

Movement behaviour of young-of-the-year porbeagle shark (*Lamna nasus*) in Northwest Atlantic Ocean in comparison with older animals



Wendy Shue¹, supervised by Heather Bowlby²

¹Department of Biology, Dalhousie University; ²Bedford Institute of Oceanography, DFO



Introduction

Porbeagle shark (*Lamna nasus*) is an endothermic shark species that are found in temperate water around the globe except for the North Pacific Ocean. In the Northwest Atlantic, it was previously hypothesized that the porbeagles had an annual migration cycle where males and females mate in the Georges Bank and the Grand Banks in the fall, and mature female sharks migrate to the Sargasso Sea to pup in the Spring and Summer [1]. However, a recent study revealed that mature female porbeagles are more likely to reproduce only every two years, which also implies that the Sargasso Sea may not be the pupping ground [2]. This study aims to characterize the swimming behaviour and migration pattern of the young-of-the-year (YOY) porbeagles in the Northwest Atlantic in comparison with older animals to provide insights into the possibilities of porbeagle pupping grounds in Canadian waters.

Material & Methods

Tagging

From April 2005 to August 2021, eight YOY and 45 Age 1+ porbeagle sharks were tagged using pop-up satellite archival tags (PSATs) off the east coast of Nova Scotia and Newfoundland, primarily between June and August. Sex and fork length (FL) were assessed onboard; sharks smaller than 81 cm FL were classified as young-of-the-year (YOY).

Data Analysis

Movement tracks were constructed using GPE3 software and analyzed using the “RchivalTag” package in R [3]. Swimming speeds were calculated by partitioning movement trajectories into daily and hourly segments using “adehabitatLT” package in R [4]. Time-at-depth (TAD) and time-at-temperature (TAT) profiles were constructed by binning depth and temperature data from the retrieved tags, also using the RchivalTag package [3]. Bathymetry data was obtained using “marmap” package in R [5] and was used to partition the water column into quartiles to compare the depth distribution of the sharks in the water column in deep (>200 m) versus shallow (<200 m) water. Levene’s test for homogeneity of variance was used to compare the distribution of variance in relation to the median.

Results

YOY sharks remained close to the Georges Bank throughout the year and showed non-linear movements, subtly prone to move northward in the summer and southward in the winter (Fig. 1). Age 1+ sharks exhibited clear seasonal migration where aggregations took place in the summer months on the Georges Bank and the Grand Banks. In winter, immature sharks and mature males either migrated slightly southward to close to 40° N or offshore. Most mature females migrated to the Sargasso Sea by April, although two remained off the south and southeast coast of Nova Scotia until early Spring, respectively.

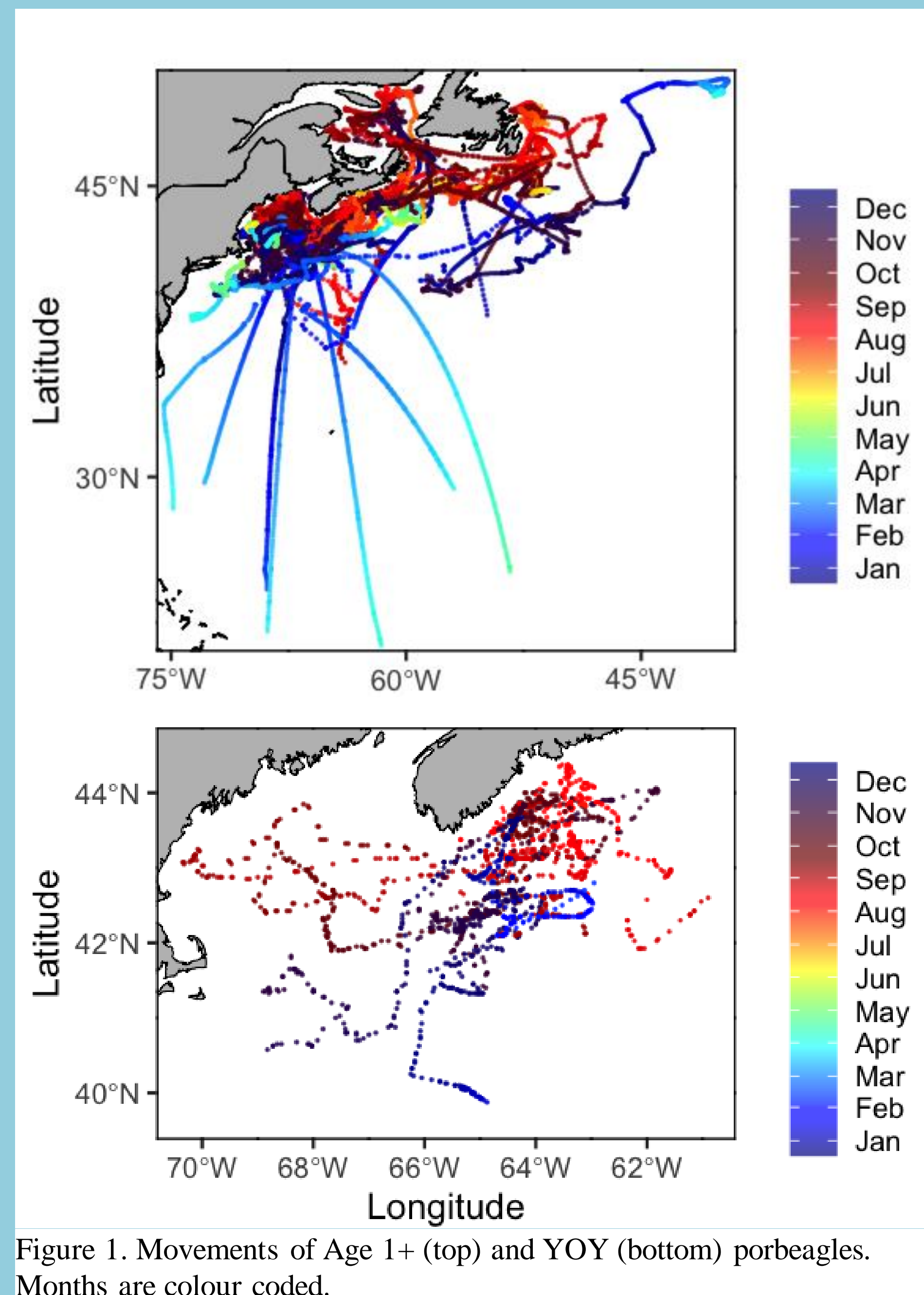


Figure 1. Movements of Age 1+ (top) and YOY (bottom) porbeagles. Months are colour coded.

The median dive depths of YOY and Age 1+ animals were 32 and 64 m, and the maximum depths were 552 and 1992 m, respectively. YOY porbeagles spent 69% of the time between 9–15 °C, while older animals only did so 52% of the time. Levene’s test for homogeneity of variance revealed both TAD ($F = 494.29$, $p < 0.001$) and TAT ($F = 164.58$, $p < 0.001$) profiles of the two age classes differed significantly (Fig. 2).

Results

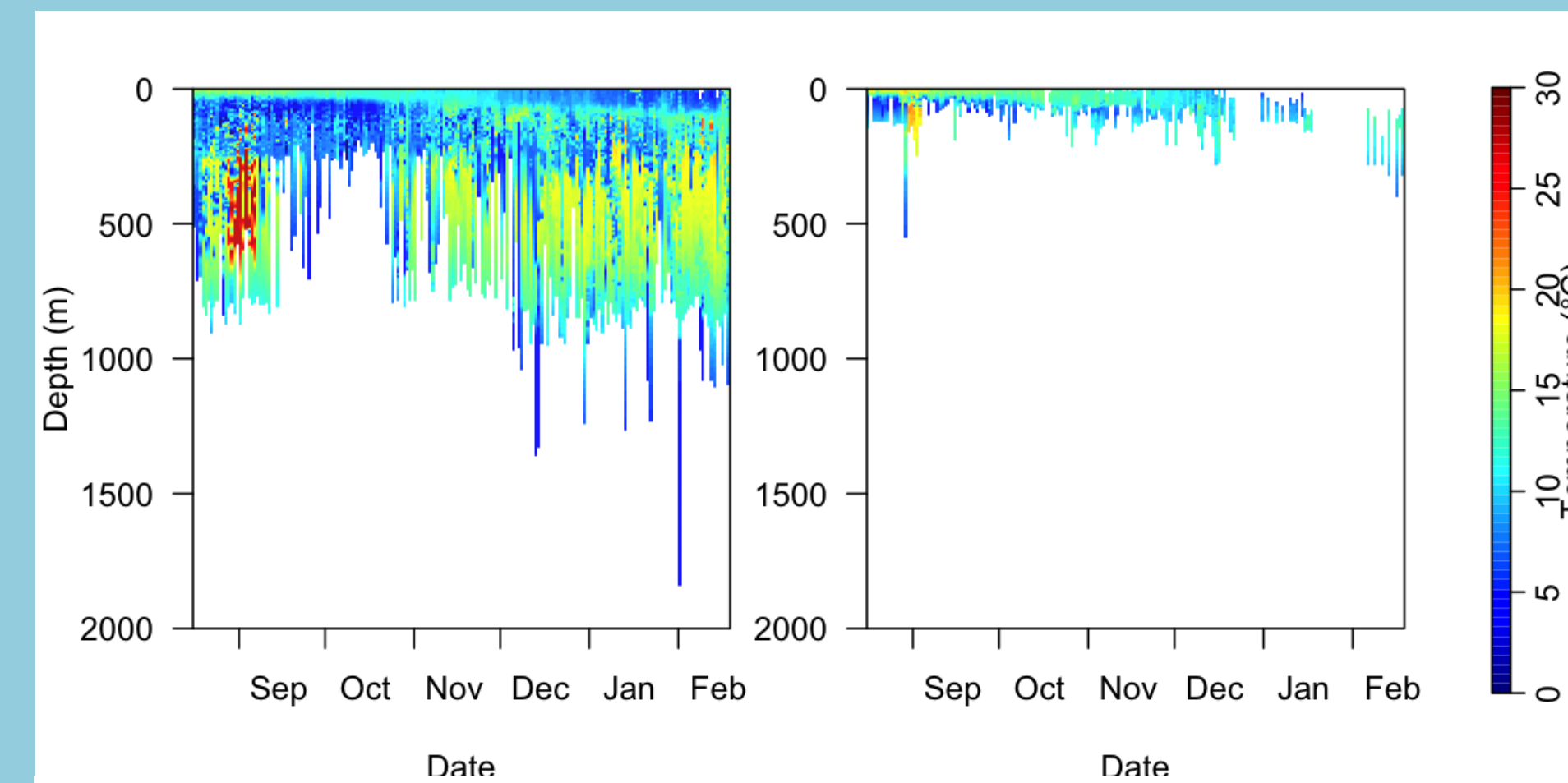


Figure 2. Depth-temperature profiles of Age 1+ (left) and YOY (right) animals

The medians of the two age classes were effectively identical (Age 1+: 0.80 km/h; YOY: 0.85 km/h), although the result of Levene’s test for homogeneity revealed that the variances were significantly different ($F = 17.966$, $p < 0.001$; Fig. 3).

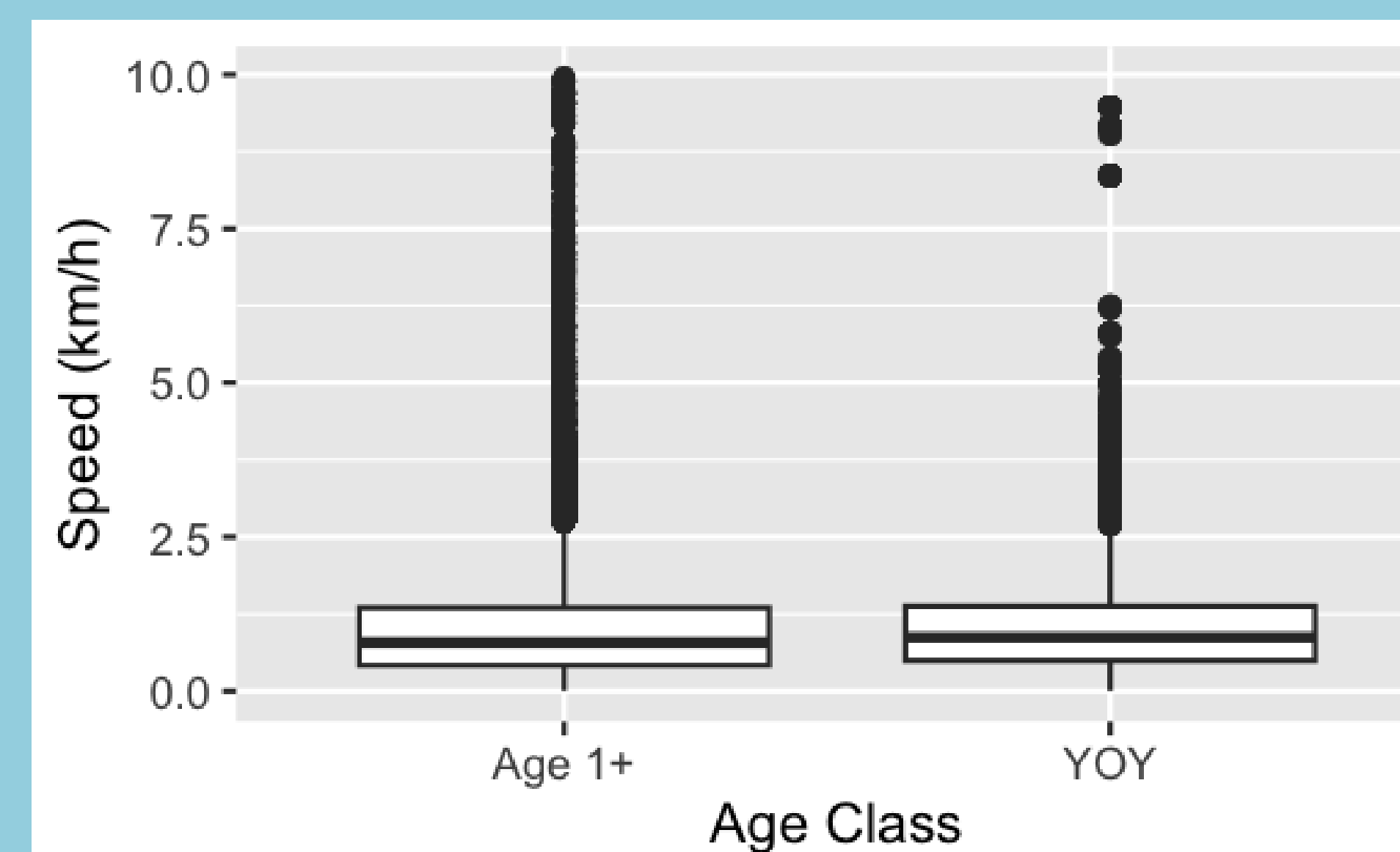


Figure 3. Distribution of swimming speeds

Both Age 1+ and YOY sharks prefer the top 25% of the water column the most (Fig. 4). For YOY animals, time spent beyond the 200 m bathymetric contour was approximately 1/3 less than within, while older animals spend about the same time in deep and shallow water.

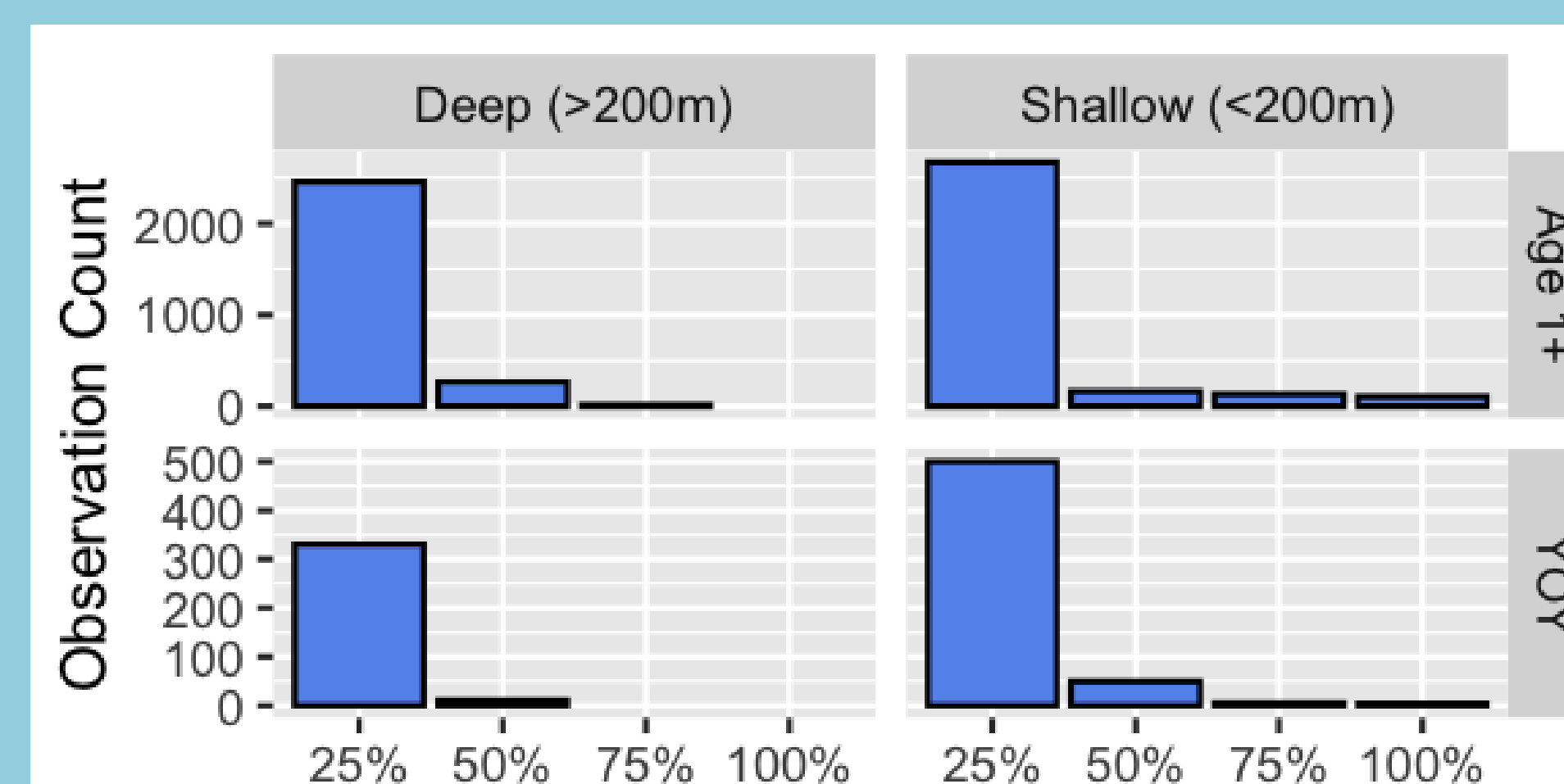


Figure 4. Time spent at deep vs. shallow water

Discussion & Conclusion

YOY porbeagles have different swimming and migratory characteristics than Age 1+ animals. It is manifested in the following aspects:

- **YOY do not exhibit long-distance migration** as opposed to older animals, and their movements are rather arbitrary and non-linear (Fig. 1), which is in line with previous literature [6];
- **YOY animals experience a more restricted temperature and diving depth range** than older animals (Fig. 2), which is possibly because they do not have the same capacity to achieve and maintain localized endothermy;
- Although the median speeds are similar, **YOY sharks have a smaller variance** and thus are likely to **spend more time at lower speeds** (Fig. 3);
- **YOY animals are more tightly bound to the coastal areas** compared to older animals, as the time spent within the 200 m bathymetric contour was substantially less than older animals (Fig. 4). While we do recognize that the small sample size of the YOY porbeagles may lead to some biased inferences, the results of the study still contribute to our understanding of the porbeagle shark’s behaviour. Overall, YOY porbeagle sharks differ from older sharks in their migration pattern, depth and temperature range, swimming speed variability, and preference for shallow water.

References

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