North Atlantic Right Whale
Autonomous Acoustic Monitoring

Contract No. N62470-15-D-8006—18F4109

Woods Hole Oceanographic Institution
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FINAL REPORT

Overview

Two Slocum gliders equipped with digital acoustic monitoring (DMON) instruments were deployed and operated in the mid-Atlantic Bight to the north and south of Cape Hatteras during the winter of 2018-2019. The gliders were remotely piloted to survey along pre-determined transects as local currents allowed, and sensor data were relayed to shore every 2 hours and posted on a publicly accessible website, dcs.whoi.edu. DMON data were reviewed daily by trained NAVFAC personnel, and the results of their review were posted on the same website, distributed to interested parties by text and email message, and made available for display in the Whale Alert app. Of the four baleen whale species monitored, humpback whales were the most commonly encountered, followed by fin, sei, and right whales. Only a single bout of right whale calls was detected by the glider deployed to the north of Cape Hatteras.

Work Completed

Glider operations

Two new G3 Slocum gliders were prepared for deployment during the fall of 2018. A new DMON2 instrument was installed in the science bay of each glider; this project marked the first deployment of the DMON2 instrument at sea in an autonomous platform. The gliders were ballasted in Woods Hole for the expected water density in the study areas to the north and south of Cape Hatteras, and then shipped to the Duke University Marine Laboratory in Beaufort, North Carolina. One glider (we14) was brought to Hatteras, North Carolina and deployed by the F/V Albatross II on January 22, 2019, and the other glider (we15) was brought to Wanchese, North Carolina and deployed by the F/V Kahuna on January 23, 2019. Both deployments were conducted by Ben Hodges (WHOI).

The gliders were piloted by the principal investigator to conduct cross-shelf transects from roughly 20 m depth to the shelf break as the local currents allowed. Although winter storms tended to move the glider deployed north of Cape Hatteras off the predesigned survey track, we15 generally stayed in the study area and was able to move across the shelf successfully (Figure 1). The glider south of Cape Hatteras was initially deployed in Raleigh Bay, but had a difficult time navigating there (Figure 2). The Gulf Stream comes close to the shelf break there, and there are frequent jets on the shallow shelf. This glider attempted to reach and pass Cape Lookout several times to enter Onslow Bay, but it was delayed by strong local currents.

Early in its mission, glider we14 was moving perilously close to the shelf break in Raleigh Bay where it was in danger of being caught in the Gulf Stream, and the glider was commanded to increase its swim speed by increasing the extent of the buoyancy pump (thereby alternately becoming much more and much less dense than the surrounding water than usual, thereby increasing both its vertical and horizontal speed). This maneuver was successful and the glider stayed on the shelf, but it repeatedly made contact with the sea floor, which filled its nose cone with sediment and effectively disabled the acoustic altimeter housed in the nose cone. After diagnosing the problem, the principal investigator traveled to Hatteras, North Carolina on February 1, 2019, intercepted we14 at sea aboard the F/V Albatross II, cleaned the nose cone, and re-deployed the glider to continue on its mission (Figure 3).

Glider we14 did reach Onslow Bay late in its mission and surveyed there for several days before returning to Raleigh Bay for recovery. It was swept across Diamond Shoals by strong local currents and both gliders were recovered by Ben Hodges from the F/V Kahuna near Oregon Inlet on March 18, 2019 (Figure 4).

Oceanographic observations

The gliders were equipped with sensors to measure pressure, temperature, conductivity (from which salinity can be derived), chlorophyll fluorescence, and turbidity. The glider transmitted these data in near real time (every 2 hours), so they were available for viewing in real time on the dcs.whoi.edu website. Glider we15 moved across the shelf to sample both the broad shallow shelf waters as well as waters near the shelf break (Figure 5), whereas glider we14 remained in the shallow shelf waters by necessity to avoid being swept offshore by the Gulf Stream (Figure 6). The temperature and salinity observations clearly show the two very different environments in which the gliders were deployed. The area north of Cape Hatteras was much cooler and fresher, reflecting currents originating to the north and the influence of relatively cold slope waters that are sourced from north of the Gulf Stream wall. The area to the south of Cape Hatteras was much warmer and saltier, reflecting the strong influence from the Gulf Stream and coastal waters originating to the south.

Near real-time whale detections

The DMON was programmed with the low-frequency detection and classification system (LFDCS; Baumgartner and Mussoline 2011, Baumgartner et al. 2013), and detection data were transmitted in near real time to shore where they were reviewed by a NAVFAC analyst (after Baumgartner et al. 2019, submitted). Humpback whales dominated the detection data north of Cape Hatteras (Figure 7), and fin whale detections were fairly common as well. Sei whale calls were detected on only one occasion, and there was a single day (February 13) with several right whale calls (an example is shown in Figure 8). An aerial survey was triggered by the right whale detections, but coordination took time and the Coast Guard C130 flight was not conducted until February 17 with Virginia Aquarium & Marine Science Center observers Sarah Mallette and

Joanna Daniel aboard. No right whales were seen during the flight. The flight was coordinated by Tim Cole (NOAA NEFSC), Mike Deal, Dave Stutt, Weston Dodson (USCG), and Sue Barco (Virginia Aquarium & Marine Science Center). Important lessons were learned during this exercise that can be applied to future rapid-response flights triggered by right whale detections.

Very few whale calls were detected on we14 south of Cape Hatteras (Figure 9). The only species that was observed with enough confidence to designate as detected was humpback whales (Figure 10). There was no convincing evidence of right whale acoustic occurrence in the area monitored by we14.

Future work

There were several lessons learned about conducting near real-time passive acoustic surveys in the mid-Atlantic Bight during the project. Navigation of the gliders, particularly the glider deployed south of Cape Hatteras, could be improved with two modifications to the gliders. The first modification is installing a buoyancy pump capable of moving more quickly, which would limit the time the glider halts its forward motion when changing its buoyancy. We used pumps rated for 200 m, but the gliders remained in waters of 50 m or less for much of their mission. By changing to a 50-m pump, the glider will be able to change its buoyancy much quicker, thus flying more efficiently and improving both navigation and energy consumption. The second modification is to add a thruster that will allow the glider to generate forward momentum with a propeller driven by an electric motor. The thruster would only be used in situations where the glider cannot maintain navigation using the buoyancy pump and it is in danger of being carried out of the study area by the local currents (the thruster is costly in energy consumption and makes noise, so it is appropriate to use only in emergency circumstances). The thruster would be particularly useful when navigating near the Gulf Stream and currents threaten to blow the glider off course. Both a 50-m pump and a thruster will be installed for the winter 2019-2020 project.

From an acoustics standpoint, another lesson learned concerned the DMON2 hydrophone housing on the top of the glider science bay. Both gliders were outfitted with an aluminum cage over the hydrophone to protect the hydrophone from damage. From the near real-time estimates of background noise shortly after deployment, there was more very low-frequency noise than we typically observe on gliders equipped with DMON hydrophones, and we suspected that the cage was causing flow noise on the hydrophone. Interception of we14 to clean its nose cone afforded an opportunity to remove the cage and observe the change in the low-frequency noise. As suspected, the removal of the cage reduced the flow noise significantly (Figure 11). This was the first (and last) time cages will be used to protect glider-mounted hydrophones.

References

Baumgartner, M.F., J. Bonnell, P.J. Corkeron, S.M. Van Parijs, C. Hotchkin, B.A. Hodges, J. Bort Thornton, B.L. Mensi and S.M. Bruner. Slocum gliders provide accurate near real-time estimates of baleen whale presence from human-reviewed passive acoustic detection information. Frontiers in Marine Science. submitted.

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Baumgartner, M.F. and S.E. Mussoline. 2011. A generalized baleen whale call detection and classification system. Journal of the Acoustical Society of America 129:2889-2902.

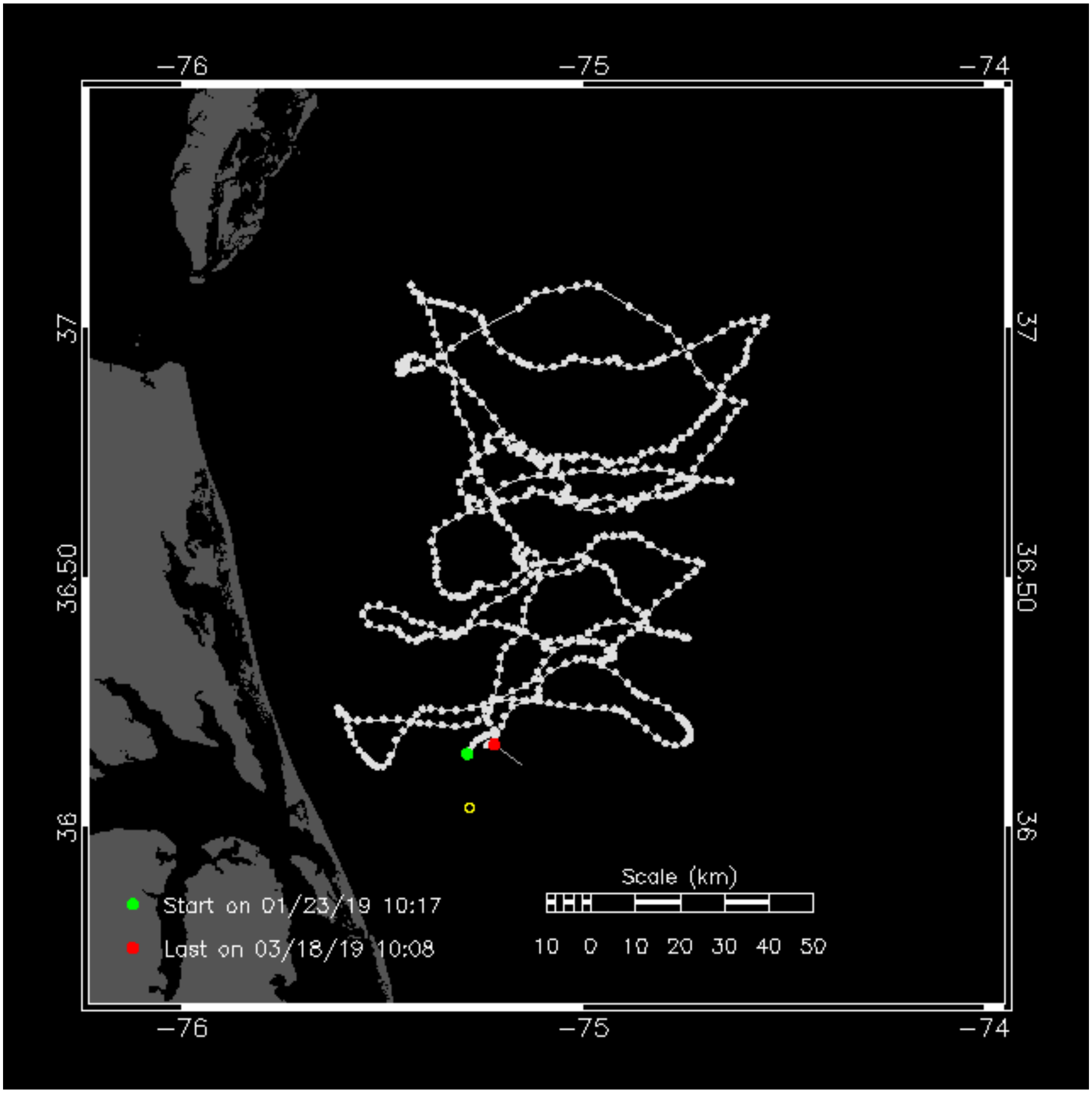

Figure 1. Track of glider we15 deployed north of Cape Hatteras.

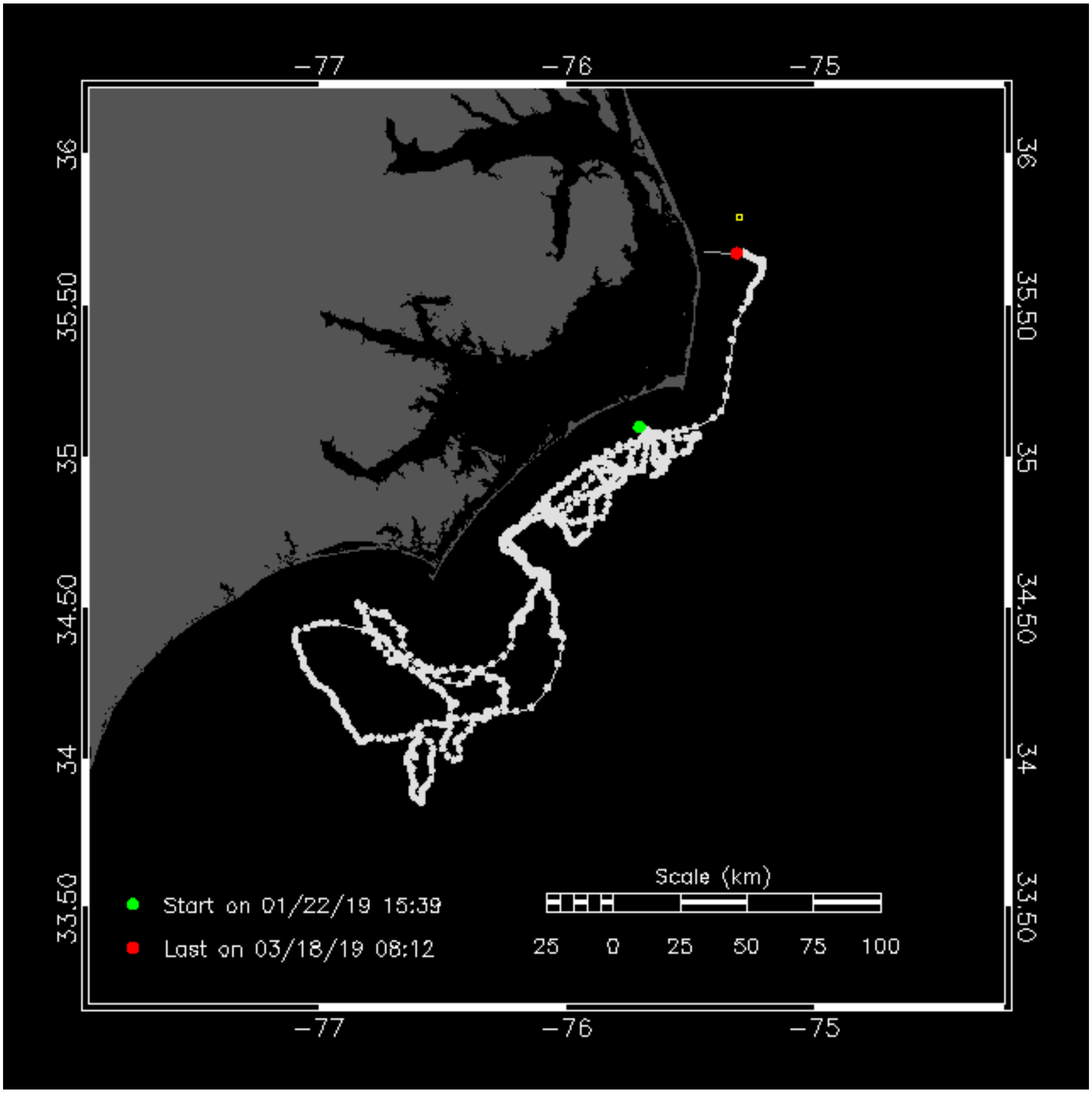

Figure 2. Track of glider we14 deployed south of Cape Hatteras.

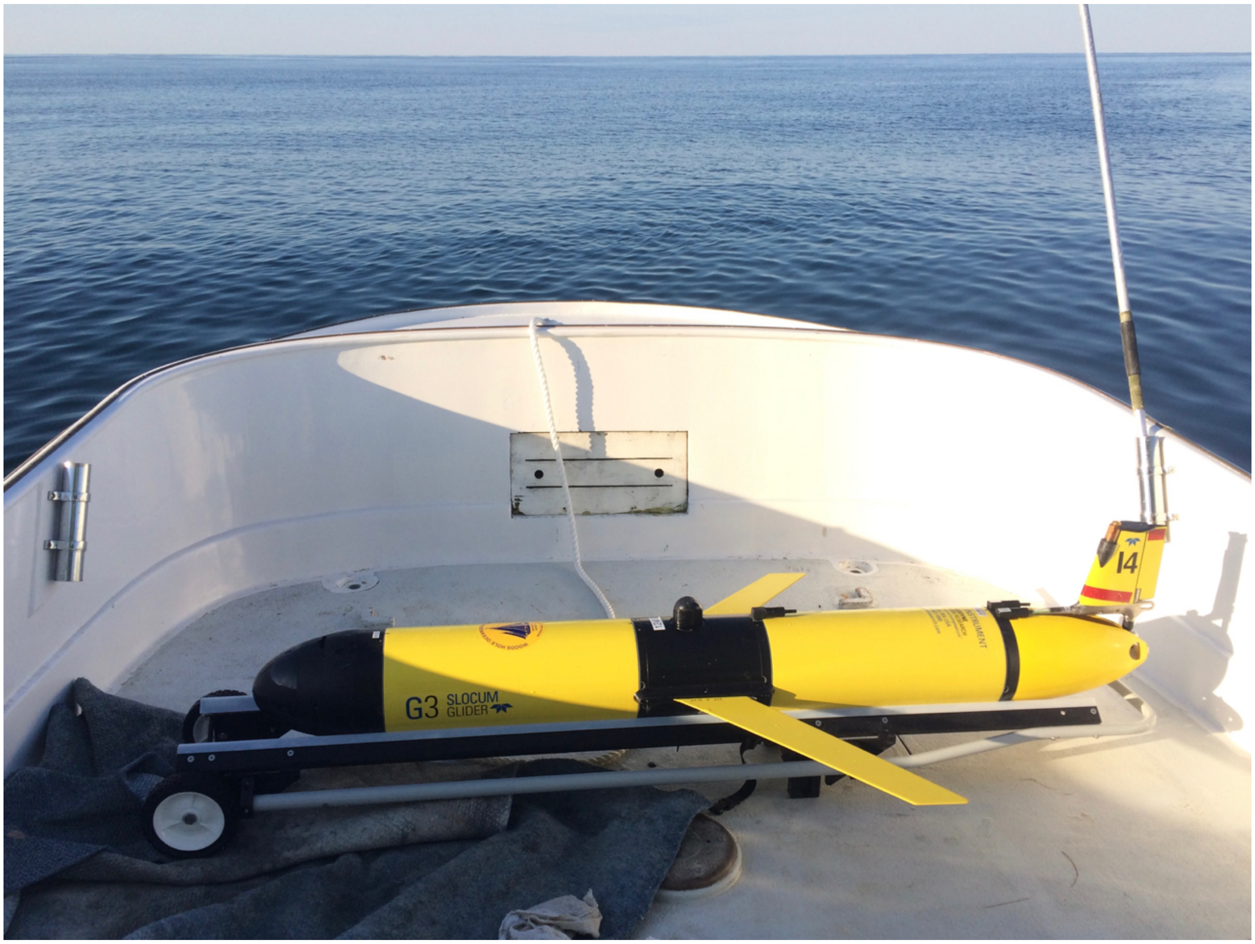

Figure 3. Glider we14 on February 1, 2019 after its nose cone was cleaned of sediment and the protective hydrophone cage was removed.

Figure 4. Gliders we14 and we15 after recovery on March 18, 2019. Note difference in biofouling – we14 was deployed south of Cape Hatteras and has much more biofouling than we15, which was deployed north of Cape Hatteras. Also, note the protective cage over the hydrophone on we15, while the cage on we14 was removed when it was intercepted to clean out the nose cone on February 1.

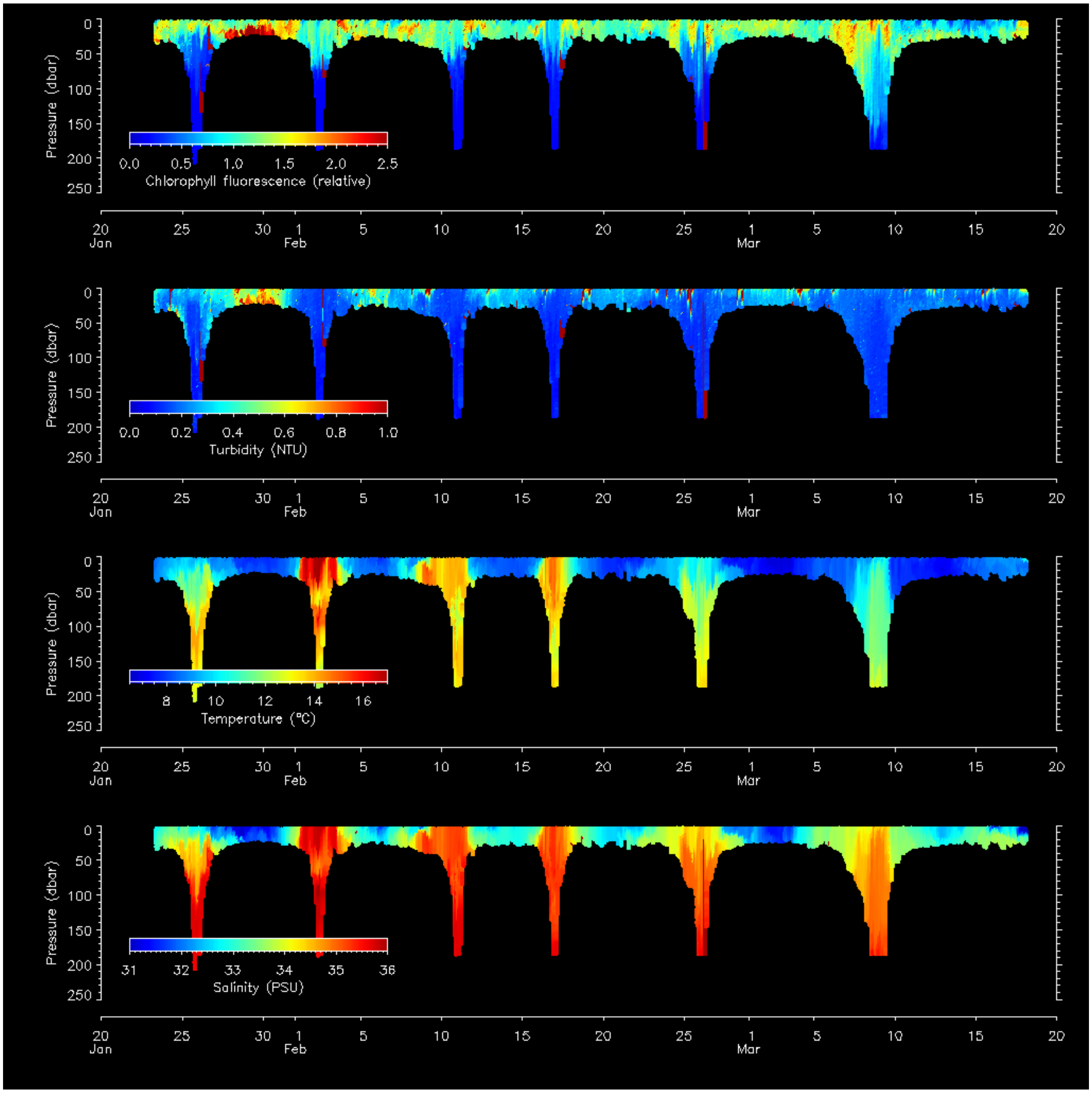

Figure 5. Oceanographic observations of chlorophyll fluorescence, turbidity, temperature and salinity (derived from conductivity) measured by glider we15. Note strong cross-shelf variability as the glider surveyed to the shelf break (~200 m = 200 dbar).

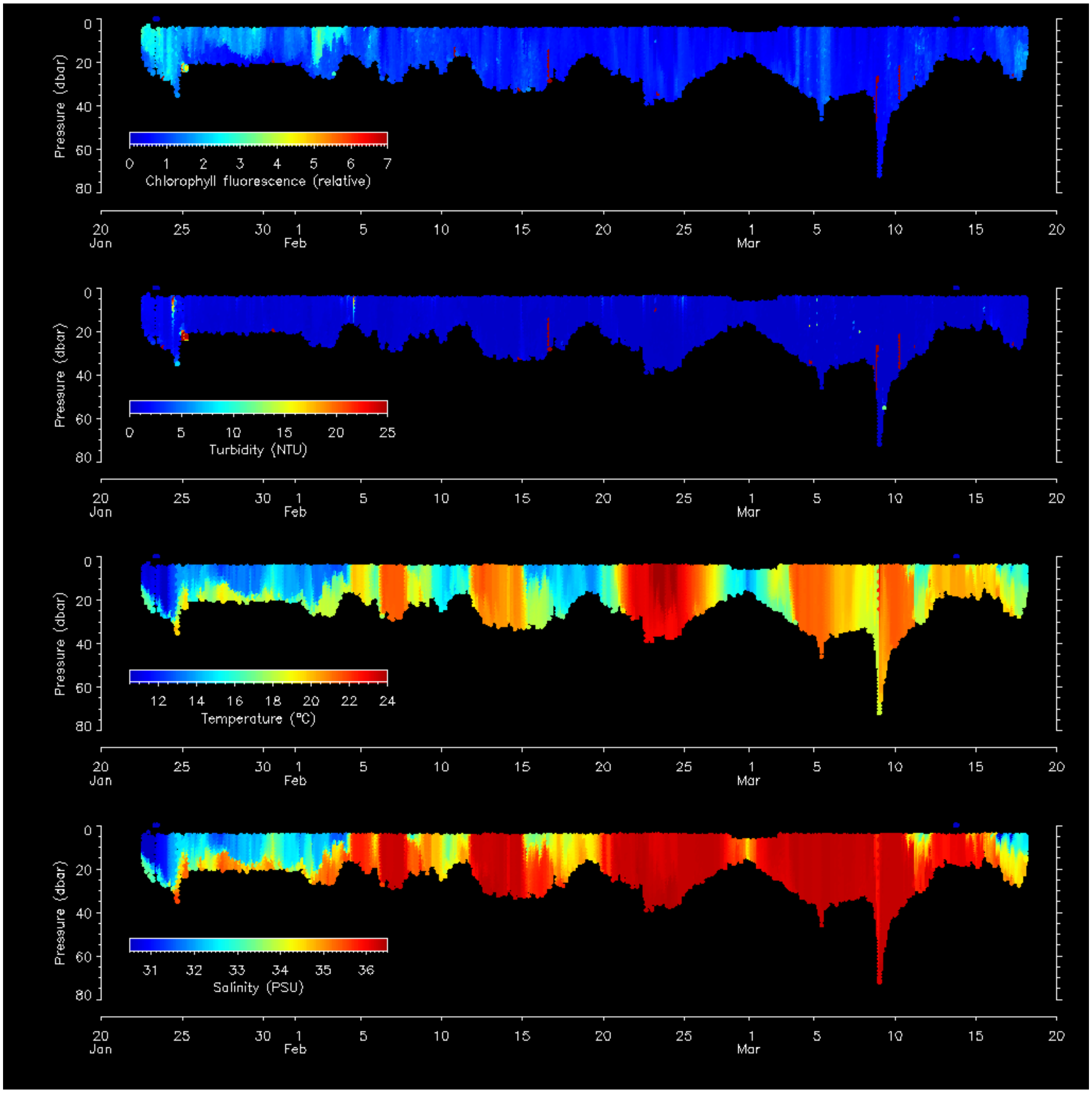

Figure 6. Oceanographic observations measured by glider we14.

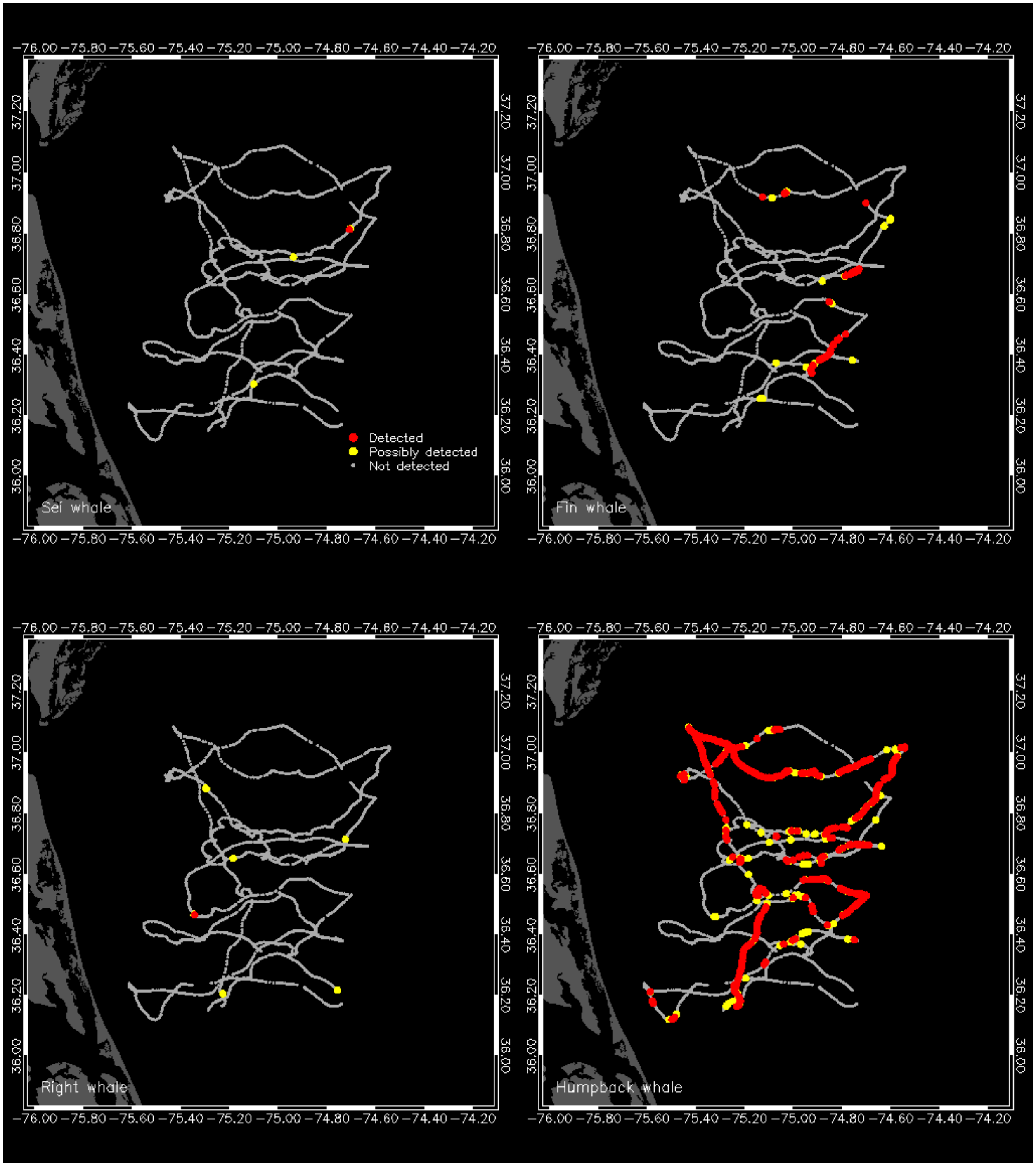

Figure 7. Near real-time detections of baleen whales from glider we15.

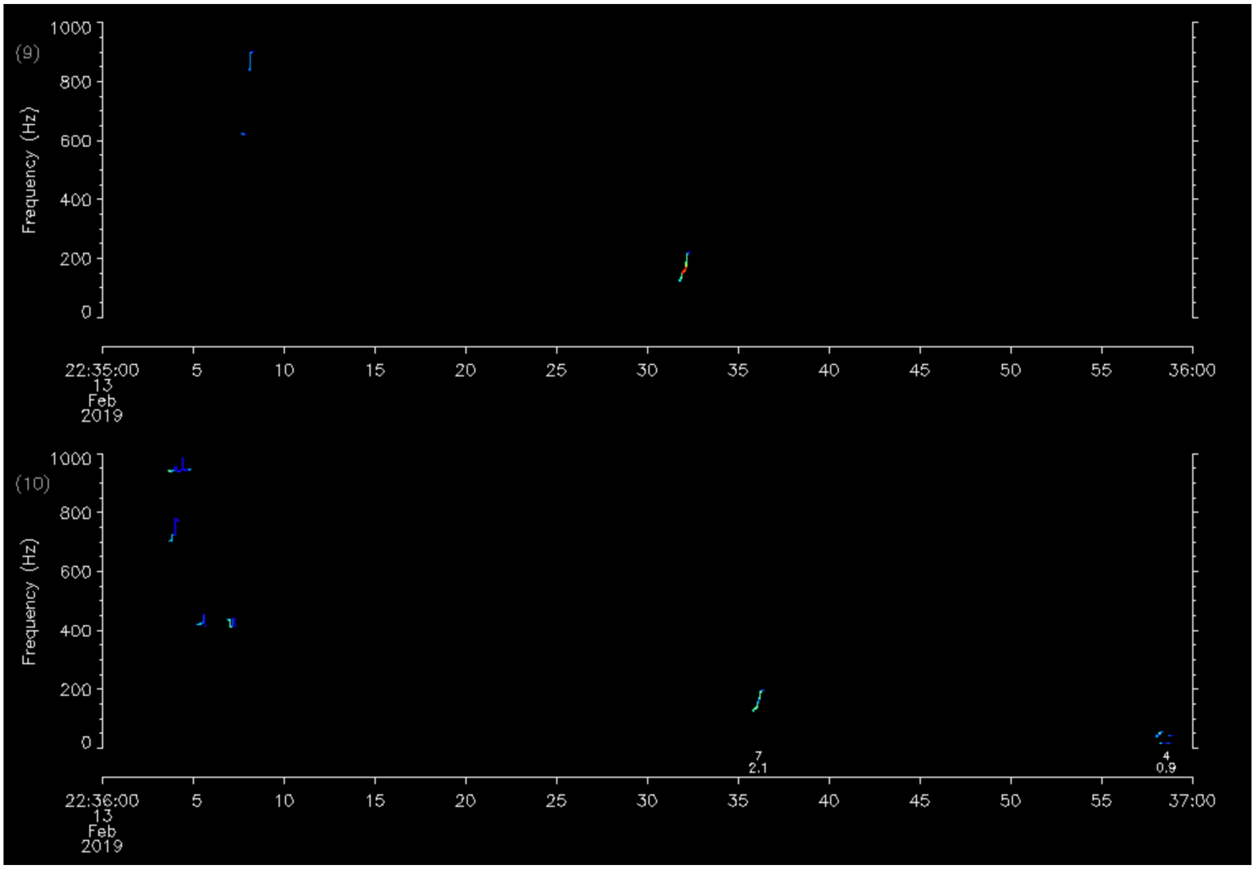

Figure 8. Pitch tracks of right whale upcalls detected in near real time from glider we15.

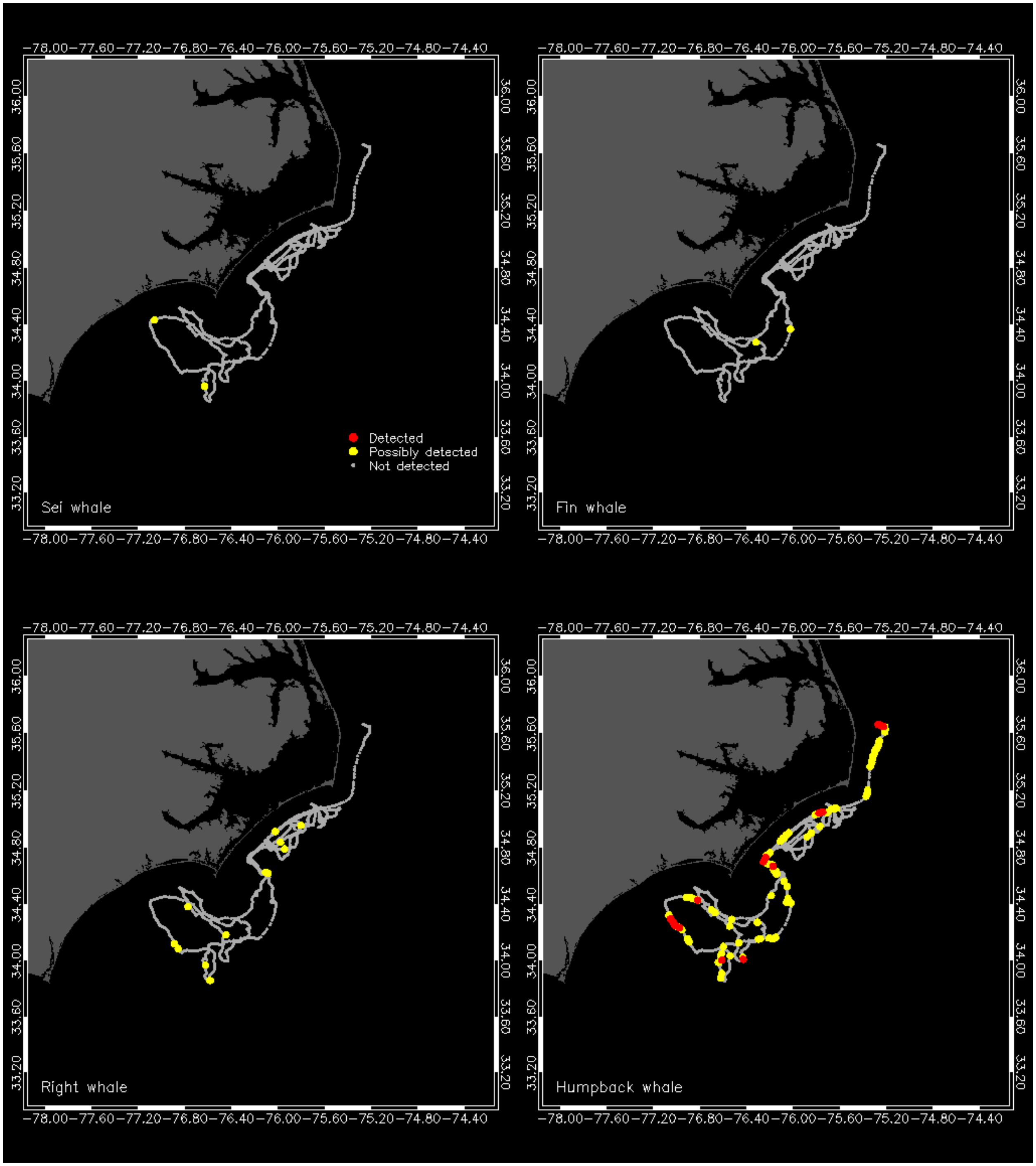

Figure 9. Near real-time detections of baleen whales from glider we14.

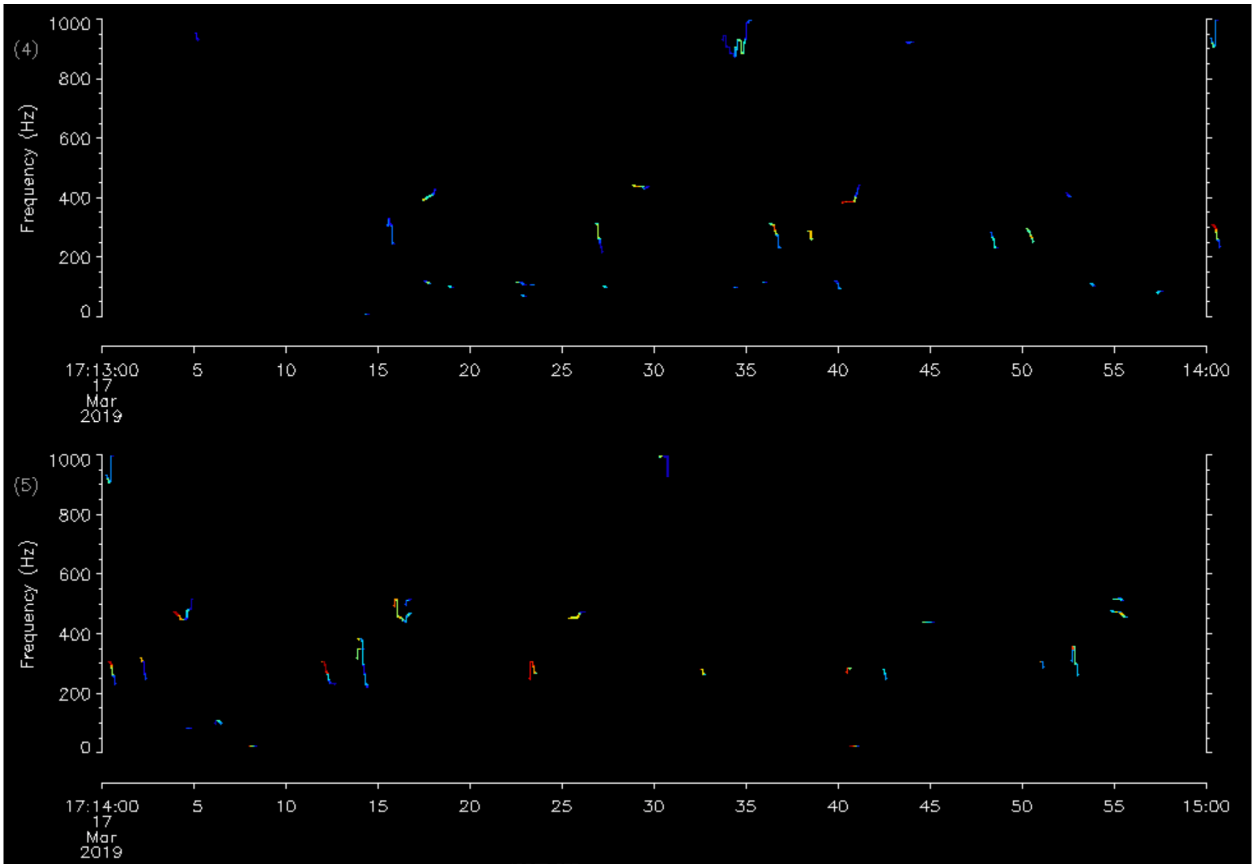

Figure 10. Patterned calls of a humpback whale song detected on glider we14.

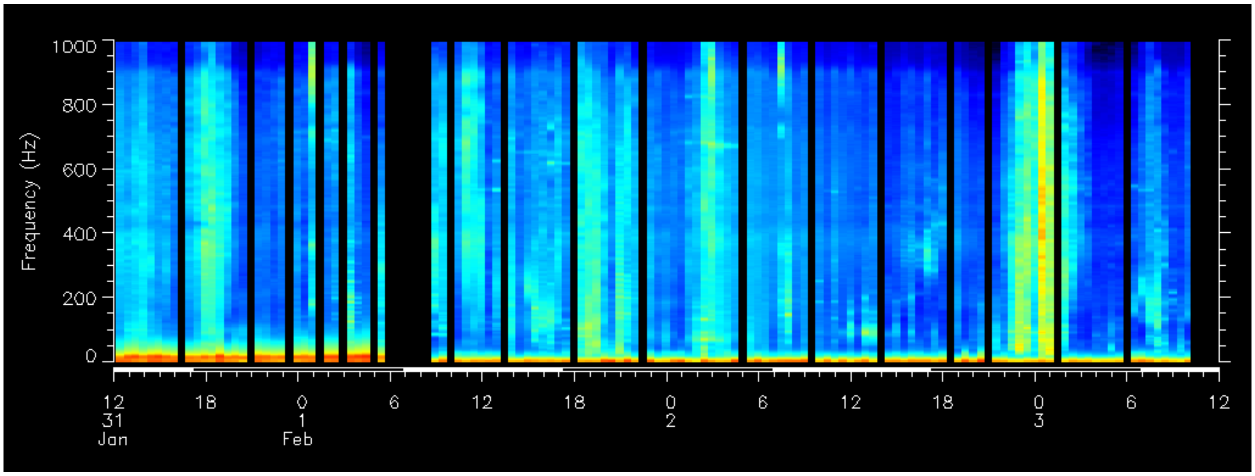

Figure 11. Background noise from glider we14 before and after removal of the protective aluminum cage over the DMON2 hydrophone (warm colors are loud, cool colors are quiet). Note the change in the very low-frequency noise after removal of the cage in the early morning hours of February 1.