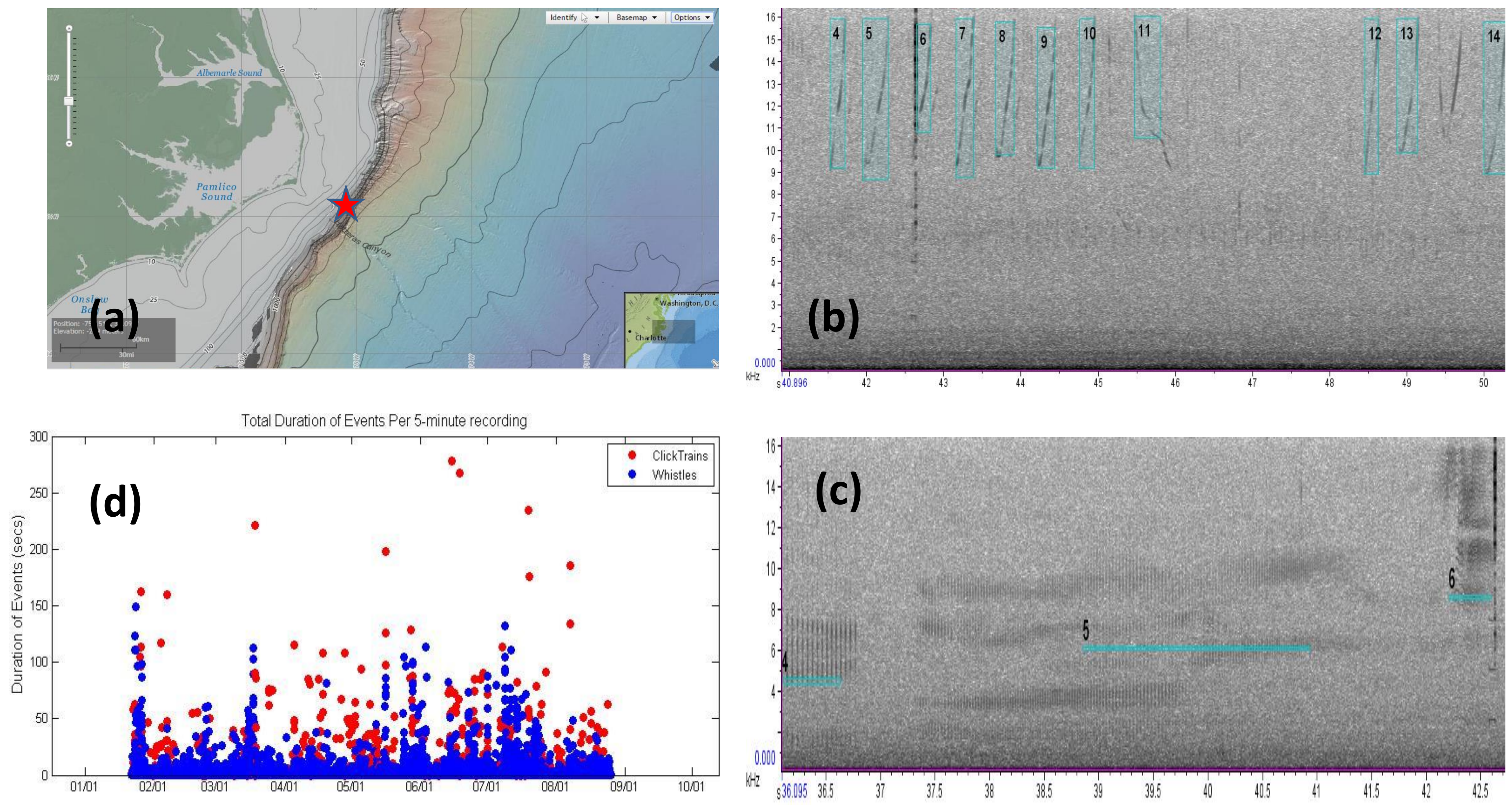
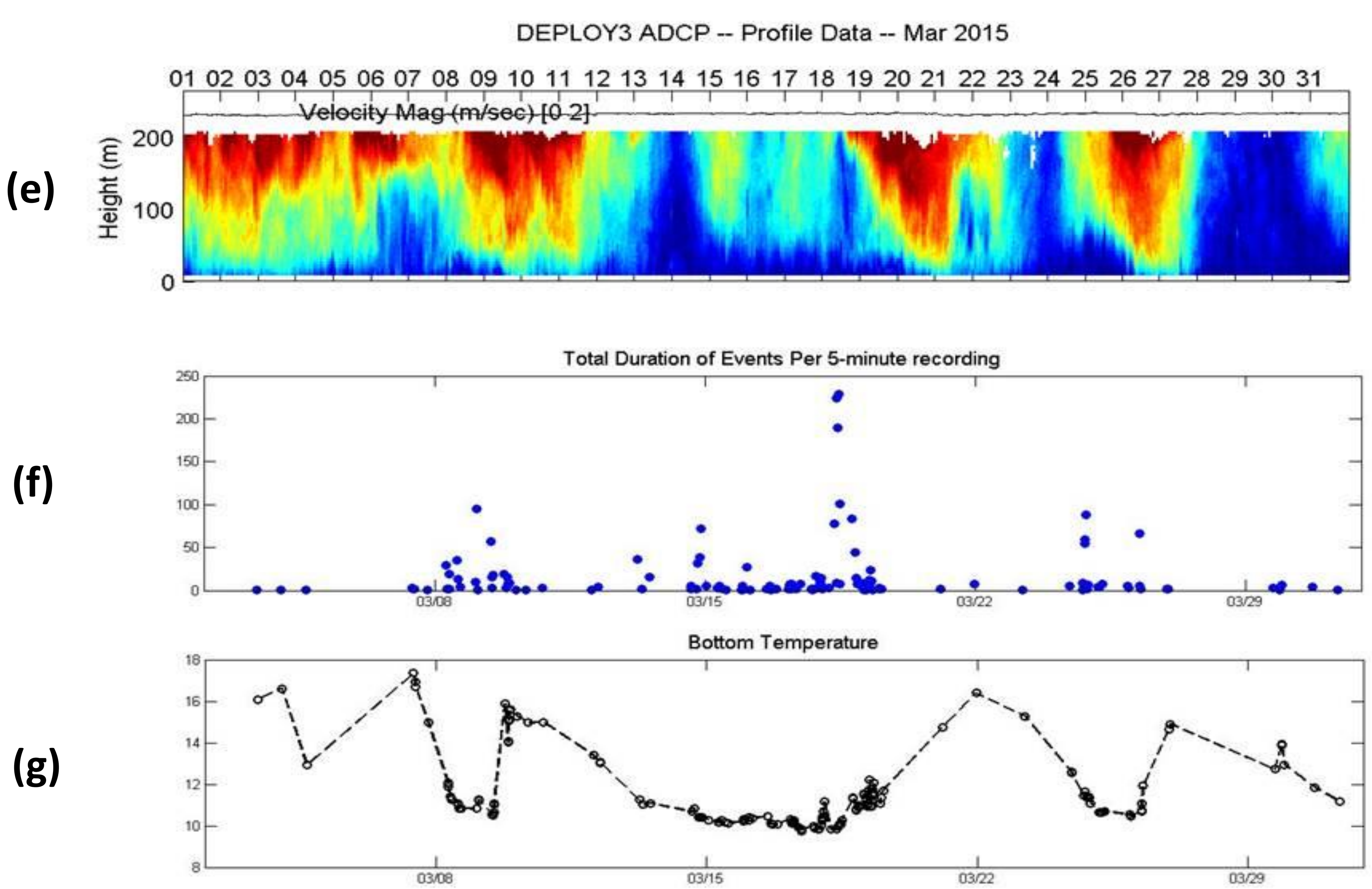
Detection of marine mammal vocalizations off Cape Hatteras, modulated by the Gulf Stream



A hydrophone was deployed **(a)** on the continental slope off Cape Hatteras, North Carolina, USA for 7 months—from late January to late August 2015—at a depth of 230m. The Aural-M2 hydrophone was configured to sample at 32768 samples/second, recording for 5 minutes out of every half-hour. For each recording interval, we looked for **(b)** whistles and **(c)** clicks trains. Whistles were detected using Silbido. Clicks were detected using a Teager–Kaiser energy operator (after high-pass filtering). Clicks were then grouped into click trains. For each 5-minute recording interval, we measured **(d)** the total duration of click trains and the total duration of whistles.



We found a strong correlation between the duration of click trains and the bottom temperature at the mooring location. For example, we zoom in on the month of March. From the mooring's ADCP data, **(e)** shows the magnitude of the velocity of the current above the mooring as a function of depth (y-axis) and time (x-axis). From the vertical structure of the velocity field, we can tell whether the Gulf Stream is above the mooring or farther offshore. From the mooring's hydrophone data, **(f)** plots the total duration (in seconds) of detected click trains for each of the 5-minute recording intervals. From the mooring's CTD data, **(g)** shows the temperature on the bottom (at the mooring) during each of the 5-minute recording intervals.

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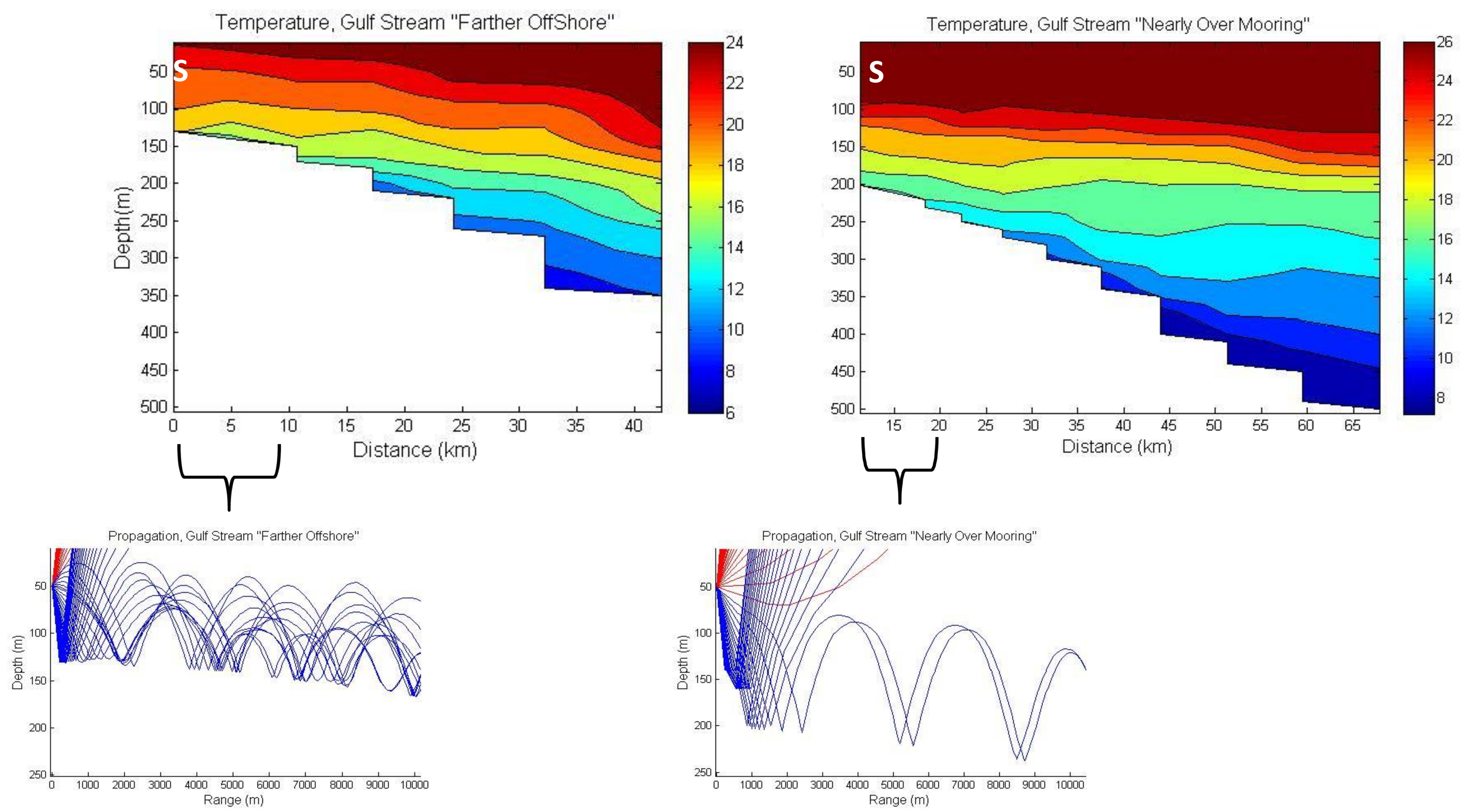

Zooming in on a 10km range, rays within a ~10 degree arc can propagate more than 2km down the slope for this scenario

Zooming in on a 10km range, only rays within a 1.5 degree arc can propagate more than 2km down the slope for this scenario.

One possibility is that the correlation is truly related to marine mammal abundance. The marine mammals may be following the cold bottom water, which originates north of the Gulf Stream. An alternative is that the correlation might be related to a change in acoustic propagation.

Therefore, our next step was to model the acoustic propagation under two scenarios:

-The Gulf Stream is "farther offshore" with respect to the mooring position
-The Gulf Stream is "nearly over" the mooring position

We found a representative transect nearby for each of our scenarios from Robert Todd's Spray gliders. His glider transect 15C066, section 7 represents the scenario where the Gulf Stream is "Farther Offshore", and glider transect 15A065, section 9 represents the scenario where the Gulf Stream is "Nearly Over Mooring".

For each scenario, we calculated sound speed profiles. Using bellhop, we then modeled the acoustic propagation (in 2D), with the source (S) located at a depth of 50m. For each scenario, we modeled rays emanating seaward from the source, from 20 degrees above horizontal to 20 degrees below horizontal. (The source location would be consistent with marine mammals foraging at a depth of 50m near the shelf break.)

For this source depth, we found that when the Gulf Stream was "far offshore", the propagation was slightly more favorable. When the Gulf Stream was "nearly over the mooring", the arc of angles that could propagate more than 2km down the slope was reduced by a factor of six. This would suggest that the correlation is merely due to changes in acoustic propagation.

On the other hand, clicks must be within a few kilometers to be detected. Since the difference between these propagation models is not great for ranges *below 2km*, the correlation *could be* due to marine mammal abundance….

ACKNOWLEDGMENTS:
We would like to thank Dr. John Bane of the University of North Carolina at Chapel Hill for his review and input. This project was funded by the North Carolina Renewable Ocean Energy Project.