Investigation of Nearshore Migration of Atlantic Salmon in the Gulf of Maine Region

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http://www.seagrant.umaine.edu/program/nmfs-nearshore-salmon-ecology
Workshop #2 Abstracts

**Overview of Gulf of Maine (especially coastal) surface circulation**

Neal Pettigrew, University of Maine

Surface currents in the Gulf of Maine (GoM) are complex and variable. However, the coastal circulation patterns in spring and summer are dominated by the Gulf of Maine Coastal Current system that flows cyclonically from Nova Scotia to Cape Cod. After the spring freshet and prior to the fall overturn, the GMCC has two major branches, the Eastern Maine Coastal Current (EMCC) that flows southwestward from Grand Manan Island to the vicinity of Penobscot Bay, and the Western Maine Coastal Current (WMCC) that flows southwestward from Penobscot toward Cape Ann (Churchill et al. 2005, Pettigrew et al. 2005). The degree of connection between these two currents is quite variable and plays a potentially important role in the ultimate destination of material transported alongshore. The EMCC is typically substantially stronger than the WMCC, and much of its transport turns offshore near Penobscot Bay thus interrupting the continuity of the southwestward coastal flow. In extreme case little of the EMCC water continues on to the western shelf. At the other extreme there are seasons and years in the GMCC is more like a continuous flow along the coast. When there is a great deal of flow-through the currents in the WMCC may be twice their usual strength, and in the case of late seasonal northeast winds, the GMCC as a whole may flow at nearly 1 $ms^{-1}$.

The Gulf of Maine Ocean Observing System (GoMOOS) includes an array of buoys that make direct current measurements in the GMCC. A comparison of currents east and west of Penobscot Bay has proven a useful indicator of the degree of continuity or connection between the EMCC and the WMCC. These data are available in realtime via the internet at http://gyre.umeoce.maine.edu and http://www.gomoos.org. There are indications that the circulation patterns in outer Penobscot Bay are linked to both the EMCC and the WMCC. Examples of analyses showing seasonal and interannual variability circulation features will be presented.

**Environmental Monitors on Lobster Traps**

Jim Manning, NMFS, Woods Hole, MA

eMOLT is a collaboration of industry, government, and academia (funded by the Northeast Consortium since 2001) that develops low-cost strategies for continuous monitoring of physical variables at fixed locations around the Gulf of Maine and the Southern New England Shelf. With the help of nearly 100 lobstermen, the objective is to maintain the observations for years to come and contribute to the region's ocean observing system. The most significant findings from the various phases of the project will be presented including: a) a quick look at the temperature variability, b) the cumulative result of over 300 satellite-tracked drifter paths, and c) a brief description of new instrumentation under development. For the purposes of this workshop, results will focus on mid-coast Maine with some discussion on data access (see emolt.org).

# **Forecasting circulation and hydrography of the Gulf of Maine**

Huijie Xue, University of Maine

An operational forecast system has been developed as an integral component of the Gulf of Maine Ocean Observing System (GoMOOS). It has been used daily since 2001 to produce short-term forecasts of the circulation and hydrographic properties in the Gulf of Maine. The framework of the forecast system will be presented, and comparisons between the predicted and the observed temperature (both *in situ* and satellite-derived) and velocity will be discussed. In general, the assimilation algorithm is stable and produces robust SST patterns. Seasonal variations in temperature and the coastal current are reasonably reproduced. The forecast system can be used effectively to simulate the transport of waterborne particles and biological organisms in the Gulf of Maine. For example, a coupled biophysical, individual-based model has been developed and embedded in the forecast system to model the transport and development of lobster larvae in the coastal Gulf of Maine. The individual based model considers patterns of egg production, temperature-dependent larval growth, stage-explicit vertical distributions of larvae, and mortality. Seasonal and interannual variability in post-larva distributions can be estimated in response to real-time currents and temperature in the Gulf. The Gulf of Maine operational forecast can be viewed at http://rocky.umeoce.maine.edu/GoMPOM/ and a summary of the lobster larval individual based model and the simulations can be found at http://rocky.umeoce.maine.edu/synthesis_lobster.html.

**Remote sensing of sea surface temperature in the Gulf of Maine**

Andrew Thomas, University of Maine

Satellite sea surface temperature (SST) and ocean color data (chlorophyll concentrations, CHL) received and processed at U. Maine provide synoptic views and a consistent multi-year time series of surface temperature and chlorophyll in the Gulf of Maine. Both data sets are at a 1km spatial resolution, the SST begins in 1985, the chlorophyll in 1997, with both continuing to the present day. Coverage is daily. However, cloud cover effectively restricts the temporal resolution to ~ weekly. Individual day, weekly and monthly products are routinely produced and archived. From these both climatological averages and interannual anomalies are calculated. Both SST and CHL imagery strongly reflect overall Gulf of Maine circulation and bathymetric patterns. Interannual anomalies show clearly the strong heterogeneous nature of surface patterns in the Gulf of Maine, making clear statements about "warm" or "cold" years difficult. Examples will be shown to illustrate satellite data effectiveness and coverage as well as the limitations of the data. Examples of analyses showing seasonal and interannual variability over the time periods of data availability will be presented. Many of these data products can be viewed at the U. Maine Satellite Data Lab web site: www.seasurface.umaine.edu.

**Perspectives on changes in post-smolt growth and survival for Bay of Fundy and Nova Scotia Atlantic coast Atlantic salmon populations**

Jamie Gibson

Atlantic salmon populations in Bay of Fundy and Nova Scotia Atlantic coast (Southern Upland) rivers have been in decline for well over two decades. Return rates currently differ by about an order of magnitude within this region, with higher return rates being observed for outer Bay of Fundy and Southern Upland (SU) populations than for inner Bay of Fundy (iBoF) populations. Two recent research initiatives, focused on addressing questions about why marine survival has changed, are described. In the first of these projects, post-smolt scale circulus spacing patterns for two SU salmon populations were compared with spacing patterns from two iBoF populations to determine if growth patterns differed among these populations, and if growth patterns had changed as the abundance of these populations declined. During summer and autumn, mean circulus spacing in the iBoF populations, known to have occupied the outer Bay of Fundy during these seasons, was lower than in the SU populations, which are known to migrate to the North Atlantic. Similarities in circulus spacing patterns within SU populations are suggestive of a common marine distribution with a change in spacing identified for the 16th to 25th circuli pairs between pre-1990 and post-1990 samples. These pairs correspond roughly with the late fall and early winter seasons. In contrast, a cluster analysis revealed that within the geographically intermediate Big Salmon River (iBoF), some individuals exhibited wider spacing patterns that resemble the distant migrating SU populations, while others exhibited narrower spacing similar to another iBoF salmon population. Within the Big Salmon River, the relative abundance of the wider and the narrower spacing patterns varied in the earlier years, but all fish sampled since 1999 exhibited wider spacings similar to distant migrating SU populations. The apparent disappearance of the narrower pattern, characteristic of localized migration and indicative of historical iBoF populations, suggests that local migration may not presently be a successful strategy for these populations. In the second project, a population model was used to evaluate changes in mortality in the Big Salmon River salmon population over a 42 year period. The types of data collected on iBoF salmon populations vary from 1954-2005 and include: recreational catch and effort, fence counts, redd counts, dive counts and juvenile densities estimated by electrofishing. Recreational catch and effort data (1951-1990) document removals from the river from the general public. A counting fence (1966-1972) was operated on the river where both smolt and adult salmon were enumerated duringg migration. Redd, dive and shoreline counts (1988-2002) give an index of spawner abundance for those years. Juenile densities were estimated by electrofishing (20 years of data between 1966-2002) for three age groups of juvenile salmon. Despite considerable gaps within the data series, annual estimates of at-sea mortality, and the rate at which fish mature, were obtained for the years 1964-2004 by fitting a population model to the 17 data series simultaneously using maximum likelihood. The resulting at-sea mortality time series was then used to examine relationships between survival and anthropogenic, climatic, environmental and oceanographic variables. At-sea mortality was estimated to vary from ~78% to ~99% over this period. Linear regression techniques were then used to test for significant relationships between yearly at-sea mortality rates and 72 indices related to ten proposed hypotheses for decline. Five indices show significant regressions (p-value $\leq 0.05$ and R2 $\geq 0.30$, threats: seals, aquaculture, cormorants), but due to the nature of those individual datasets there is the potential for spurious correlations. More importantly, there are 60+ indices representing seven threats that show highly non-significant regressions, contributing to the ‘hypothesis reduction’ of the threats to iBoF populations. Together, these analyses suggest that ecological community shifts (predator/prey) or interactions with farmed salmon are more plausible explanations for the decline in abundance of iBoF salmon than are changes in environmental conditions or in fisheries (although temperature relationships warrant further investigation).

## Cod demise and crustacean rise: How have mysid populations changed?

Peter Jumars

This question cannot be answered. That situation is unfortunate, but the reasons for it are informative. Mysids occupy dynamic, difficult-to-sample environments. They migrate both daily and seasonally and are favored foods of both groundfishes and pelagic fishes. Evasion of nets by mysid schools is well documented. There is no reliable estimate of their historical or current abundance, but they are ideal foods for fishes that are of order 10 cm long. Mysids are notoriously omnivorous. High-frequency acoustics begin to answer some questions, but raise many more about whether mysids play lead roles or bit parts in nearshore food webs.