Migration timing of commercially important fishes in the New York Bight

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Introduction

The continental shelf along the Northeast coast of the U.S. (NEUS) is broad, with shallow water depths extending 200 km offshore. The water properties of this region are largely determined by the positions and strengths of the Labrador Current (carrying cold, fresh water equatorward) and the Gulf Stream (carrying warm, saline water poleward). High resolution climate models have indicated the NEUS shelf is warming nearly three times faster than the global average (Saba et al., 2015). And the 2021 New York Bight Indicator Report found evidence of ocean temperatures in the region increasing in all seasons in both surface and bottom waters (Nye et al., 2021).

The NEUS shelf has supported commercial fishing for several centuries. Today commercial and recreational fishing contributes billions of dollars annually to the region's economy (National Marine Fisheries Service, 2023). As such, effective fisheries management is paramount to the region. Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) was an important commercial species until they were severely overfished. A moratorium was enacted on the fishery in 1998 and the species was listed as endangered in 2012. Today, there is little evidence of population recovery. This delay is largely attributed to life history characteristics, such as slow growth and late maturity; but, is exacerbated by anthropogenic impacts such as incidental capture in fisheries and potentially climate change. This study aims to use acoustic data collected in the Rockaways (Fig. 1), an area of high incidental capture of Atlantic Sturgeon (Dunton et al., 2010) and a known aggregation site, to identify the environmental drivers of migration and how climate change may impact migration timing in the future.

Methods

- The Data Set:
  - 158 acoustic receivers over 12 years (2010 – 2022) yielding ~4 million detections of 718 individual Atlantic Sturgeon

Environmental Variable	Location	Source
Local Temperature	NY Harbor (40.369 N, 73.703 W)	National Data Buoy Center
River Temperature	Tivoli North Bay (42.036 N, 73.925 W)	NOAA National Estuarine Research Reserve System (NERRS)
Regional Temperature	30 randomly selected points on the shelf	JPL MUR MEaSUREs Project

- The Models:
  - Generalized linear models (GLMs) were fit using a Gamma distribution and forward selection to find the best predictors of Julian day for the 10th, 50th, and 90th percentiles of Atlantic Sturgeon arrival and departure from the Rockaway array each year
  - Model selection was done using Akaike information criterion (AIC)
  - Forecasting was performed using the best models with simulated temperature data to predict changes in migration timing due to a warming climate

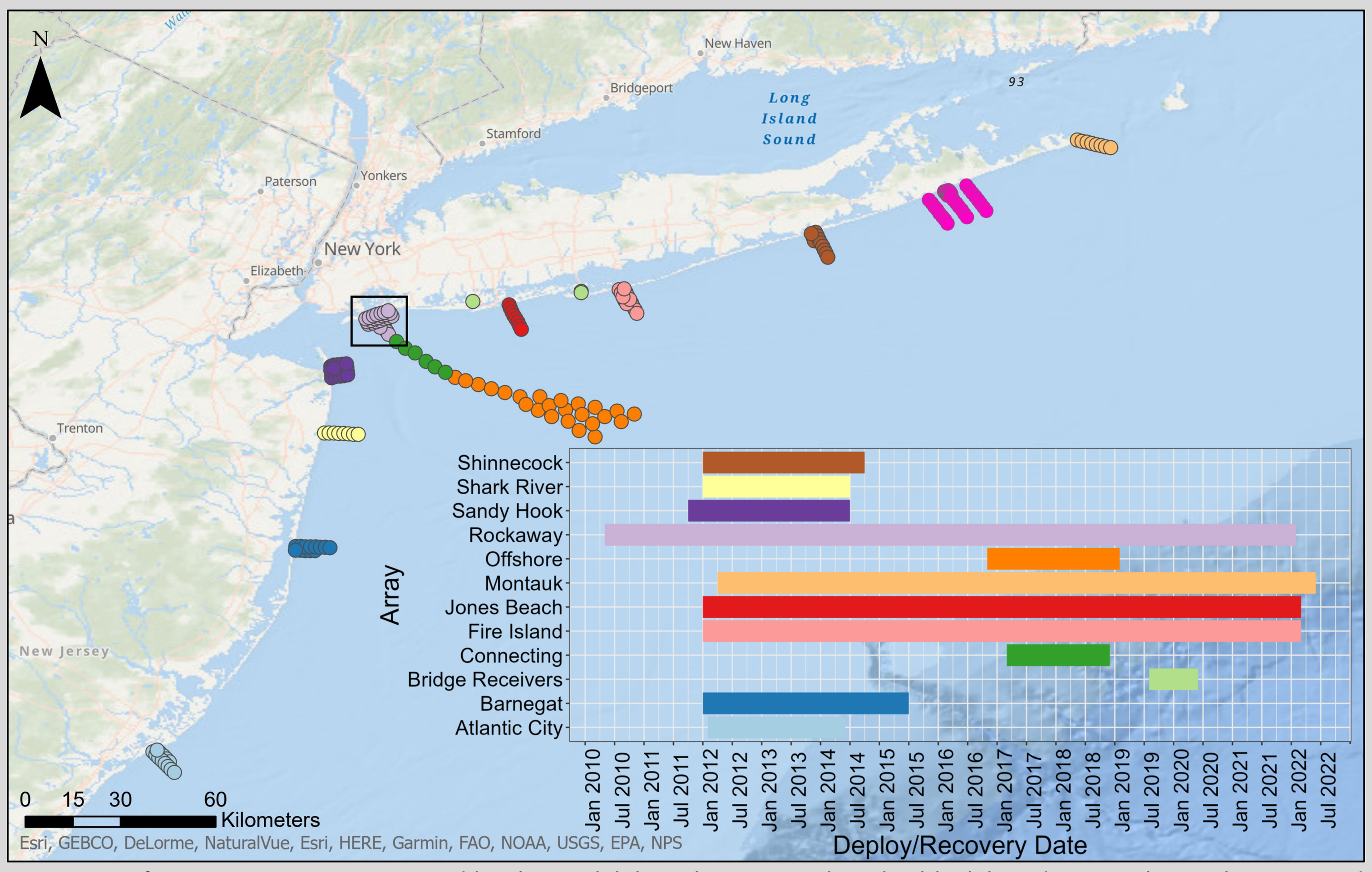

Figure 1: Map of acoustic arrays maintained by the Frisk lab in the New York Bight, black box denotes the Rockaways, and the duration of data collection for each array.

Results & Discussion

- All the best models had photoperiod and one of the temperature parameters as covariates
  - Lunar phase was never significant and was removed from all models
- Photoperiod and temperature appear to be cues to migration
  - Results support those found in Ingram et al. (2019)

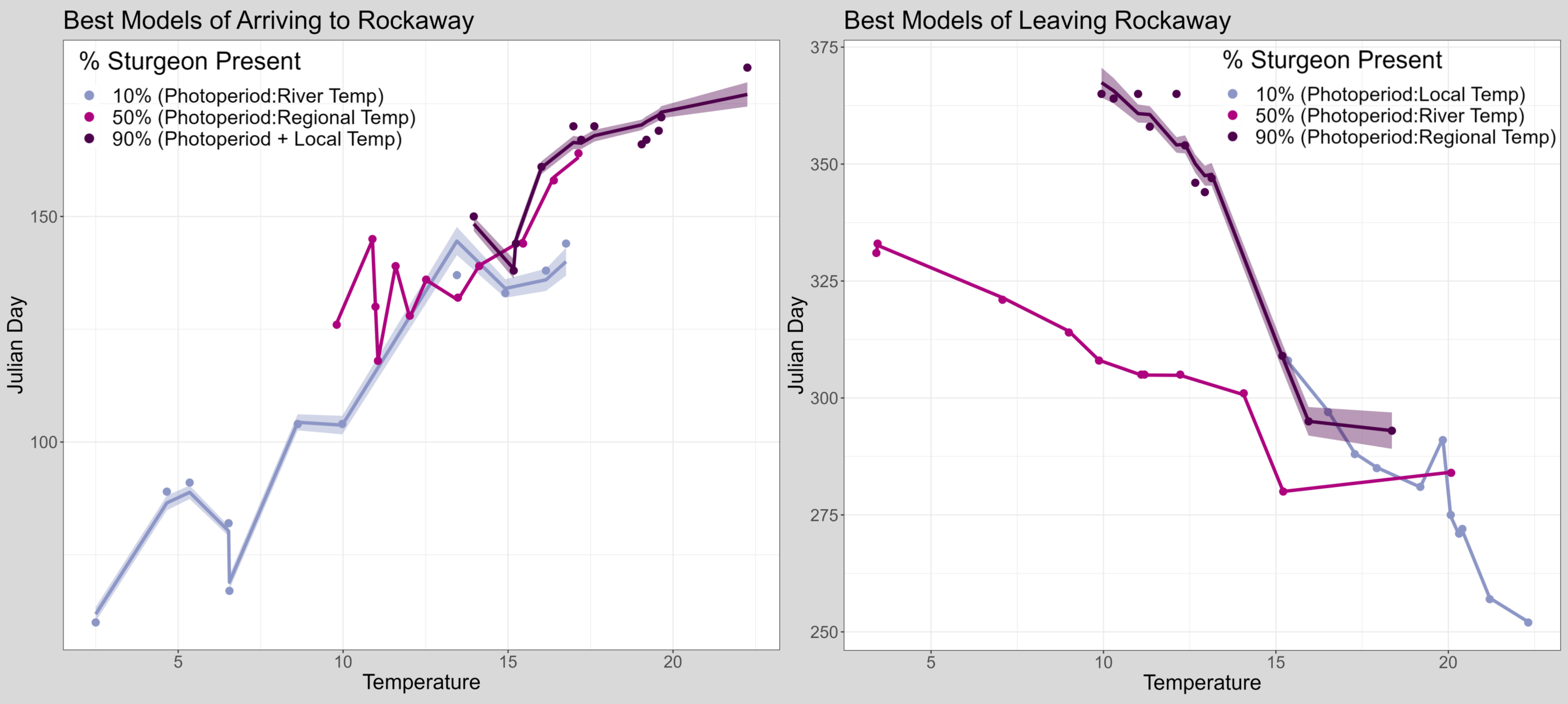

Figure 2: Right panel shows model results for the 10th, 50th and 90th percentiles of Atlantic Sturgeon arriving to the Rockaways plotted against temperature. Left panel shows model results for the 10th, 50th, and 90th percentiles of Atlantic Sturgeon departing from the Rockaways plotted against temperature.

Model Results

Model	Model Formula	Deviance		Degrees of Freedom		n
		Null	Residual	Total	Residual	
10% Arrive	Julian Day ~ Photoperiod * River Temperature	0.870	0.007	10	7	11
50% Arrive	Julian Day ~ Photoperiod * Regional Temperature	0.098	0.0001	11	8	12
90% Arrive	Julian Day ~ Photoperiod + Local Temperature	0.071	0.0036	11	9	12
10% Leave	Julian Day ~ Photoperiod * Local Temperature	3.56E-12	8.33E-06	10	7	11
50% Leave	Julian Day ~ Photoperiod * River Temperature	2.97E-02	5.83E-06	10	7	11
90% Leave	Julian Day ~ Photoperiod * Regional Temperature	0.074	0.001	11	8	12

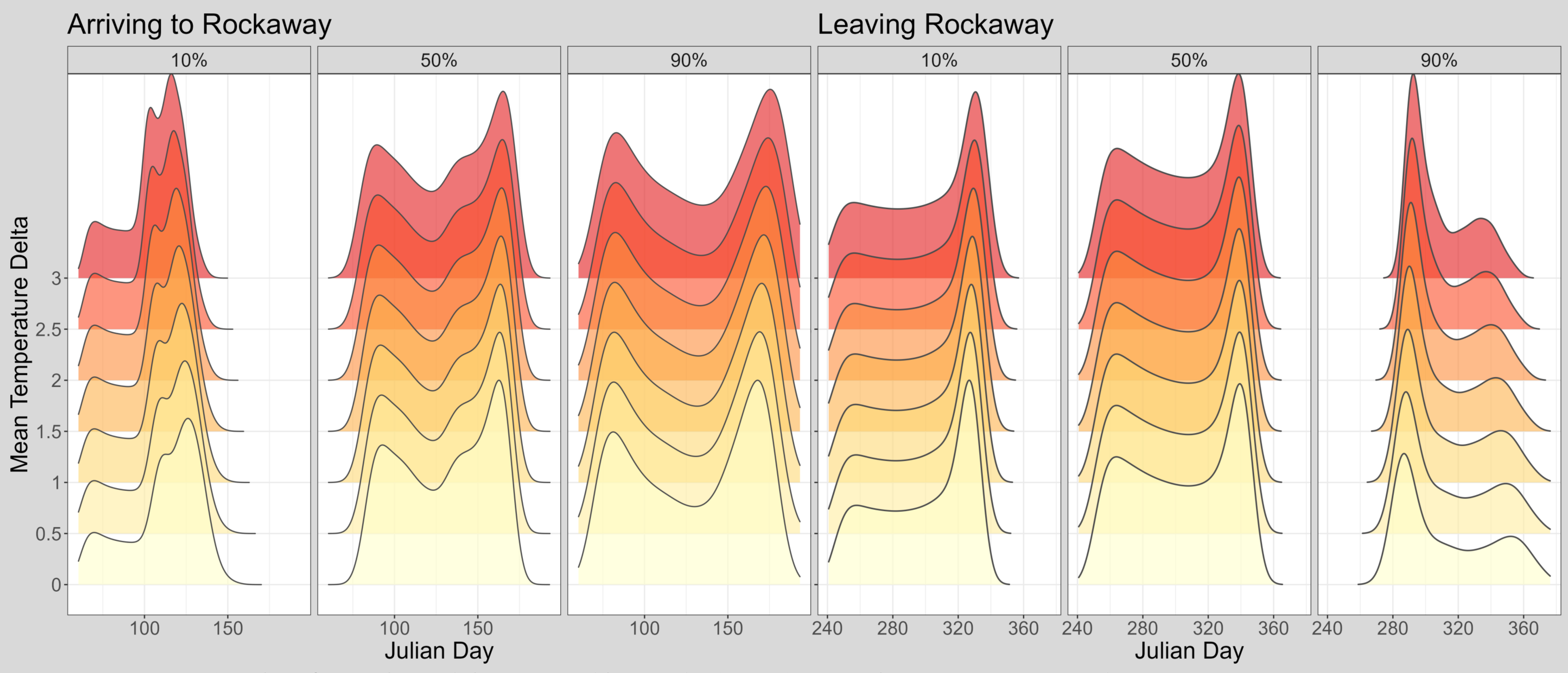

Figure 3: Density plots for each model generated by prediction using simulation temperature data.

Median Arrival/Departure Dates for Observed Data versus Simulated Data

Model	Median Date (Julian Day)	+3˚C Median Date (Julian Day)	Delta (days)	Model	Median Date (Julian Day)	+3˚C Median Date (Julian Day)	Delta (days)
10% Arrive	116.15	109.15	-7	**10% Leave**	304.51	305.71	1.2
50% Arrive	133.98	133.65	-0.33	**50% Leave**	304.39	304.26	-0.13
90% Arrive	132.67	137.3	4.63	**90% Leave**	302.61	301.32	-1.29

Under warmer conditions, the first 10% of Sturgeon may arrive earlier whereas the median date of arrival for 90% is later. This may result in Sturgeon inhabiting the Rockaways for longer periods in the spring. Conversely, the median departure date for the first 10% of fish is later while the median departure date for the 90th percentile is earlier. These results suggests sturgeon may occur at high densities for a longer period in the spring in the Rockaways region, but for a shorter period in the fall. Since photoperiod is a fixed annual cycle, there is likely a limit to how much the arrival and departure dates can change due to temperature. These data can be used to inform management and provide a base for predictive models of sturgeon presence in the Rockaway region, an area of high incidental capture (Dunton et al., 2010), to aid in lessening anthropogenic mortality of the species.

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