Environmental Drivers of Presence and Abundance of Epipelagic Species in an Oligotrophic Basin

Impulsores Ambientales de La Presencia y Abundancia de Especies Epipelágicas en una Cuenca Oligotrófica

Facteurs Environnementaux de la Résence et de L'abondance D'espèces Épipélagiques dans un Bassin Oligotrophe

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EXTENDED ABSTRACT

The marine pelagic environment is the most substantial environmental realm on the planet, and can be defined as the physical, chemical, and biological attributes that make up the open-ocean marine water column from the surface to the sediments on the ocean floor. Unlike the more static nature of coastal and terrestrial habitats, the dynamic coupling of physical and biotic processes on various overlapping scales drive species. interactions. At the broadest scale, temperature drives the distribution of pelagic species as they follow their preferred temperature gradients (Humston et al, 2000). At finer scales, tides, lunar illumination, geomorphic structure, and wind drive more localized aggregations of pelagic species (Calatayud Pavía et al, 2023). The objectives of this study are to get a better understanding of (1) the environmental variables that drive the presence and abundance of species that occur in subtropical epipelagic oligotrophic waters (2) uncover potential species associations to characterize patterns in the epipelagic community structure.

Data were collected using offshore visual transect surveys in the Exuma Sound, The Bahamas, from May 2018 to March 2020. Both transects were 13 km long with the inshore transect over 500 meters of water and the offshore over 1,000 meters. Each time an individual was sighted a GPS location, time, and species identifications down to the lowest taxonomic level possible was taken. Various abiotic variables were collected prior to the transect (Beaufort scale, glare). Wind and tides were collected from historical datasets from The Bahamas Department of Meteorology and NOAA, respectively.

All modeling was performed at the transect level. There was a total of 32 species present across 13 species groups of marine vertebrates were modeled each in terms of 1) observed presence/absence (occurrence) and 2) overall number observed throughout each transect per effort minute (abundance). Occurrence models were constructed as individual boosted regression trees (BRTs). Prior to modeling, transects were randomly partitioned into a training set containing 112 (80%) of the original 141 transects. The remaining 29 transects were used as a validation set to test the performance of each model. For occurrence models, performance was evaluated using a combination of type I error, type II error, and area under the curve (AUC). The decision boundary across models depending on the distribution of validation outcomes. For abundance models, AUC was used as the primary evaluation metric. Occurrence and abundance were analyzed against multiple environmental factors (48-hr average combined wind speed and direction, transect location, lunar illumination, Beaufort scale and season) along with co- occurrence of other species to characterize patterns in the epipelagic community structure.

Out of 13 species groups, our seabirds, tern, and shearwater groups were suitable for our models and performed well with AUC values of 0.77, 0.86, and 0.81, respectively. From the 20 predictors, 48-hour combined wind speed & direction, and season played significant roles influencing these models (Table 1). Lunar illumination also had a relatively high relative influence but was not statistically significant for any of the models (Table 1). For terns, shearwaters, and seabirds overall, the observed occurrence was more likely following periods of both low- and high-speed offshore winds ($p<0.01$). We hypothesize that the offshore wind is driving upwelling along the shelf, increasing the nutrients in surface waters as both transects were within 3.2 km of the shelf (Rykaczewski and Checkley, 2007). For season, all individuals were more likely to occur during the warm & wet season (May – October) ($p<0.01$). It is speculated that the birds in our study are all primarily migratory seabirds, which often move to the Southern Hemisphere for winter, returning to northern latitudes in the summer.

Correlation analyses of abundance trends suggested the existence of several interspecific interactions within both site locations. Among these interactions included a strong positive correlation (Pearson) between tern and tuna abundance ($r = 0.8$) (Figure 1). There were also two other weaker correlations between mahi and flying fish ($r = 0.4$), and gulls and terns ($r = 0.3$) (Figure 1). These correlations we are seeing are associated with facilitative foraging between sub-surface

Predictor	Total positive observations	Any seabird presence	Tern presence	Shearwater presence
Lunar illumination	-	31%	11%	14%
Wind speed & direction	-	26%	35%	30%
Season	-	19%	9%	13%

Table 1. Relative influence of predictors for occurrence models.

predators and seabirds (Goyert et al, 2018).

This data provide valuable insight into the characterization of the environmental drivers of epipelagic species in a subtropical oligotrophic environment. There was evidence of season being a large-scale driver of occurrence, which potentially sheds light on the movement of seabird species in The Bahamas throughout the year. Also, 48-hr wind patterns acted on a smaller scale to drive localized aggregations of species. We also were able to begin to shed light on potential species associations, particularly between sub-surface predators and seabirds, which helps us to characterize the community within the Exuma Sound.

KEYWORDS: Condo, Casita, Crawfish, Bahamas

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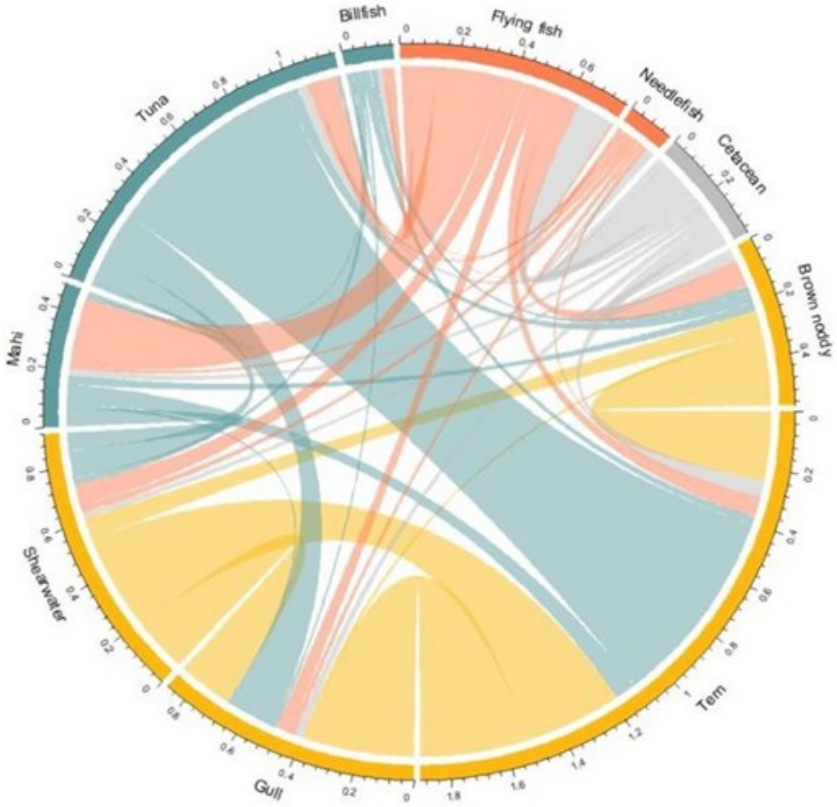

Figure 1. Pearson correlation matrix values for abundance outcomes presented in a circle graph.