Gulf Stream Note # 1 - 2021
The Gulf Stream near the Rhumb Line Rhode Island Sound to Bermuda May 1, 2021
An Analysis of Conditions

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With something more than a month to go to what we all hope will be the start of several races from New England to Bermuda it's time for most navigators to begin studying the Gulf Stream and its probable influence on race strategy. For those less than familiar with the Stream, the Gulf Stream Primer, posted on both the 1-2 and Marion sites, is a good place to start. Fundamentally, the Gulf Stream is a well-defined boundary current separating the colder waters of the U.S. continental shelf from the warm waters of the Sargasso Sea surrounding Bermuda. Temperature contrasts accurately define all aspects of the Gulf Stream. From the Straits of Florida to Cape Hatteras this current proceeds to the north along the edge of the continental shelf following a near linear path with minimal irregularities. In the vicinity of Cape Hatteras flow direction shifts to the northeast and the current progressively diverges from the continental shelf. As the flow proceeds offshore, the initial linear flow pattern becomes progressively more complicated replaced by meanders and eddies of warm and cold water shed to the north and south of the main body of the Stream. This complex pattern typically displays significant variability in both space and time. This is the current regime often encountered along and near the rhumb line New England to Bermuda. An understanding of Stream location and structure is essential to optimum routing for most boats. Add to this the fact that the warm waters of the Stream often influence local weather and we can add safety to the benefit of a careful early study of the Gulf Stream for those planning a crossing or transit.

Typical of most years, satellite views of the Gulf Stream during January and February of 2021 were limited due to persistent cloud cover. It's important to remember that imagery during the week before the race could well be similarly limited complicating late race planning. Observations starting now is the best way to avoid these "complications".

As conditions improved in early March satellite infrared imagery of sea surface temperatures (SST) showed the main body of the Gulf Stream (north edge) crossing the rhumb line near 38^0 N 68^0 30'W or approximately 240 nm from Rhode Island Sound (Fig.1). Flows proceeded from the northwest to the southeast along the west margin of a prominent meander extending east with a wavelength of more than 240 nm and an amplitude (crest to trough) of 70nm. This pattern is becoming more common and contrasts with patterns seen in late winter 10-20 years ago. In addition, the behavior of the meander, which we expect should migrate to the east at rates of 10-20nm/day, is today more commonly stationary increasing in amplitude or even regressive, moving to the west. This behavior makes accurate predictions of meander form and migration more difficult increasing the value of direct observation.

Satellite altimetry based modeling of the currents associated with the March 11 SST distributions shows the evident abrupt change in flow direction in the area of the meander and the typical 30nm distance separating the sharp increase in temperatures at the north edge of the Stream and the area of highest current speeds (Fig.2). In this "core" of the current flows are proceeding to the south and east nearly parallel to the rhumb line. On approach to 37^0N, the flows turn to the east crossing the rhumb line at a near right angle before turning further to the northeast. The altimetry based model shows a substantial area to the west of the rhumb line to 35^0 N affected by the meander. Beyond this area to Bermuda flows are weak setting generally to the east. The single organized flow feature is a counter clockwise rotating eddy to the southeast of Bermuda which has the potential to affect currents in the vicinity of the finish. Note that we are comparing the model results for the 13^{th} of March (Fig.2) to the SST plot for the 11^{th} (Fig.1). This two day difference is the time required to process the altimetry data obtained on 11 March.

By early April the meander straddling the rhumb line in March had migrated to the east leaving behind a nearly linear wake with only slight indication of a next phase meander near 69^0 W (Fig.3). The northern edge of the main body of the Stream crossed the rhumb line at a right angle at 38^0 N. In our next view of the Stream on 18 April (Fig.4) the northern edge of the Stream had moved slightly to the north but retained a linear

form across the rhumb line. An evident meander was forming near 71^0 W. which, as discussed above, would be expected to progressively deepen and migrate to the east across the rhumb line. This development however, failed to occur with the Stream returning to a near linear form by 30 April (Fig.5). To the east, the meander which crossed the rhumb line in early April similarly showed little easterly movement but a substantial increase in amplitude. The four-day composite image (Fig.6) provides a particularly interesting view of the Stream structure and the extent of the variability to the east of the rhumb line. There is also some slight indication of a meander forming to the west of the rhumb line. This possibility will be followed with interest over the next month.

The altimetry based model for 3 May (Fig.7) shows flows crossing the rhumb line at right angles as part of a developing meandering pattern with crests to the west near 71^0 30' W and to the east near 67^0 45' W. To the south an organized cold core ring is located near 35^0 N 70^0 W. The expected drift to the west should reduce the influence of this feature on flows along and adjacent to the rhumb line. There is another counter clockwise rotating feature to the west of Bermuda which is likely a remnant of the ring observed in March (Fig. 2). The model indicates that flow speeds in this are relatively low but given its location it still may affect the area of the finish and warrants careful monitoring.

Since today many are making use of various routing programs (e.g. Expedition) which require GRIB file input of current data and often use NOAA's Real Time Ocean Forecast System (RTOFS) it is advisable compare the above satellite observations and the altimetry based model to the RTOFS product. The model run of April 28 (Fig.8) shows close agreement with the Navy SST plot (Fig. 9) to the west of the rhumb line. To the east however, the differences in SST distributions are substantial and appear to be increasing with distance downstream. These variations can be expected to be accompanied by similar differences in current velocity sufficient to affect optimum routing. We will ty to explore the cause of these differences in more detail in the next GS Note. For the moment these differences should make clear the value of using a variety of data, both model and observation, as a basis for developing race strategy and optimum routing.

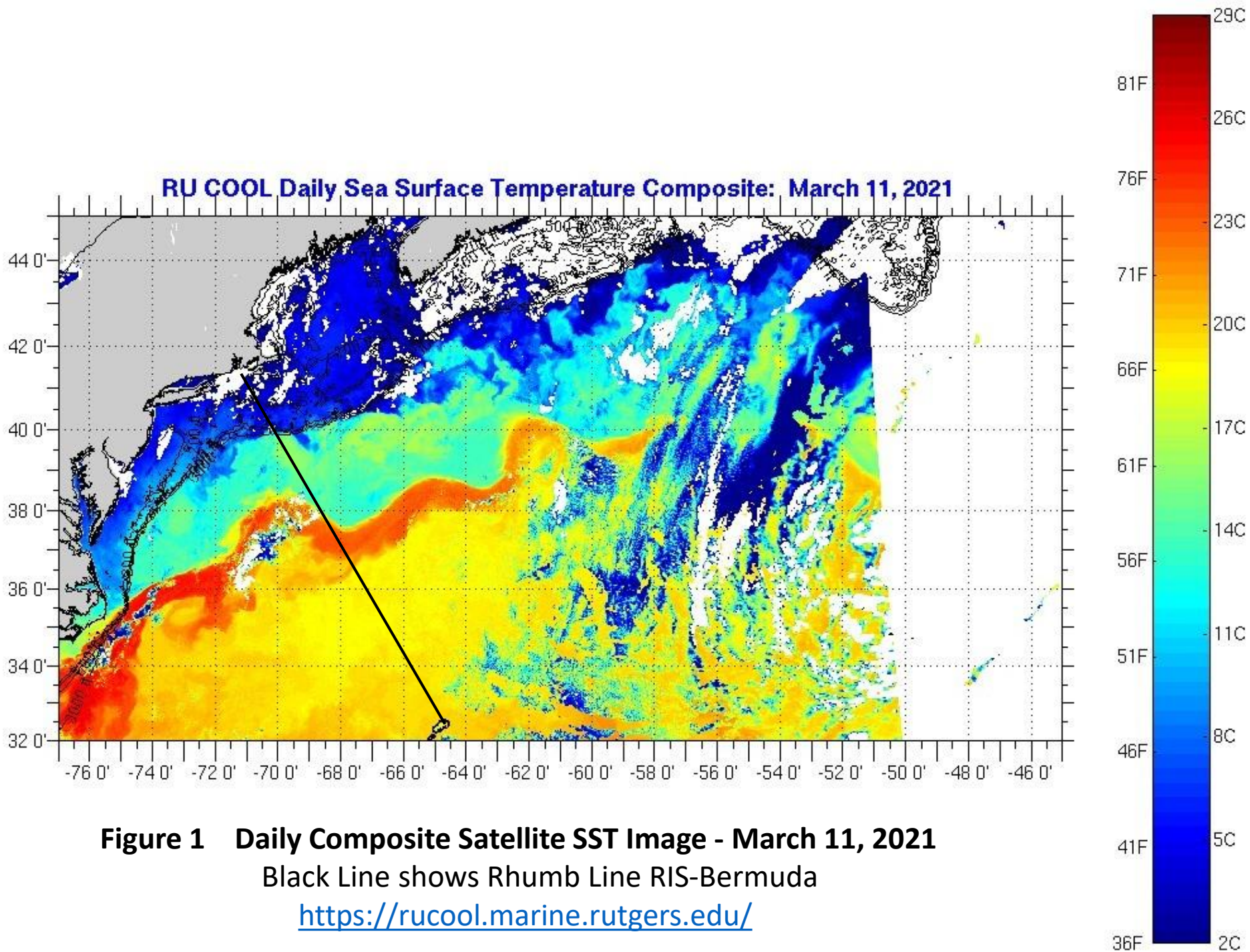


Figure 1 Daily Composite Satellite SST Image - March 11, 2021

Black Line shows Rhumb Line RIS-Bermuda

https://rucool.marine.rutgers.edu/

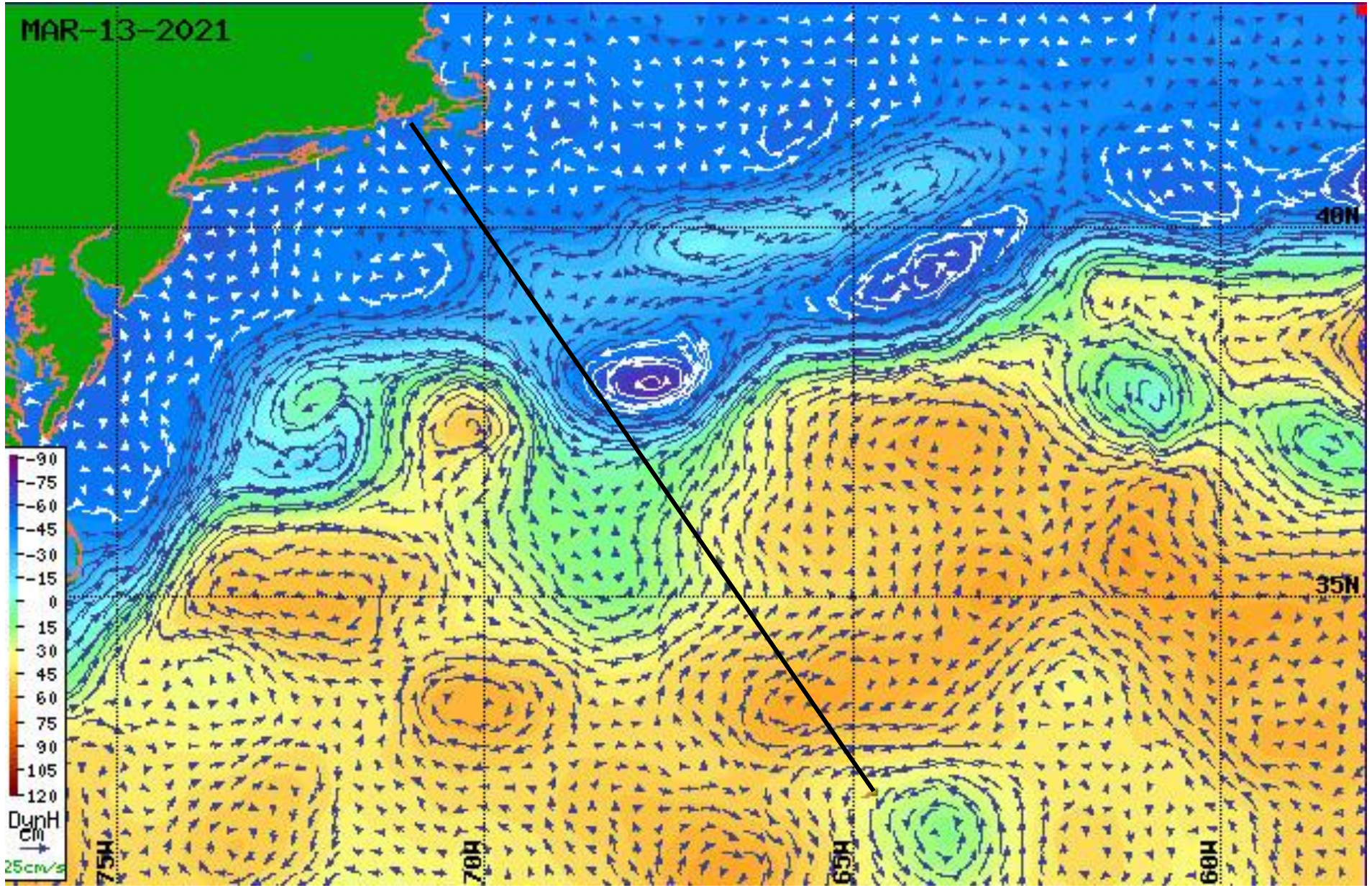


Figure 2 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- March 13, 2021

Black Line shows RIS-Bermuda Rhumb Line

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

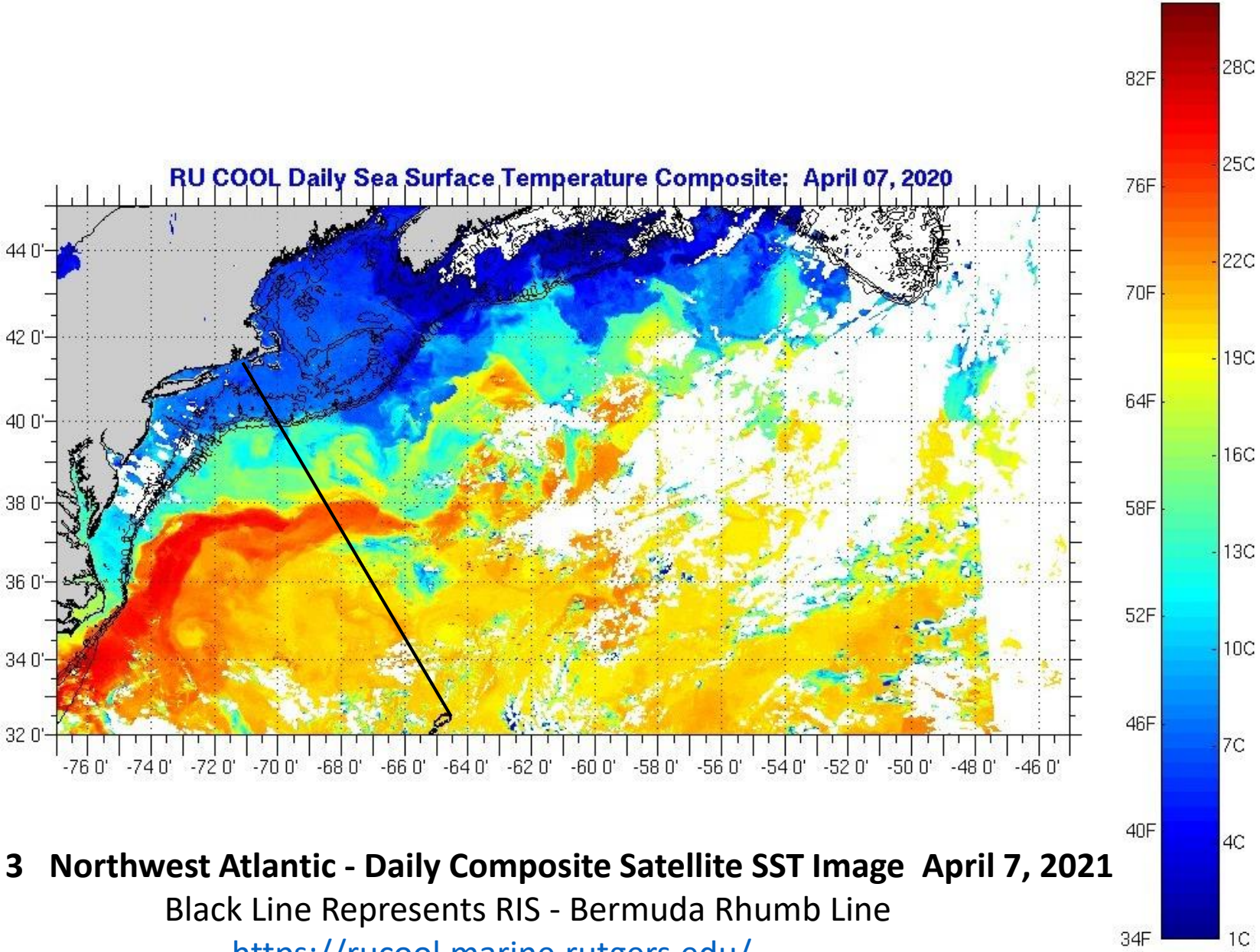


Figure 3 Northwest Atlantic - Daily Composite Satellite SST Image April 7, 2021

Black Line Represents RIS - Bermuda Rhumb Line

https://rucool.marine.rutgers.edu/

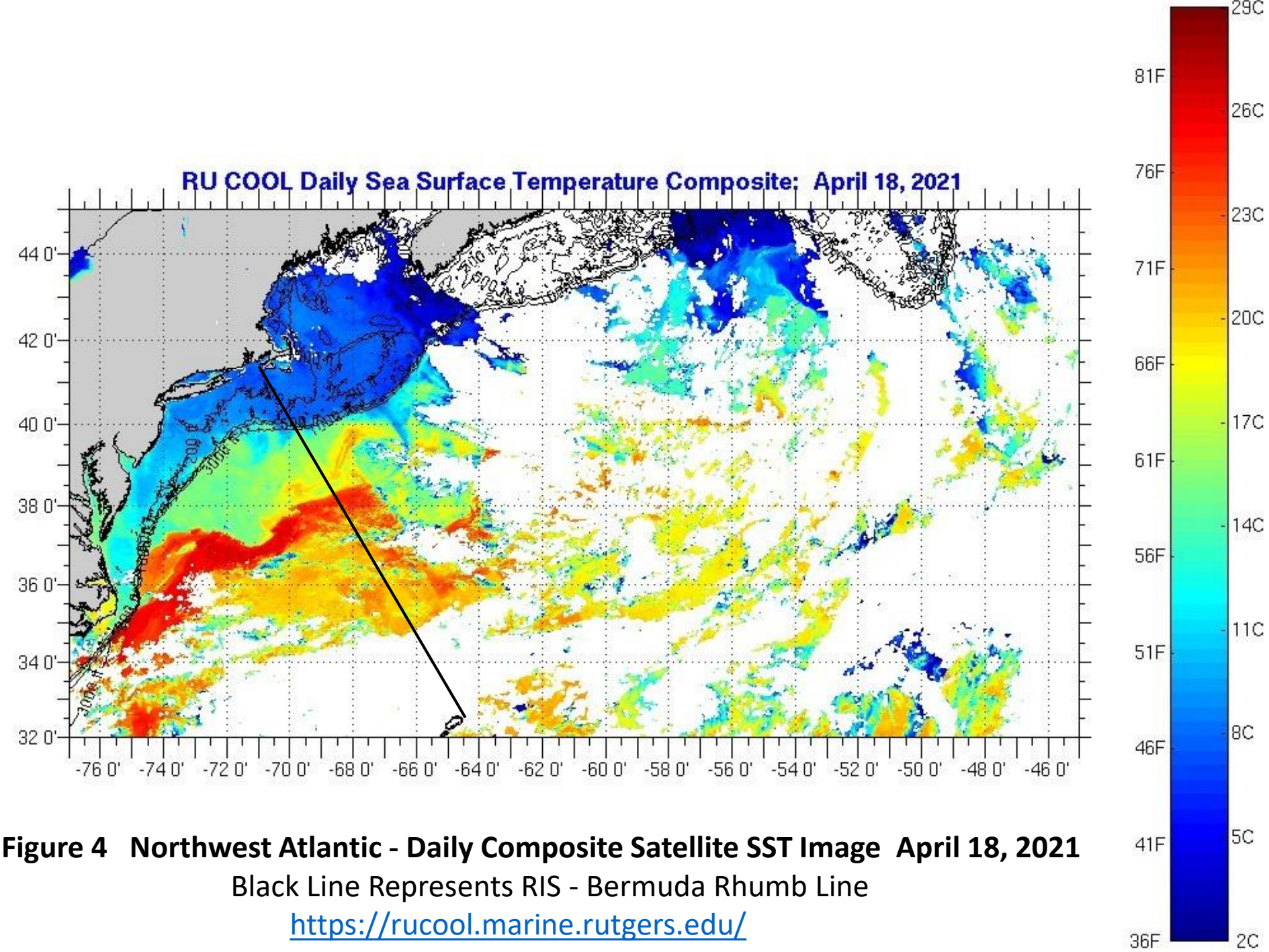


Figure 4 Northwest Atlantic - Daily Composite Satellite SST Image April 18, 2021

Black Line Represents RIS - Bermuda Rhumb Line

https://rucool.marine.rutgers.edu/

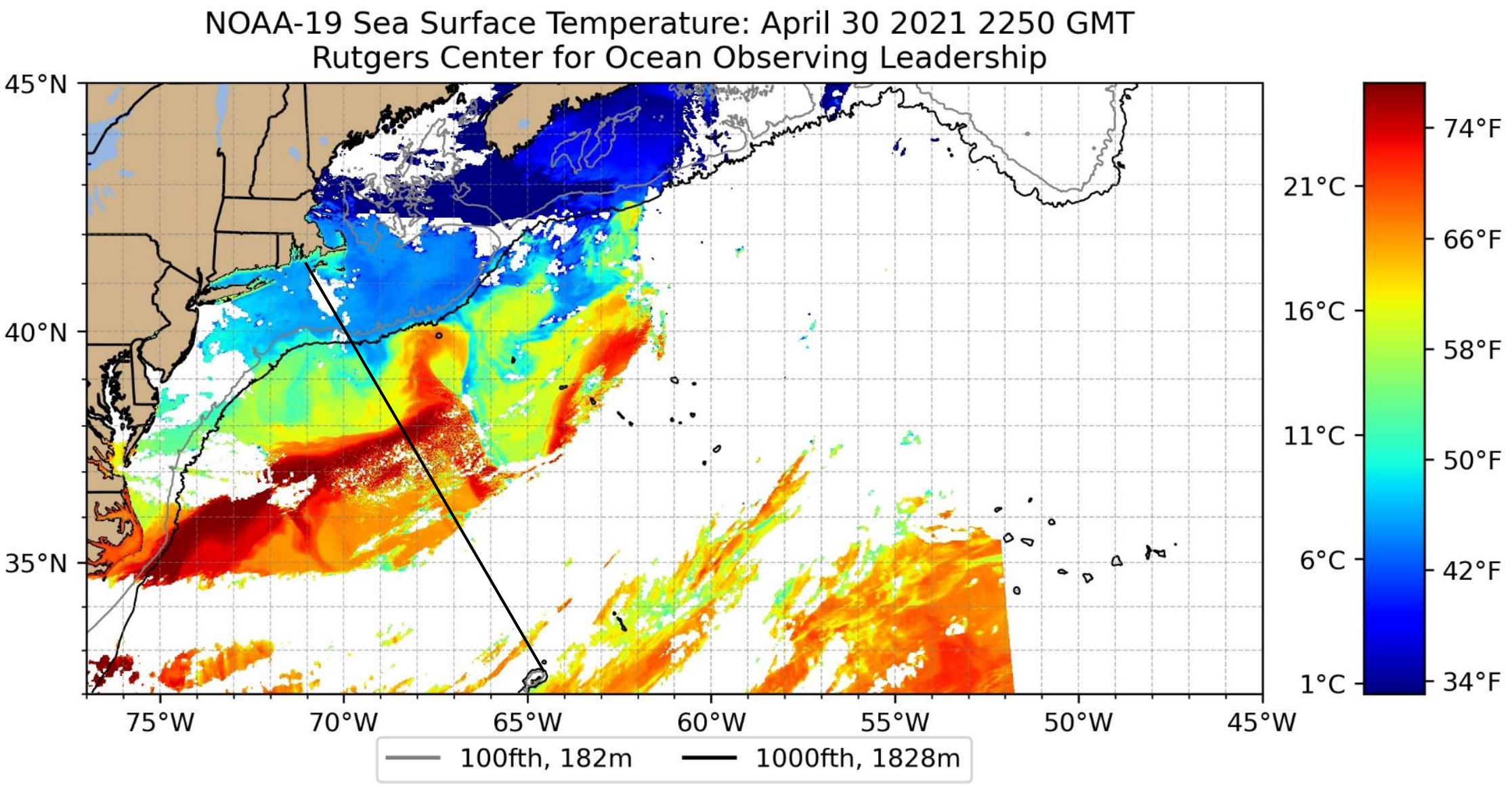


Figure 5 Instantaneous Satellite SST Image 2250 GMT April 30, 2021

Black Line Represents RIS - Bermuda Rhumb Line

https://rucool.marine.rutgers.edu/

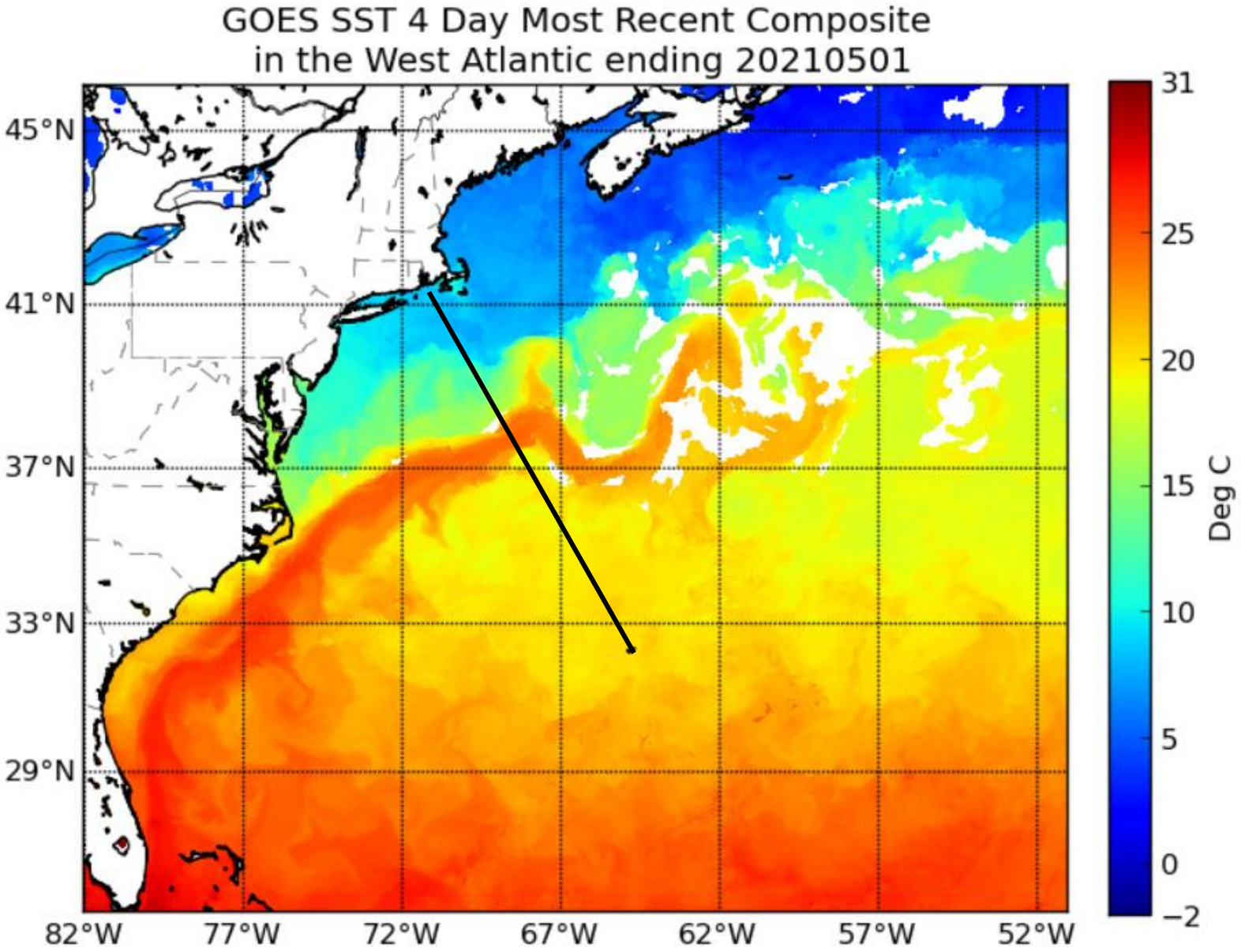


Figure 6 Four Day Composite Satellite Image Surface Water Temperatures May 1, 2021

Black Line Represents RIS - Bermuda Rhumb Line

https://ocean.weather.gov/Loops/ocean_guidance.php?model=GOES&area=MidAtl&plot=sstrec&day=0&loop=1

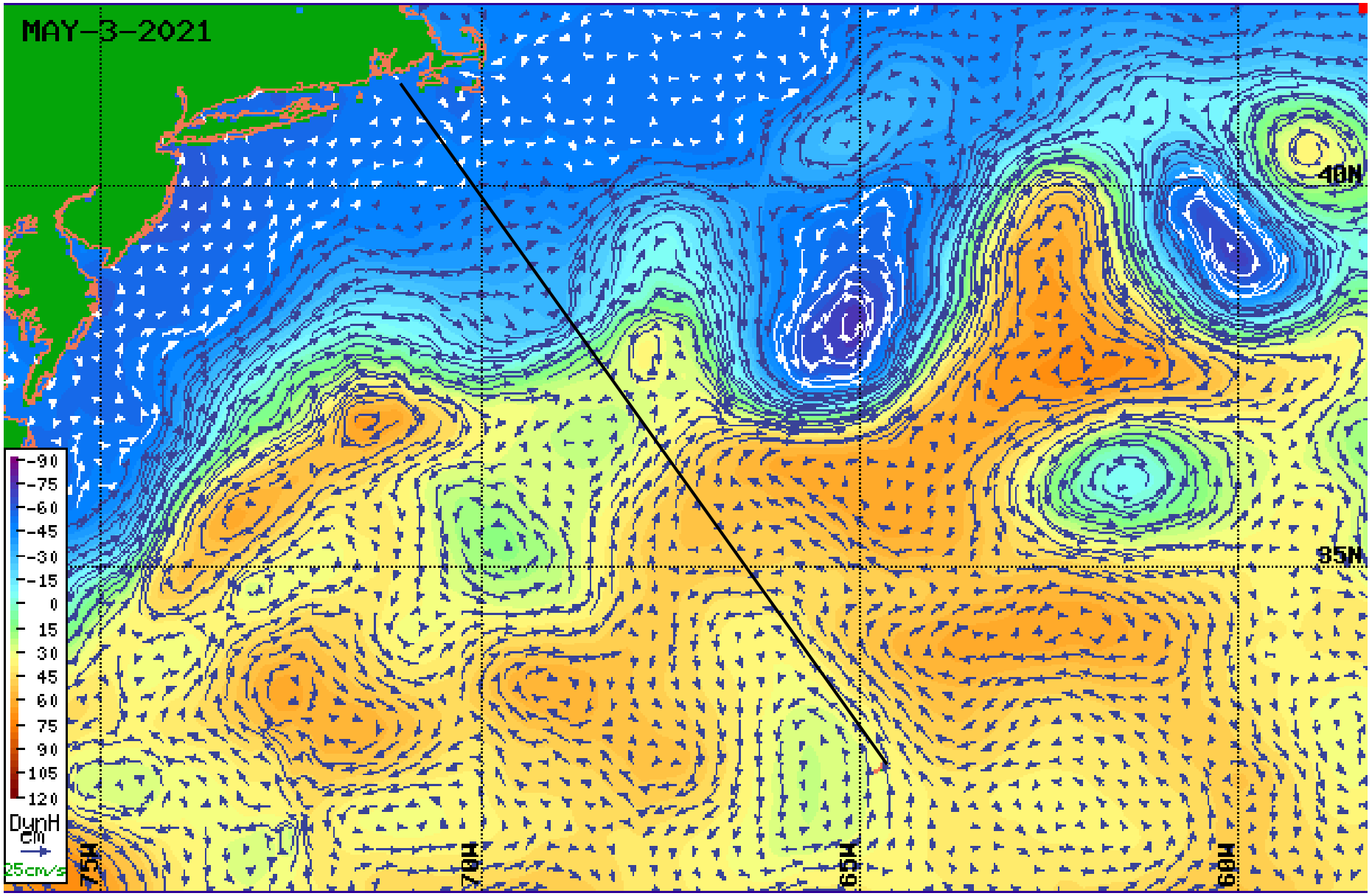
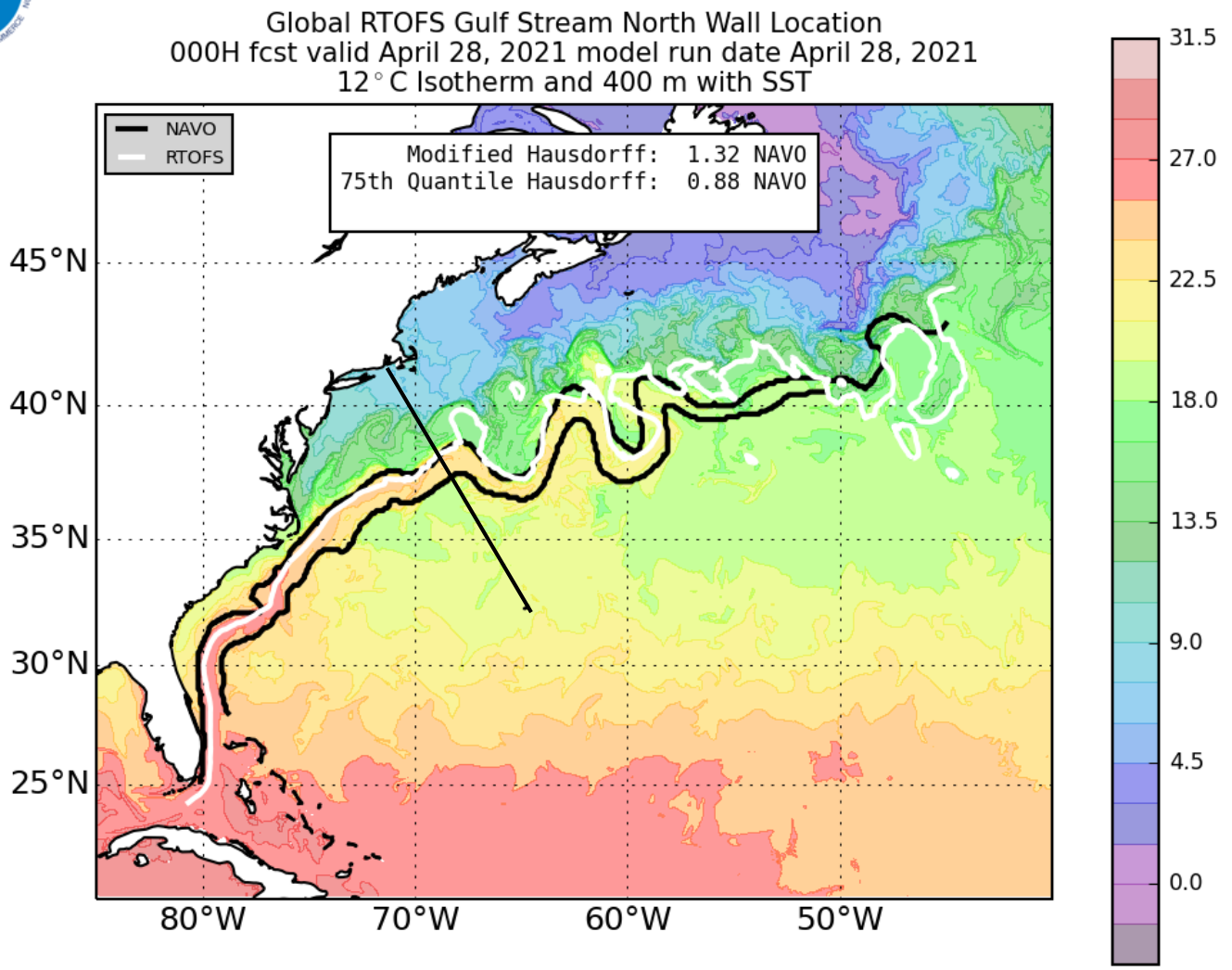


Figure 7 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- May 3, 2021

Black Line shows RIS-Bermuda Rhumb Line

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



NCEP/EMC Verification Post Processing Product Generation Branch 29 Apr 2021 *onHera*

Figure 8 Global RTOFS Model Sea Surface Temperature April 28,2021

Black Line Represents RIS-Bermuda Rhumb Line

[Global RTOFS WBC Frontal Analyses (noaa.gov)]

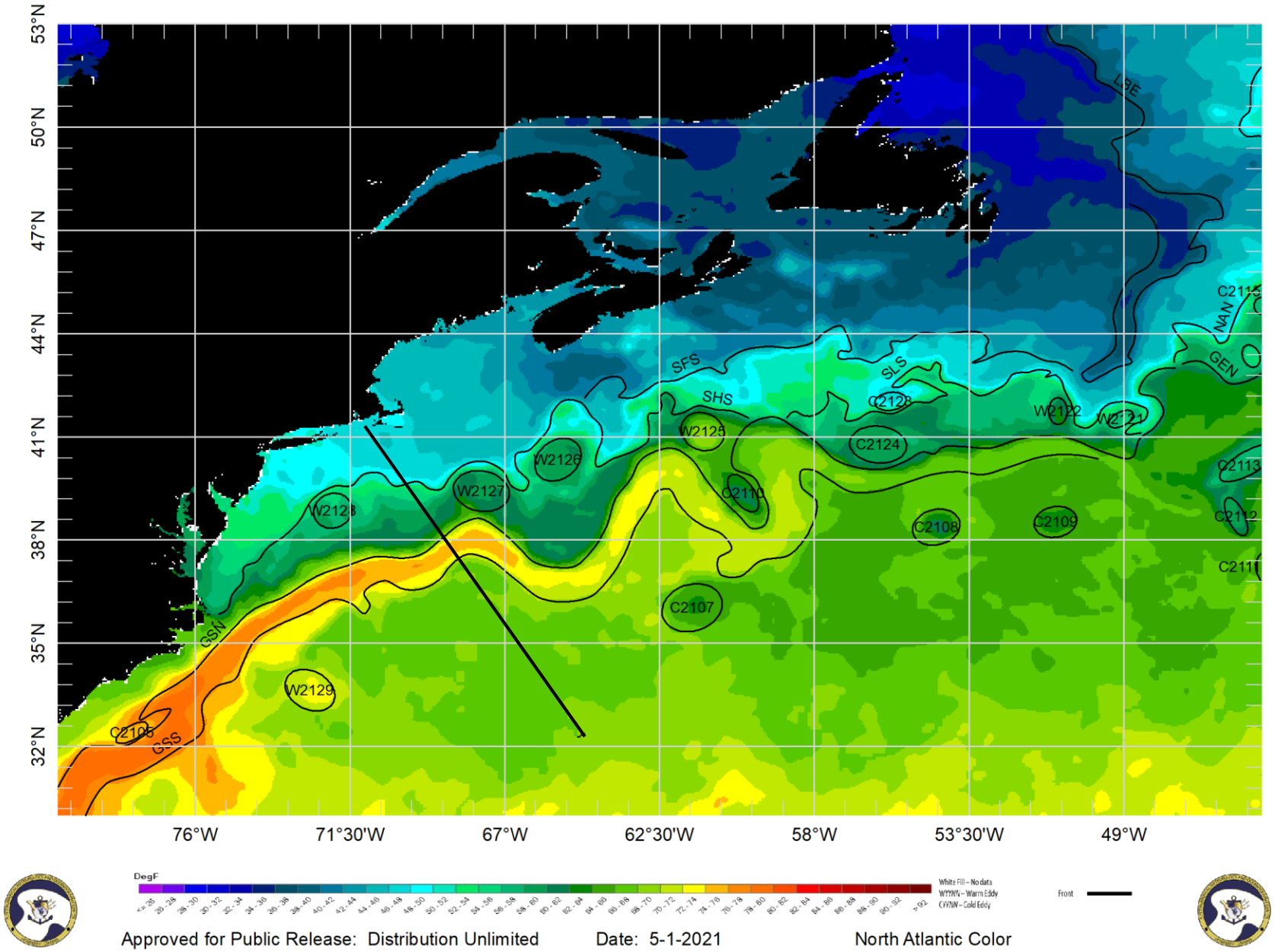


Figure 9 Sea Surface Temperatures NW Atlantic Ocean May 1, 2021

Black Line Represents RIS-Bermuda Rhumb Line

https://www.ncei.noaa.gov/jag/navy/data/satellite_analysis/gsncofa.gif?id=75957