Estimation of Behavioral States in Migratory Post-Breeding Male Green Sea Turtles (*Chelonia mydas)* in Fernando de Noronha, Brazil

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Introduction

- Animal movement is often investigated through satellite tagging (telemetry) and is used to understand an organism's space-use and behavior.[1]
- To increase our understanding of movement patterns and behavioral states of sea turtles across life stages and sex, data is needed on adult male sea turtles.
- To address this scientific gap we will estimate the behavioral states of adult post-breeding male green sea turtles (*Chelonia mydas)* off the coast of Brazil using state-space models (SSM) and identify behavioral trends along turtle tracks.
- **Hypothesis:** There will be a clear distinction between behavioral states, where area-restricted search (ARS) behavior is exhibited near the shallow breeding site and foraging grounds, and migratory behavior over deep water.

Figure 1. (A) Study area off coast of Brazil; Fernando de Noronha.

Figure 1. (B) Image shows satellite tag attached to sea turtle. Tags transmit location data when animals surface.

Methods

- Eight post-breeding adult male green sea turtles were fitted with satellite tags in Fernando de Noronha off the coast of Brazil in 2021, resulting in N = 24,168.
- In R, a programming language for statistical computing, a correlated random walk (CRW) continuous-time space model was applied, regularized at 12 hours. Location error was accounted for by SSM to produce "true" tracks.[2]
- Behavioral index was calculated for each turtle and mapped along turtle tracks to explore behavior and movement patterns.
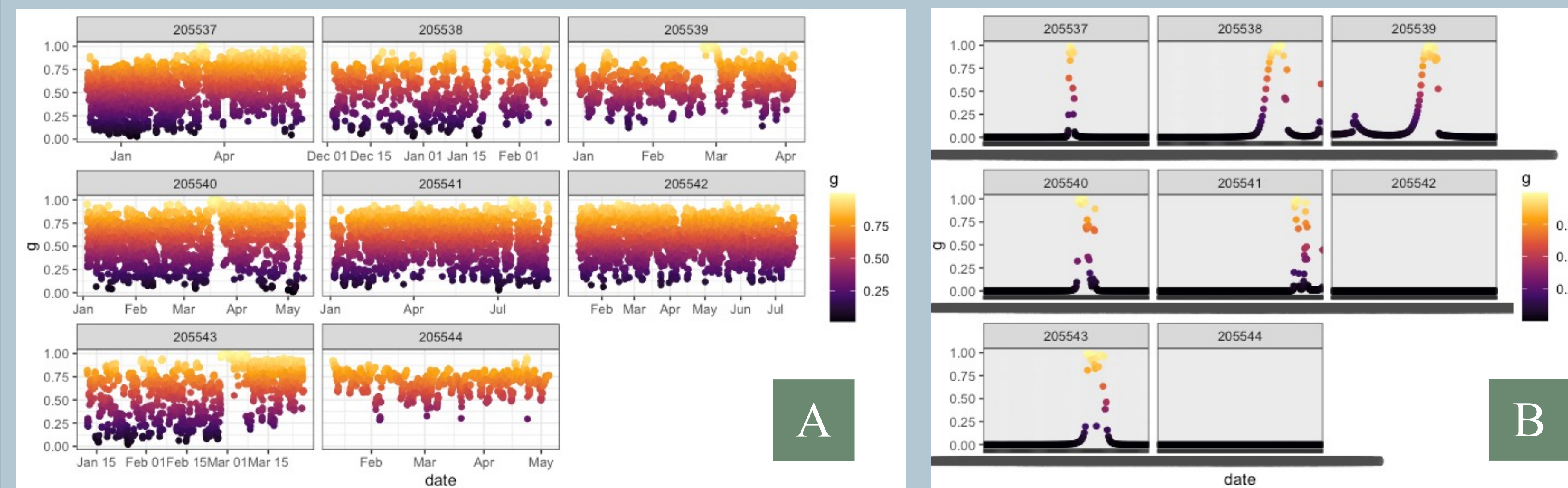
Results

Figure 2. Behavior of sea turtles can be inferred using the behavioral index (gamma values).[3] The SSM considers persistence in direction and velocity to estimate behavioral states. Values closer to zero are related to ARS or foraging behavior, characterized by higher turning frequency and reduced speed. Values closer to one are related to migratory behavior. **Figure (2A)** is not regularized, where observations range from .5 to 1 hour; **figure (2B)** is regularized at 12 hours.
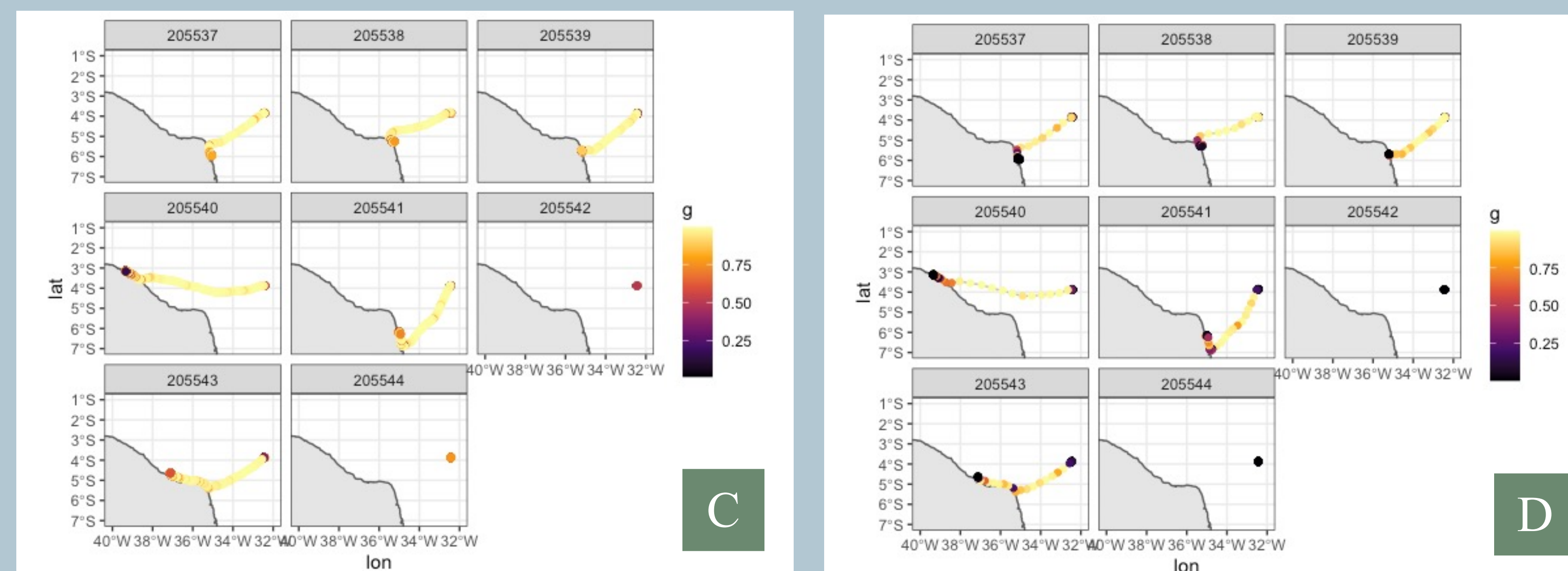

Figure 3. Maps show behavioral states plotted along individual turtle movements tracked. **Figure (3C)** is not regularized; **figure (3D)** is regularized at 12 hours. Six of eight sea turtles migrated post-breeding from Fernando de Noronha to Brazil's coast. Turtles 205542 and 205544 remained near the island. A distinct behavioral state switch from foraging behavior to migratory can be observed in both plots.

Conclusion

- A distinct change in behavior was detected in six of eight turtles as they migrated from Fernando de Noronha to Brazil's coast, characterized by relatively straight, persistent movement between shores.
- Two turtles stayed resident to Fernando de Noronha and is an example of variability in migratory decisions.
- Due to high temporal and spatial resolution of data, migratory periods became clear when model was regularized to 12 hours.
- Behavioral state switch did not begin immediately post-breeding indicating male sea turtles are particularly vulnerable to disturbance and injury during this time period. Protecting areas surrounding known breeding areas should therefore be prioritized in conservation efforts.

Future Directions

- Combine movement and environmental data to analyze impact of habitat features on movement decisions and habitat selection.
- Compare to other behavioral state estimation models and use models able to estimate more than two behavioral states.
- Investigate turtle presence trends in space-use with commercial fishing vessels or other anthropogenic factors (i.e., tourism).
- Influence of abiotic factors (sea-surface temperature, ocean currents) on behavior and movement patterns.

Acknowledgments

References

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