



## Gulf Stream Characteristics

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Note No. 2

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After our last view of the Gulf Stream on May 17th the warm core feature north of 38N continued to track to the east in close contact with the main body of the Stream. Over the next eight days the clockwise flows associated with this feature served to mix the cold waters of the core with the warmer bordering waters resulting in a progressive decrease in the diameter of the core. By May 25th the core diameter, which on the 15th was nearly 80nm, was down to approximately 30 nm (Fig. 1).

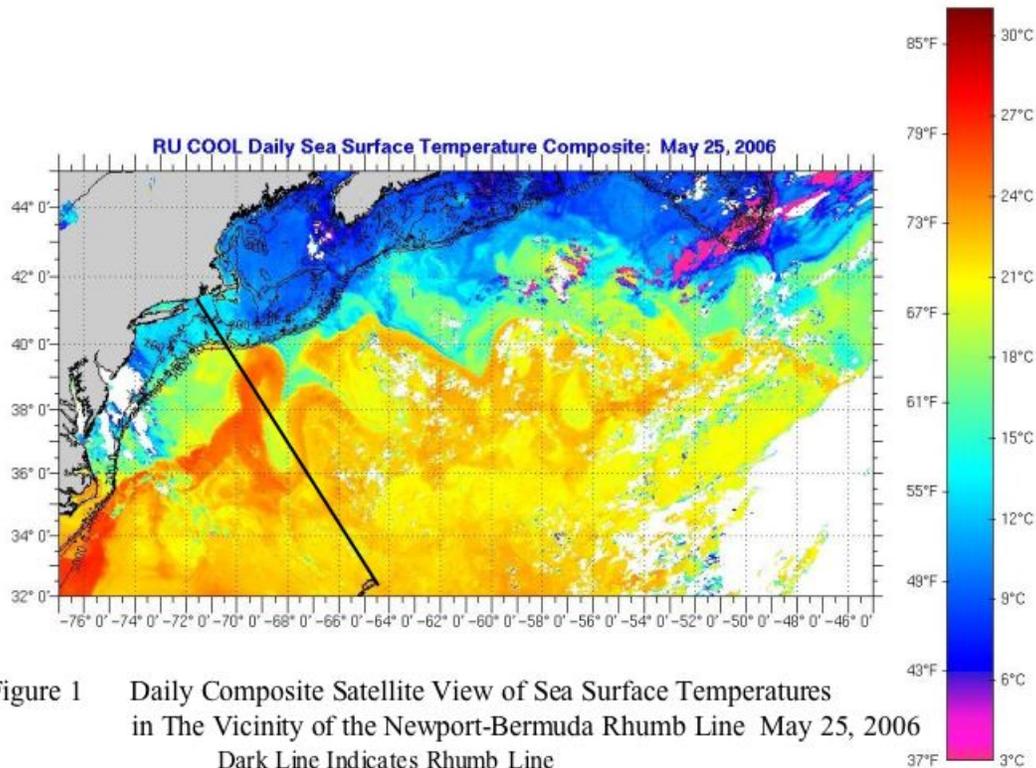
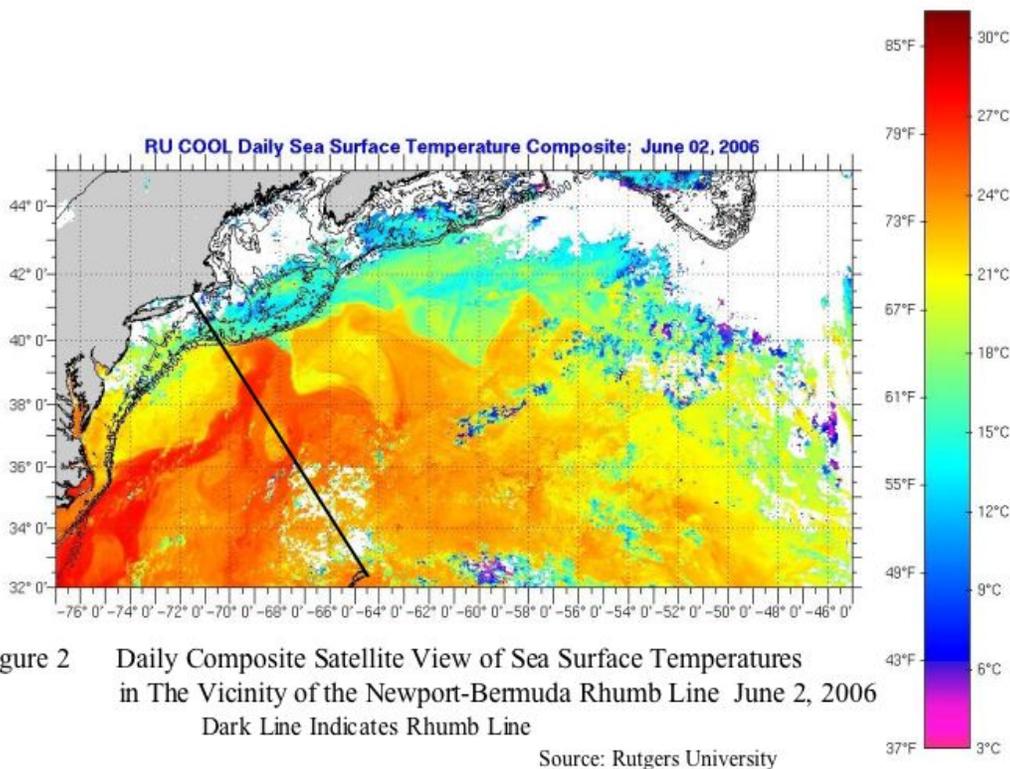


Figure 1 Daily Composite Satellite View of Sea Surface Temperatures in The Vicinity of the Newport-Bermuda Rhumb Line May 25, 2006  
Dark Line Indicates Rhumb Line

Source: Rutgers University

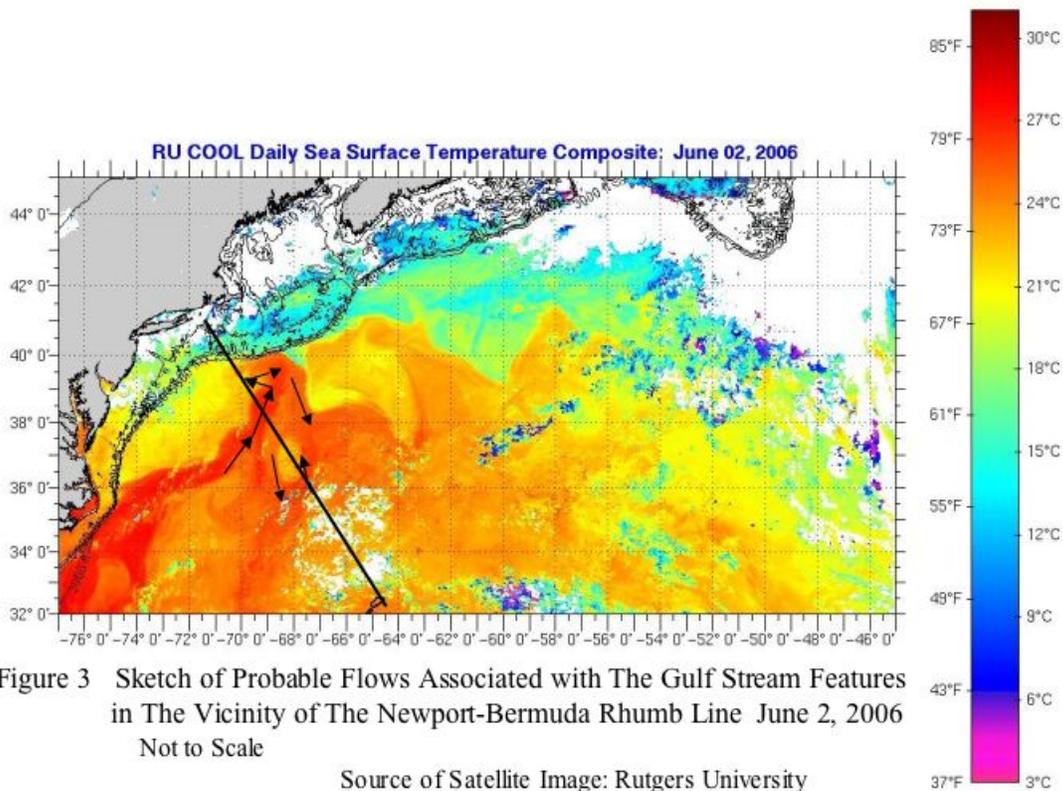
Over this period the band of surrounding warm water had increased in width to approximately 60 nm while the separation from the main body of the Stream disappeared. To the south of this feature the meander observed in the May 15th image had significantly deepened resulting in an evident north to south flow between 37 30 N and 36 N along 68 30 W, or approximately 45 nm to the west of the rhumb line (Fig.1). With a maximum width of approximately 50 nm the eastern margin of this meander crossed the rhumbline from south to north in the vicinity of 37 N 68 W producing adverse currents for Newport-Bermuda bound boats over a distance of nearly 120 nm of the rhumbline. The thermal gradients associated with this well defined feature favor relatively strong currents (i.e. maxima in excess of 4 kts) throughout much of this area.

By June 2nd the complex flow pattern observed along the rhumb line between 36 N and 39 30 N, including the warm core feature and the deep meander in the main body of the Stream, had changed significantly (Fig.2).



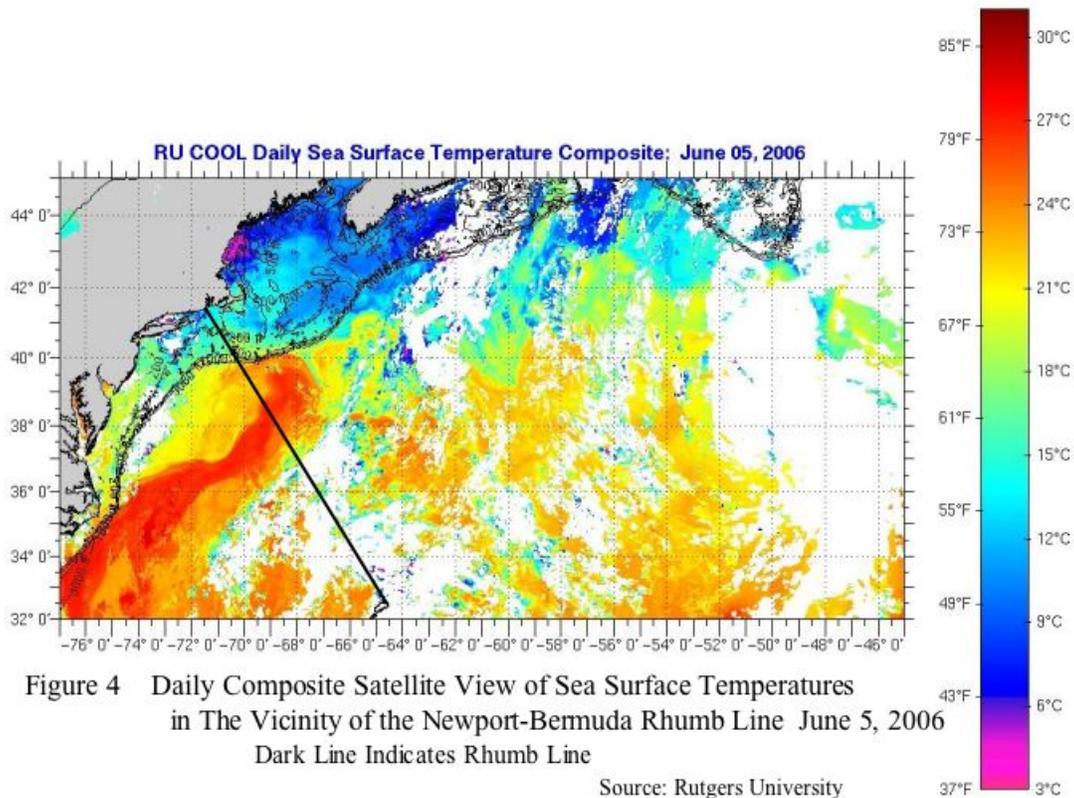
Over this one week period the eastward migration of the main body of the Stream north of 38 N resulted in continuing mixing and the ultimate disappearance of the warm core feature, the pinching off of the meander and the associated formation of a cold core ring centered near 37 N 68 W straddling the rhumb line, and the development of a west tending tongue of warm water across the rhumb line in the vicinity of 40 N, along the outer limits of the continental margin. The current direction associated with each of these features can be estimated by remembering that an observer in the northern hemisphere

with warmer to the right will be looking downstream. An approximation of these directions is shown by the arrows in Figure 3.



The extensive alteration in the structure of the Gulf Stream during the last week in May, 2006 provides graphic illustration of the rates at which features can change and the benefit of relatively high frequency observations of sea surface temperature patterns. The composite image of June 2 (Fig.2 and Fig.3) also suggests that the current speeds associated both with the main body of the Stream and the cold core feature are relatively high. The temperature gradients associated with these features exceed 4oC over relatively short distances favoring significant changes in water column density and associated pressures. These horizontal gradients in water column pressure drive flows in a manner similar to the influence of barometric pressure on atmospheric flows, otherwise known as winds. As noted above, the temperature gradients associated with the main body of the Stream crossing the rhumb line in the vicinity of 39 N suggest current speeds in excess of 4 kts. Flows around the perimeter of the cold core feature are expected to slightly lower with speeds ranging between 2 and 3 kts. In both cases flow maxima are to be found in the area of the maximum thermal gradient generally found along a line located approximately 30nm in from the cold water margin. Optimal tactical use of the relationships between water temperature, density/pressure gradients and current speeds is best realized by on-board monitoring of both water temperature and the rate of change in water temperature.

Since June 2nd direct views of sea surface temperature distributions along and adjacent to the rhumb line have often been restricted by cloud cover. The composite image of June 5th, providing a view of the region north of 37 30 N, indicated that the main body of the Stream and the associated westward tending tongue of warm water had drifted slightly to the east. The tongue continued to influence flows in the vicinity of 39 30 N while the main course of the Stream crossed the rhumb line near 38 45 N 69 15 W (Fig. 4).



This latter crossing was essentially similar in direction relative to the rhumb line to that observed on the June 2nd image (compare Fig.3 and Fig.4). Unfortunately, cloud cover obscured the cold core feature on the 5th. Examination of a three day composite image for the period ending June 7th indicates that this feature has drifted slowly to the west relative to its June 2nd position (Fig. 5) resulting in a northerly flow along approximately 45 nm of the rhumb line. Southerly flows are to be found along a line approximately 45 nm west of the rhumb line. If past trajectories of cold core features are used as a guide this westerly drift is expected to continue for times beyond interest to the Newport-Bermuda racer. This has obvious tactical implications and should be carefully monitored during both the trip to and from Bermuda.

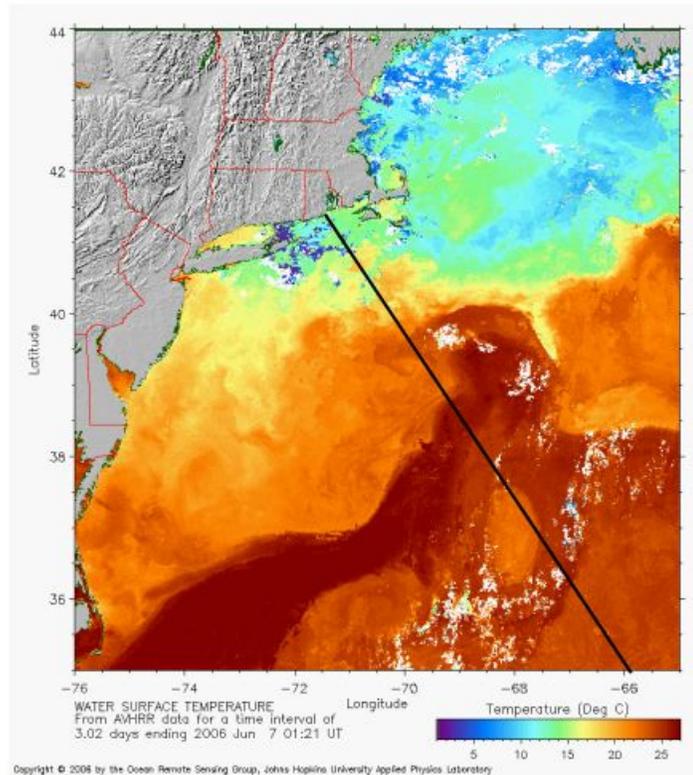


Figure 5 Three Day Composite Satellite View of Sea Surface Temperatures June 4-7, 2006

It's interesting to note that the cold core feature is surrounded by a number of thermal fronts of varying intensity (Fig.5). The temperature-density-pressure gradients associated with each of these latter features should be expected to produce some flows with speed and direction governed by the strength of the gradient and its positioning relative to the view (i.e. course) of the observer. An estimate of the extent, magnitude and direction of the flows associated with these secondary thermal features can be developed by review of the results of the USN computer model (Fig. 6) to be found at [http://www7320.nrlssc.navy.mil/global\\_nlom32/gfs.html](http://www7320.nrlssc.navy.mil/global_nlom32/gfs.html) listed on the Gulf Stream and Weather links on the Race homepage.

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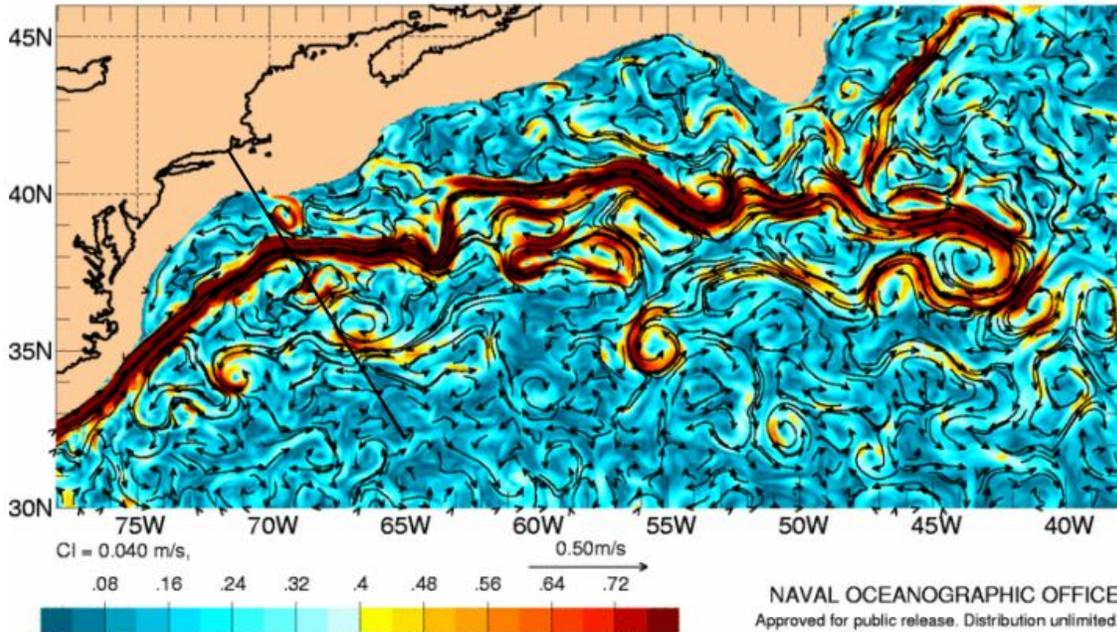


Figure 6 USN Numerical Model Simulation of Currents in the Gulf Stream and Surrounding Waters. June 5, 2006

see:[http://www7320.nrlssc.navy.mil/global\\_nlom32/gfs.html](http://www7320.nrlssc.navy.mil/global_nlom32/gfs.html)

These model data indicate that beyond the immediate vicinity of the Stream a “patch-work quilt” of flows is to be expected in the area south of 35 N to Bermuda. In contrast to the conditions encountered during the 2004 race, there does not appear to be any large scale organized flows south of 35 N. There is however, a warm core feature immediately south of the cold core ring just north of 35 N. The satellite images (preferably the instantaneous rather than the composites) should be carefully examined over the next week to verify the existence of this feature if at all possible.

The results of numerical modeling of the Gulf Stream have become increasingly accurate over the past two years. Although the models do not yet provide an exact replication of the satellite views of sea surface temperature (SST) patterns they do simulate each of the major features, including the large patch of warm water bordering the continental margin as well as the cold core ring, reasonably well. The results do suggest that the main body of the Stream is separated from the warm water patch north of 38 N. This result is clearly at odds with the satellite image. This, however does mean that the satellite image is necessarily the correct view since these results might well be biased by the averaging associated with the development of the daily composite. The fact that the warm patch seems to be drifting to the east is more telling and suggests that the feature is not separated to any great extent and is most likely part of the Stream. The indicated separation is most likely a modeling artifact associated with model resolution and dynamics. The accuracy of this supposition is best established by comparisons of model results to the satellite views similar to the way that we compare predicted weather conditions to those observed.