Gulf Stream Note #1- 2017
The Gulf Stream in the Vicinity of the Rhumb Line Newport to Bermuda
May 5, 2017
An Analysis of Conditions

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With less than a month to go to the start of the Bermuda 1-2 and slightly more for the Marion-Bermuda Race it's not at all too early to start looking at both the probable weather conditions this year and the structure of the Gulf Stream in the vicinity of the rhumb line. I'll leave the weather issue with simply a recommendation that attention be paid to the setup of the 500mb surface and that it is often useful to gain some historical perspective by visiting the National Weather Service archives at https://nomads.ncdc.noaa.gov/ncep/NCEP to review past race conditions. For the Gulf Stream a place to start for those less than familiar with this ocean current system might be my Gulf Stream Primer which will be posted on the Race home page.

Recall that the Gulf Stream is an energetic western boundary current flowing from the vicinity of Cape Hatteras towards the northeastern Atlantic. The current represents a sharp boundary between the cooler waters over the New England continental shelf and the distinctly warmer waters of the Sargasso Sea surrounding Bermuda. This thermal boundary is typically the first indication of your arrival in the Stream. This fact makes a reliable simple method to monitor water temperatures while underway an absolute necessity.

The position and course of the Gulf Stream to the northeast of Cape Hatteras typically displays significant variability sometimes changing substantially in less than a week. This variability and its significance in terms of current speeds and directions represents a particular navigational challenge for New England sailors enroute to or from Bermuda. This challenge is best addressed by early and methodical study of the Stream.

We are fortunate today to have on the internet a variety of observations and model data detailing Gulf Stream position and structure. Some number of these sources can also be received offshore depending on the available bandwidth of the onboard receivers. The significance of this limitation depends on the time variability of the Stream. In most cases for the typical 3 to 5 day race to Bermuda Stream structure is relatively invariant. The extent that this is true is a principal component of early study and cannot ever be assumed.

Stream study typically begins by an examination of satellite infrared (IR) images showing sea surface temperatures (SST) in the northwestern Atlantic. There are a number of sources providing these data (see Bermudarace.com – Resources – Gulf Stream and WX) of which I usually select the Rutgers University site (https://rucool.marine.rutgers.edu/). This site provides both a number of instantaneous images over the day as well as a single daily composite image

which reduces the effect of cloud cover at some cost in spatial resolution. If available, it's useful to compare an instantaneous to the composite to determine the extent to which the optical averaging, used to produce the composite, may affect a Stream feature important to you. Remember the systems providing these images were not designed with small boat sailors in mind. As a result the sailor concerned about a fifty or 100ft patch of the ocean may well be influenced by flow features not observed by the satellite with a spatial resolution of approximately 1 km.

In early April the northern boundary of the Gulf Stream crossed the Newport-Bermuda rhumb line at a point approximately 230nm from Newport (Fig.1). A mass of warm water extended to the north of the boundary for a distance of approximately 60nm with temperatures approaching 19^0C. Given the contrast in temperatures between this water mass and the adjoining continental shelf water it's like that this feature would display some amount of clockwise flow similar to a classic warm core ring. Its position bisected by the rhumb line gives it limited navigational significance.

The core of the current, located in an area approximately 30nm to the south of the northern boundary of the Stream, flows from the northwest to the southeast across the rhumb line before turning counterclockwise towards the northeast. Maximum speeds of approximately 5kts may be found in the core. Remember that the current structure is quite "filamentous" and discontinuous sometimes making it difficult to locate the maxima. Being satisfied with 3 kts of current is often wise.

To the south of the Stream a filament of warm water extends to the southwest before recurving near 35ºN forming what appears to be a cold core ring centered at 35º 30'N 67º 30'W. A counterclockwise flow can be expected in this feature with maximum speeds of approximately 3kts producing adverse currents along 60nm of the rhumb line for boats heading to Bermuda. This ring may drift slowly to the west depending on the extent to which it is influenced by the main body Gulf Stream flows. Alternatively it could be entrained or remain stationary for extended periods of time. Given its location it clearly has the potential to affect navigation to and from Bermuda and as a result warrants attention.

Over the next week to 17 April (Fig.2) the Stream remained relatively unchanged in the vicinity of the rhumb line. The northern boundary was again located approximately 230nm from Newport and was bordered by a warm water mass straddling the rhumb line. The flow of the main body of the Stream was more nearly west to east than in early April with the meander displaced to the east well clear of the rhumb line. To the south a cold core ring was evident in the IR image centered near 35º N 68º W with a diameter of approximately 120nm. The eastern margin of this ring is in contact with the rhumb line and can be expected to produce 3kts of adverse current for boats heading to Bermuda. The slight displacement relative to its position on 9 April (Fig.1) suggests that it is clear of direct main body flow influence.

Although over the next few days there was substantial cloud cover degrading image quality and areal coverage the IR satellite image of the 21st showed a change in Stream structure north of Cape Hatteras and the apparent beginning of a downstream propagating disturbance similar in form to an oscillation traveling down a line (Fig.3). This is representative of the classic beginning of a meander pattern.

Near the rhumb line the northern boundary remained in place approximately 240nm from Newport with flows proceeding west to east across the line. The cold core ring remained centered as before with no discernible displacement.

Examination of the next week's series of IR images shows the disturbance initially formed near 38ºN 73ºW propagating progressively to the east and deepening along the northern boundary of the Stream (see https://rucool.marine.rutgers.edu/). By the 3rd of May this had produced a deep meander in the vicinity of the rhumb line displacing the northern boundary of the Stream along the line by 40nm to the south and producing a rotation in direction of the core of the current resulting in flows across the rhumb line from the northwest to the southeast or very nearly parallel to the rhumb line (Fig.4). Further to the east the Stream displayed several large amplitude meanders with wavelengths in excess of 120nm. Although degraded by clouds the IR image continues to indicate the presence of a cold core feature along 35º N with some suggestion of a westerly displacement relative to its position on the 21st. We are fortunate to be able to investigate this possibility using another tool that is insensitive to cloud cover.

Since the launch of the TOPEX/Poseidon satellite in 1992 global sea surface elevations have been accurately measured using radar. Such measurements are not affected by clouds. Variations in sea surface heights are directly related to ocean circulation and the governing factors. Although the data provided by the satellite are discrete since the orbiting satellite cannot provide a snapshot view of the entire ocean they can serve as input to a model able to provide such a synoptic view. Such model views are available at several sites but over the past 10-12 years I have found the version provided by NOAA's AOML facility particularly useful (see http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html). To make use of this application be sure JAVA is installed on your computer and that the JAVA security allows the NOAA website.

Examination of the altimetry based model results for 5 May 2017 (Fig.5) representing conditions on 3 May (a two day delay is needed for processing time) provides clear indication of the complex circulation associated with the meander shown in the 3 May satellite image (Fig.4) as well as the existence and structure of the cold core ring centered at 35º N 68º 30' W. Remember that the altimetry based model results should be used primarily to define Stream structure and location of features and not the absolute value of the associated currents. The model provides only slight indication of a westerly drift of the ring although the lobe along the easterly margin is typical of some displacement. Given this and the fact that clear avoidance of the ring or adverse currents enroute Bermuda would add substantial miles to the track it would

appear that for the moment a rhumb line course is favored despite the possibility of 30-60 miles of adverse 2-3kts of current between 35º and 36ºN. All of this on the assumption that the winds permit this course. With these possibilities in mind this feature is to be carefully observed over the next few weeks up to the start using all of the observational and model tools at our disposal. The combination of factors affecting strategic planning in this case should make clear the value of an early start to the study of the Gulf Stream for those sailing to Bermuda. The same can be said about the weather.

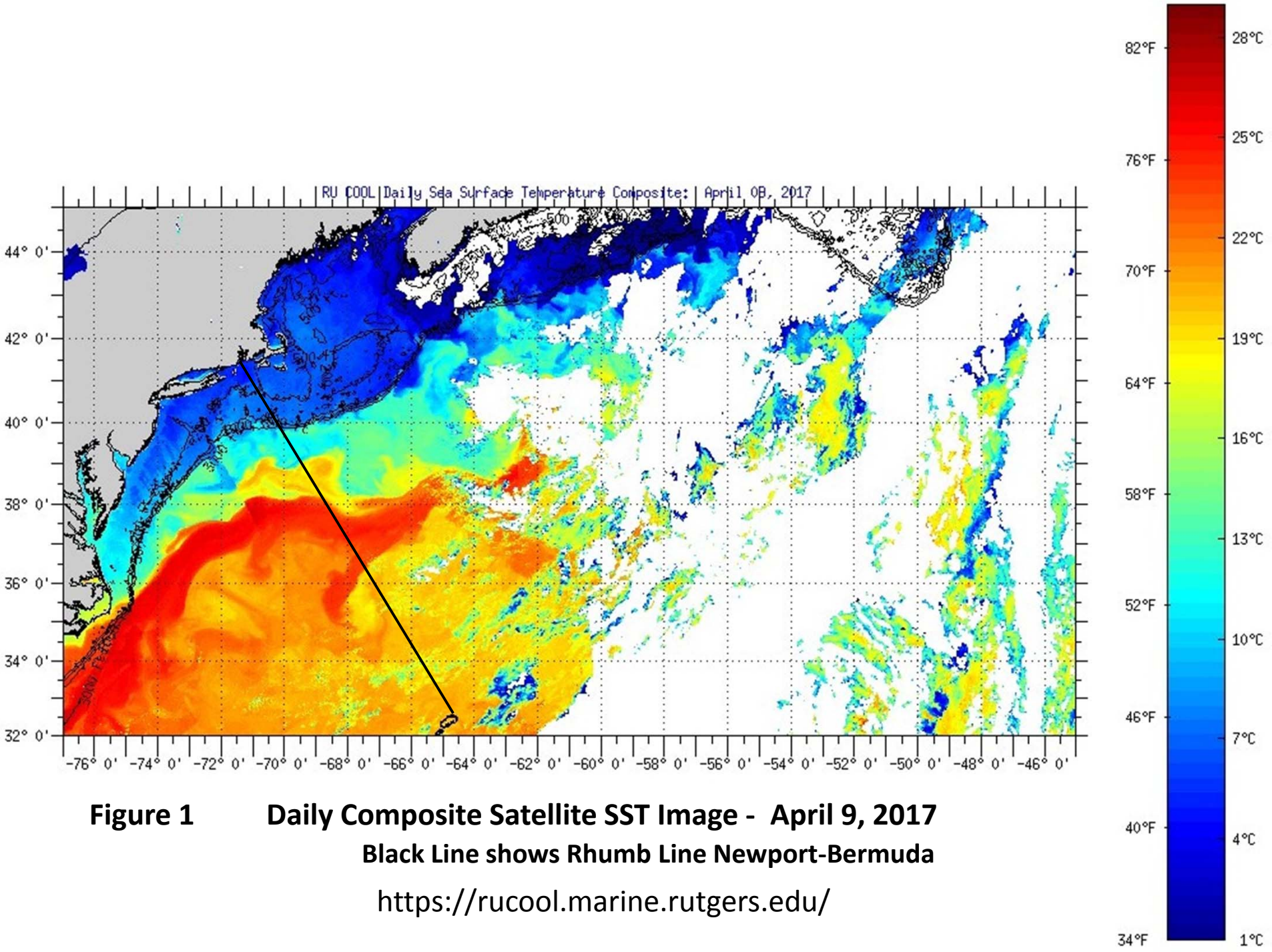

Figure 1 Daily Composite Satellite SST Image - April 9, 2017

Black Line shows Rhumb Line Newport-Bermuda

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

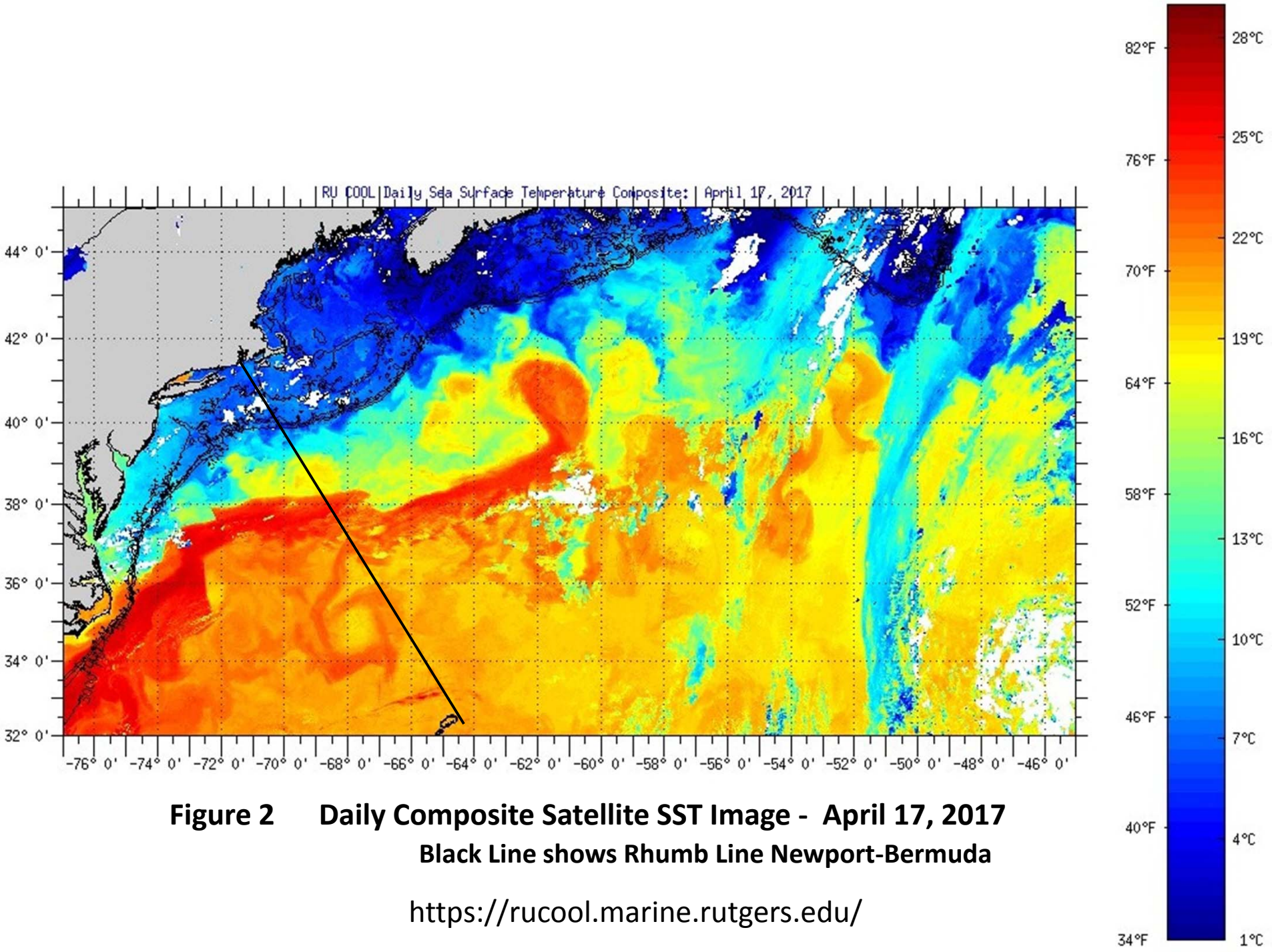

Figure 2 Daily Composite Satellite SST Image - April 17, 2017

Black Line shows Rhumb Line Newport-Bermuda

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

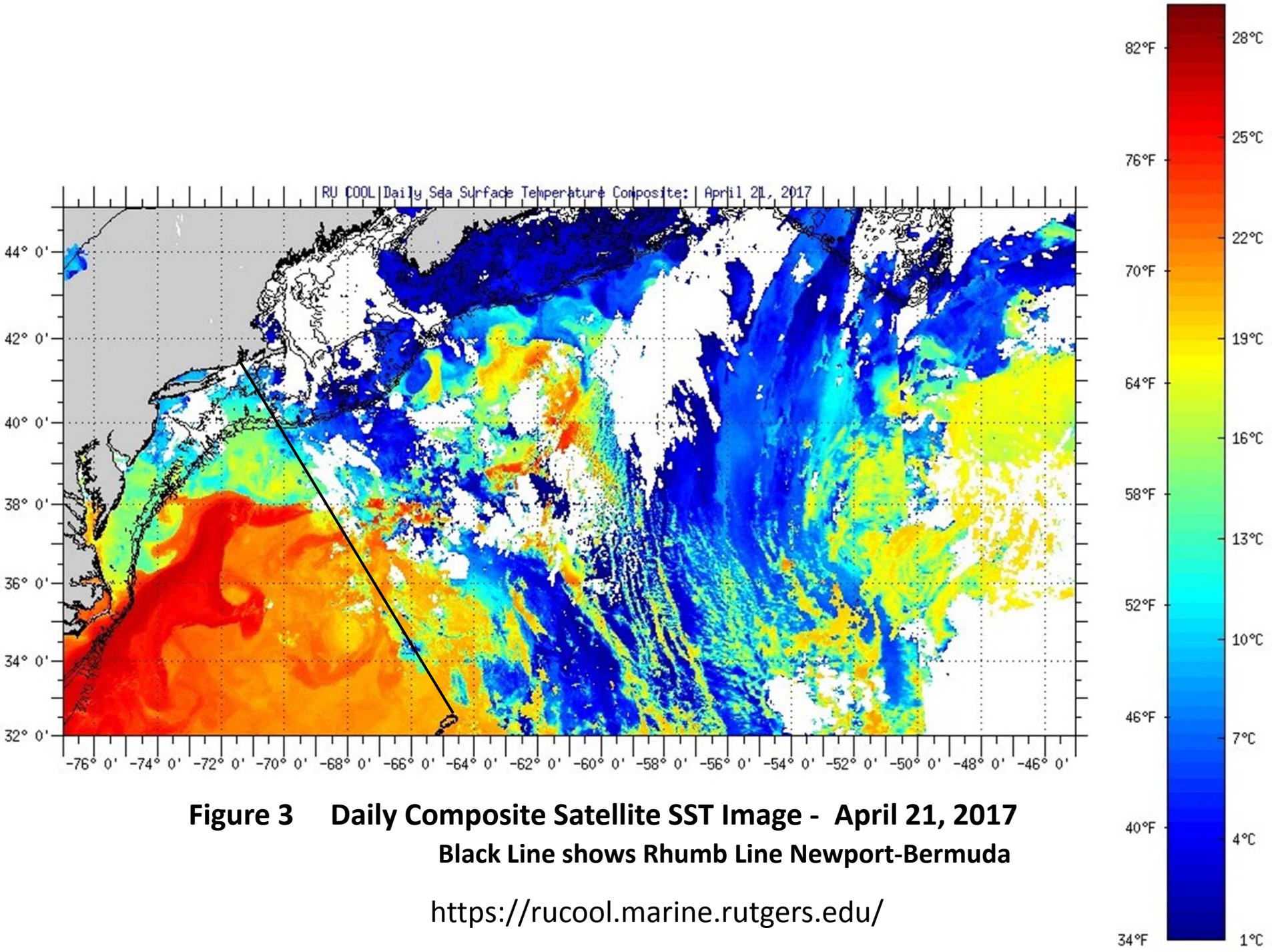

Figure 3 Daily Composite Satellite SST Image - April 21, 2017

Black Line shows Rhumb Line Newport-Bermuda

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

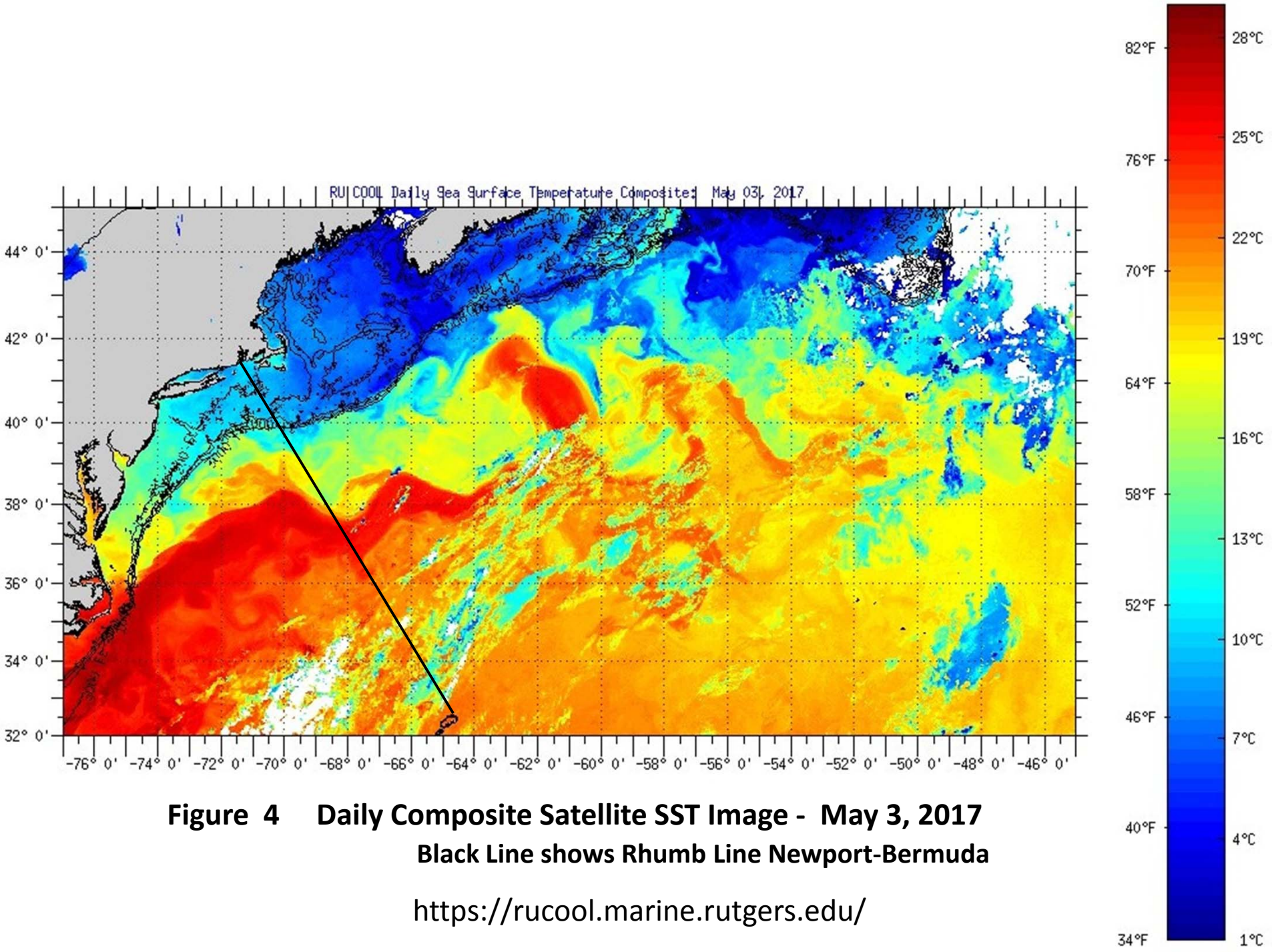

Figure 4 Daily Composite Satellite SST Image - May 3, 2017

Black Line shows Rhumb Line Newport-Bermuda

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

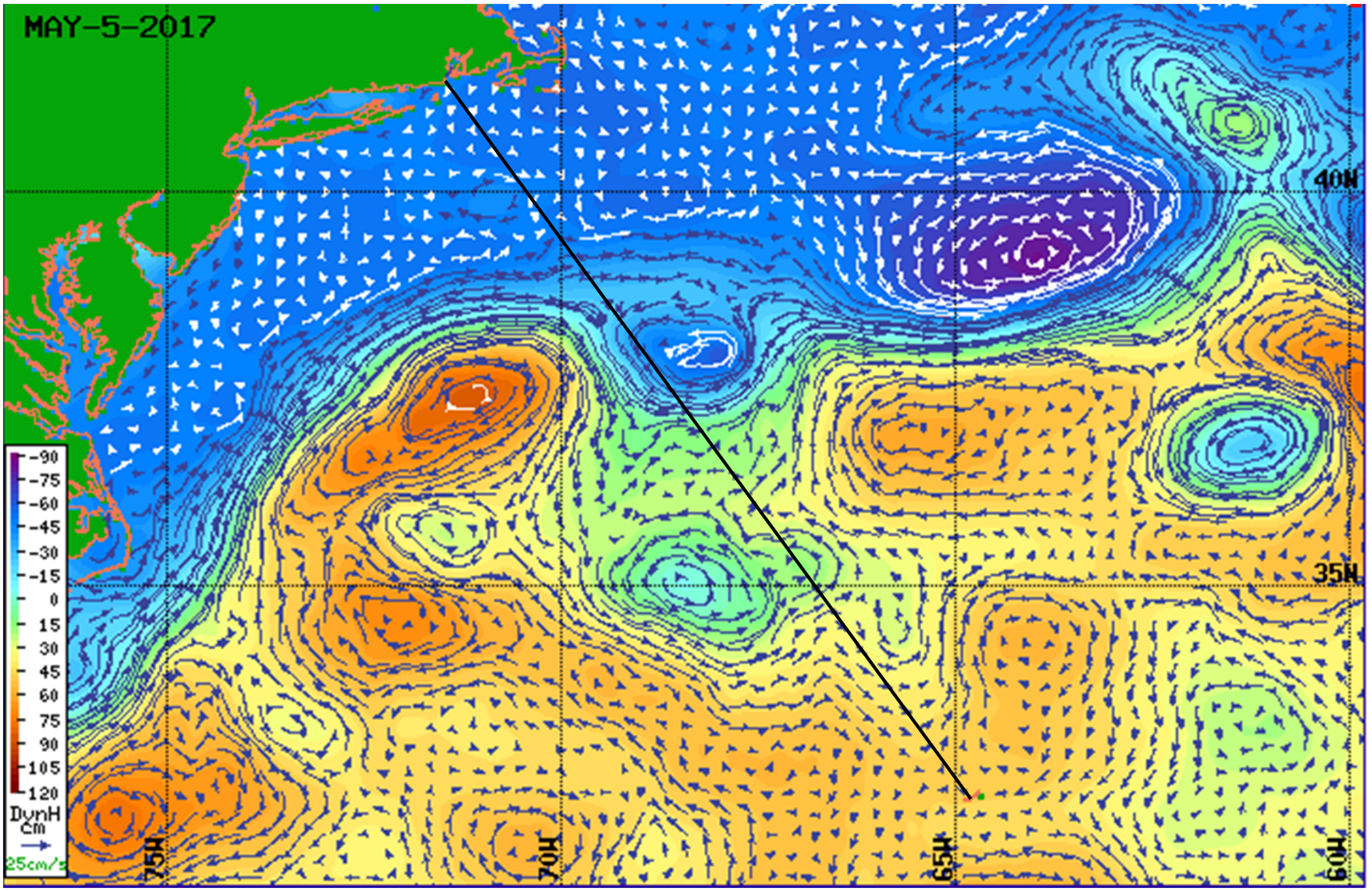

Figure 5 Satellite Altimetry Derived Surface Currents- NW Atlantic Region- May 5, 2017
Black Line shows Rhumb Line Newport-Bermuda

http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html