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Habitat connectivity in a catadromous fish

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Using network analysis techniques, where nodes represent physical locations of receivers and edges are movements between locations, we explored the connectivity of habitats during the spawning and non-spawning seasons among 280 Common Snook surgically implanted with acoustic transmitters along the east coast of Florida. Comparisons of the number of movements between nodes, centrality, and gateways over 5 years revealed differences in habitat use and connectivity between seasons. During the non-spawning season, estuarine and riverine habitats were the center of activity compared to the spawning season when movements were more centralized around inlets and to a lesser degree, estuaries. Amongst years, habitat had a higher influence on movements than region during the spawning and non-spawning seasons. Overall, the population of common snook on the eastern coast of Florida showed low centrality.

Introduction

Habitat connectivity is an important factor in gene flow, local adaptation, and persistence of a population (e.g., Baird 1999). Network theory is an emerging analysis methodology for acoustic telemetry that describes and tests the connectedness of locations (i.e. receivers or nodes) through movements (i.e. ties) (Jacoby et al. 2012). The objectives of this study were to 1) determine which are the most important sites in the receiver network according to degree, closeness, and betweeness; 2) quantify the influence of habitat and region on movements and; 3) evaluate the spatial centralization of the common snook population on the east coast of Florida. Objectives were examined on biannual scale: non-spawning (16 October – 14 April) and spawning (15 April – 15 October) seasons.

Materials and Methods

Tagged fish were monitored within a collaborative array of over 200 receivers spanning >320 km from Ponce Inlet to Delray (between 29°04′N, 80°55′W and 26°28′N, 80°02′W). Within the array, Fish and Wildlife Research Institute (FWRI) staff deployed and maintained 62 automated Vemco acoustic receivers in rivers, estuaries, inlets, nearshore and offshore environments. Additional receivers were maintained by several organizations in the Florida Atlantic Coast Telemetry (FACT) group. During sampling from February 2008 to July 2012, adult-sized Common Snook were implanted with Vemco V-16 transmitters having an expected battery life of 4 years.

Prior to analyses, 'false' detections and single detections were removed from the dataset (Pinnock 2012). Exclusion of tagged fish from analysis based on low detection duration and/or suspect detection data has become more common in telemetry-based studies (e.g., Bijoux et al. 2013; Young et al. 2014). Tagged fish with <10 days detection duration in a season were removed from analysis for that season. Validation of detection data was achieved using SAS 9.3 software.

Network matrices were modeled using modified absolute interaction data (AID) where the number of movements of an individual between receiver A and B in less than 24 hours was divided by the total number of fish that moved between receiver A and B in less that 24 hours. Network visualization was achieved with Netdraw software with coordinate and spring imbedded networks by season and year. Node-based centrality measures (degree, betweeness, and closeness) were compared between years and seasons to determine the importance of receiver sites within the network (objective 1). A density model of variable homophily (ANOVA) was used assess the influence of habitat and region on movement (Objective 2). The model fit is indicated by the r2 coefficient. Network-based measures of centrality were compared to evaluate the degree of spatially heterogeneity of the population (objective 3). All analyzes were conducted in Ucinet 6.0 software.

Results

Two hundred eighty sexually mature Common Snook were implanted with V-16 acoustic transmitters tagged in all 5 systems (river, 52; estuary, 38; inlet, 103; nearshore, 54; offshore, 33). Surgery and release methodologies were considered successful based on high survival rate (95%) and healthy recaptures (Young et al. 2014). An average of 25.1% of detection data were invalid (false and single detections) and removed, resulting in a dataset > 7.5 million valid detections during Feb 2008 - Oct 2013.

Low network centralization (<2%) and high node size and edge weight suggest common snook utilize a greater area during the spawning season but movements were not focused. Number and direction of ties suggest common snook approach spawning sites through the estuary from the north. During the overwintering season, tagged fish were detected on significantly fewer receivers; combined with a marginally higher network centrality (<3%) and lower node size and edge weight this suggests that movements are smaller and more localized during this time period. Segregation of the population between inshore and offshore sub-populations was most evident during the overwintering season with moderate exchange occurring during the spawning season through nearshore habitat. Overall, spatial utilization of the population changed dramatically between seasons, this result emphasizes the importance of understanding temporal shifts in habitat prioritization for spatial management of catadromous species.

Discussion

The application of network theory to animal movements proved useful in establishing spatial usage of Common Snook regionally and between habitats. Common Snook are eurhayline, utilizing all available habitats along the east coast of Florida. We show that, despite genetic homogeneity of the population, the population is made up of components that use habitats in different ways. Furthermore, we show that habitat use shifts during the spawning season, when most exchange between inshore and offshore residing fish occurs.

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