decrease revenue due to reduced reproductive rates.
- Decrease revenue due to incidents of human pathogens (e.g., *Vibrio parahaemolyticus*) or to the imposition of new rules to reduce risks of outbreaks.
 - Summer closures



Potential impacts from ocean acidification

- Decrease growth rates and survival rates of shellfish.
- Decrease economic value of shellfish and decrease revenue of shellfishers.
- Change how shellfish can be grown and harvested.



Non-climate stressors interact with climate change impacts



- Shoreline development, armoring, and erosion
- Nutrient loading
- Lack of genetic diversity of seed
- More intense farming
- Harbor user conflicts

Mitigation and adaptation strategies

- Many potential management actions identified.
- Prioritization, design, implementation will involve multiple actors at different scales of governance.

Massachusetts Vp Control Plan for 2014

APRIL 4, 2014



DEPARTMENT OF PUBLIC HEALTH
BUREAU OF ENVIRONMENTAL HEALTH

DEPARTMENT OF FISH & GAME
DIVISION OF MARINE FISHERIES

DEPARTMENT OF AGRICULTURAL RESOURCES

Potential strategies to address impacts of climate change on shellfish

Climate Change Outcomes	Implications	Shellfish Advisory Board	Board of Health	Waste water Manag. Planning Committee	Con Com	Natural Resource Advisory Board	Planning Board	Select board	State agencies (DMF, DPH)	Federal agencies (NPS)
Chronic inundation (SLR)										
Episodic flooding										
Erosion										

- A matrix to organize information about
 - impacts of climate change on shellfish and shellfishers
 - actions by the Town of Wellfleet Boards and Committees, state agencies, and federal agencies
- Clarify limits of power, conflicts, gaps
- Identify co-benefits
- Actions are not prioritized or ranked.
- Actions are presented to further discussion within the Town about how to respond to climate change.

Climate Change Outcomes	Implications for shellfish and shellfishers	Additional implications to community	Shellfish Advisory Board	Board of Health	Comprehensive Wastewater Management Planning Committee	Conservation Commission	Marina Advisory Committee
Coastal erosion from storms with increased intensity	<ul style="list-style-type: none"> • Impair access to grants • Reduce harvestable areas • Reduce intertidal zone • Increased costs (gear, maintenance, boat, etc.) 	<ul style="list-style-type: none"> • Property damage • Erosion of shoreline 	<ul style="list-style-type: none"> • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) 	<ul style="list-style-type: none"> • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) 	<ul style="list-style-type: none"> • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement) 	<ul style="list-style-type: none"> • Protect wetlands • Evaluate policies for beach nourishment and recommend more environmentally safe strategies • Write orders of conditions for new buildings and septic systems • Evaluate and recommend soft solutions (rather than hard structures) for shoreline protection 	<ul style="list-style-type: none"> • Recommend salt marsh restoration, oyster reef restoration, eel grass restoration (storm surge buffering and sustainable water quality/fish spawning habitat improvement)

Resources for future planning

- Reports
 - Potential Impacts of Climate Change and Variability on Shellfish Resources
 - Potential Impacts to Health of Harbor, Shellfish Resources, and Commercial Shellfishing in Wellfleet Harbor From Sea Level Rise
 - Adaptation Strategies to Address the Potential Impacts of Climate Change and Variability on Shellfish Resources in Wellfleet Harbor
 - Reports available at (for the moment...)
 - <http://www.seri-us.org/content/fisheries-and-climate-Wellfleet>
- A new [website](#)



Planning for Climate Change Impacts on Shellfish in Wellfleet Harbor

Shellfish play a vital role in the ecology of **Wellfleet Harbor** and the economy of Wellfleet. Currently, Wellfleet produces about 23% of the shellfishing landings in the Commonwealth, worth approximately \$4,500,000. Wellfleet ranks second to Duxbury in terms of commercial shellfish production. However, shellfish are particularly vulnerable to climate change and variability. The National Marine Fisheries Service ranks shellfish as among the most vulnerable of fish stocks in the northeastern US.

This website provides an overview of the **climate-related threats** to shellfish and commercial shellfishing in Wellfleet Harbor and potential





This website summarizes the information developed by a Working Group on Climate Change impacts on shellfishing in Wellfleet Harbor. The Working Group met from 2013 – 2015 to identify the following :

- threats to shellfishing in Wellfleet Harbor from climate change
- the role of shellfish in mitigating impacts from climate change and other environmental hazards in Wellfleet Harbor
- strategies to increase the resilience of Wellfleet and its shellfishery in a time of climate change.

More information about the Working Group, including its goals and members, can be found in [here](#).

FULL REPORTS

- Potential Impacts of Climate Change and Variability on Shellfish Resources [\[DOWNLOAD\]](#)
- Potential Impacts to Health of Harbor, Shellfish Resources, and Commercial Shellfishing in Wellfleet Harbor From Sea Level Rise [\[DOWNLOAD\]](#)
- Adaptation Strategies to Address the Potential Impacts of Climate Change and Variability on Shellfish Resources in Wellfleet Harbor [\[DOWNLOAD\]](#)

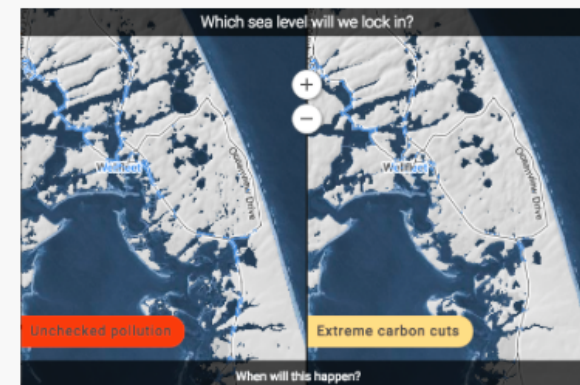


Threat : Sea Level Rise

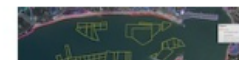
Sea level rise in Wellfleet, MA is predominantly a combination of **rising ocean waters** and **land subsidence**. Changes in **sediment transport** within the harbor may also affect relative sea level rise, by changing the amount of sand deposited on the bottom in different locations. An additional factor that may increase sea level rise in the northeastern US compared to other parts of the globe is the slowing of ocean currents.

In the northeastern US the combination of rising ocean waters and land subsidence is leading to higher relative sea level rise compared to many other coastlines in the US and elsewhere. Since 1900 the rate of sea level rise in the northeast has exceeded the global average by approximately 4 inches to about 1 foot in the Northeast versus about 8 inches globally over the past 110 years. The most recent assessments project a global sea level rise of 1-4 feet by 2100, with the northeast continuing to exceed global averages.

RELATED REPORT : [Sea Level Rise: Understanding and Applying Trends and Future Scenarios for Analysis and Planning](#)



[VIEW Surging Seas Interactive](#) (Climate Central)





Sea level rise will impact embayments and marshes that support shellfish.

According to the US Climate Science Program, “degradation and loss of tidal marshes will affect fish and shellfish production in both the marshes themselves and adjacent estuaries.”



Impacts of Sea Level Rise on Access to Grant Areas in Wellfleet Bay

[\[VIEW REPORT \]](#)

IMPACTS

IMPLICATIONS

ACTIONS

Sea Level Rise Impacts Relevant to Shellfishing

1. Increasing salinity in estuaries by extending saltwater penetration upstream. Increased salinity has been linked to higher QPX mortality in clams and MSX infections in oysters.
2. Loss of habitat, including important foraging and nursery habitat for some species. Loss of habitat is

Saving Paradise: Sea Level Rise, Changing Cape Cod's

Climate change in Massachusetts

precipitation (2100).

Parameter	Current Conditions (1961–1990)	Predicted Range of Change by 2050	Predicted Range of Change by 2100
Annual temperature ¹ (°C/°F)	8/46	2 to 3 / 4 to 5	3 to 5/5 to 10 ^{**}
Winter temperature ¹ (°C/°F)	-5/23	1 to 3 / 2 to 5	2 to 5 / 4 to 10
Summer temperature ¹ (°C/°F)	20/68	2 to 3 / 4 to 5	2 to 6 / 4 to 10
Over 90 °F (32.2 °C) temperature ² (days/yr)	5 to 20	—	30 to 60
Over 100 °F (37.7° C) temperature ² (days/yr)	0 to 2	—	3 to 28
Ocean pH ^{3,4}	7 to 8	—	-0.1 to -0.3*
Annual sea surface temperature (°C/°F)	12/53 ⁵	2/3 (in 2050) ⁵	4/8
Annual precipitation ¹	103/41 cm/in.	5% to 8%	7% to 14%**
Winter precipitation ¹	21/8 cm/in.	6% to 16%	12% to 30%**
Summer precipitation ¹	28/11 cm/in.	-1% to -3%	-1% to 0%**
Streamflow—timing of spring peak flow ¹ (number of calendar days following January 1)	85	-5 to -8	-11 to -13 ^{**}
Droughts lasting 1–3 months ¹ (#/30 yrs)	13	5 to 7	3 to 10 ^{**}
Snow days (number of days/month) ¹	5	-2	-2 to -4 ^{**}
Length of growing season ¹ (days/year)	184	12 to 27	29 to 43

Table 1: Changes in Massachusetts' Climate

Sources: 1-Hayhoe et al., 2006; 2-Frumhoff et al., 2007; 3-IPCC, 2007; 4-MWRA, unpublished; 5-Nixon et al., 2004

Note: All numbers have been rounded to the nearest whole number. Unless otherwise indicated, the predictions for the year listed as 2050 are for the period between 2035–2064. * Global data; **Predictions for period between 2070–2099

(MA Climate Change Adaptation Report 2011)