Gulf Stream Characteristics
February 22, 2002
Note No.1

Gulf Stream Analysis 2002: Some Initial Thoughts

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In contrast to conditions encountered less than 20 years ago, racers entering the Newport Bermuda Race of 2002 will have available to them a variety of data detailing long and short term weather patterns as well as the position, shape and form of the Gulf Stream. These data are easily accessible via the web and in combination with low cost graphics programs can be displayed in multi colors both afloat and ashore. Despite this ease of accessibility however, the transformation of these raw data to information sufficient to provide a basis for tactical decisions requires at least an elementary understanding of the behavior of weather and/or ocean current systems, their interactions, and the factors affecting change. Most sailors believe that they possess this understanding when it comes to weather and many often develop their own forecasts using Federal or private service surface analyses and model results received via fax. All of us, sailor and non-sailor alike, seem to be keen observation lists and to some extent weather addicts as evidenced by the popularity of the Weather Channel and Website weather. Ocean currents however, seem to be a different matter. Few would claim to understand the governing factors and even fewer would have the temerity to make predictions regarding future flows. Until recently these beliefs would have been entirely understandable. In the case of the Gulf Stream, for example, despite a long history of observation quantitative understanding and the beginnings of dynamic modeling date from the early 1950' s. Oceanographic surveys detailing its dynamic nature followed shortly thereafter. But it was the addition of satellite observations in the 1960' s and 70' s and their ability to "put a face" on this large, and rather remote, ocean feature that really facilitated a quantum leap in understanding of Stream structure and dynamics. With some understanding of the factors controlling the makeup of the Stream and its velocity field in combination with daily satellite images we are now presented with a range of data similar to that available to the meteorologist. This provides the opportunity for each of us to develop analyses of Stream behavior sufficient for most tactical decision making.

The understanding necessary to allow analyses of available Gulf Stream data for the purposes of optimum routing is rather rudimentary. We first need to understand that the

Gulf Stream is a northeast tending boundary current formed between the warm waters of the Sargasso Sea and the colder waters of the east coast U.S. continental shelf. The spatial gradient in water temperature provides a key indicator of Gulf Stream location, structure, and velocity. Next we need to recognize that this feature, particularly in the region north and east of Cape Hatteras, varies significantly in space and time. On occasion, this variability leads to instabilities and the breaking off of segments of the Stream forming discrete "rings" or "eddies" both inshore and offshore of the main body of the current. Each of these rings displays its own unique temperature signature and well defined ,if localized, velocities often equal in magnitude to those observed within the core of the Stream. Following formation, the rings tend to develop a characteristic drift or trajectory and to display a finite life. These movements and the resulting interactions with the main body of the Stream or other flows proceeding along the bordering continental shelf favors the formation of a flow regime in the vicinity of the rhumb line with all the qualities of a "patch-work quilt". Detailing the patterns associated with this quilt represents the challenge of Gulf Stream analysis.

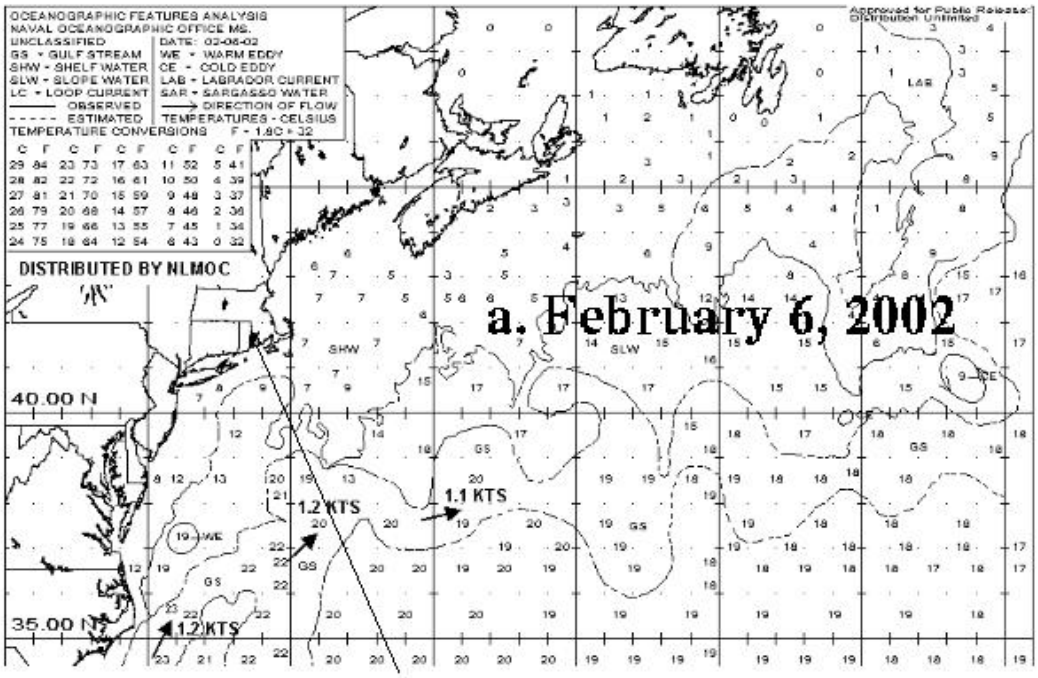
Although it may appear to be a daunting task, much of the data required to define the flow characteristics and structural features of the Gulf Stream is now available to us and easily accessible. Realization of their ultimate utility however, requires care in interpretation and an understanding of the errors inherent in each data set. These are precisely the same requirements encountered in the analysis of meteorological data so they come as no surprise. In both cases they are best satisfied by study extending over a period of time long compared to the time scales of variability. For the Gulf Stream this time scale is on the order of months. That is to say that Stream variations in structure and position as well as in the drift and trajectory of rings and the resulting velocity patterns may vary significantly over the course of a week or so. To detail this variability sufficient to predict future evolution requires observations extending over a period of time that is long relative to a week i.e. on the order of a month. The variability in Stream structure observed over the past few weeks provides a particularly graphic illustration of these characteristic time scales and the associated alterations in Stream structure (See Attached Fig .)

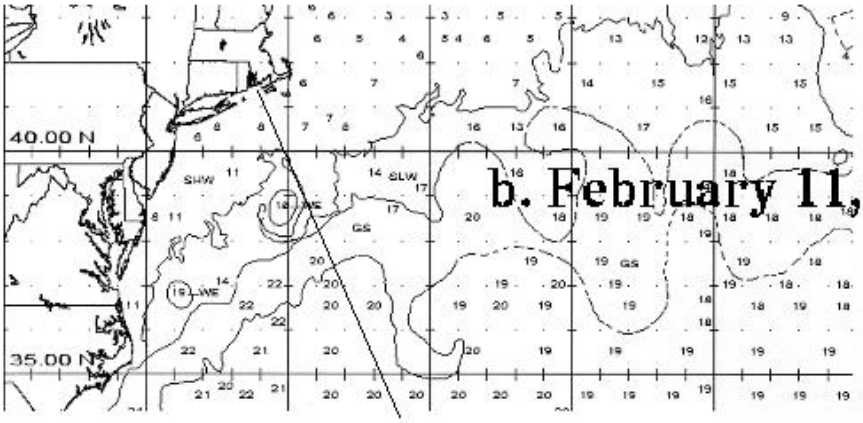
Examination of the surface thermal data provided by the U.S. Navy (available at www.nlmoc.navy.mil/cgi-bin/main.pl?ocean or www.weatherimages.org - both linked on the Race Home Page)) shows that on February 6th the Stream in the vicinity of the rhumb line (shown as the solid line extending approximately from Newport to Bermuda on a, b, and c .) was a relatively broad feature with water temperatures of approximately 200C. Flows were predominantly to the northeast across the rhumb line and there were no evident rings in the immediate area. A single warm core ring was present to the east of the entrance to Chesapeake Bay. Proceeding east of the rhumb line flow trajectories in the core of the Stream rotate to the southeast under the influence of a meandering that continues beyond 60W.

The Stream structure observed on the 6th of February remained essentially constant for the remainder of the week. Between the 8th and the 11th however, a portion of the Stream broke to the north forming a warm core ring immediately adjacent to the rhumb

line near 39N-70W (See b on Attached Fig .)The main body of the Stream is shown as a much narrower feature and the meander pattern has changed. Each of these features has the potential to significantly alter the velocity field in the vicinity of the rhumb line. The short period of time necessary to affect a major alteration in Stream structure clearly illustrates the value of repeated observation sufficient to define the conditions favoring instability and subsequent ring formation.

Carrying on the observations to the 22nd of February (See c on Attached Fig.) adds nicely to the above showing a continuation in the narrowing of the main body of the Stream, the formation of a second warm core ring near 40N-65W and the slow westerly drift of the ring formed prior to the 11th. The deep meander in the Stream in the vicinity of 60W may in time favor the formation of an additional ring, this time to the south of the Stream, having a cold core. There are clearly a number of features worth watching over the next few months as a preface to the definition of conditions in existence during mid June. A summary of these observations will be presented from time to time on the Race Homepage. Watch for them ! In the meantime read the Gulf Stream Notes prepared for the past two races (see Race Home Page) and review some of the selected reference materials. I believe that you will find this an interesting and rewarding exercise.


OCEANOGRAPHIC FEATURES ANALYSIS
NAVAL OCEANOGRAPHIC OFFICE MS.
UNCLASSIFIED
DATE: 02-06-02
GS - GULF STREAM
SHW - SHELF WATER
SLW - SLOPE WATER
LC - LOOP CURRENT
WE - WARM EDDY
CE - COLD EDDY
LAB - LABRADOR CURRENT
SAR - SARGASSO WATER
OBSERVED
ESTIMATED
DIRECTION OF FLOW
TEMPERATURES - CELSIUS
TEMPERATURE CONVERSIONS F = 1.8C + 32
DISTRIBUTED BY NLMOC
a. February 6, 2002
40.00 N
35.00 N
1.2 KTS
1.1 KTS
1.2 KTS
SHW
SLW
GS
WE
CE
LAB


b. February 11,2002
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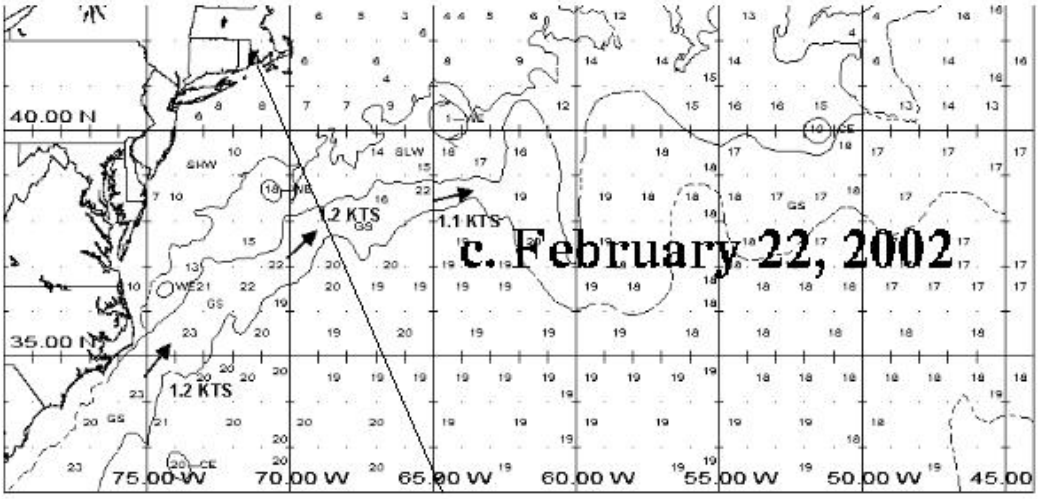
c. February 22, 2002
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