The Gulf Stream Near the Rhumb Line Newport-Bermuda May 14, 2012
An Analysis of Conditions

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With slightly more than one month to go until the start of this year's Newport to Bermuda Ocean Race it's time 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 introductory article in the Notice of Race and posted , with this first note, on the Race homepage (www.Bermudarace.com). For many years this range of features was less than well understood and yet more difficult to accurately define. After 1957 and the beginnings of the satellite age this situation began to rapidly change as measurements and observations of sea surface temperatures and elevations over large areas of the ocean came together with increased computing power and computer based modeling skills to supplement historical shipboard observations. For some time the results of these efforts were difficult for the civilian sailor to obtain. With the increasing power of the web that's no longer the case. All of the data necessary to plan race strategies are available for our use, many both onshore, before the Race, and offshore, during the passage down and back. To realize full value of these resources however, does necessarily require some work and study. This note and the ones to follow before the June 15th 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.

Examination of the composite SST satellite image for May 12th (Fig.1) shows the rhumb line crossing the northern margin of the main body of the Gulf Stream near 38^{o} N or approximately 240 nm from Newport. The crossing is marked by an abrupt increase in water temperatures from approximately 50° F (~10° C) to 80° F (~25° C). Flows are proceeding from west to east across rhumbline. Stream structure to the east and west of the rhumbline is essentially linear with only a minor meander in the vicinity of the "corner" near 38°N 70°W where the northeast going Stream coming from Cape Hatteras changes direction to a more nearly east going flow in a relatively short distance. This pattern was prevalent throughout the late winter early spring period and by April 16th had very nearly assumed the form evident in May (Fig 2). The April SST image suggests that a meander is developing. Comparisons to the May 12th image (Fig.1) however, shows that contrary to expectations meander amplitude had decreased during the period. The crest however, retained much of its earlier form and did proceed nearly 30nm to the east closing the rhumbline. This feature has the potential to alter the orientation of the Stream flow relative to the rhumbline over the next month and bears close observation.

Moving next to the areas north and south of the main body of the Stream, the May 12th SST image shows a relatively slow increase in water temperatures along the rhumbline north of 38° N (Fig.1). To the west of the rhumbline this composite image shows an area of evidently warmer water centered near 39° 30' N 71° W. A similar area of warm water was observed along the rhumbline in the image of April 16th (Fig.2). This earlier image showed a discrete parcel of warm water surrounded by cooler water, a distribution characteristic of a warm core ring centered on the rhumb line. Such a pattern in water temperature and associated water column densities favors a clockwise flow with maxima of approximately 3 knots. Such rings tend to drift slowly to the west and will in time dissipate due to contact with the bordering continental shelf and/or the northern margin of the main body of the Gulf Stream. Typical lifetimes are on the order of months. The May 12th image (Fig.1) shows that the warm core ring observed in April has drifted to the southwest and is beginning to dissipate. If this process continues this feature will have little effect on local flows by June 15th.

To the south of the main body of the Stream the May 12th composite SST image (Fig.1) shows an "interesting" thermal pattern between 36 and 37° N on and just to the east of the rhumbline. The warm water tongue along the rhumbline starting near 68° W appears to represent waters shed from the larger feature to the east. The tongue surrounded by cooler water favors a clockwise flow proceeding northwest to north and east to the west of the rhumbline and east to southeast along the western side of the rhumbline. This "warm core like" feature will tend to have speeds that will be lower than a typical warm core ring but they still may prove an impediment depending on routing. It's another feature to be watched over the next month.

East of the rhumbline along 66° W between 36 and 37° 30' N the composite image (Fig.1) shows an SST distribution with warmer waters surrounding (or nearly surrounding) a parcel of cooler water. At the moment this feature appears to be attached to the main body of the Stream. This may however, be an artifact of the compositing process. Determination of attachment is best realized using altimetry based modeling of ocean currents and sea surface heights available at http://www.aoml.noaa.gov/phod/work/trianes/INTERFACE/index.html rather than standard SST data. In addition to providing some indication of probable flows, altimetry is also insensitive to cloud cover a factor affecting all SST images to some extent. Examination of the model results for 12 May (Fig.3) posted on 14 May, shows an evident closed feature centered near 36° 45' N 65° 45' W essentially the center of the feature shown on the SST image (Fig.1). Water temperature and associated water column densities favor a counterclockwise flow in this cold core ring with maximum speeds of approximately 3 knots. Note that the altimetry model tends to underestimate speeds but has been found to provide accurate indication of the location of the majority of the Gulf Stream features.

The altimetry based model also shows a weaker clockwise flow in the area of the "tongue" of warm water discussed above (Fig.1). If the more dominant cold core ring remains clear of direct Stream influence both features should drift to the west at speeds averaging approximately 2-3nm/day. Such a drift would bring the western margin of the ring onto the rhumbline by 15 June. Flows would proceed from northwest to southeast potentially providing a favorable boost to Bermuda again depending on routing. This looks to be another feature worth watching.

To the south of the tongue and cold core ring the altimetry based model shows a counterclockwise circulating feature to the west of the rhumbline centered near 33° N 66° W. This feature is generating adverse currents along the rhumbline to Bermuda at the moment. Its trajectory is not simply predicted and it may be relatively stationary over the next month or more since it's well clear of Gulf Stream influence. On the other hand, the drift of the larger features to the north may displace it to the west. Given it's location it should be added to the list of features to be studied.

Beyond the detailing of rings and ringlike features inferred from the SST images the altimetry based model also shows two clockwise eddies in the vicinity of the "corner" of the main body of the Stream at 38° N 71-72° W. These features appear associated with the meander and may drift to the east over the next month potentially affecting flows in the vicinity of the rhumbline. If they do and retain their current structure they clearly will have to be considered in route planning.

It's interesting to note that the altimetry based modeling provides no indication of any well developed warm core feature in the area north of the main body of the Stream. The feature may be too disperse to display an evident sea surface height signature.

The above reviews of primary observations and NOAA altimetry based modeling provide a solid basis for evaluations of the variety of other Gulf Stream models often used in routing programs such as those developed by the Naval Research Laboratory and available at http://www7320.nrlssc.navy.mil/global_nlom32/gfs.html . Such comparisons and the use of a variety of data and data sources is recommended as part of the Race planning process.

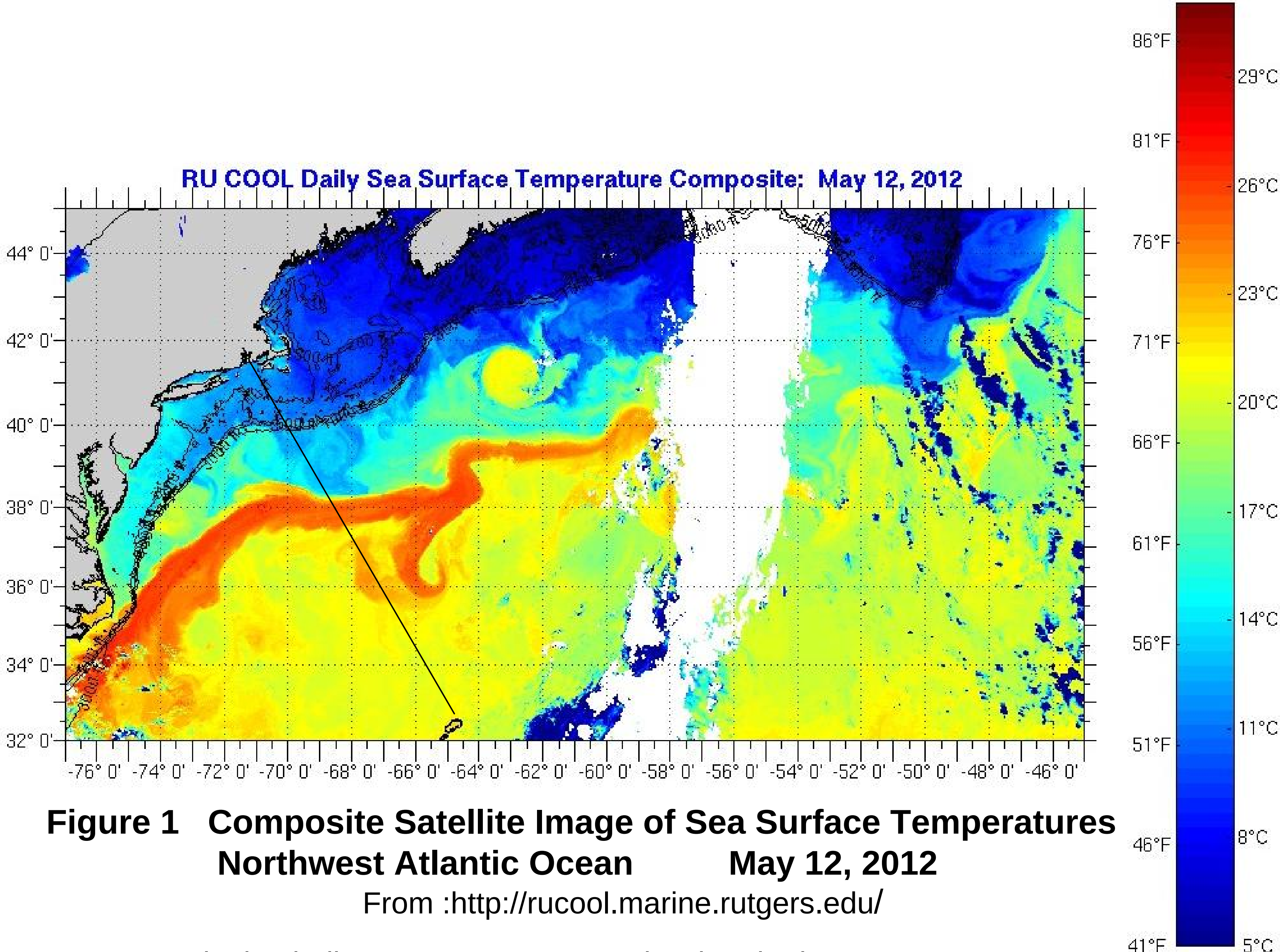

Figure 1 Composite Satellite Image of Sea Surface Temperatures
Northwest Atlantic Ocean May 12, 2012

From :http://rucool.marine.rutgers.edu/

Dark Line indicates Newport-Bermuda Rhumb Line

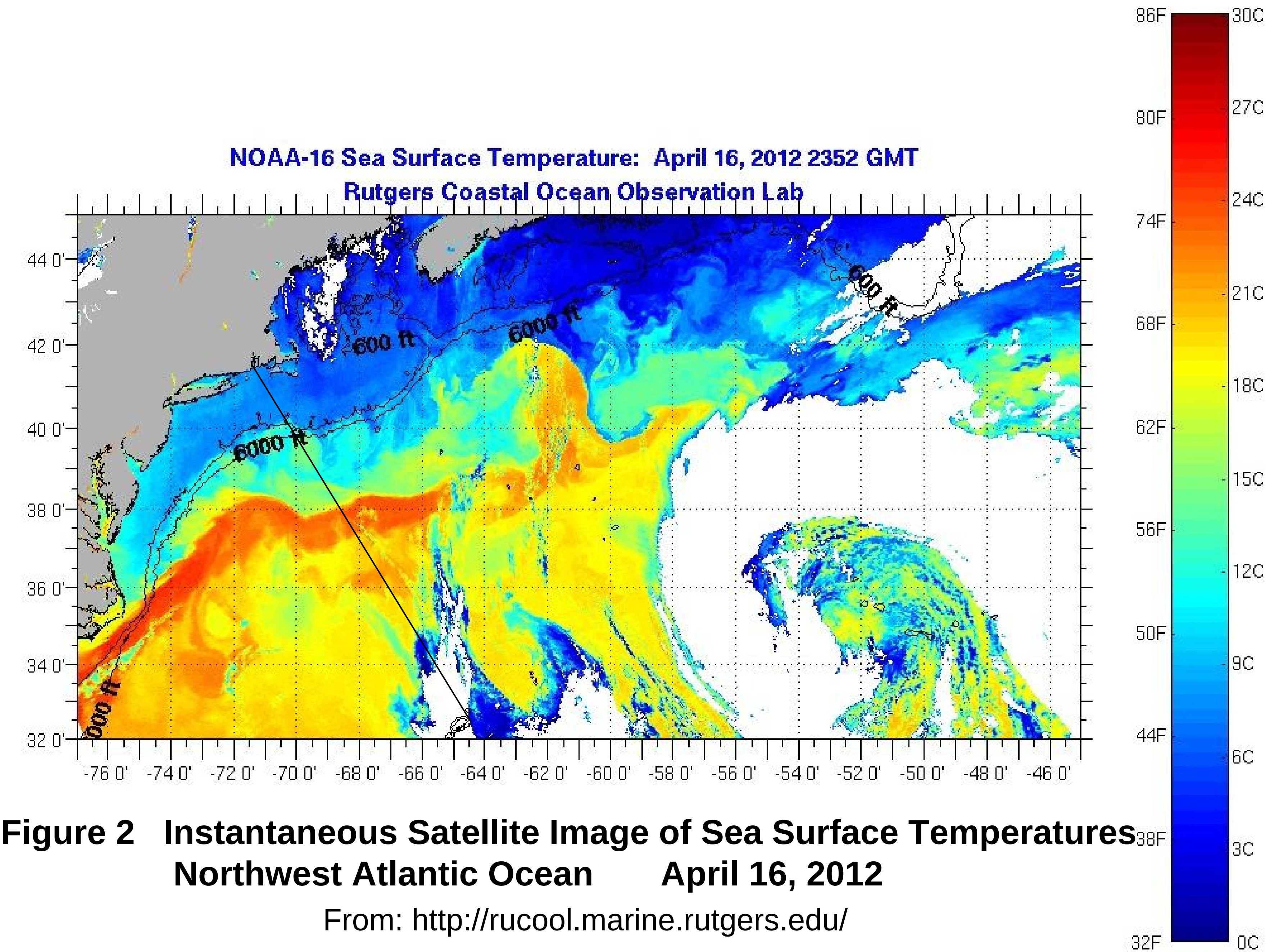

Figure 2 Instantaneous Satellite Image of Sea Surface Temperatures
Northwest Atlantic Ocean April 16, 2012

From: http://rucool.marine.rutgers.edu/

Dark Line indicates Newport-Bermuda Rhumb Line

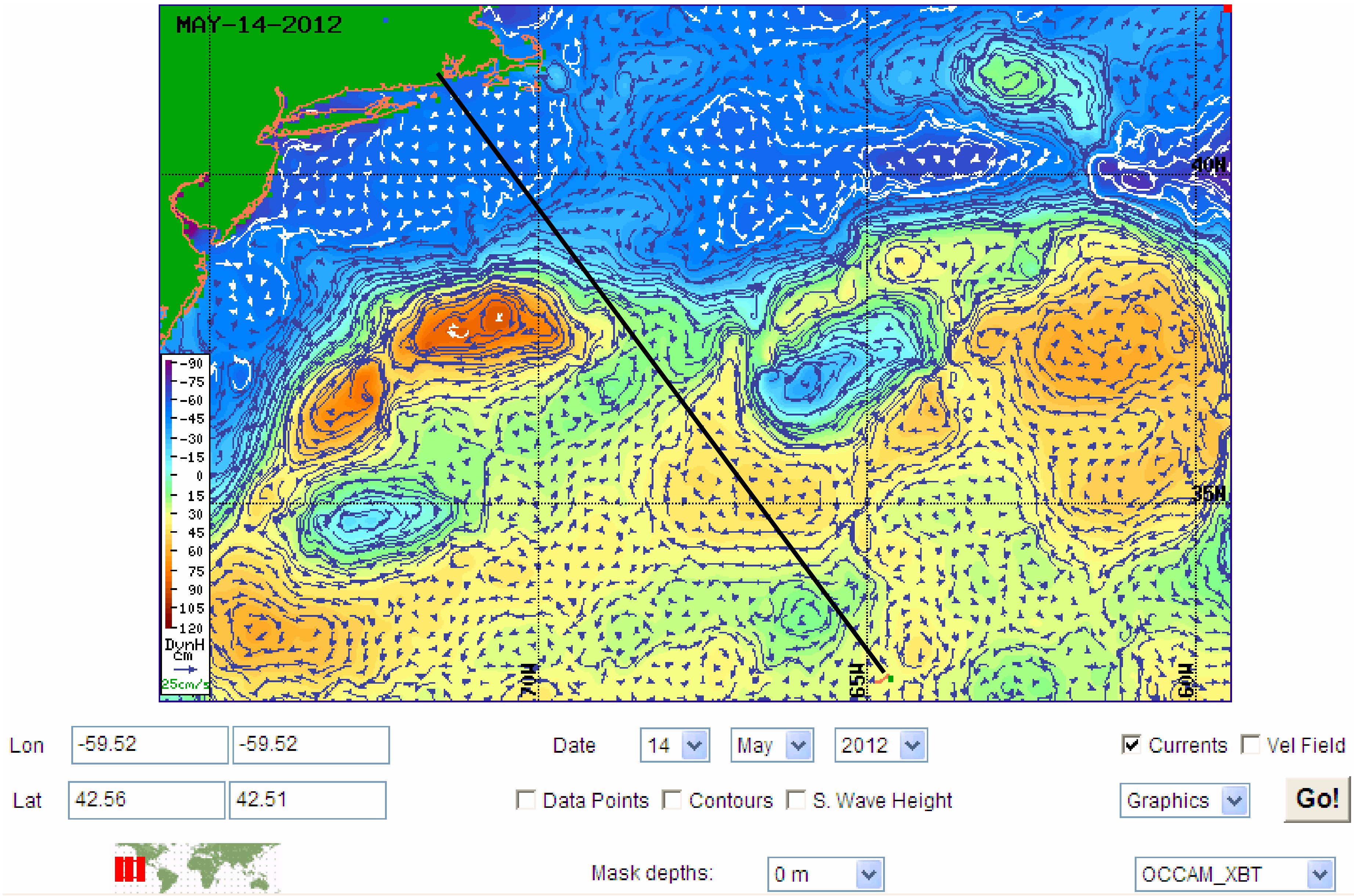

Figure 3 Altimetry Based Model Results Showing Currents and Sea Surface Heights in The Vicinity of The Newport-Bermuda Rhumb Line

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