American Lobster Settlement Index | Update 2018

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http://umaine.edu/wahlelab/current-projects/american-lobster-settlement-index/

With US lobster landings looking like they may be either stabilizing or slipping off their 2016 all-time high, and Canadian landings surging ahead, many in the industry and management on both sides of the border are wondering how the landscape may change for the future of North America's most valuable fishery. Even as 2018 landings are still being tallied in some sectors, Maine reported a 7% uptick from its 16% downturn in 2017. Canadian harvests on the other hand have been booming, with Gulf of St. Lawrence fisheries reporting double-digit increases over the past few years. Widespread declines in settlement in the Gulf of Maine over the past few years have raised concerns over the future of this region's fishery. But mixed signals about the strength of up-coming year classes have left some uncertainty about what these declines mean for future recruitment there. While the ALSI suggests some weak year classes coming down the line, Maine Department of Marine Resources (DMR) trawl and ventless trap surveys show especially large numbers of sublegal lobsters in deep waters. On the other hand, large settlement increases and rising landings in the southern Gulf of St. Lawrence leave little doubt about the prospect of a bright future there. In this *Update* we take a closer look at 2018 and how we evaluate the forecasting value of the ALSI time series.

Settlement 2018: Our last *Update* reported the tremendous settlement surge on the north shore of PEI. In 2018 we saw a repeat performance (**Fig. 1**), with settlement nearly doubling again, and average densities of young-of-year lobsters in northern PEI exceeding our previous all-time high at Beaver Harbour, NB, in 2006. By contrast, counts in Northumberland Strait have remained low. Sampling on the Cape Breton and Canso shores of Nova Scotia was discontinued after a series of very low settlement years, so it is hard to say how far the settlement boom may have extended to that area. Southwest Nova Scotia also reported a strong 2018 with St. Mary's Bay at record highs, and Lobster Bay on par with its previous highs. Beaver Harbour, NB, and Maine's 'Downeast' shore, reported only a minor uptick, and the remainder of the Gulf of Maine, from Mt. Desert to Cape Cod Bay, continued their string of well below-average numbers. Areas south of Cape Cod again report barely detectable settlement.

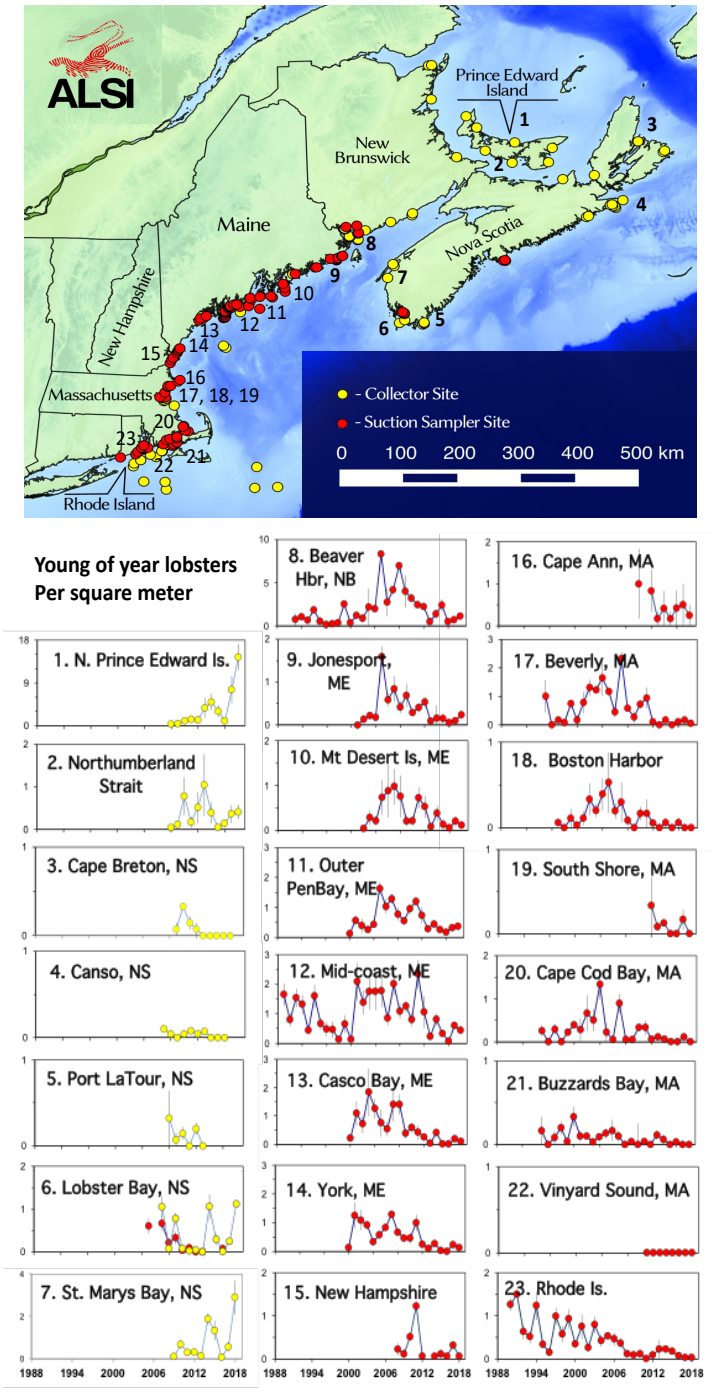

Figure 1. ALSI sampling in New England and Atlantic Canada. Diver-based suction (red) and vessel-deployed collector (yellow) sampling locations and corresponding time series of young-of-year (YoY) settlement for selected groups of sites in numbered study areas.

The anatomy of a forecast: How well does the settlement index predict subsequent landings? In this *Update* we ask how well we predicted landings trends given what we knew only in 2013? This is like asking how well your phone's weather app predicted today's temperature several days ago, except on a scale of years instead of days. Each year, the vast majority of the lobster harvest comprises new recruits to the fishery – those that have just grown into legal size. The volume of landings is therefore highly dependent on new entrants to the fishery. Regional and interannual temperature differences cause lobsters to take anywhere from 5 to 10 years to enter the fishery after larvae settle; a year of recruitment therefore represents a mix of ages. Taking these complexities into account, the annual ALSI survey provides an early warning of the strength of upcoming year classes several years in advance of the harvest. **Fig. 2** illustrates how we translate the settlement index into a landings forecast and validate the prediction. In *Update* 2015 we showed that settlement is a key determinant of subsequent lobster landings in statistical reporting areas from Rhode Island to the Bay of Fundy. Further improvements to the predictions come by incorporating regional differences in temperature that affect growth, and shell disease prevalence that affect mortality.

To validate the model the first step is to test the strength of the relationship between the model-predicted trend and the observed trend in landings. This is called "hindcasting." We found a statistically significant relationship between settlement and reported landings for 9 of 10 areas between New Brunswick and Rhode Island. We give examples of six study areas in **Fig. 2**. Current record landings in the Gulf of Maine can be traced back to an expansion of settlement into eastern Maine and the Bay of Fundy that peaked between 2005 and 2008 (Beaver Harbour, for example), but was weaker in mid-coast Maine and the western Gulf of Maine. The collapse of the southern New England fishery is linked to declines in settlement tied to shell diseased broodstock (**Fig. 2A-C**).

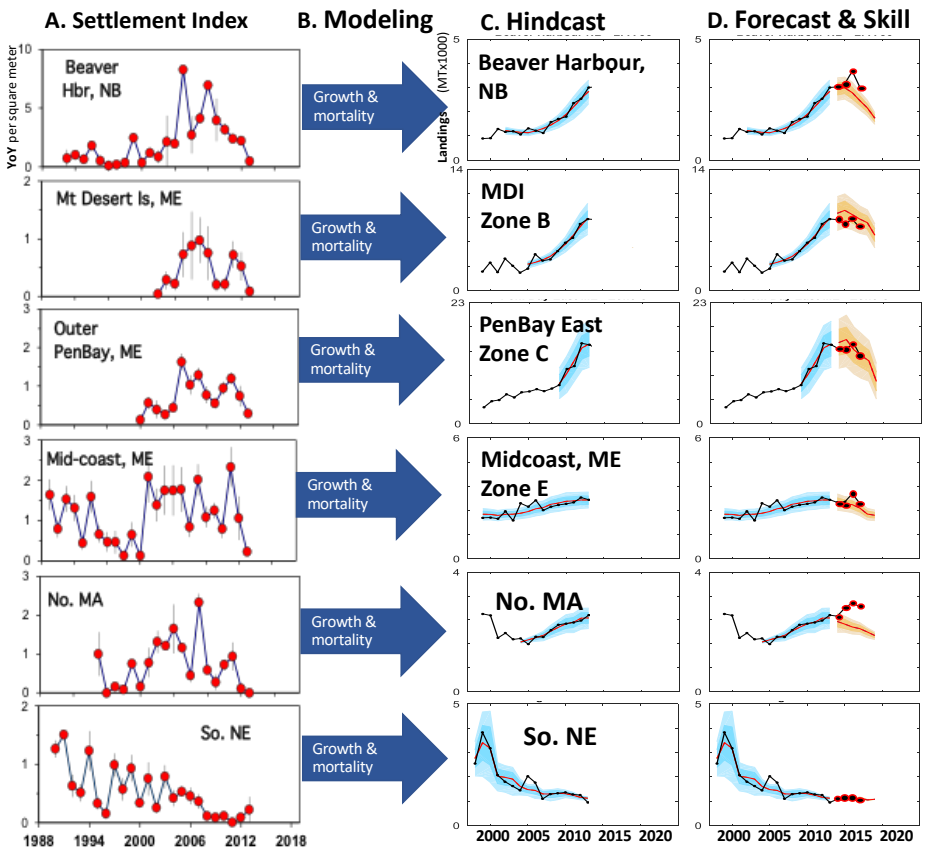

Figure 2. Anatomy of forecast model development and validation. A. The settlement index is the primary input to the predictive model. Here we show six of our longer ALSI time series through 2013 from areas with a range of environments and settlement trajectories. **B.** The model itself includes mathematical expressions for growth and mortality tailored to each study area; **C. Hindcast** model validation is a statistical comparison of the modeled fishery recruitment trend (red line within the blue confidence interval) to the observed landings (black line). **D.** On the strength of hindcast, we **forecast** landings in the out-years, beyond 2013, shown as the red line within the orange confidence interval. The **"skill"** of the forecast is assessed as more years of landings accumulate. Depending on how well the model forecasts future landings, it may or may not need to be tuned and updated.

The next step evaluates the skill of the 2013 version of the model to forecast landings trends in the out-years for which future harvest were yet to be seen. **Fig. 2D** compares the forecast to landings after four more years of landings have accumulated. For most sectors the prediction aligns quite well with landings in the out-years, but under-predicts landings in some cases: northern Massachusetts (Cape Cod Bay to the NH border), for example. Considerable departures such this suggest landings may be subsidized by immigration from the northeast or harvesting outside the monitoring area.

In short, models represent hypotheses; there is no crystal ball. Our hypothesis is that lobster settlement trends accurately capture young-of-year abundance trends and that variations in young-of-year abundance drive landings. This is consistent with the historical pattern across a wide range of areas. Evaluating forecasts as we did above provides a test of the hypotheses embedded in the model. In the end, the main goal of our research is to help stakeholders in the lobster fishery gain the lead time to make choices; to consider the implications of potential declines in the fishery; and to understand the perceived benefits and risks of using such a forecasting tool. **θ**