The Gulf Stream Near the Rhumb Line Newport-Bermuda May 10, 2022
An Analysis of Conditions

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With slightly more than one month to go until the start of this year's Newport - Bermuda Ocean Race it's none too early for anyone involved in planning race strategies to start the study of the Gulf Stream in earnest. For those less than familiar with the Stream and its attendant features including current structure, warm and cold core rings, and meanders I'd suggest reading my Gulf Stream Primer posted on the Race homepage (www.Bermudarace.com) under the Resources tab – Gulf Stream and WX. With the power of the Web all of the data necessary to plan race strategies are available for your use, many both onshore, before the Race, and offshore, during the passage down and back. To realize full value of these resources however, does require some work and study. This note and the ones to follow before this year's June 17th start are intended to assist in these efforts.

Recognizing that the Gulf Stream is typically a well defined boundary current between the warm waters of the Sargasso Sea surrounding Bermuda and the cooler waters off the east coast of the United States it's logical to begin study by examining data detailing sea surface temperatures in the vicinity of the rhumb line. A number of web sites can be used to obtain these data (see links listing on Bermudarace.com). I typically start with a review of the sea surface temperature (SST) satellite images at (http://rucool.marine.rutgers.edu/) , a site maintained by Rutgers University. This site provides both instantaneous SST images and daily composites allowing analysis of Stream characteristics during periods of moderate cloud cover. Comparisons of the two types indicates that compositing (typically a daily average of conditions but sometimes longer) does degrade accuracy slightly but the loss is generally small since the structure of the Stream seldom changes significantly over the averaging period. Still, care is recommended in the interpretation of composite images. The Rutgers site also provides an archive of past satellite images useful in the study of changes in Stream position or structure. The Ocean Prediction Center provides another source of four day composites of the Stream in a loop that is of particular value in evaluating the rate of evolution of flow features. See https://ocean.weather.gov/Loops/ocean_guidance.php?model=GOES&area=MidAtl&plot=sstrec&day=0&loop=1

Satellite views of sea surface temperatures in the vicinity of the Newport-Bermuda rhumb line in early February showed the Gulf Stream crossing the rhumb line at a near right angle near a point approximately 240nm from Newport (Fig.1). The main body of the Stream shown in darkest red, representing the highest water temperatures, displayed a clear meandering pattern beginning shortly after passing Cape Hatteras. By early April (Fig.2) this meander had changed form slightly with some evident displacement to the east.. Along the rhumb line the Stream crossing point was nearly identical to that observed in early February. The easterly movement of the meander caused a slight clockwise rotation in the Steam crossing angle with flows in April proceeding from the northwest to the southeast across the rhumb line.

By later March the trough to the east of the rhumb line in early March (Fig.2) rather than continuing an easterly migration. as expected from past experience, backed to the west resulting in an abrupt deepening of the trough (Fig. 3) and a change in current direction with flows in the main body of the Stream now proceeding in a south easterly direction parallel to the rhumb line before turning progressively to the east to cross the rhumb line at a point nearly 300nm from Newport. This change in meander migration patterns has become increasing common over the past ten years and may be the result of some alterations in the amounts of water supplied to the Gulf Stream from points to the south. Whatever the reason the result has been the development of meander patterns that are often complex and evolving in ways that are difficult to predict. This behavior makes early observation particularly important.

Over the next month the meander trough near the rhumb line backed progressively to the west, deepened slightly and formed a near circular pattern (Fig.4) The resulting “oxbow” produced flows across the rhumb line proceeding from the southwest to the northeast. The extremity of this pattern gave every indication that it would shortly “pinch off” from the main body of the Stream to form a cold core ring. It’s interesting to note that the duration of this evolution over a period of approximately 30 days is nearly identical to previous events that resulted in ring formation. This may be a typical ring evolution time. Keep this in mind in the evaluation of future events.

By 1 May the satellite imagery, although degraded by cloud cover, gave every indication that the meander had “pinched off” forming a cold core ring to the west of the rhumb line centered near 36^{o} N 68^{o} 30’ W (Fig.5). A new meander limb was formed along 38^{o}N resulting in flows across the rhumb line from the northwest to the southeast at a point approximately 240nm from Newport. The Altimetry based model data (Fig. 6) provides more detail on Stream structure on the 1st of May (remember that there is a two day delay associated with the processing of the altimetry data) showing a relative deep meander crossing the rhumb line and a free standing cold core ring to the west. The ring at this time appears to be in close contact with the main body of the Stream which may affect its future movements.

Over the next week the altimetry based model of 10 May shows the western limb of the meander moving slightly to the east resulting in southeasterly flows paralleling the rhumb line before crossing from the northwest to the east southeast near 37^{o} 30’ N 68^{o} W (Fig. 7). The cold core ring has moved slightly to the west suggesting that it stands, to some extent, clear of direct Stream influence. The altimetry based model also shows a complexity of currents along the rhumb line to the east of the cold ring as well as a second cold ring on the rhumb line near 35^{o} N 67^{o} W and a broad area of weak but adverse northwesterly going flows on approach to Bermuda. This combination has the potential to significantly affect optimum routing. It also represents a challenging scenario for the computer models used to detail and predict the flow in the vicinity of the rhumb line. The U.S. Navy HYCOM model, for example, which together with the NOAA Real Time Ocean Forecast System (https://polar.ncep.noaa.gov/global/fronts/?) is often used in routing programs (e.g. Expedition), shows a reasonable representation of the main body of the Stream and the meander limb along the rhumb line (Fig. 8) but less detail of the cold rings and associated currents. The extent to which this affects routing solutions needs to be carefully studied over the next few weeks. Careful attention should also be paid to the trajectory of the cold rings (expected to drift to the west at ~o.1kts if clear of Stream influence) and the migration of the meander. Each of these factors will affect the selection of Stream entry points and the subsequent track to Bermuda.

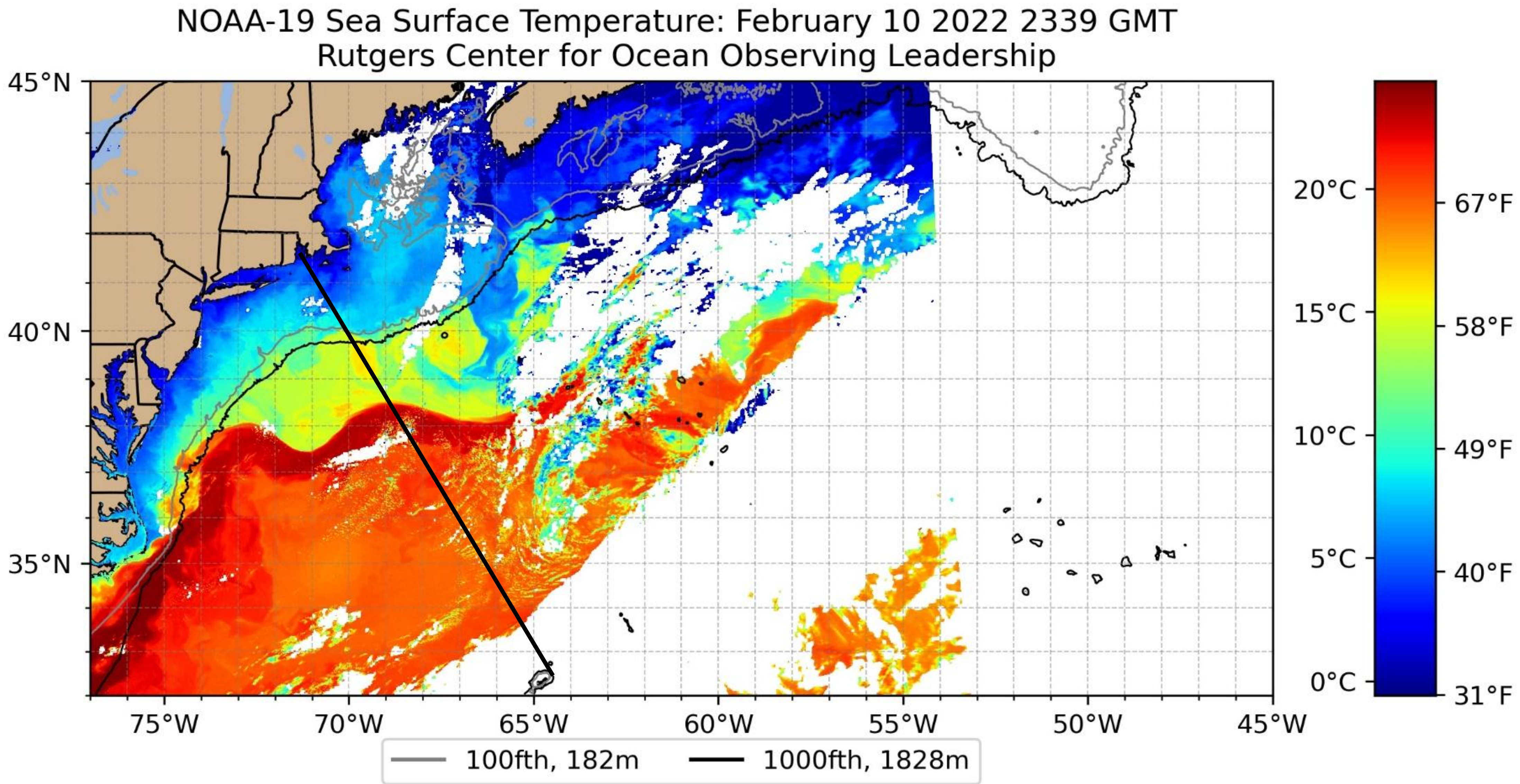
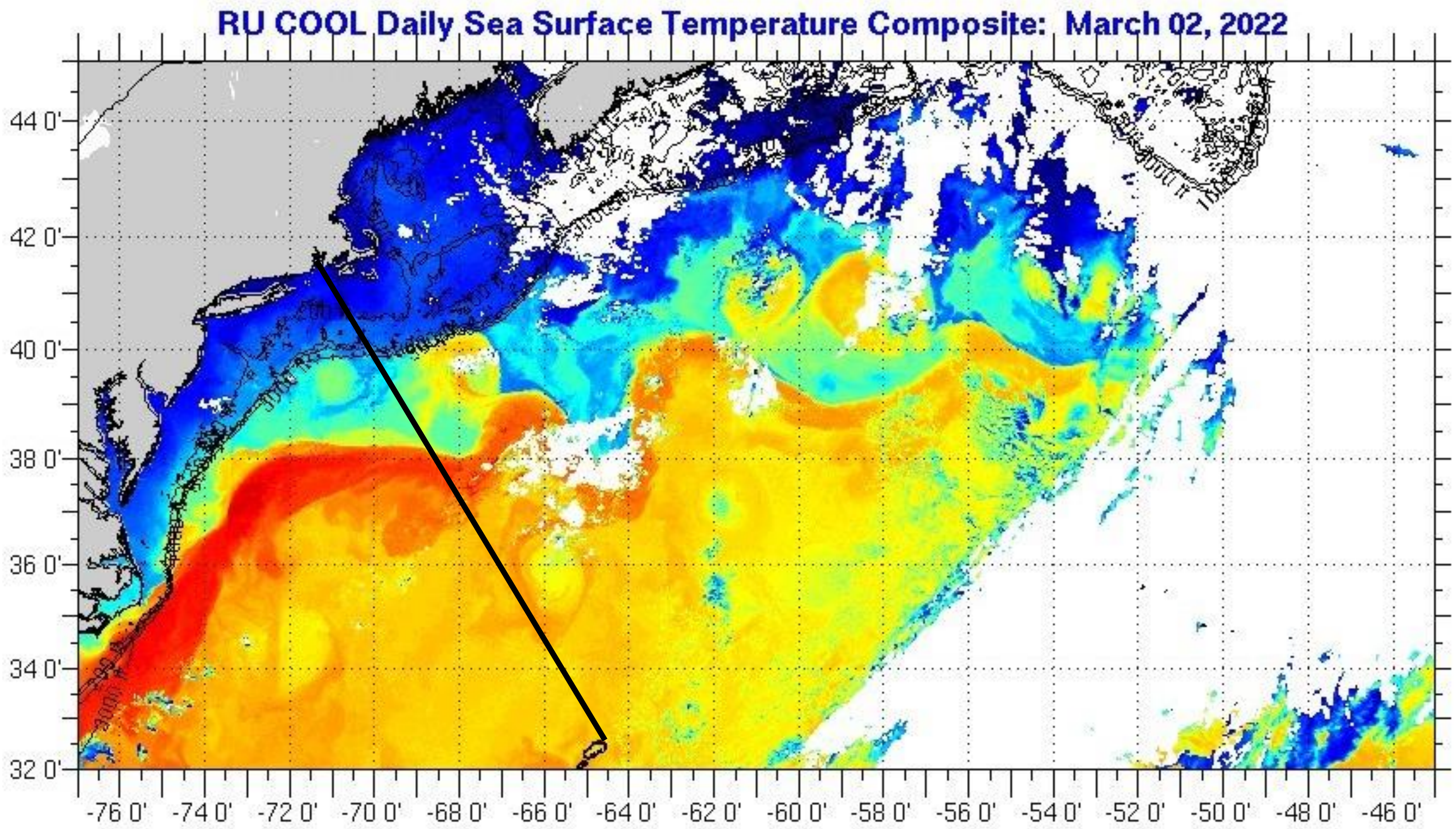


Figure 1 Satellite Image of Sea Surface Temperatures Northwest Atlantic Ocean February 10, 2022

https://marine.rutgers.edu/cool/sat_data/

Dark Line indicates Newport-Bermuda Rhumb Line



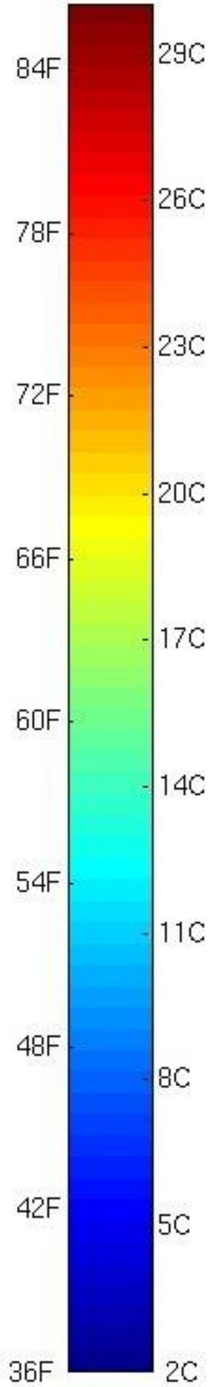


Figure 2 Composite Satellite Image of Sea Surface Temperatures

Northwest Atlantic Ocean March 2, 2022

https://marine.rutgers.edu/cool/sat_data/

Dark Line indicates Newport-Bermuda Rhumb Line

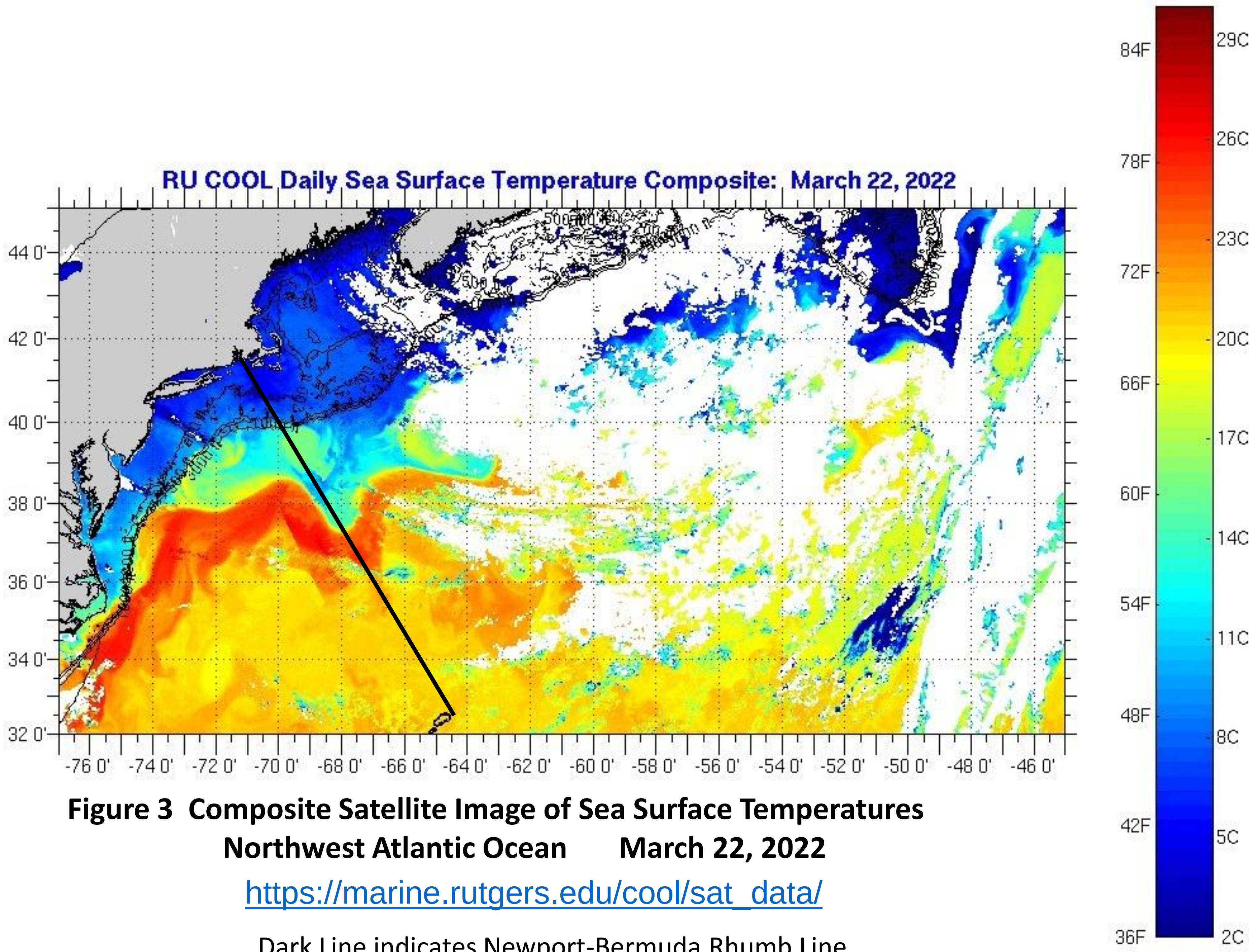


Figure 3 Composite Satellite Image of Sea Surface Temperatures
Northwest Atlantic Ocean March 22, 2022

https://marine.rutgers.edu/cool/sat_data/

Dark Line indicates Newport-Bermuda Rhumb Line

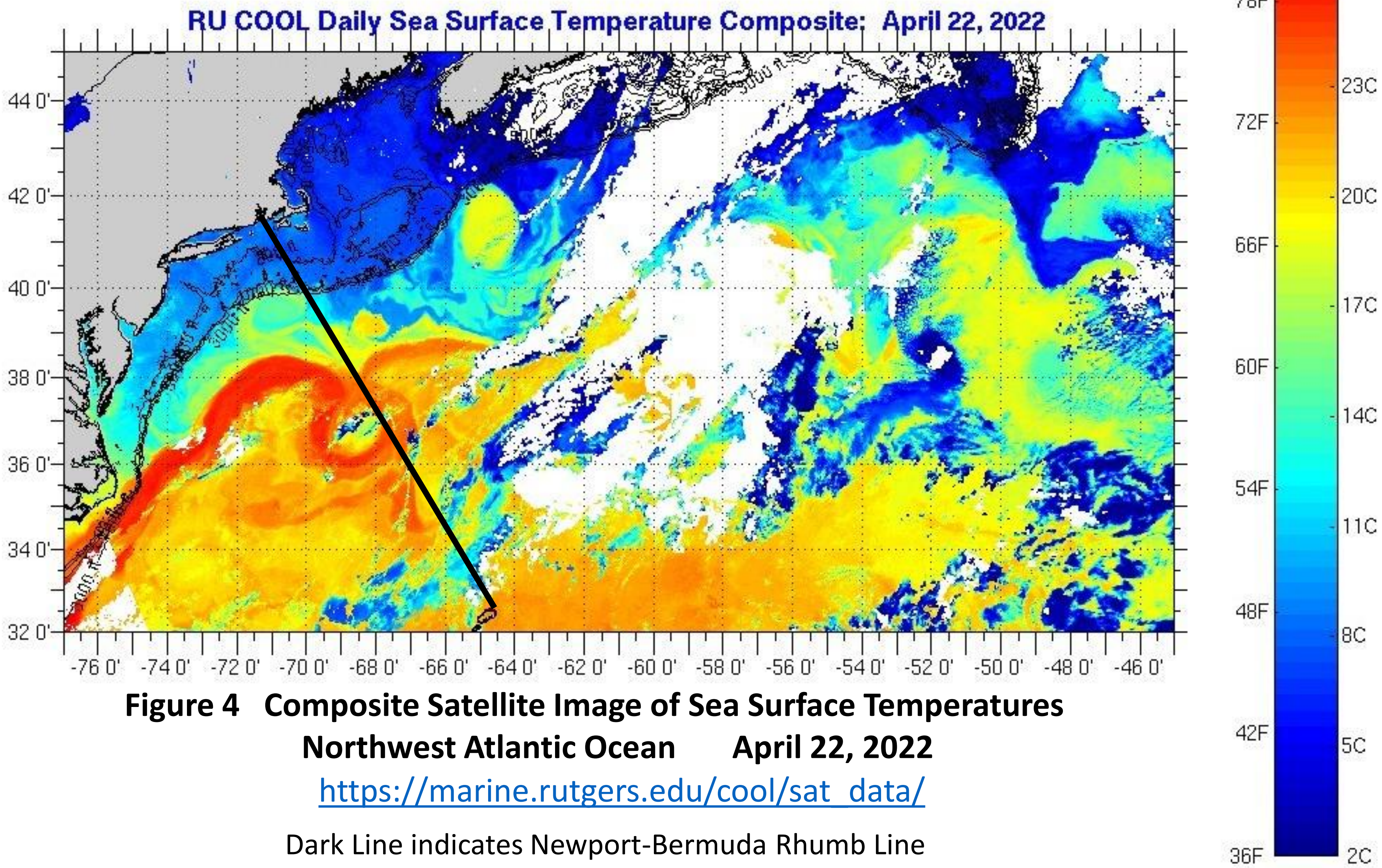


Figure 4 Composite Satellite Image of Sea Surface Temperatures

Northwest Atlantic Ocean April 22, 2022

https://marine.rutgers.edu/cool/sat_data/

Dark Line indicates Newport-Bermuda Rhumb Line

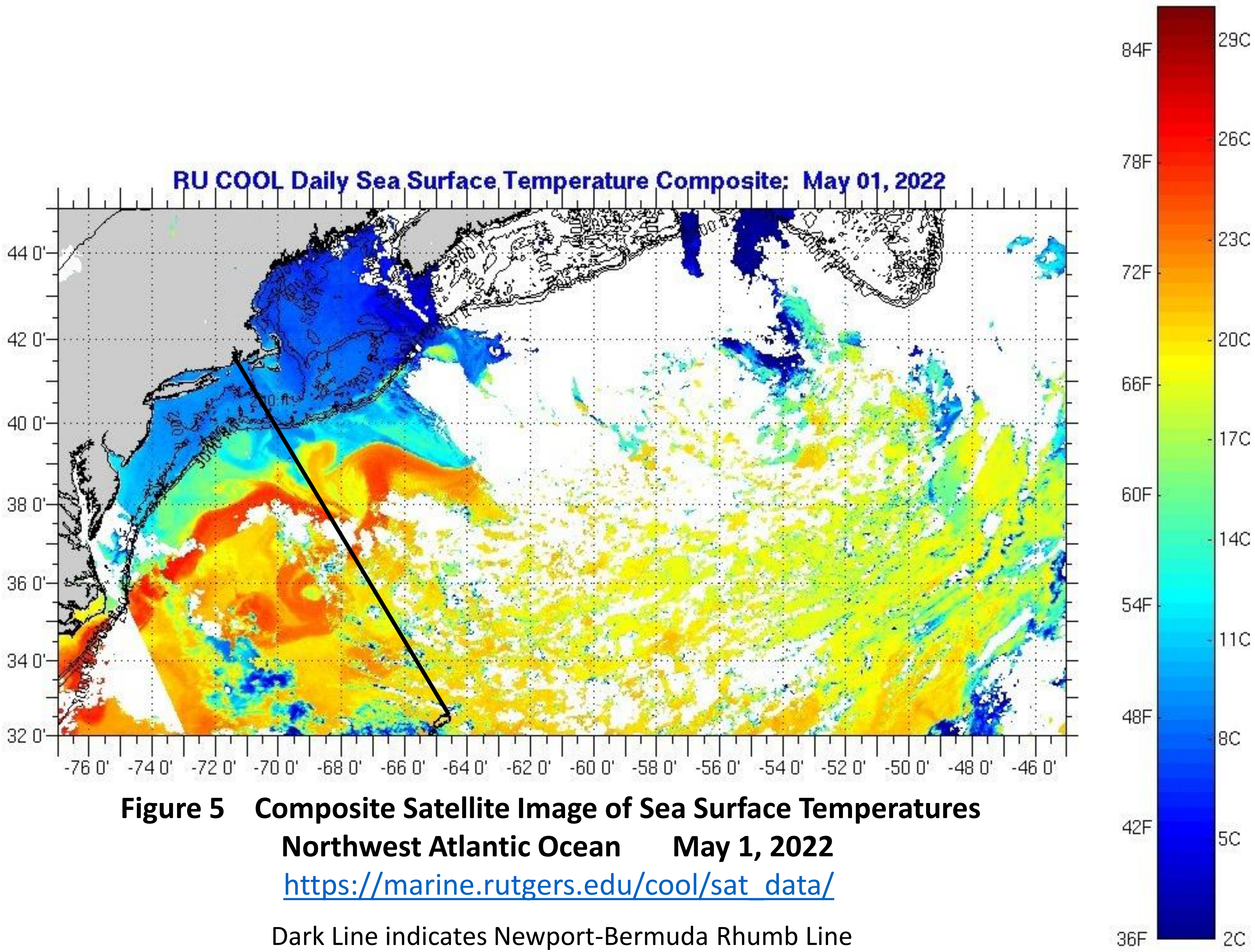


Figure 5 Composite Satellite Image of Sea Surface Temperatures
Northwest Atlantic Ocean May 1, 2022

https://marine.rutgers.edu/cool/sat_data/

Dark Line indicates Newport-Bermuda Rhumb Line

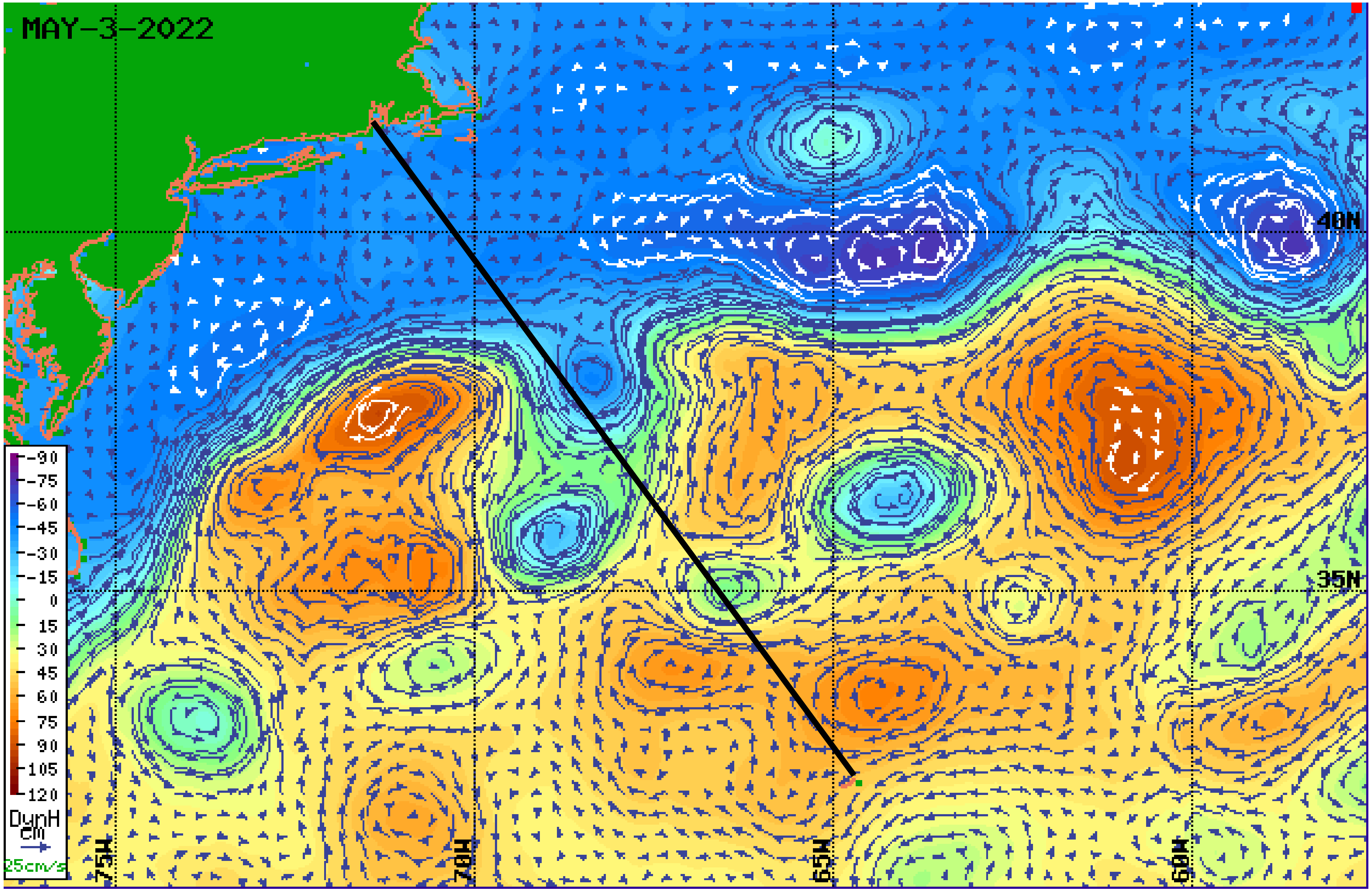


Figure 6 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- May 3, 2022

Dark Line Indicate Newport Bermuda Rhumb Line

https://cwcaribbean.aoml.noaa.gov/CURRENTS/index.html

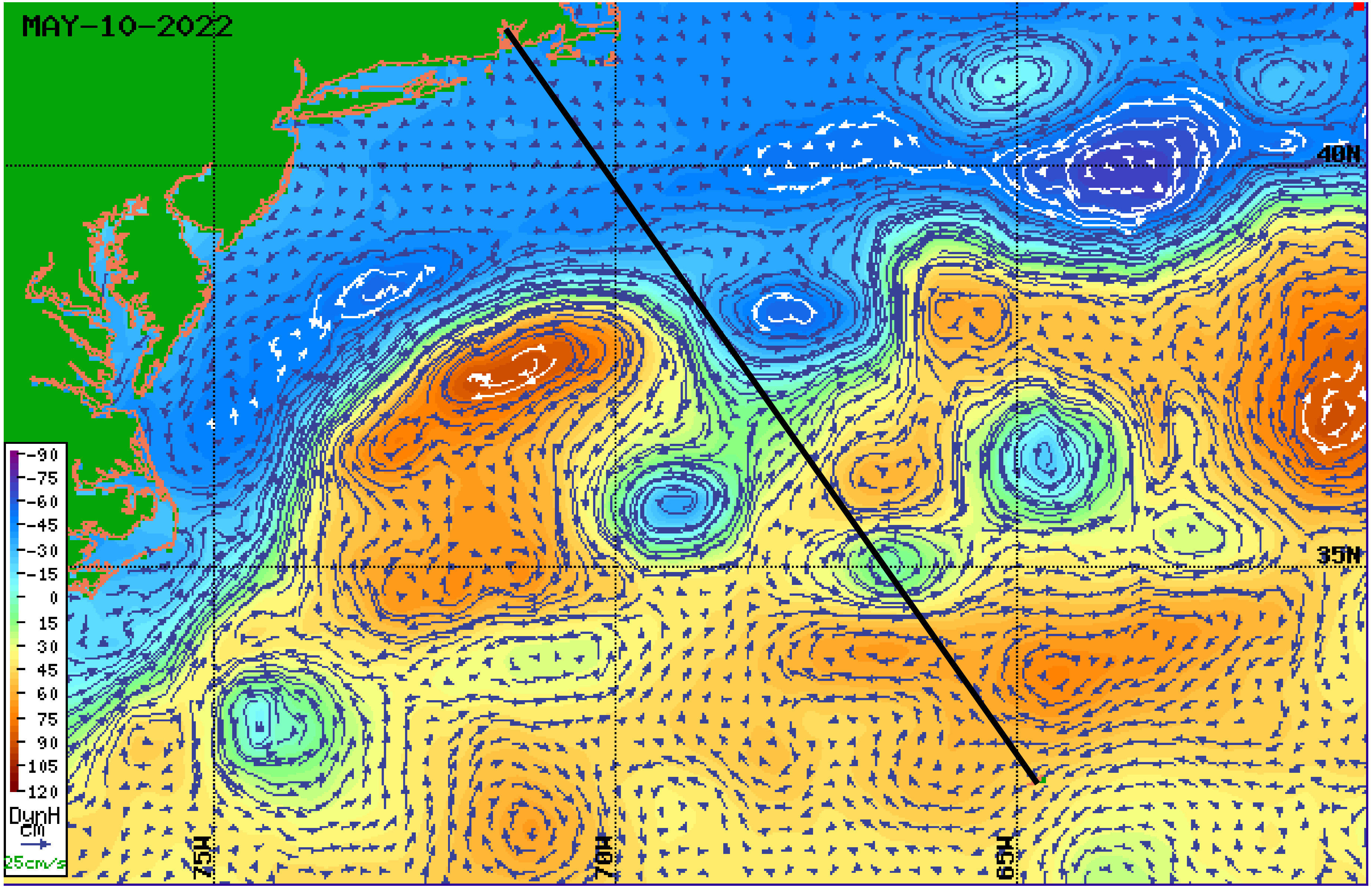


Figure 7 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- May 10, 2022

Dark Line Indicates Newport Bermuda Rhumb Line

https://cwcaribbean.aoml.noaa.gov/CURRENTS/index.html

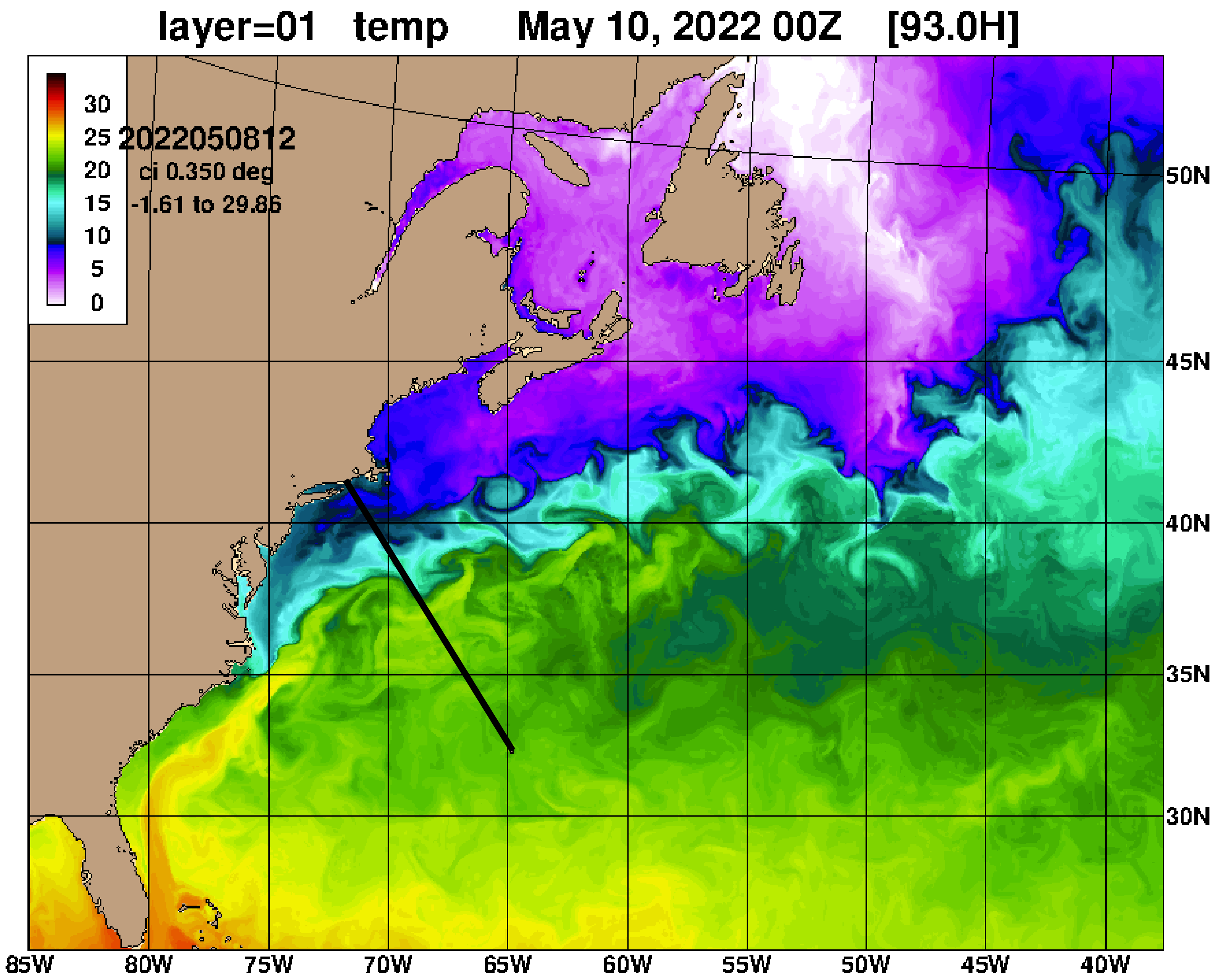


Figure 8 USN HYCOM Model of NW Atlantic Sea Surface Temperatures May 10, 2022

Dark Line Indicates Newport Bermuda Rhumb Line

https://www7320.nrlssc.navy.mil/GLBhycomcice1-12/