Assessing the capacity of various pelagic shark species to serve as ocean observing platforms in the Mid-Atlantic Bight and beyond

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Premise

- Accurate storm-forecasting is critical for coastal communities in the Mid-Atlantic Bight (MAB), & current data-collection methods are costly & spatially limited.
- Biologging conductivity, temperature, & depth (CTD) tags provide a pathway for marine life to serve as more cost-effective oceanographic data collectors; pelagic sharks in particular have potential to fill this gap as ocean observers if fit with these tags.
  - To maximize CTD tag data collection for storm forecasting, ideal candidate shark species will regularly surface & surface long enough for satellite data transmission.
  - Successful oceanographic data collection will require verification of tag CTD performance relative to existing ocean sensing technology.
- **Objective**: 1) Identify the surfacing time & sampling frequency across pelagic sharks; 2) quantify error & bias in tag versus glider CTD measurements.
- **Hypothesis**: 1) Highly migratory pelagics will surface more frequently & for longer periods of time; 2) Error & directional bias between prototype tag & Slocum glider CTD measurements in the MAB will be substantial.

Methods

- Assessment of shark species suitability:
  - Argos smart position & temperature (SPOT) tag data was collected for 14 species globally from 2002-2022.
  - Time at surface was estimated by location class (LC) quality & frequency relative to track length and diving depth; surfacing frequency was estimated by regression of number detected transmissions ~ hours since tag deployment.
- Assessment of CTD tag performance:
  - Prototype CTD tag (Sea Marine Research Unit) was deployed attached to a G2 Slocum glider (Teledyne Webb Research) in March 2022 for a 25-day mission (Figure 1). Both devices sampled at 1 Hz.
  - Tag & glider CTD data were separated into paired upcasts & downcasts. Tag performance relative to glider sampling ability was assessed via calculation of root mean square error (RMSE) & bias.

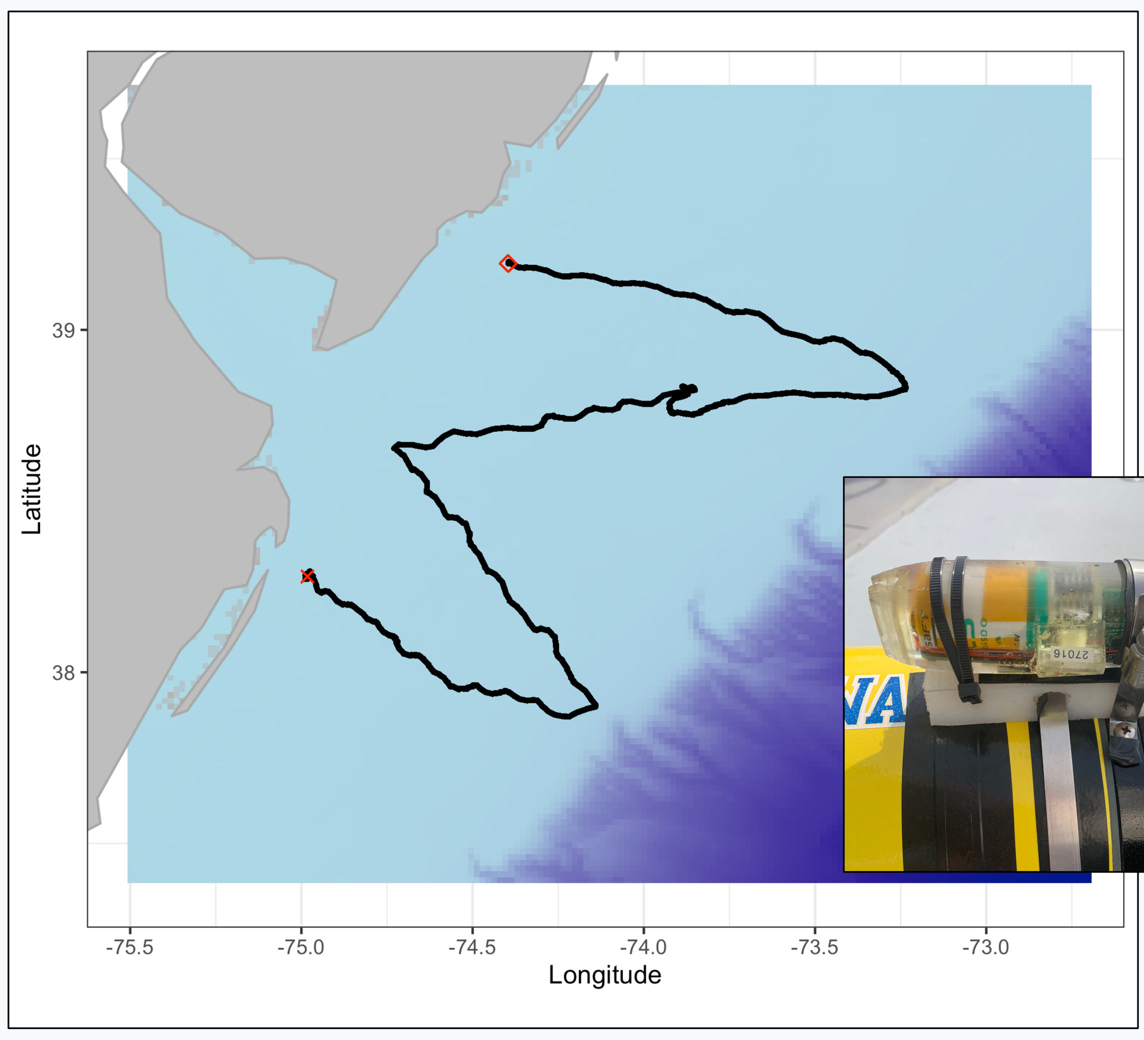

Figure 1. Trajectory of March 2022 glider-tag deployment. Black points indicate glider surfacing events; the red triangle & cross indicate deployment and recovery locations. Inset image shows prototype CTD tag mounted to glider.

Conclusions

- Common thresher, whale, blue, and juvenile white sharks → favorable time spent at surface, surfacing rates, and proportions of quality location class relative to track lengths
- Silvertip and silky sharks → surface less frequently and for less time (though residency index suggests high number surfacing events relative to track length)
- Error between tag and glider CTDs is low (less than 1/10th of a unit); temperature and conductivity bias suggests tag measures consistently cooler temperature and higher conductivity than glider

Results

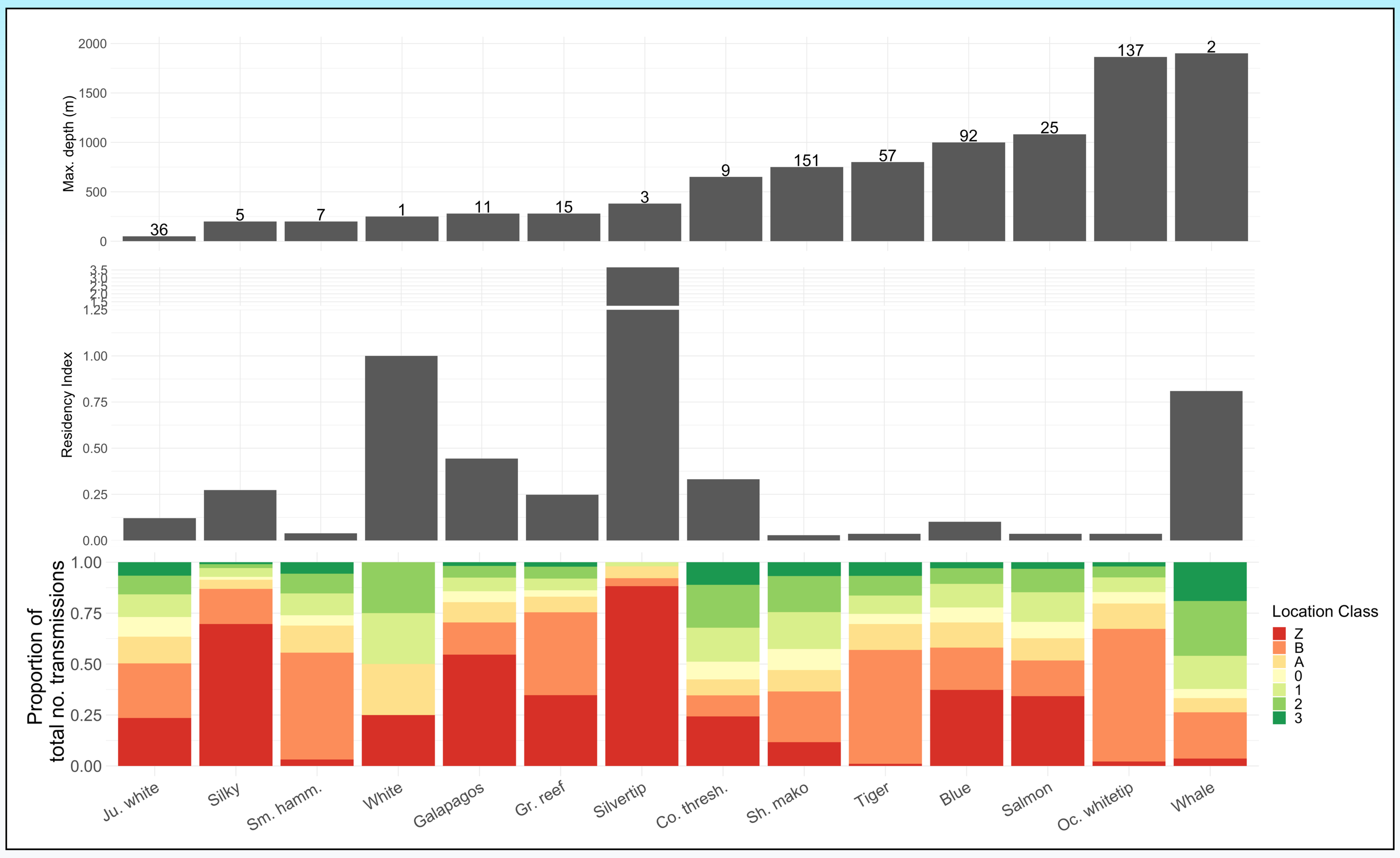

Figure 2. Top panel: maximum depth achieved by each species, with number of tagged individuals per species denoted above each bar; middle panel: residency index defined as the ratio of the average number of daily transmissions relative to the average track length (in days), per species; bottom panel: corresponding proportions of location class by category out of raw transmissions obtained by each species.

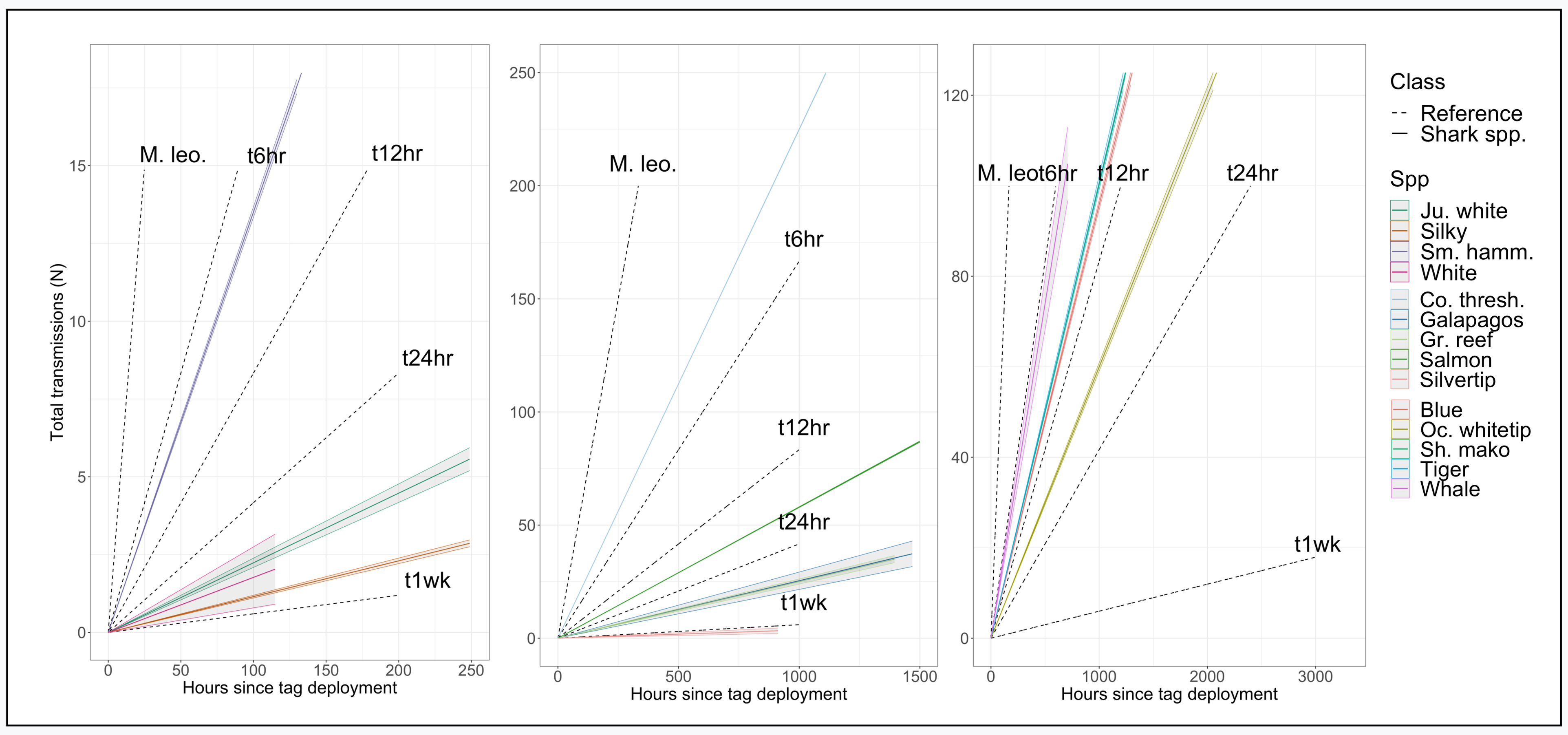

Figure 3. Predicted total number of transmissions as a function of time across sharks of various maximum depth diving capacities. Sharks that dive ≤ 250 m are presented in the left pane, > 250 & < 750 m in the middle pane, & ≥ 750 m in the right pane; solid lines refer to shark species; black dashed lines refer to artificial transmission rates, where t6hr refers to 1 transmission every 6 hours; t12hr to 1 transmission every 12 hours; t24hr to 1 transmission every 24 hours; t1wk to 1 transmission every week; & M. leo. (*Mirounga leonina*, southern elephant seal) to the rate determined for southern elephant seals based on satellite tracking data. Shaded regions give upper and lower 95% confidence intervals.

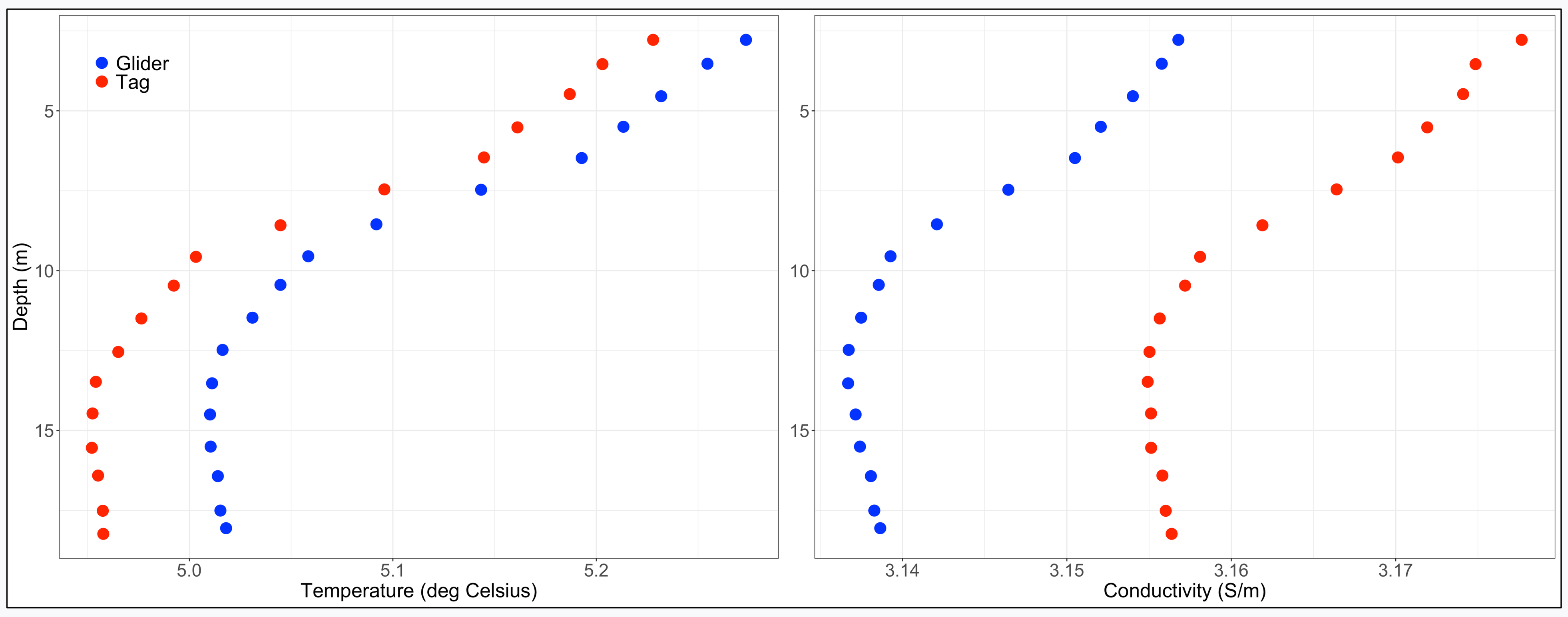

Figure 4. Average temperature (left panel) and conductivity (right panel) measurements recorded in a single upcast by the glider (blue) and tag (red) CTDs. Values are averaged across 1 m depth increments.

Table 1. Number of upcast and downcast profiles and corresponding average root means square error (RMSE) and bias values for temperature and conductivity, aggregated across paired glider and tag profiles by 1 m depth bins.

		Temperature (°C)		Conductivity (S/m)	
	N, Profiles	RMSE	Bias	RMSE	Bias
Upcast	1,122	0.069	2.47	0.028	-0.65
Downcast	1,146	0.068	2.49	0.028	-0.71

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