New England Lobster Settlement Index: *Update 2005*

Climate Controls?

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The New England lobster settlement index survey has several new developments to report on the coverage and utility of the time series. Currently supported by three US states and Canada's Department of Fisheries & Oceans (DFO), one of the central goals is to better understand the causes and consequences of variable larval supply to regional differences and time trends in the adult population. This update briefly summarizes the 2005 settlement patterns and features a new development in the program.

- ***Expanding Horizons:*** In 2005, John Tremblay, of DFO Canada, led pilot sampling at six new sites in Lobster Bay, southwest Nova Scotia, broadening the geographic scope of the survey (Fig. 1). He reported densities of young-of-year lobsters comparable to counts on the other side of the Gulf in Maine during the same year (Fig. 2).

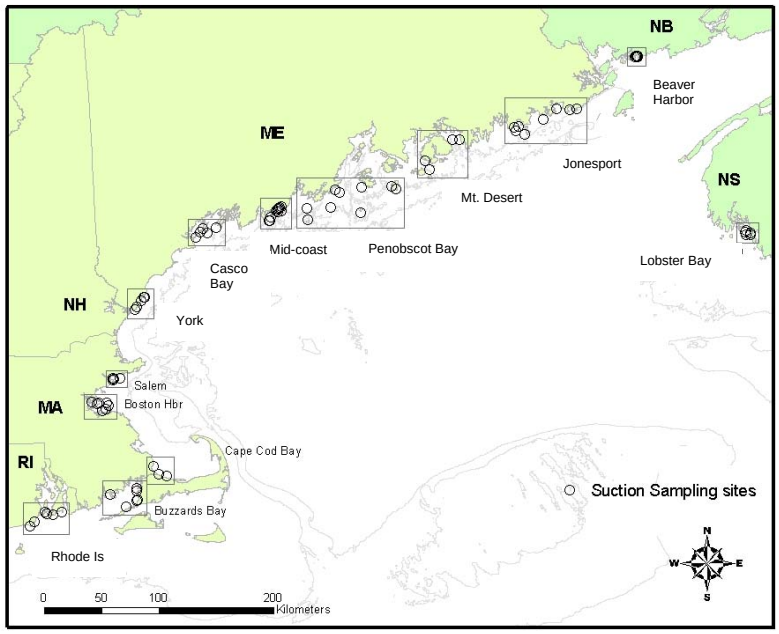

Fig. 1. Sampling sites of the New England lobster settlement index. Initiated at a few sites in Maine and Rhode Island in 1989-90, the survey now spans some 65 sites from RI to New Brunswick. Six new sites in Lobster Bay, Nova Scotia were sampled in 2005. Boxes surround sites used for regional averages shown in Fig. 2. Surveys are conducted by divers using suction samplers in shallow rocky nurseries.

- ***Eastern Pulse:*** Most regions in 2005 saw the continuation of the stretch of strong settlement since 2001. The remarkable feature of this year's survey was the pulse of high settlement in eastern Maine and New Brunswick (Fig. 2). Eastern Maine, which historically has received a relatively poor supply of settlers, saw higher densities that are more comparable to western Maine. Most remarkable were the astronomically high numbers in Beaver Harbor, NB, a location that has historically had high numbers. This pulse of settlement in eastern Maine may bode well for recruitment to the fishery in the future. In last year's update, for example, we reported how the settlement index was proving to be of predictive value for trends in the abundance of lobsters about to enter Rhode Island's fishery. But the question remains: what drives variability in settlement in the first place?

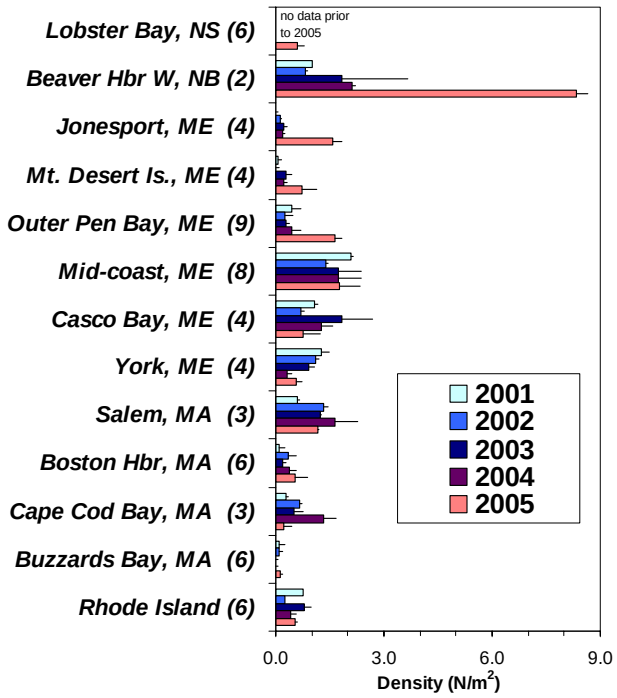

Fig. 2. Regional average lobster settlement throughout New England from 2000 to 2004. Number of sites averaged for a region in parentheses.

- ***Links to Climate:*** We are interested not only in future projections, but in looking back in time to understand the conditions during the larval hatch and development period that might explain the ups and downs in the supply of settlers. While the number of egg-bearing females is not likely to change much from year to year, the environmental conditions that affect the transport and survival of larvae hatching from those females can vary dramatically, and are therefore considered to be an important player in settlement patterns. In our 2003 update we explained how time trends in settlement have proven to be synchronous over large geographic areas; that is, when it is a strong settlement year in mid-coast Maine, for example, it also tends to be a strong year in Beaver Harbor, New Brunswick, and Salem, Massachusetts at opposite ends of the Gulf of Maine. We must conclude that whatever forces drive annual variability in settlement, they are operating at large geographic scales. Larger scale processes likely to be operating synchronously are ocean circulation and weather. This large scale spatial coherence, as it is called by oceanographers, suggests that lobster settlement is coupled to changes in the ocean-atmosphere system around the Gulf of Maine.

In a preliminary analysis led by oceanographer Andrew Pershing, Cornell University, we have discovered that the time series of lobster settlement in mid-coast Maine, our longest time series, mirrors the pattern of an atmospheric measure called the *"mean summer 700 millibar geopotential height anomaly"* (Fig 3). Atmospheric pressure, measured as millibars (mb), is about 1013 mb at sea level, and it decreases with greater altitude. The *700 mb geopotential height* is the altitude at which the atmospheric pressure is 700 mb. That height varies as low and high pressure systems move through a region. The *height anomaly* is the difference between the measured height and the long-term average height at that location. High values of geopotential indicate elevated atmospheric pressure, such as occur when a "Bermuda High" brings hot sunny weather to New England during the summer. Gradients in geopotential height indicate the strength and direction of large-scale winds. In this preliminary analysis, we found no strong east-west or north-south gradients in the geopotential fields associated with lobster settlement, either during low or high settlement years. This suggests that winds may not play as important a role in large scale variability, contrary to our original hypothesis. Instead, high settlement was associated with generally higher pressure (upper half of Fig 3b) and low settlement with lower pressure (lower half of Fig. 3b). At the scale of this analysis, an increase in the regional average geopotential likely indicates a northerly shift in the path of the jet stream, resulting in a warmer atmosphere, warmer sea surface temperatures, and in turn, more rapid lobster larval development. Less time spent in the water column should reduce larval exposure to predators and their chances of being dispersed offshore.

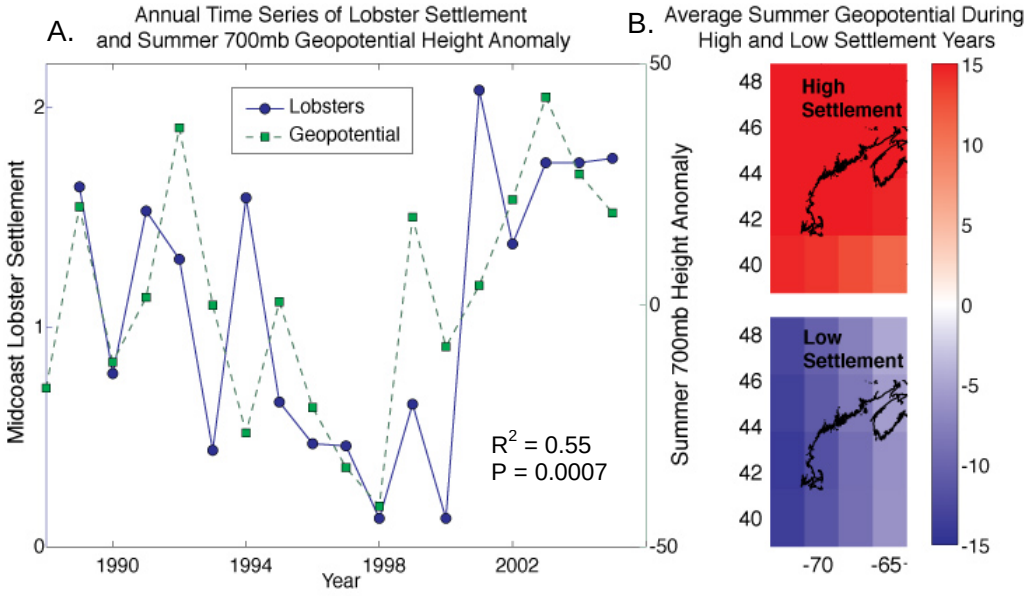

Fig. 3. **Atmospheric correlates of settlement.** (a) Correlated time series of mid-coast Maine settlement (circles) and summer geopotential in the northeast US (squares). (b) Geopotential gradient maps associated with high (top) and low (bottom) settlement years. Absence of strong gradients suggests wind is not as strong a factor as suspected (from Wahle & Pershing in prep.).

This is only the first step in an analysis exploring the atmospheric and oceanographic conditions determining patterns of settlement in time and space. The correlation between settlement and geopotential may provide a way to estimate the impact of global climate change on one aspect of lobster biology.