Session: Climate Research

Evidence for Regime Shifts on the Northeast U.S. Continental Shelf

Charles Perretti, Laurel Smith, Ryan Morse, Sean Lucey, Michael Fogarty & NEFSC Climate, Ecosystems, and Habitat Study Group

Marine ecosystems often experience rapid, persistent changes in state known as regime shifts. Identifying and understanding the mechanisms behind these shifts is highly important given their large ecological and economic impacts. Regime shifts are especially well documented in the Northeast U.S. Continental Shelf ecosystem. Decadal shifts in salinity have been observed in the North Atlantic for more than 100 years (Dickson *et al*. 1988, Sundby and Drinkwater 2007), shifts in phytoplankton are well documented, as are shifts in zooplankton community composition (Bi *et al.* 2014 and references therein).

Although there is broad evidence for regime shifts in water mass properties and low trophic levels of the Northeast U.S. Shelf, there is less evidence for shifts in higher trophic levels, particularly in fish taxa. Fish populations are often impacted by both top-down and bottom-up forcing, which makes identifying regime shifts more challenging, particularly when analyzed in a single-species context. Here we seek to complement earlier analyses centered on individual stocks with an explicitly multivariate approach focused on testing for coherent and persistent phase shifts in recruitment success for a suite of stocks on the Northeast U.S. Continental Shelf. We then test for possible underlying environmental drivers.

We estimated recruitment success using both stock assessments and direct observations from the NEFSC bottom trawl survey. Our primary index of recruitment was the ratio of recruit biomass to spawner biomass (*i.e.*, the survival index), and we also estimated recruitment success as the residual from a best-fit spawner-recruit model. In addition to the recruitment indices, we examined changes in fish condition (weight-per-length anomalies), and the copepod community abundance and structure. A cluster analysis with temporal contiguity constraints (Legendre and Legendre 1998) was used to test for change points in each set of time series.

We found evidence for three recruitment phases in all of the fish datasets— an initial phase of low recruitment through the late 1980s, a phase of high recruitment through the 1990s, and finally a return to low recruitment through the end of the time series (Figure 1). We also found evidence for distinct regimes in fish condition, with the 1990s being a period of above-average condition, and the 2000s being a period of below-average condition.

We found similar change points in the copepod community— the 1980s comprised a period of low copepod abundance, the 1990s were characterized by high abundance, and in the 2000s a return to low abundance occurred. Similarly, the size-ratio of dominant copepods exhibits distinct regimes—the 1980s were dominated by large copepods (e.g., *Calanus finmarchicus*), the 1990s were dominated by small copepods (e.g., *Pseudocalanus newmani*), and the 2000s were again dominated by large copepods.

There is also a latitudinal gradient in the strength of regimes. The Gulf of Maine exhibited the strongest regimes in both fish recruitment and copepod community structure, the Mid-Atlantic Bight was the least affected by regimes, and the Georges Bank region is between the two.

Regime-like behavior in fish recruitment, and the ecosystem more broadly, holds important implications for management. If shifts in productivity states remain unrecognized and unaccounted for through adjustment in management reference points, particularly during reduced productivity periods, risk to the population(s) may be underestimated.

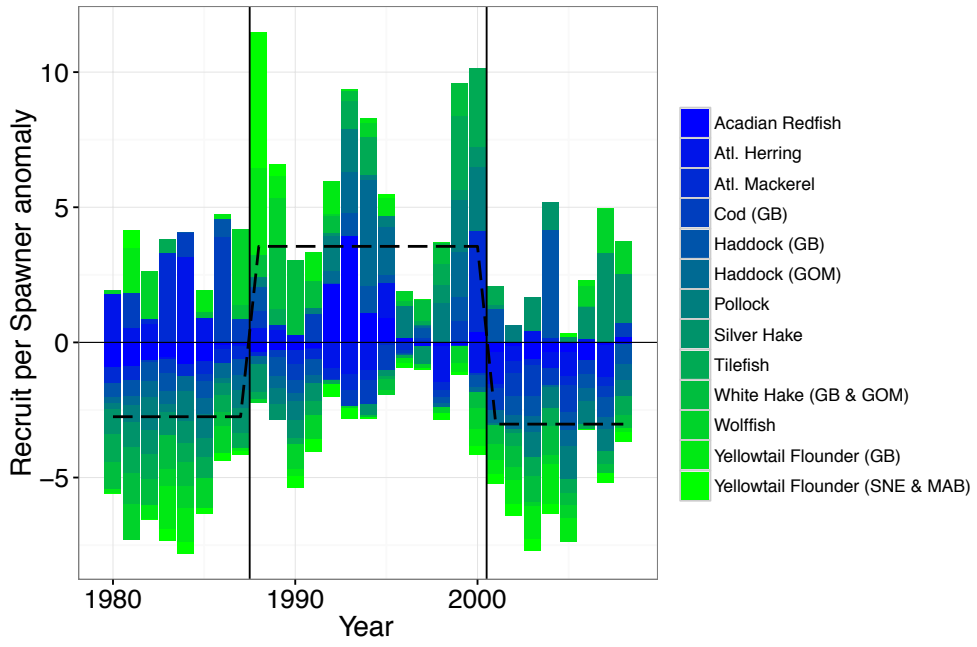

Figure 1. Recruitment regimes for all fishes assessed from 1980 – 2008. The vertical lines are the regime shift change points, and the dashed line is the annual summed anomaly averaged throughout each regime.