Quarterly Climate Impacts and Outlook

Gulf of Maine Region

June 2016

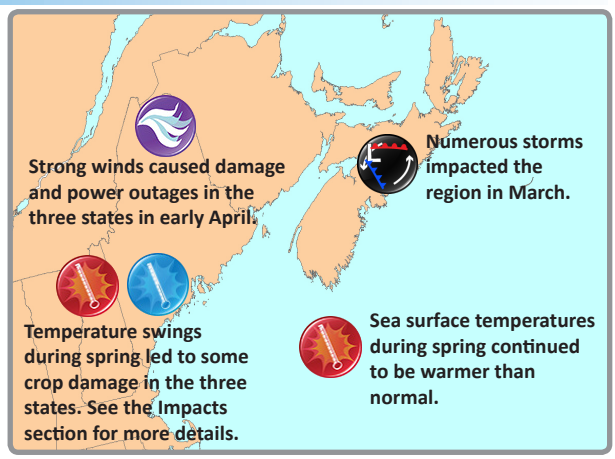
Gulf of Maine Significant Events - *March–May 2016*

Storms frequently tracked through the region during March. Some of the large events are highlighted below.

- **March 2–3**: Up to 34 cm (15 in.) of snow fell in northern Maine and northern New Brunswick, while the rest of the region saw up to 36 mm (1.40 in.) of rain. Northern Maine accumulated up to 1 cm (0.40 in.) of ice.
- **March 5**: A nor'easter dropped up to 30 cm (12 in.) of snow in Nova Scotia. Wind gusts of up to 80 km/h (50 mph) led to whiteout conditions.
- **March 21**: Most of the region saw up to 25 cm (10 in.) of snow. However, the Acadian Peninsula saw up to 48 cm (19 in.) of snow and up to six hours of near zero visibility, resulting in schools being closed for two days.
- **March 25–26**: Mixed precipitation impacted the region. The greatest snow totals of more than 20 cm (8 in.) were in northeastern New Brunswick. Central parts of the province experienced up to 18 hours of freezing precipitation. Snow and ice turned to rain in Nova Scotia, where up to 30 mm (1.20 in.) of rain fell. Up to 18 cm (7 in.) of snow and up to 0.8 cm (0.3 in.) of ice accumulation were reported in northern Maine, with the rest of the three states generally seeing rain.
- **March 28–29**: Up to 32 cm (13 in.) of snow fell in northern New Brunswick and northern Maine and up to 65 mm (2.60 in.) of rain fell in the rest of the region.

At the beginning of April, snow on the ground was above normal in northern New Brunswick but below normal in southern New Brunswick.

In **early April**, two strong cold fronts produced wind gusts up to 124 km/h (77 mph) in New England. The winds caused structural damage, downed trees and powerlines, and left more than 70,000 customers in Massachusetts and Maine without power. Wet snow from **April 9 to 10** brought down trees and powerlines in Nova Scotia, leaving more than 16,000 customers without power. Numerous flights were also delayed. A storm from **April 11 to 12** dropped up to 78 mm (3.10 in.) of rain on New Brunswick.



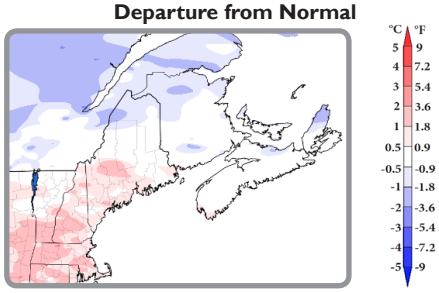
Northern Maine and northern New Brunswick saw up to 20 cm (8 in.) of snow in **mid-May**. Caribou, ME received 11.4 cm (4.5 in.) on the 16th, which was the site's largest snowfall so late in the season. Cold water temperatures and windy conditions through mid-May led to reduced lobster catches around P.E.I.

Seasonal snowfall (October–May) was near to below normal in New Brunswick, near to above normal in P.E.I., and varied in Nova Scotia. In the three states, seasonal snowfall was below normal, with the largest deficits of more than 2 m (6 ft.) in southwestern Maine. Concord, NH had its fourth least snowy season. With limited snowpack, little spring flooding occurred.

Regional Climate Overview - *March–May 2016*

Temperature

Departure from Normal

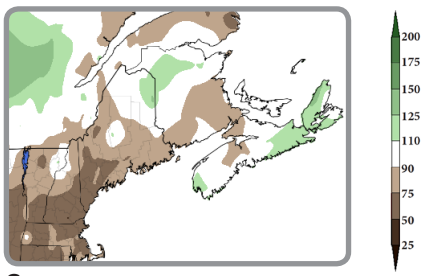


Spring temperatures (averaged over March, April, and May) ranged from 2°C (4°F) below normal to 2°C (4°F) above normal (map above). In **March,** temperatures ranged from 3°C (5°F) below normal to 3°C (5°F) above normal. The coldest areas were in northern New Brunswick, while the warmest areas were in Massachusetts, New Hampshire, and southern Maine. **April** temperatures ranged from 3°C (5°F) below normal to near normal, with the coldest areas in northwestern Maine and northwestern New Brunswick. In **May,** temperatures ranged from near normal to 2°C (4°F) above normal for a majority of the region.

Temperature and precipitation normals based on 1981–2010. Canada and ocean precip data: Canadian Precipitation Analysis. U.S. precipitation data: interpolated station data.

Precipitation

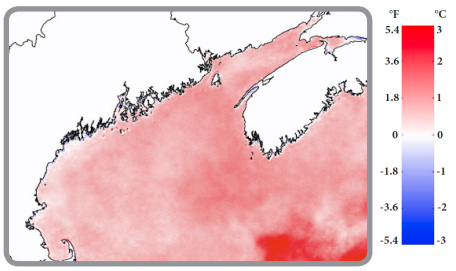
Percent of Normal



Spring precipitation (accumulated from March through May) ranged from 50% to 150% of normal (map above). In **March,** precipitation ranged from 50% to 200% of normal. The driest areas were in eastern Massachusetts, while the wettest areas were in northern Maine. **April** precipitation ranged from 25% of normal to near normal in the three states. Precipitation in the Maritimes ranged from 25% of normal in eastern New Brunswick to 150% of normal in northern Nova Scotia. In **May,** precipitation ranged from 25% of normal in parts of the three states to 150% of normal in northeastern New Brunswick and Cape Breton, NS, with most areas seeing 50% to 110% of normal. Parts of the three states were abnormally dry due to below-normal spring precipitation.

Sea Surface Temperatures

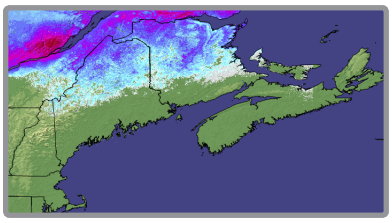
Departure from Normal

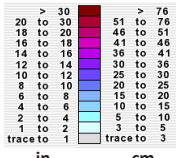


Spring sea surface temperature anomalies in the Gulf of Maine were warmer than the spring long-term average over the entire region. Temperatures over coastal areas of eastern Maine, New Brunswick, and Nova Scotia were 0.5°C (1°F) to 1.5°C (2.7°F) above normal. Off the coast of Massachusetts and western Maine, temperatures were 0.5°C (1°F) above normal. Temperatures were 0.5°C (1°F) to 1.5°C (2.7°F) above normal over deeper basins in the central Gulf of Maine and Scotian Shelf. These warm anomalies continue a region-wide continuous warm surface ocean period that began in September 2015.

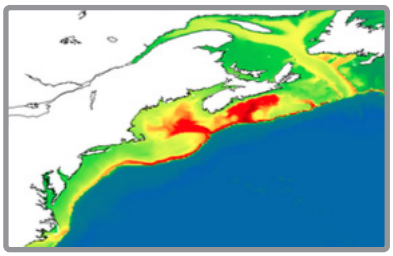
Sea surface temperature anomalies based on 1985–2016. Mean SST anomalies from NOAA AVHRR data. Credit: University of Maine School of Marine Sciences and NERACOOS

Regional Impacts - *March–May 2016*





Modeled snow water equivalent for April 1, 2016. Credit: NOAA's National Operational Hydrologic Remote Sensing Center.



NOAA high-resolution global climate model projection of bottom ocean temperature change under an atmospheric carbon dioxide doubling experiment.

Spring Temperatures

Spring featured summer-like warmth in March and winter-like cold in April. On March 9, high temperatures were up to 14°C (25°F) above normal. Boston, MA and Concord, NH had their warmest temperature so early in the calendar year with a high of 25°C (77°F). Lake Winnipesaukee, New Hampshire's largest lake, had its earliest ice out on record (since 1887) on March 18, which was five days ahead of the previous record (set in 2012) and the first time it occurred on an astronomical winter day. In addition, warm temperatures led to some bears coming out of hibernation up to a month early. Arctic air moved into the region in early April. Boston, Concord, and Portland (ME)'s high temperatures on the 4th ranked as their third all-time coldest for April. Low temperatures on the 5th were up to 14°C (25°F) below normal. Concord, NH had its all-time coldest April temperature on record with a low of -16°C (4°F). According to U.S. Department of Agriculture crop reports, the cold temperatures damaged some apple, raspberry, and blueberry buds.

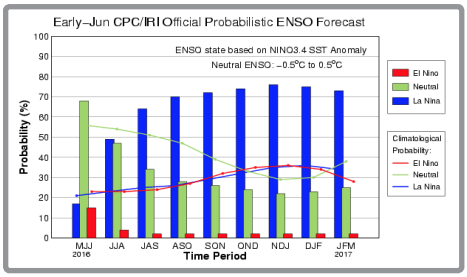
Ocean Impacts

A study found that the Gulf of Maine waters are "yellowing" by using the Forel-Ule color scale, a color index that indicates the color of the water and helps determine biological activity. An increase in precipitation over the past few decades washed more dissolved organic matter into rivers and increased river discharge, which carried the matter into the Gulf. This organic matter led to reduced water transparency and decreased productivity of phytoplankton, an essential part of the food chain. The effect was most noticeable along Maine's coast. Precipitation and discharges of organic matter are expected to increase over the next century. A study by Saba et al. (2016) found that a high-resolution global climate model was more accurate than coarse-resolution models at resolving regional circulation patterns and submarine topographic influences on ocean temperature and salinity in the U.S. Northeast Continental Shelf (Cape Hatteras, NC to the Gulf of Maine). The carbon dioxide doubling response from this model (bottom left figure) shows that bottom ocean temperature in the Shelf, particularly in the Gulf of Maine, warms at a rate nearly 2–3 times as fast as the coarser models. This enhanced warming is accompanied by an increase in salinity due to circulation changes.

The Government of Canada released a report highlighting climate change impacts, risks and opportunities, case studies, and adaptation approaches along Canada's marine coasts. The report mentions that median sea level rise by 2100 under a high-emissions scenario is expected to be 80–100 cm (2.6–3.3 ft.) at Saint John, NB; Halifax, NS; and Charlottetown, P.E.I. In addition, tidal range and water level extremes are expected to increase by 5–20 cm (2–8 in.) in the Bay of Fundy due to tidal resonance.

Regional Outlook - *Summer 2016*

La Niña



As of early June, El Niño dissipated and ENSO-neutral conditions were present in the equatorial Pacific Ocean. Most models predict La Niña conditions will develop during summer, with a 75% chance of La Niña during fall and winter. Currently, forecasters are expecting a weak or borderline moderate La Niña.

Temperature and Precipitation

For June–August, NOAA's Climate Prediction Center (CPC) and Environment and Climate Change Canada (ECCC) are both calling for an increased chance of above-normal temperatures for the Gulf of Maine region.

The CPC is forecasting an increased chance of above-normal precipitation for the three states for June–August. The U.S. Drought Outlook indicates dry conditions are expected to ease in New England. ECCC is forecasting an increased chance of above-normal precipitation in eastern New Brunswick and western P.E.I., with equal chances for the rest of the Maritimes.

Atlantic Hurricane Season

NOAA's 2016 Atlantic hurricane outlook indicates a near-normal season is most likely. There's a 70% chance of 10–16 named storms. Of the named storms, 4–8 could become hurricanes, with 1–4 of those becoming major hurricanes. Even though a near-normal season is most likely, there is a chance the season could be above or below normal. Two factors influencing this year's outlook are the Atlantic Multi-Decadal Oscillation (AMO) and La Niña.

The AMO is a naturally occurring variability in sea surface temperature in the North Atlantic. There is a cool phase, associated with low hurricane activity, and a warm phase, associated with high hurricane activity. Since 1995, the AMO has been in a warm phase. However, the past three hurricane seasons have been below normal and accompanied by a shift toward the cool phase. There is some uncertainty if this shift is temporary or not. There's a 70% chance of La Niña conditions during the peak of hurricane season. While La Niña favors a more active hurricane season, its strength and impacts are uncertain. Indications are this season could be more active than the past few.

The Atlantic hurricane season runs from June 1 through November 30, with a peak from mid-August to late October. There have already been three named storms: Hurricane Alex in January, Tropical Storm Bonnie in late May, and Tropical Storm Colin in early June.

Gulf of Maine Region Partners

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Northeast Regional Climate Center
www.nrcc.cornell.edu
National Oceanic and Atmospheric Administration
www.noaa.gov
National Centers for Environmental Information
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Climate Prediction Center
www.cpc.noaa.gov
Regional Climate Services
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Gulf of Maine Research Institute
www.gmri.org
State Climatologists
www.stateclimate.org
National Integrated Drought Information System
www.drought.gov
Cooperative Institute for the North Atlantic Region
www.cinar.org
Gulf of Maine Council on the Marine Environment, Climate Network
www.gulfofmaine.org/climatenetwork
Northeastern Regional Association of Coastal and Ocean Systems
www.neracoos.org
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