The Gulf Stream Near the Rhumb Line Newport-Bermuda June 2, 2008
An Analysis of Conditions

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The Gulf Stream in the vicinity of the Newport Bermuda rhumb line has over the past month continued to display active development with an associated complex pattern of sea surface temperature gradients. The crest of the meander crossing the rhumb line in early May (see Note 1 Fig. 2) remained nearly stationary for much of the month varying only in form. This absence of the expected easterly migration is unusual but by no mean unprecedented and is another indication of the value of early and continuing observations of Stream structure. By the 22nd of May (Fig.1) the crest of the meander was in essentially the same position observed on the 2nd of May crossing the rhumb line at a point approximately 180 nm from Newport. Flows at the crossing point proceeded to the east and southeast. To the west of the rhumb line the meander displayed significant steepening leading to an interesting bifurcation of the Stream (i.e. the anchor shaped pattern) favoring the formation of two counter rotating features one clockwise (cw) and the other counterclockwise (ccw). Despite the rotary form these are not classic Gulf Stream rings but simply flow features associated with a division of the main body flow and associated local water temperature (i.e. water density) gradients. The eastern counterclockwise feature would have produced northerly flows along the rhumb line in the vicinity of 36° N 68° 30' W.

After the 22nd of May the crest of the meander began a progressive migration to the west with little effect on the speed or direction of the Stream associated flows crossing the rhumb line or on the location of the crossing point relative to Newport by the 29th (Fig.2). This relatively abrupt instability brought the main body of the Stream in close proximity to the rhumb line near 37° N 68° 30' W resulting in an area approximately 60 nm in length of foul currents along and across the rhumb line. To the south of this area the complex of water temperature gradients appear to support several rotary current features although from this Figure the precise location and nature the flows are difficult to accurately define. Such definition benefits from the availability of supplementary altimeter data discussed in Note #1.

By the 31st of May the daily sea surface temperature (SST) composite image (Fig.3) shows a continuing westward extension of what is becoming an evident tongue of the Gulf Stream bearing little resemblance to the original well ordered sinuous meander. There is a slight indication of a narrowing at the base of the feature suggesting that it may well “pinch-off” to form a classic warm core ring positioned north of the main body of the Stream. Until this occurs however, this feature will continue to represent the primary pathway for Gulf Stream flows causing an evident northwest to southeast current across the rhumb line near 39° N (~ 165 nm from Newport) followed by a complex of foul currents south of 38° N. Again the foul currents

result primarily from the proximity of the main body of the Stream which in crossing the rhumb line near 37° N produces first a southwest to northeast flow that then rotates counterclockwise through north before proceeding to the west near 37° 30' N along the evident tongue of warm water (Fig.3). The complex of water temperature gradients across the rhumb line shown in the three day composite ending on the 29th (Fig. 2) continues to be evident to the south of this area.

The complex of features evident in the surface thermal images also appears in the altimeter data (Fig. 4). These latter data provide a clear indication of the relationship between water column heights and flow and may be thought of as being similar to a weather chart showing areas of high and low pressure. Just as in the atmosphere where pressure is related to air temperature here spatial variations in water temperature result in spatial variations in water column density leading to spatial variations in pressure sufficient to produce currents. It's important to remember that it is the gradients in pressure (water temperature) that cause flows, the stronger the gradient the stronger the flow. As a result it's sometimes difficult to estimate speeds if only surface thermal data are available. The limited spatial resolution of most of the surface water temperature images particularly in the vicinity of convergence zones such as the meander and tongue of warm water presently affecting the rhumb line makes accurate estimation of gradients impossible. The thermal data do provide an extremely valuable indication of Gulf Stream structure and the position and form of a variety of associated features such as meanders and rings. Prior to the availability of accurate sea surface height data the thermal data were the only way to estimate current speeds and directions. The addition of altimeter data has the potential to significantly increase the accuracy of these estimates.

A comparison of the altimeter data (Fig.4) to the one day SST composite (Fig.3) shows that while the northern edge of the main body of the Stream crosses the rhumb line in the vicinity of 39° N the flow maximum is to be found approximately 20 to 30 nm to the south. Monitoring of surface water temperatures should show this to be the area of most rapid change. Flow directions are consistent with the thermal image.

Proceeding south down the rhumb line the altimeter data indicate that a north going counter current will be found in the vicinity of 37° 30'N affecting approximately 60nm of the track. This flow is associated with the inflection of the main body of the Gulf Stream discussed above. The altimeter data indicate that the rhumb line grazes the easterly edge of the main body current with maximum flows found to the west of the rhumb line. This together with the possibility that the warm water tongue may over the next few weeks 'pinch-off" to form a ring makes this an important area for pre-race study.

South of the inflection flows are nearly perpendicular to the rhumb line with only a slight northeasterly component. In the vicinity of 36° N the altimeter data indicate that the complex of thermal features observed in the SST data are reasonably well organized forming a relatively large clockwise rotating warm core ring with a smaller warm core feature to the east of the

rhumb line. It's not immediately evident however, whether there are one or two features or rings in this area. There is a suggestion of two distinct features although this may be something of a model artifact. What is clear is that the flow from this feature (or features) along the rhumb line is at the moment quite weak. Continuing south the altimeter data show reasonably favorable currents along the rhumb line to Bermuda .

To summarize, The Gulf Stream in the vicinity of the Newport to Bermuda rhumb line continues to display moderate to extreme variability. Over the remaining time to the start of the Race it's more than likely that there will be a substantial change in Stream structure features. Given the observed rates of change affecting the Stream over the past few months it's possible that major changes might even occur over the period of the Race. Study is advised!

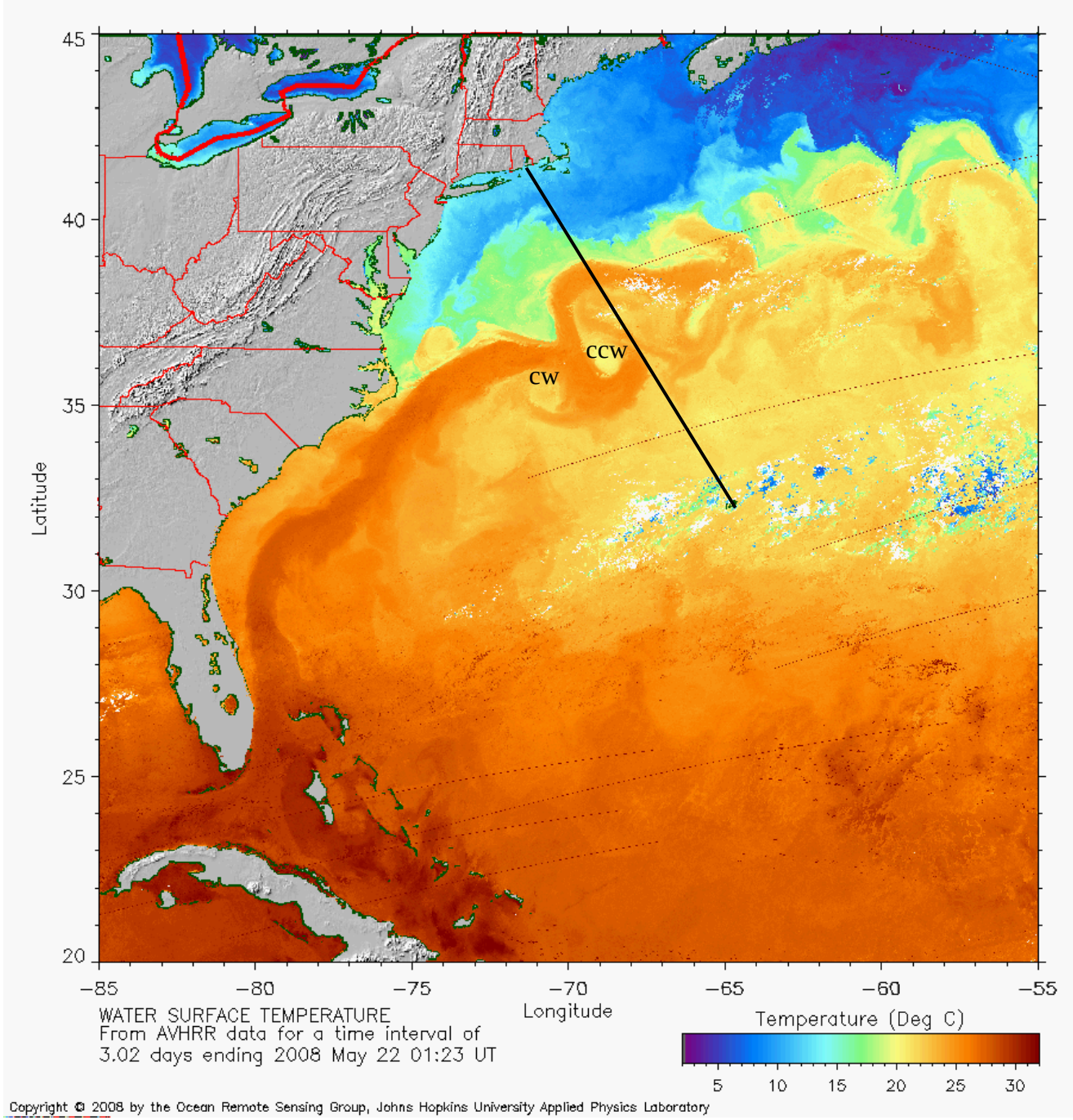

Figure 1 Three Day Composite Satellite Image of Sea Surface Temperatures May 22, 2008

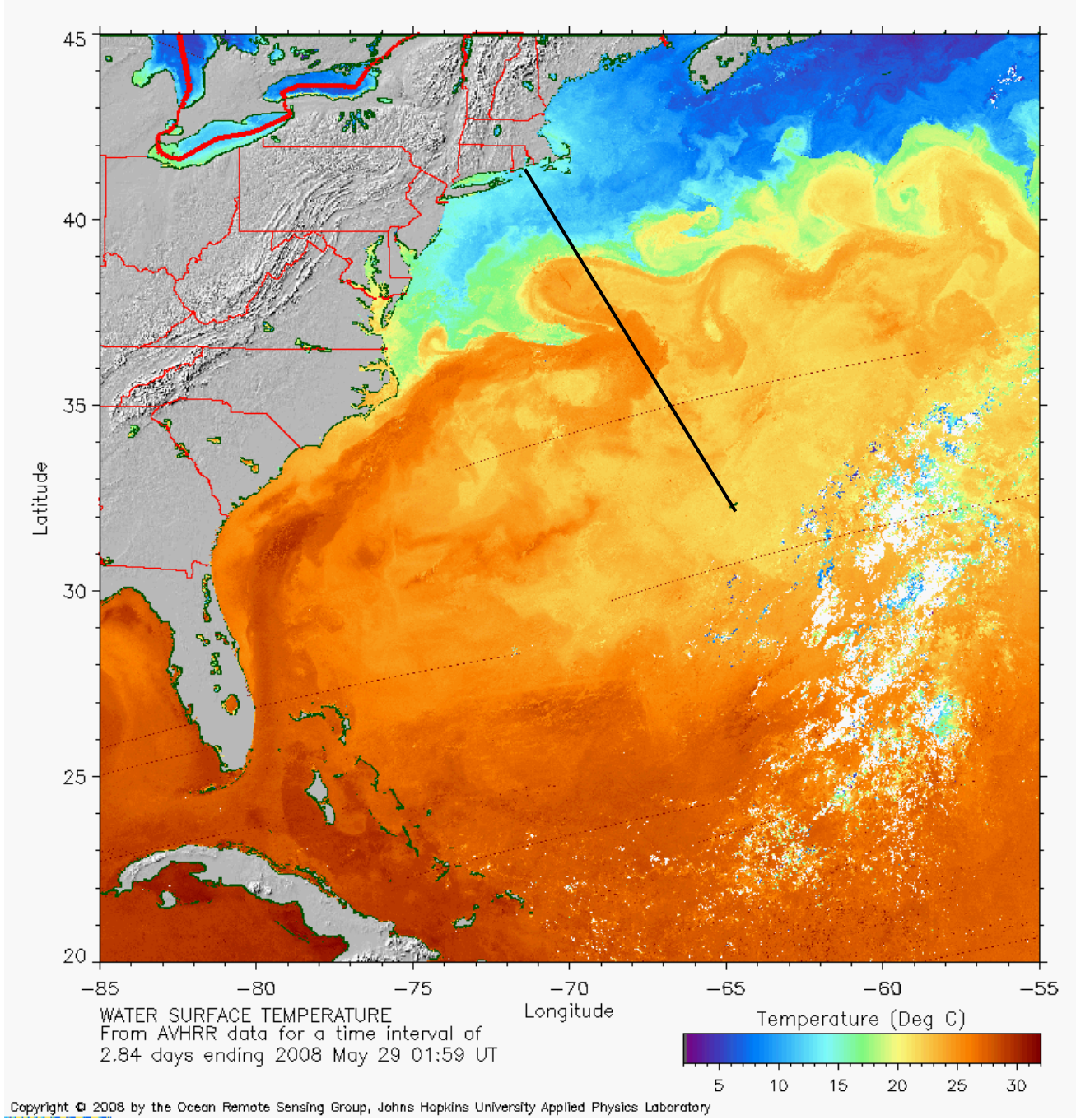

Figure 2 ~ Three Day Composite Satellite Image of Sea Surface Temperatures May 28, 2008

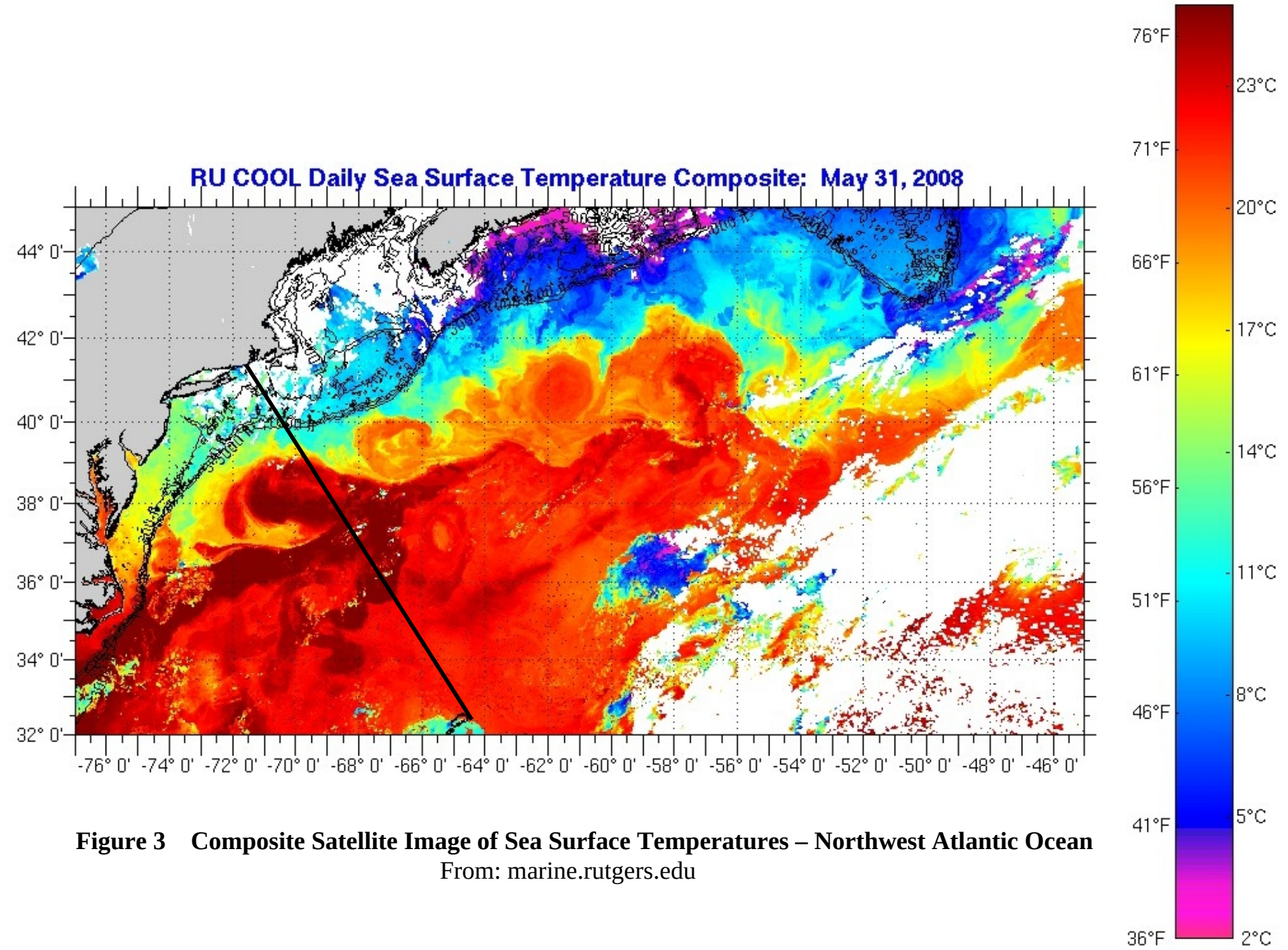

Figure 3 Composite Satellite Image of Sea Surface Temperatures – Northwest Atlantic Ocean
From: marine.rutgers.edu

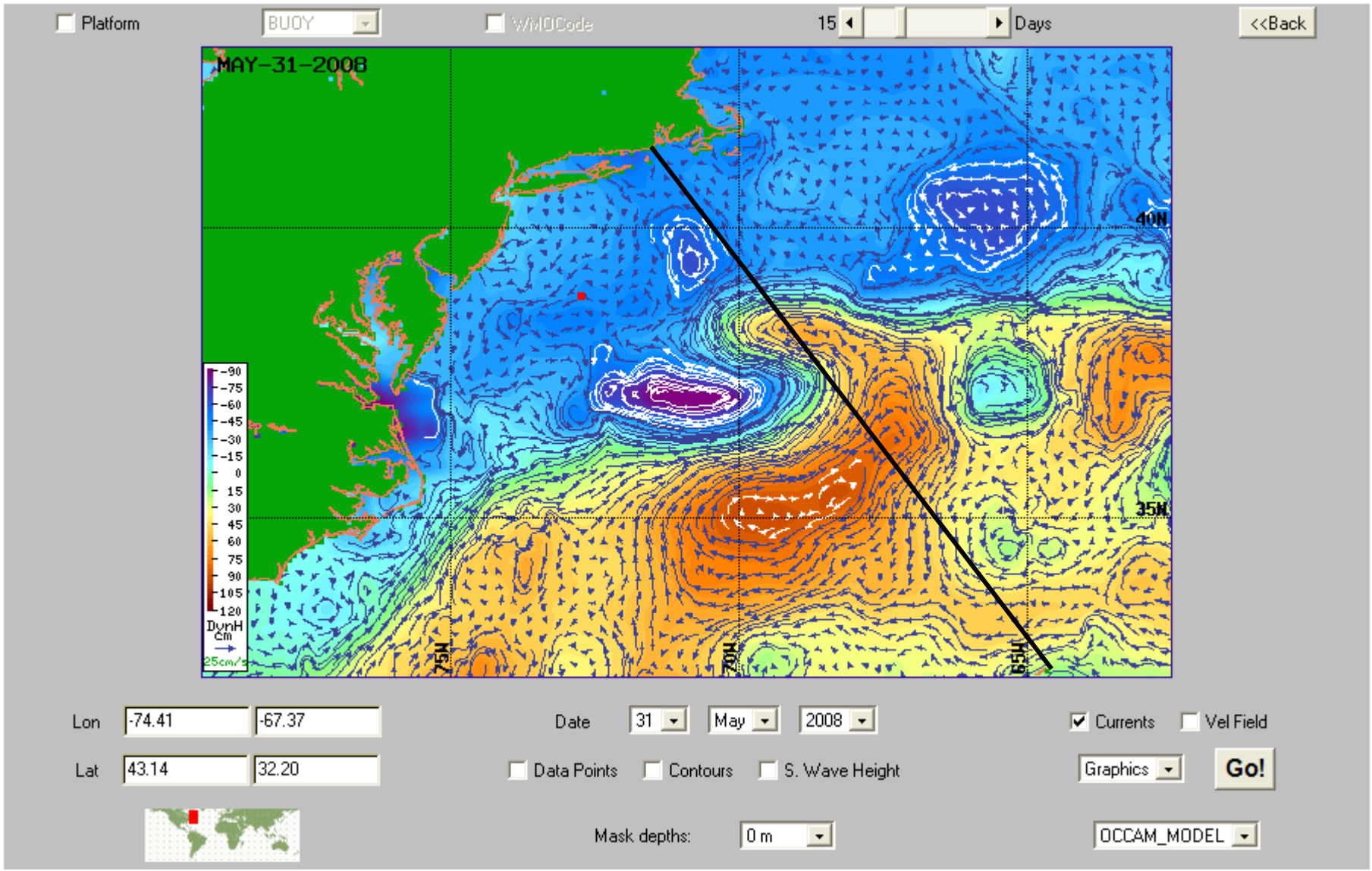

Figure 4 Current Speeds and Directions in the Vicinity of the Newport-Bermuda Rhumb Line Based on NOAA/AOML Altimeter Data May 31, 2008

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