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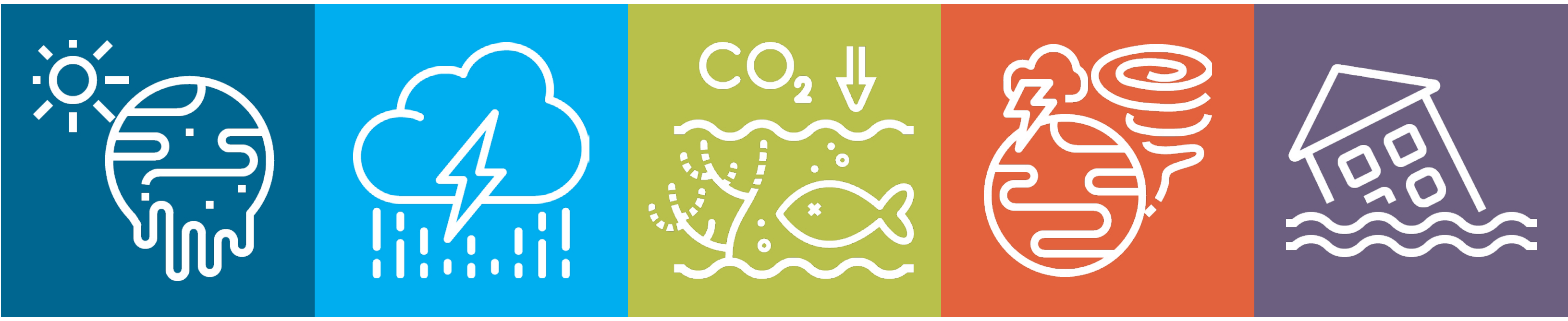
Climate Change and Aquaculture in Connecticut's Long Island Sound



Climate change is a global challenge. It has the potential to impact environmental, animal, and human health, as well as the economy

The food production sector is particularly susceptible to changes in the climate. These changes have far-reaching societal impacts such as increased food prices and food insecurity. Aquaculture farms are especially vulnerable to climate change as organisms and operations are continually exposed to temperature and chemical fluctuations in the ocean and air.

Scientists believe there may be greater impacts to shellfish aquaculture compared with finfish production (Froehlich, Gentry & Halpern 2018). The United States is the worlds' third largest producer of shellfish. The cultivation of oysters, clams, and mussels comprises nearly 50% of marine aquaculture production by volume and 75% by value (NOAA 2017). Connecticut has a multi-million dollar aquaculture industry, and is a major player in the U.S. shellfish market. From local to global scales, the shellfish aquaculture industry is at risk to the effects of a changing climate. There are five key ways that climate change can pose a threat to shellfish aquaculture including: temperature extremes, changing precipitation patterns, ocean acidification, severe weather, and sea level rise.

These factors have the potential to affect production, infrastructure, and sales (De Silva and Soto 2009, Barange et al. 2018). However, while many of the consequences of climate change on aquaculture remain unclear, some negative impacts have already been observed (Weatherdon et al. 2016).

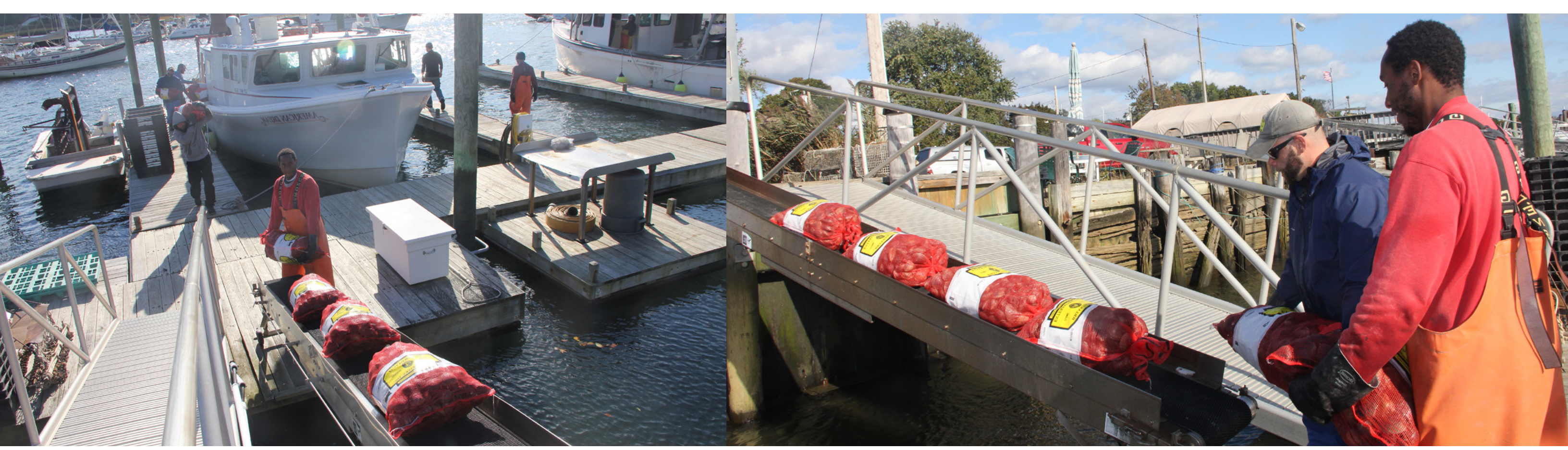


Photo (Left and Right): Workers at Briarpatch Enterprises in Milford, CT, offload bags of clams harvested from Long Island Sound onto a conveyor belt. The conveyor belt lifts the bags into a company truck that transports them to the warehouse for processing. Photos by Judy Benson, Connecticut Sea Grant.

Temperature Extremes

Rising average air and water temperatures, as well as more extreme heat waves and cold spells, are likely to affect aquaculture. Farmed shellfish may be stressed or die as a result of extreme temperatures and exposure. It is likely that shellfish farmers will also have to deal with new pests and pathogens.

Impacts to cultivated shellfish need to be monitored. Extreme temperatures may also expose workers to challenging and potentially unsafe working conditions. In Connecticut, farmers have already been dealing with the impacts of a pathogenic bacteria of concern. Vibrio parahaemolyticus is a naturally occurring bacteria that can sicken consumers when shellfish are eaten raw. This bacteria proliferates at higher temperatures. To minimize product exposure to extreme heat, regulators have recently required actions such as reduced trip lengths and rapid cooling of shellfish on the boat using ice (Connecticut Department of Agriculture, Bureau of Aquaculture). These modifications of storage and shipping practices are helping the shellfish industry adapt to and mitigate the effects of foodborne pathogens in a changing climate.

Some shellfish farmers are experimentally growing native sugar kelp (*Saccharina latissima*). This is used as a food ingredient in specialty markets. In Connecticut this kelp is already growing at the southern limit of its distribution. The crop has been initially successful. The future for this industry is unknown because of a shift in temperatures due to climate change.

Precipitation and Salinity

Precipitation patterns are changing in the Northeast, and these changes can impact aquaculture. For instance, the frequency of heavy rain events in the U.S. has increased in the last two decades (NOAA 2018). Models predict that this trend will continue (Ren et al. 2013).

In the Northeast, the observed change in very heavy rain during the last century was +55% (Easterling et al. 2017). According to Huang et al. (2017), coastal areas received more total and extreme precipitation on average than inland areas. Rainfall can introduce pollution such as bacteria and viruses, nutrients, and other contaminants from surface runoff and storm water. Filter-feeding shellfish capture these particles in the water. To protect human health, local and state regulators monitor water quality in shellfish harvest areas. Harvesting areas are closed following heavy rainfall events and reopened when favorable water quality results are obtained.

Frequent and intense rainfall events have already increased the frequency and duration of temporary harvest area closures in some Connecticut towns (Connecticut Department of Agriculture, Bureau of Aquaculture). Most businesses can adjust operations to deal with short-term closures and associated delays of income. However, more frequent and longer duration closures or permanent closures would put shellfish aquaculture at significant risk for loss of market share, income loss, loss of jobs, and business closure and consolidation.

Episodes of heavy rainfall and drought can also dramatically affect the salinity of seawater. Runoff from heavy rains may temporarily reduce salinity (due to freshwater inputs from land), while droughts may increase salinity (due to reduced freshwater input). Shellfish can tolerate a wide salinity range, though early life stages can be more vulnerable to extreme environmental conditions including low salinity. Also, certain shellfish parasites such as *Perkinsus marinus* (Dermo disease) thrive in higher salinities caused by drought conditions. These parasites pose a threat to both wild and farmed shellfish populations (Sunila 2010).

Ocean Acidification

Ocean acidification happens when the pH of seawater drops (becomes more acidic) over a period of time. In essence, the removal of atmospheric carbon dioxide by oceans results in the production of carbonic acid, which lowers pH and acidifies ocean waters (NOAA 2019). Ocean acidification poses a serious risk to shellfish aquaculture, and especially to early-life-stage shellfish.

Scientists have demonstrated that ocean acidification can affect the ability of shellfish to survive, build shells, and grow (Green 2009). Local scientists are just beginning to measure environmental conditions to better understand how pH fluctuates in estuarine environments (Wallace et al. 2014). Daily and seasonal fluctuations in pH are characteristic of coastal habitats. The effects of pH fluctuations on marine organisms, such as shellfish, represents an active field of research. Some shellfish hatcheries are mitigating the effects of ocean acidification by adding soda ash to seawater. This artificially raises the pH of the seawater, making it less acidic than the seawater they draw into their facilities from the ocean.

Severe Weather

Frequent nor'easters and subtropical storms have heavily impacted coastal Connecticut, causing catastrophic loss of life, property damage, and coastal erosion. While the NOAA National Hurricane Center website provides data showing an increasing trend in the named storms in the Atlantic Basin including subtropical storms, there is a great deal of variability from season to season.

Storm trend projections are very difficult to predict and there are no definitive projections for Connecticut as yet (Seth et al. 2019). Seaside operations can be particularly vulnerable to wind, waves, and surging seas. Protecting aquaculture facilities, vessels and gear from these forces can be a considerable challenge given the uncertainty in storm predictions. Aside from impacts to shoreside infrastructure, aquaculture businesses have been impacted by damage or loss of gear and vessels, lost days at sea, and harvest area closures. When possible, farmers move vessels and cultivation gear to more sheltered locations, but not all have such options.


Photos (Left): Workers sort freshly harvested oysters in the warehouse at Norm Bloom & Son Oysters in Norwalk, CT. (Right): Workers at the Briarpatch Enterprises warehouse in Milford, CT, load and unload clams onto a machine that sorts and bags the shellfish according to size. Photos by Judy Benson, Connecticut Sea Grant.

Sea Level Rise

Across the globe, communities are dealing with the threat of rising sea levels. Sea level rise is accelerating more rapidly in some locations than others. The Connecticut Institute for Resilience & Climate Adaptation (CIRCA) recommends planning for a sea level rise of about 0.5m (20 inches) above the present national tidal datum in Long Island Sound by 2050.

In its 2010 report, the Adaptation Subcommittee to the Governor's Steering Committee on Climate Change identified shellfish production as one of the top five most imperiled agricultural planning areas in the state. Most aquaculture operations rely on shore-side infrastructure and facilities that, due to their proximity to the sea, are inherently vulnerable to sea level rise. This infrastructure can include man-made docks, building structures, mechanized refrigerated units, outdoor ice machines, tanks, processing equipment, hatcheries and any structure identified for use by a seafood operation, as well as roads leading to and from these facilities. Shoreline resilience is based on geology and topography so resilience of any particular aquaculture operation will be site dependent. Elevating structures may be one useful mitigation strategy, but relocating is unlikely to be a feasible approach especially for hatcheries that draw seawater directly from Long Island Sound. Even if operations had the flexibility to elevate or relocate such infrastructure, these measures may be cost prohibitive.

Conclusion

The shellfish aquaculture industry is acutely aware of changes in the coastal ocean environment that affects their operations. The challenges posed by climate change are recognized by industry leaders.

In fact, concerned farmers recently formed a national climate change coalition to share stories of impact and work with governmental agencies to address climate change issues (The Nature Conservancy 2018). Scientists, regulators and the industry are continually making observations and measurements to better understand how the climate is changing on local and global scales. Further, they are seeking to assess threats to both water-based aquaculture operations and shoreline infrastructure in the state of Connecticut. If aquaculture operations or the associated infrastructure are impacted by climate change, there may be cascading effects to the economic development of the municipality or region. Identifying these threats now will enable the aquaculture industry to develop adaption strategies that not only build resilience, but also ensure that future shellfish production is sustainable.

Photos (Left): Jimmy Bloom, operations manager at Norm Bloom & Sons Oysters, shows oysters raised in an upweller at the company's Norwalk facility. (Right): A vessel loaded with oysters harvested from Long Island Sound docks and prepares to offload at Norm Bloom & Son Oysters in Norwalk, CT. Photos by Judy Benson, Connecticut Sea Grant.

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