Partial Migration by New York Harbor and Hudson River Striped Bass: Insights through Multivariate Analysis

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Summary

Partial migration, by which contingents within populations undertake divergent migrations, is common in marine fishes but remains poorly documented. Intrapopulation groups of fish with similar seasonal migration behaviors were noted early in the fisheries literature and have attracted increased interest for their role in population resilience. Here we used acoustic telemetry to test historical hypotheses on contingent structure for striped bass *Morone saxatilis* in the Hudson River, which harbors one of the largest populations of this species. Season and region of release were used as design elements to evaluate three principal contingents. A total of 51 implanted striped bass were recorded in New York Harbor (NYH), Hudson River, and other estuarine and coastal receiver arrays from June 2010 through December 2011. Principal component and cluster analysis of >500,000 recoveries confirmed predictions of three broad contingent behaviors, those that principally utilized the (1) upper Hudson River Estuary, (2) NYH and Lower Hudson River Estuary, and (3) coastal waters, but commingled in upper Hudson River spawning habitats during late spring. Contingent structure within Hudson River striped bass likely distributes the influences of regional fisheries, pollution, and other environmental forces, promoting stability and persistence in the overall population.

Introduction

With recent advances in acoustic tracking technologies, scientists have begun observing migration at varying scales. Of particular interest, intrapopulation groups of individuals share similar seasonal migrations that persist over much of their lifespan. The term "contingent," dates back to the origins of modern fisheries science (Hjort 1914) but was recently revived by Secor (1999), who postulated that contingents of fish remain distinct by maintaining divergent migration pathways as systems of partial migration. Through partial migration, contingents are differentially exposed to sets of habitats that cause independent outcomes, resulting in an averaging or portfolio effect (Secor in press).

Here, we tested contingent structure to better understand the practical implications of contingent structuring. We strategically placed acoustic receivers in the Hudson River and New York Harbor to test through multivariate statistics how classified contingents differed in their (1) overall and seasonal patterns of migration in the Hudson River estuary and coastal regions, (2) use of NY Harbor in particular, and (3) "choice" of migration corridors into and out of NY Harbor and Hudson River.

Methods and Materials

During the period October 2009 to May 2010, 75 striped bass were captured, implanted with an acoustic transmitter, and released in specific regions to test whether contingent behaviors persisted among seasons and years. The contingents included (1) Upper Estuary Contingent, UEC (n=15)

caught in tidal freshwater Hudson River during fall 2009, (2) Lower Estuarine Contingent (n=40) caught in NY Harbor region during fall 2009, and (3) an Ocean contingent OC (n=20) of large (>700 mm TL) ripe adults captured in the Hudson River during the 2010 spring spawning season. Transmitters were surgically implanted. Fish were detected by remote receivers in (1) Upper and Lower Estuary regions of the Hudson River; (2) NY Harbor ; (3) the South Shore of Long Island ; (4) Southern New England ; and (5) Delaware Bay. The primary study objective was to evaluate whether seasonal habitat use differed among contingents. The term of the study was 1 June 2010 to 1 December 2011. Habitat regions included Upper Hudson River, Lower Hudson River, NY Harbor, Long Island, and Coastal, the latter including Delaware Bay. The resulting data were numbers of days in which an individual was detected at a certain receiver site or within a greater spatial area. These data were employed in analyses at two temporal levels, the entire study period and each of six seasons.

Multivariate analyses of regional habitat incidence were conducted using Principal Component Analysis and hierarchical cluster analysis. The first approach allowed reduction of a large dataset of daily records of individuals among regions, followed by *a posteriori* tests for contingent effects. The second approach was used to uncover additional structure that was not specified in the experimental design (i.e., groups in addition to the three tested contingents).

Results and Discussion

This telemetry study on 75 tagged striped bass (51 analyzed) confirmed that at least three contingents exist within the Hudson River stock and that they follow divergent, but overlapping, migration pathways. The contingents of striped bass shared similar seasonal migration behaviors, which likely have population level consequences for how individuals encounter pollution, water quality, foraging and reproductive conditions, and fishing pressure (Secor 1999).

Multivariate analyses indicated that the LEC exhibited greater variability in regional habitat use patterns than other contingents. Still, from a broad regional perspective, the LEC showed a higher affinity for a mix of NYH and coastal habitats than did the other two contingents. At finer resolution – apparent in the cluster analysis - contingent sub-groups were identified with varying affinities for more exclusive NYH incidence or increased reliance on either western Long Island or more distant coastal regions. The UEC showed expected patterns of residency throughout most of the year (Wingate & Secor 2007), with the exception of winter where they occupied down-estuary regions. No striped bass were observed to remain in the Upper Estuary during winter months. Also conforming to predicted behaviors, the OC spent the least amount of time in the upper or lower estuaries, appearing there solely during the spawning season.

The multiple statistical approaches used in this study complemented each other to confirm general contingent behaviors while also documenting previously unknown levels of migratory diversity. Results from the PCA and contingency table analysis converged and demonstrated the validity of contingent structure in the Hudson River striped bass population.

References

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