NOAA Technical Memorandum NWS SR-159

SWIFT BOAT '94

USING A FAST CHASE BOAT TO INVESTIGATE OFFSHORE WEATHER FEATURES IN CONJUNCTION WITH WSR-88D OBSERVATIONS

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August 1994

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1. Introduction

The National Weather Service (NWS) is modernizing offices, equipment, and products, and enhancing the training of its employees in order to heighten services it provides to the nation. A cornerstone of the modernization is the WSR-88D (Weather Surveillance Radar—1988 Doppler). The national network of WSR-88D radars will provide nearly complete coverage of the United States and the adjacent coastal waters.

With the Doppler radar, forecasters will have the ability to remotely evaluate wind fields over large areas, while the increased sensitivity and resolution of the WSR-88D will provide a more complete analysis of weather features. Meteorologists quickly noticed many interesting marine weather features when the first of these radars was installed in a coastal environment at Melbourne, Florida, in October 1991. Persistent offshore convection, especially over the Gulf Stream, marine thunderstorms with supercell structure, intensification of cells as they move offshore, and fine lines of enhanced reflectively are just a few marine weather features observed with the radar. Unfortunately, the limited number of offshore surface observations makes complete interpretation of these features and the conditions they produce very difficult. Questions are often raised as to how these features affect mariners.

A marine operations and services plan was prepared in 1992 as part of NWS Modernization and Associated Restructuring (MAR). This plan addresses future marine services, defines new areas of marine forecast responsibility, describes implementation of new services, and provides a program for evaluating the new technology in the marine environment. A NOAA commissioned officer with sea experience and basic knowledge in marine forecasting was assigned to the NWSO Melbourne in December 1992 as part of this plan. This was done to enhance product user experience and marine forecasting expertise at the new office. This officer and NWSO personnel would combine their experience to meet the challenges of using this new technology to further knowledge of marine weather and forecasting through applied research and public education and awareness.

Melbourne forecasters recognized the need for additional offshore data in order to better interpret the mechanisms producing the observed features and the resulting conditions. The logical solution was to go offshore and investigate these features as closely as possible while they were occurring, similar to the way severe weather chase teams operate on land. Consequently, a research project was designed to look at meteorological features in the coastal waters with both the Melbourne WSR-88D and marine observations from an instrumented vessel.

Through real-time coordination between a radar meteorologist and the vessel, weather features identified on radar would be targeted for investigation and the boat directed in and around the features. Observations made from the chase vessel would supplement Surface Aviation Observations (SAO), Cape Canaveral tower wind measurements, weather buoy observations, and ship observations to provide a more complete surface observation network from which to analyze radar observed features.

2. Project Design

A project proposal was completed in March 1993 defining two different seasons in which this offshore research would be conducted. Winter and summer are generally periods when the mechanisms controlling the weather over Florida differ significantly. A research period of approximately one month was defined during each season. The winter period (mid January through mid February) would focus on extratropical features which are usually strongly influenced by the synoptic environment and mid-latitude intrusions into the Southeast. The summer period (early August through mid-September) would focus on features such as sea/land breezes, thunderstorm initiation, and waterspout formation and life cycle—features highly influenced in the summer by mesoscale environmental factors.

The proposal defined numerous goals, and specific missions were formulated to accomplish them. It set the stage for operations in the office and on board the vessel, defining several positions and associated duties. Procedures were developed for the gathering and storage of data. Specific equipment needed for the program was identified and a budget formulated to ensure this equipment could be operated and maintained during the prescribed periods.

This project was designated SWIFT BOAT (Subtropical Weather Investigation and Forecaster Training using Boat Observations and Atmospheric sampling to marine Truth the WSR-88D). The initial funding for this project was provided by NWS Southern Region Headquarters with subsequent funding from NWS Headquarters.

Goals

The following specific goals were established:

- Familiarize meteorologists with the coastal and intracoastal forecast and warning areas of responsibility from a "small craft" perspective.

- Collect meteorological observations in and around marine weather features to investigate:

  - Life cycle of offshore convective cells
  - Convective outflow boundaries
  - Cloud streets and shear lines
  - Convection in relation to areas with strong sea surface temperature (SST) gradients
  - Life cycle of waterspouts
  - Oceanographic features including rip currents, sea surface discontinuities (shear lines, current eddies), and the Gulf Stream

- Evaluate the utility and accuracy of products produced by the WSR-88D by comparison with other observations, especially:

    - Rainfall rate (Thiele 1992)
    - Offshore and intracoastal surface wind speed and direction
    - Convective and non-convective boundary identification

- Provide video and photographic documentation of the intracoastal waterway and Atlantic seaboard in the vicinity of Melbourne

    - Collect video and photographic documentation of Ponce de Leon, Cape Canaveral, Sebastian, Fort Pierce, St. Lucie, and Jupiter Inlets
    - Develop marine training video for forecasters and mariners

- Evaluate the reception range of NOAA Weather Radio and survey the utility of NWR to the local marine community

Missions

Three basic missions were developed to interrogate the marine environment and meet the established goals. Two missions were predefined to carry out routine research of the coastal waters and intracoastal waterways, including photo/video documentation of the marine environment in these two areas. The third mission allowed for the adjustment of the prescribed route in order to investigate any significant weather feature(s) detected with the WSR-88D (Choy, 1993).

Mission 1 — Take routine observations every 5 nm as the field team headed east from Port Canaveral into the Gulf Stream and back to Port Canaveral (Appendix 1). This mission was usually carried out when seas were exceptionally calm.

Mission 2 — Observe, photograph/video the near coastal and intracoastal waterways off the central Florida coast from Ponce de Leon Inlet to Jupiter inlet.

Mission 3 — Interrogate weather features observed with the WSR-88D and/or satellite data, along with the surface conditions they produced.

3. Operations: Phase I

During this phase of the project, the vessel was transported by trailer from the NOAA Aircraft Operations Center (AOC) at MacDill Air Force Base in Tampa to Port Canaveral on January 5, 1994. The vessel was moored at the Port Canaveral U.S. Coast Guard Station for the duration of the project (with the exception of a four-day operation conducted out of Fort Pierce, Florida).

After a brief outfitting and testing period, routine observations and weather missions of opportunity were carried out on a daily basis from January 10 through February 18, 1994. On March 2, 1994, the vessel was returned to the NOAA AOC in Tampa.

Equipment

A 34-ft high-speed boat, staffed primarily by NOAA Corps and NWS personnel, was used as the research platform. The boat was a reconditioned vessel which had been confiscated from drug smugglers by the U.S. Government. NOAA normally uses such vessels to enforce fishing regulations along the Florida Gulf Coast and in national marine sanctuaries. The speed and maneuverability of the boat allowed us to cover large distances offshore in a short period of time. It would also allow avoidance of fast-moving severe weather, should the conditions occur, thus providing for safety of project personnel.

The Wellcraft Scarab (cigarette boat) was powered by two 454-cubic inch displacement General Motors engines and Mercruiser outdrives. Magellan model 5200 GPS and Ratheon R21 marine radars were used as the primary means of electronic positioning of the vessel. The R21 radar was also used to locate and facilitate the interception of precipitation areas while offshore. These electronic devices, along with safety equipment and a VHF marine radio for ship-to-ship and ship-to-shore communications, were provided by NOAA AOC.

A Digitar model TWR-3 Weather Pro weather station was used to collect wind speed and direction data and back-up air temperature data. Barometric pressure was measured using an AIR-HB-1A hand held digital barometer and an ORG-105 optical rain gauge. This rain gauge was interfaced with a Sperry computer and collected rainfall rate data at one-second intervals during showers. These instruments were loaned to the project by the NASA shuttle mission weather support group and the Tropical Rainfall Measuring Mission (TRMM) project.

A sling psychrometer and additional mercuric thermometers were used for air temperature, wet bulb temperature, and sea surface temperature measurements. A Motorola 3-watt Gold Series cellular telephone and Antenna Specialties model ASMD 942M marine cellular antenna were installed to provide uninterrupted ready-access communication between the vessel and the mission coordinator. This equipment, along with VHS and 35 mm cameras, was provided by the NWS.

On shore, the Melbourne WSR-88D was operated primarily in precipitation mode Volume Coverage Pattern (VCP) A/21. The radar generated numerous products during the nine elevation angle slices every 6 min, which could be used to completely interrogate marine weather features, while the surface observations were used to evaluate and confirm the radar's ability to detect various offshore surface conditions.

Daily Operations

A research team, largely comprising NWSO Melbourne personnel, was scheduled for each day of operations. This team was divided into a field team, which would operate on board the vessel, and a shore-based team.

On shore, the Project Operations Officer (POO) (the Meteorologist-In-Charge of the NWSO) was in charge of overseeing the activities of the team. At the NWSO, in addition to operational shift personnel, a Mission Coordinator (MC) was responsible for defining the day's mission and maintaining a vigilant watch using radar, satellite, and buoy/ship observations to locate marine weather features. The MC position was generally filled by a meteorologist who was not scheduled to work the day's operational forecast shift. He/she maintained communication with the vessel and directed the field research team as necessary to accomplish the goals for that particular day's mission. When the field team reported marine conditions offshore, the MC also prepared a comprehensive Plain Language Ship report (MIAPLSMLB) and distributed it on the AFOS (Automation of Field Operations and Services) system for the benefit of the marine forecasters at the WSFO in Miami. Forecasters at the WSFO used the product in preparation of coastal waters forecasts (Appendix 1).

The field team consisted of a vessel Officer-In-Charge (OIC), Assistant OIC (AOIC), and several Data Collection Specialists (DCS). The OIC and the AOIC were responsible for the safe navigation, operation, and maintenance of the vessel and its equipment, while the DCSs were responsible for collecting wind, temperature, and rainfall data at the specific locations prescribed by the MC. At any time during a routine mission, or at the beginning of the day, the vessel could be dispatched or diverted to investigate features of interest which were being observed with the WSR-88D (Mission 3 operations invoked).

A 5 nm offshore grid of the operations area was devised to make navigation to areas of interest easier through the use of the GPS (Global Positioning System) unit (Appendix 2). The numbers of the grid points were entered into a GPS unit on board the vessel, along with their associated latitude and longitude. The navigator (either OIC or AOIC) would enter the way-point number into the GPS, and the device would direct the vessel's pilot to that point. This avoided the necessity of entering cumbersome latitude and longitude numbers each time and also reduced the time and possible errors while communicating on cellular phone. The same grid was entered into the WSR-88D as a background map so the MC could keep track of the vessel's location in relation to offshore weather features (Appendix 3).

At the end of the day, all data collected from both offshore and at the NWSO, were compiled and filed in a folder. The lead DCS wrote a brief summary of the mission, including documentation of the events, and also completed a photograph/video log. The MC made sure the appropriate radar, PC-GRIDDS, sounding, and synoptic data were correctly archived. These were also filed in the day's mission folder (Choy, 1993).

Accomplishments and Preliminary Results

During Phase I of SWIFT BOAT, 215 marine surface observations were collected during 23 daily missions. These missions accounted for some 110 vessel hours and covered approximately 140 nm of east central Florida coast (out to 50 nm) and 155 nm of intracoastal waters. Nearly every person assigned to the Melbourne NWSO participated as a DCS and/or MC during this phase of the project, gaining in the process very valuable marine experience. Additionally, five NWS employees from other Southern Region offices and one NASA technician also participated. Such experience is invaluable to the Melbourne staff and other coastal forecasters having the responsibility of a coastal marine warning and forecast program.

Several interesting weather features were investigated. In addition to scattered showers, convergent and thermal air mass boundaries were often detected. In some instances, these boundaries exhibited reflectivities in the WSR-88D consistent with precipitation when actual observations offshore could not confirm precipitation at the surface. It also appeared that some of these boundaries formed in response to and aligned with areas which exhibited strong SST gradients. High resolution velocity products were used to investigate some of these features, and they frequently indicated wind direction and/or speed variations across the boundaries. The radar wind variations correlated with some of those observed at the surface, but on at least one occasion appeared to be nearly opposite to what was observed.

Having a fast vessel allowed several observations at different locations along these features in a short period of time. This was extremely useful in the investigation of a boundary off Cape Canaveral on January 20, 1994. Shear was indicated across this fine line boundary in the lowest elevation velocity products. Tower wind measurements at Cape Canaveral, SAOs near the coast, and buoy observations indicated a wind shift between the coast and 20 nm east of Cape Canaveral. It was confirmed through offshore observations that this abrupt wind direction/speed and temperature change occurred exactly along the boundary indicated by the WSR-88D (Appendix 4).

Many water mass boundaries, shear zones, and resulting strong SST gradients were identified through ocean surface water temperature measurements. These areas with sharp ocean surface thermal differences occasionally appeared as fine lines on the WSR-88D reflectively products, possibly due to localized air mass modification resulting in air density differences across the boundary. Subtle local wind direction and velocity changes and abrupt air mass modification was also noticed with some of these features.

In addition to meteorological and oceanographic observations, an interesting biological observation was made during this project. A large Basking Shark (*Cetorhinus maximus*) was captured on video tape actively feeding on macro-zooplankton along one of these convergent water mass boundaries. Measurements made around some of these boundaries in the past have shown increased plankton concentrations (Grimes and Finucane 1991; Moser and Smith 1993). The presence of higher concentrations of plankton provides an ideal and efficient feeding area for large planktivores like the Basking Shark. This spurred the interest of the biological community as possibly the first ever photographic and video documentation of an event of this type, confirming what has long been only theorized (Hallacher, 1977).

Extensive video documentation of water and air mass boundaries was accomplished in addition to video of scattered showers and cumulus congestus cloud lines. Approximately 140 nm of the east central Florida coastline and 155 nm of intracoastal waterway were traversed and videotaped to highlight population densities and identify potential problem areas affected by coastal flooding and the hazards associated with tropical storms. This video will be used to familiarize forecasters with the local coastline and identify potential problem areas.

4. Operations: Phase II

Operations for Phase II will occur during the Florida wet season in August and September 1994. Improvements will be incorporated based on the experience gained during Phase I.

Equipment Upgrades

The marine environment is a harsh one. During Phase I, every piece of meteorological instrumentation became inoperative, at least for a portion of the time. The sudden jarring motion of the vessel in moderate and heavy seas was enough to break the mounting apparatus for the wind vane and anemometer. A sudden unanticipated wave breaking over the bow of the vessel drenched the electronic pressure measuring device and the wind recording electronics. These instruments had to be returned to the manufacturer for repair. High humidity and rain affected the computer equipment. Fortunately, the vessel itself only needed minor engine repairs to remain fully operational. Instrument status was the main limiting factor for the project, severely affecting data collection in and around marine weather features.

A major instrument refit is planned for Phase II. We hope to interface pressure and temperature sensors directly with an on-board computer to allow continuous data collection. We will seek high quality portable instruments.

Specific Phase II Goals

The project will continue to focus on intracoastal waterways and the near shore ocean environment and the relationship of these areas to marine and peninsular weather forecasting during the wet season. Specific analysis of convection initiation by sea breeze, river breeze, and intracoastal and offshore convergent zones will be accomplished; and the influence on short-term forecasting will be identified. Investigation of the coastal environment for possible waterspout formation will be conducted to continue current NWSO research in this area (Choy and Spratt 1994).

WSR-88D ground (sea) truth will also be a primary focus of Phase II operations. This will be accomplished through rainfall and wind measurements in and around offshore showers using the optical rain gauge and portable wind instruments. Video and photo documentation, along with written transcripts, will continue in Phase II. It is hoped that once this phase is completed, a training and familiarization video can be prepared for the benefit of mariners and marine forecasters.

Collection of data in the coastal area will be emphasized to provide real-time observations to meteorologists. This will enhance forecasting and provide real-time verification. Melbourne and central Florida meteorologists will be encouraged to prepare practice marine forecasts as part of Phase 2 in anticipation of assuming this function at the NWSO as part of MAR.

Finally, it is expected that some of the methods, procedures, and research results from SWIFT BOAT will have applicability in the support the NWS will provide to the 1996 Summer Olympic Games sailing venue off Savannah, Georgia.

5. Discussion

The preliminary results presented here are a qualitative overview, since data have not yet been fully evaluated. Benefits have already been realized from Phase I, however, and we have addressed some of the logistical and operational problems. In Phase II we will focus our attention on maximizing benefits while eliminating some of the problems identified in Phase I.

Training and familiarization was well received by the NWS personnel who participated in Phase I. Marine familiarization on ships has occasionally been available to NWS employees in the past, but only through working on a small craft will an operational forecaster fully realize the importance of his or her marine products. This is reflected in short summaries from some of the participants included in Appendix 5.

The speed of the vessel was an asset, especially when chasing fast moving showers; but it did come with drawbacks. The instability of the vessel in moderate and heavy seas made operations physically demanding and uncomfortable for the crew. Rough conditions eventually rendered every piece of sampling and electronic equipment on board inoperable at some point during the project, requiring timely improvisations to be made. To remedy this we will seek higher quality and more durable instruments for Phase II of the project. This, along with generally calmer conditions during the summer, will reduce the amount of missing data or estimated observations.

We experienced an unrecoverable Archive IV disk error (code 42) when attempting to replay some of the WSR-88D data. Unfortunately, this leaves no provision for the recovery of radar archived products, at least not on site. This disk failure, along with Archive III being run only periodically, accounted for the loss of approximately one week of data. Archive II (base data tapes) were requested from NCDC to recover the most important lost data. These tapes were run through a Radar Products Generator (RPG) at the NWS Operational Support Facility (OSF) and re-recorded on optical disk for use at Melbourne. This problem will be avoided in Phase II when Archive III will be operated continuously. Additionally, provisions will be made in the operating system OS/32 to periodically copy the Principal User Position's (PUP) data base to SCSI tape.

Interesting and valuable rainfall rate data were gathered in several offshore showers during Phase I, but a complete analysis of the performance and calibration of the Optical Rain Gauge (ORG) has not been completed. To facilitate this, the ORG was installed at the Daytona Beach NWS office in close proximity to the weighing and tipping bucket rain gauges. Comparisons will be made between the ORG and the standard gauges, along with the evaluation of radar computed rain rate measurements over the area prior to the beginning of Phase II.

Although seemingly unrelated to meteorology, the shark observation is important for two reasons. It shows that some of the most interesting discoveries and documentation occur by accident or pure luck. Also, meteorologists were able to gain a better appreciation for the complexity and significance of air-sea interaction. Weather and ocean currents control the survival, abundance, and distribution of fish species. Biological and physical oceanographers are now able to remotely evaluate areal productivity using chlorophyll concentration measurements from satellite. Chlorophyll is a substance found in plants and likewise phytoplankton (plant plankton), which are the basis for the marine food chain. Oceanographers will be able to forecast productivity based on observations made from space. We may be able to predict the onset of certain weather patterns by observing biological response (for example, El Niño) or biological response due to current and predicted weather. Meteorologists and oceanographers will continue to work closely with each other realizing the relationship between their disciplines (Grimes and Finucane, 1994; Moser and Smith, 1993).

SWIFT BOAT may demonstrate the utility of a roving offshore data collection vessel in support of special events such as the sailing venue of the 1996 Summer Olympic Games. A better understanding of convection initiation offshore leading to thunderstorms and instantaneous wind velocity data would allow forecasters to more accurately assess the timing and severity of nearby weather which could affect the event.

Phase I operations revealed several interesting and unique meteorological, oceanographic, and biological observations. Air-sea interaction clearly plays a pronounced role, not only in the formation and modification of marine weather features, but in the echoes detected by radar. This will be explored further in Phase II using other scan strategies (VCPs) and improved vessel instrumentation. Forecaster familiarization went as planned and was very successful. This will be continued in Phase II to help broaden the experience of forecasters who will be using new equipment. Offshore observations proved useful to marine forecasters at WSFO Miami, allowing real-time verification and facilitating forecast updates. Improvements will be made based on the experiences gained during Phase I so that the full potential of such a project can be realized in Phase II. Phase II operations are currently planned to take place from August 1 through September 9, 1994.

Acknowledgements

This project would not have been possible without the foresight and commitment from NWS Southern Region Headquarters and the NWS Headquarters Office of Meteorology. Their support is greatly appreciated. We appreciate the participation of all those who served on the research teams, the NOAA Aircraft Operations Center for allowing us the use of their vessel, Cape Canaveral U.S. Coast Guard Station for allowing us to moor the vessel at their facility, and Mr. Otto Thiele (NASA TRMM) for allowing us to use the ORG-105 optical rain gauge. The quick response by Robert Boreman (NCDC) in copying of Archive II tapes and Joe Chrisman (OSF) in running the data through an RPG surely turned a hopeless situation into a viable one. Their efforts were exemplary and surely appreciated. Additionally, we greatly appreciate the effort underway by NWS personnel at the WSO Daytona Beach who are currently working on the evaluation of the optical rain gauge.

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Appendix 1

OCEANOGRAPHIC MISSION 1 PLAN

OBJECTIVE

To investigate thermal and velocity gradients across the Gulf Stream current and relate the position of surface changes to cloud, shower, or WSR-88D detected feature formation.

BACKGROUND

Many peculiar features are observed with the WSR-88D in Melbourne and with satellite imagery. The absence of data sources over the coastal waters has made it difficult to explain the formation of these features. The primary feature of interest is the boundary. It is apparent from satellite and/or radar that boundaries develop offshore and produce a line of cumulus congestus clouds. These cloud lines have often developed showers or interacted with showers or thunderstorm outflow boundaries to produce thunderstorms. This phenomena is largely isolated to summer months, but other interesting features appear in the winter.

In the winter the warm moist air mass over the Gulf Stream may be responsible for producing fog offshore. Since there are virtually no data sources in the Gulf Stream, the occurrence of fog may be severely underestimated and not forecast. Since the current offshore hosts much of the northward shipping traffic which takes advantage of the additional speed of the current, understanding the presence and production of fog in the area is essential for an accurate marine forecast.

This routine mission will interrogate oceanographic and atmospheric changes across the strongest sea surface thermo-gradient region, the Gulf Stream's west wall. Surface and sub-surface observations will be taken east to west and again west to east (along an adjacent line) across the Gulf Stream inside front and west wall. Any feature within or near this region will be photo documented in extreme detail for later analysis.

MISSION DESCRIPTION

The DCS will be provided with the National Hurricane Center Oceanographic Analysis (AFOS MIAOCFGLM) included in the normal daily briefing package. The vessel will only make meteorological observations at stations from the coast to within 10 nm of the west wall of the Gulf Stream. At the station which is approximately 10 nm west of the Gulf Streams predicted west wall, the sampling team will stop every 5 nm at stations as it traverses the west wall and continue an additional 10 mi east into the Gulf Stream. In addition to standard meteorological measurements, the field party will make oceanographic measurements at each of these stations. A CTD, seiche disk, and refractometer will be deployed (or used) and recovered at each station. In addition to deploying these instruments, current drogues will be deployed to get a good estimate of the current's velocity at a site.

The sea surface temperature, as well as current velocity information, will be relayed to the NHC oceanographer as an Alert Administrative Message (ADM) on AFOS in the form below. Since they do not routinely operate AFOS, this will ensure the message is delivered to them.

MIAADMMIA
TTAA00 KMLB 171800

PLEASE FORWARD THIS MESSAGE TO DR. BAIG AT THE NATIONAL HURRICANE CENTER.

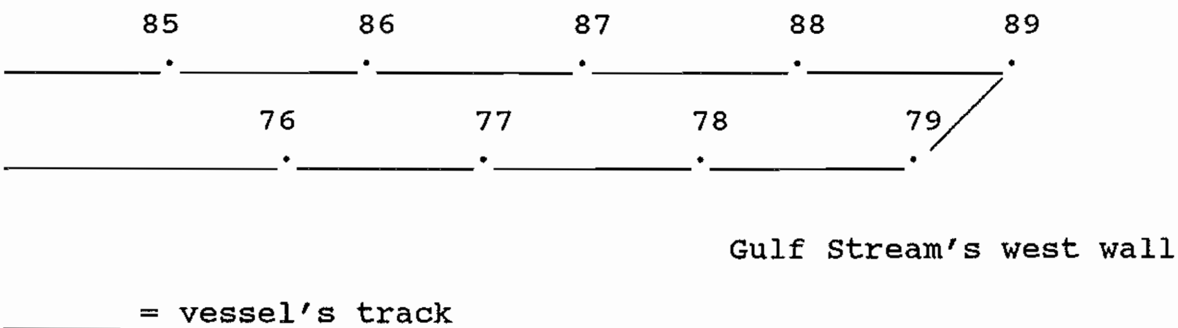
NOAA R/V NC 25 IS CURRENTLY INTERROGATING THE GULF STREAM. THE FOLLOWING IS A SUMMARY OF MEASUREMENTS TAKEN IN THE LAST FEW HOURS.

TIME(Z)	POSITION	SST	EST. DIR TRUE	MEAS. VEL
1800Z	28/00N 79/11W	25	030	1.7 KTS
1830	28/01N 79/03W	26	020	2.3
1900	27/59N 78/54W	28	025	3.4

ANY QUESTIONS SHOULD BE REFERRED TO NWSO MLB

The same procedure will be conducted in reverse along an adjacent line north or south of the line currently being investigated as the vessel returns west of the Gulf Stream, as shown below.

Station Numbers



Other meteorologically significant observational data will be relayed to the WSFO MIA for various stations before 1600 local time so they can be incorporated into the marine forecast. These will be distributed on AFOS in the following form:

Example Observation

MIAPLSMLB
TTAA00 KMLB 171500

OFFSHORE MARINE PRODUCTS
NATIONAL WEATHER SERVICE MELBOURNE FL
200 PM EST MON JAN 17 1993

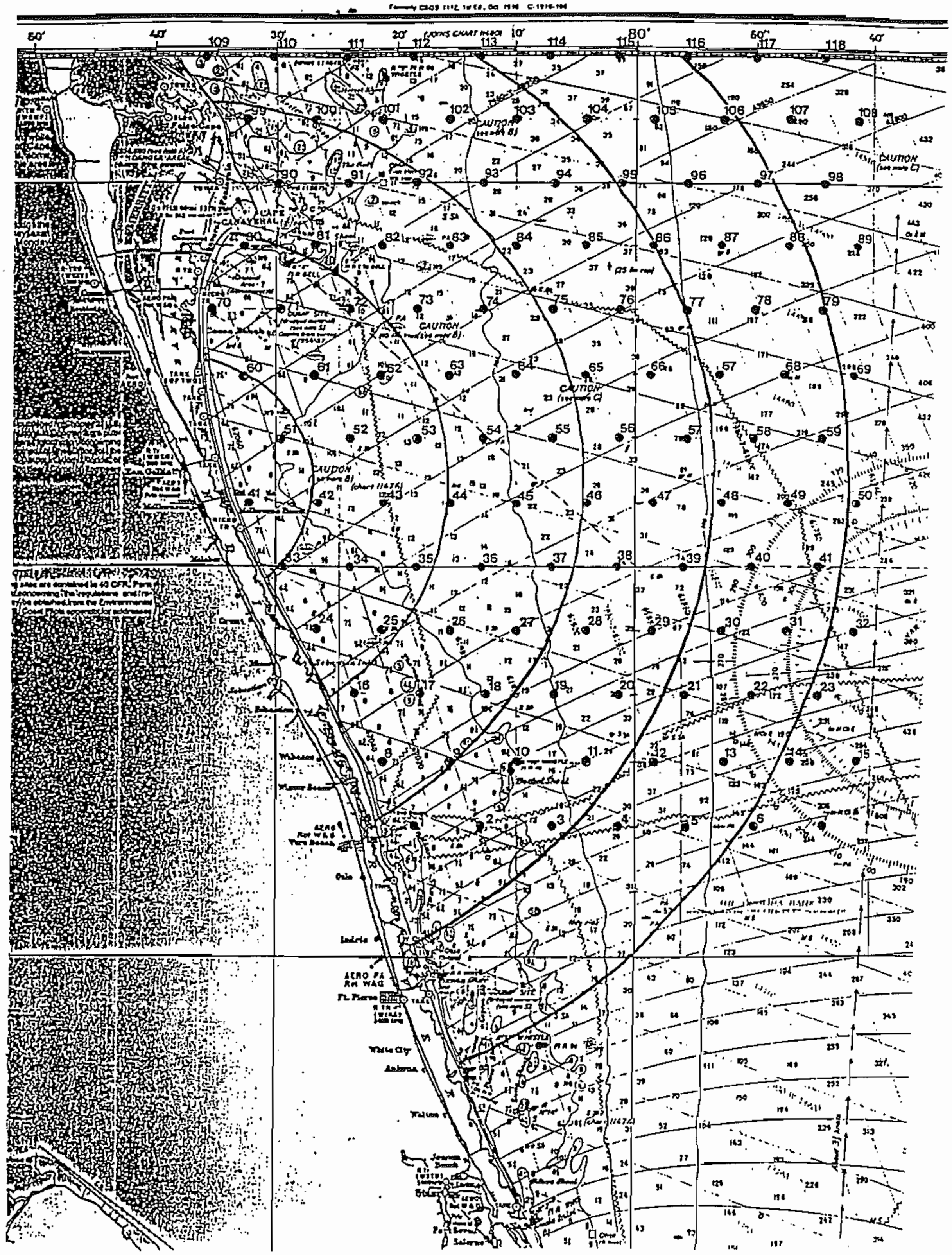
AT 155 PM EST...NOAA NC 25 REPORTED

UTC TIME	POSITION	WIND(DEG/KT)	HT PD EST SEA	AIR TEMP/ DEW PT	VIS(NM)
1800	28/00N 79/11W	030/10	2 FT 6 S	71/54	10
1830	28/01N 79/03W	020/11	3 FT 4 S	72/56	8
1900	27/59N 78/54W	025/10	3 FT 3 s	73/72	3

REMARKS: NORTH WIND OVER THE GULF STREAM HAS PRODUCED SHORTER PERIOD WAVES AND SUBSEQUENT CHOPPY CONDITIONS. VISIBILITY REDUCED IN PATCHES OF FOG MAINLY OVER THE GULF STREAM.

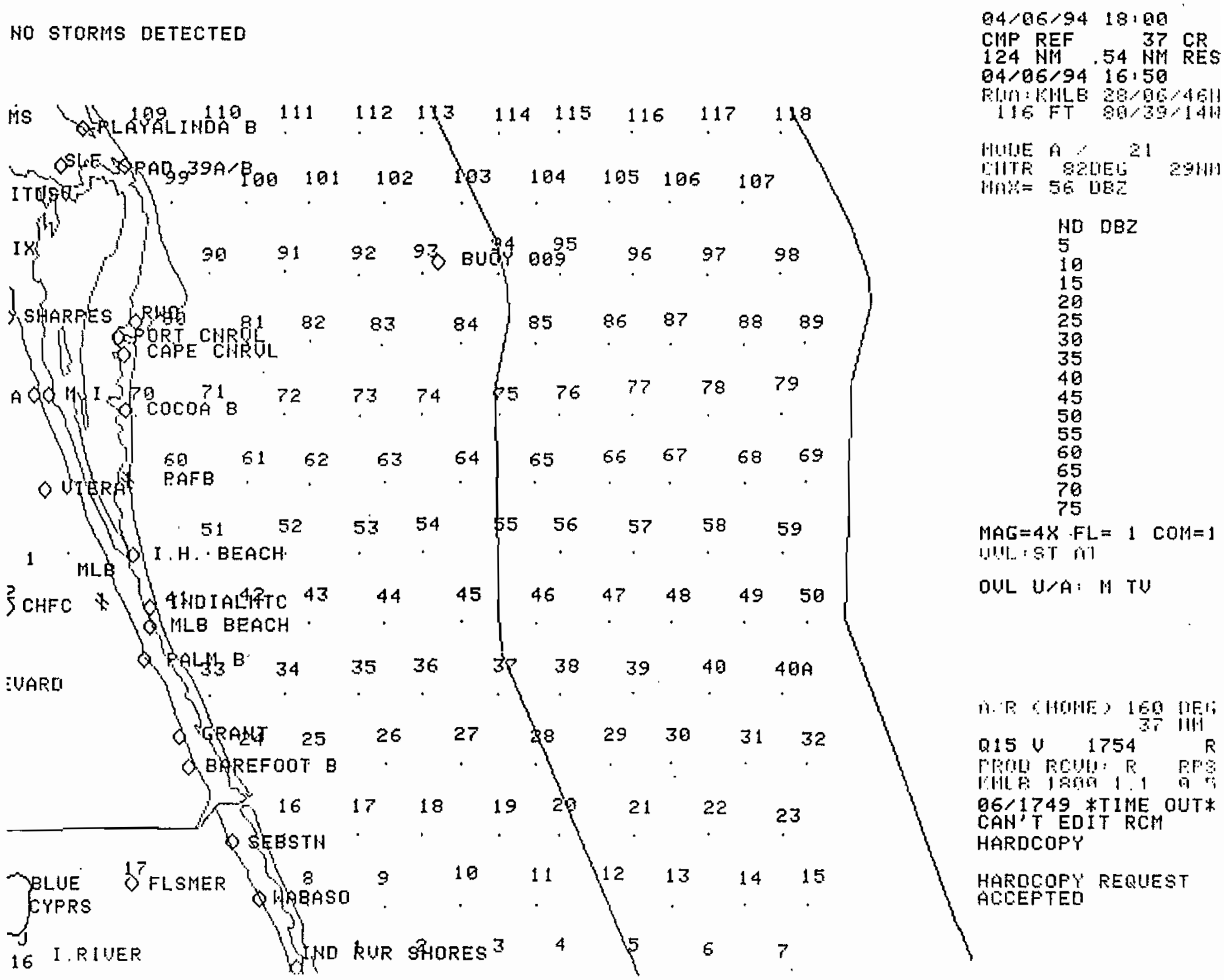
Appendix 2

Working Chart of the Operations Area with Plotted Station Numbers



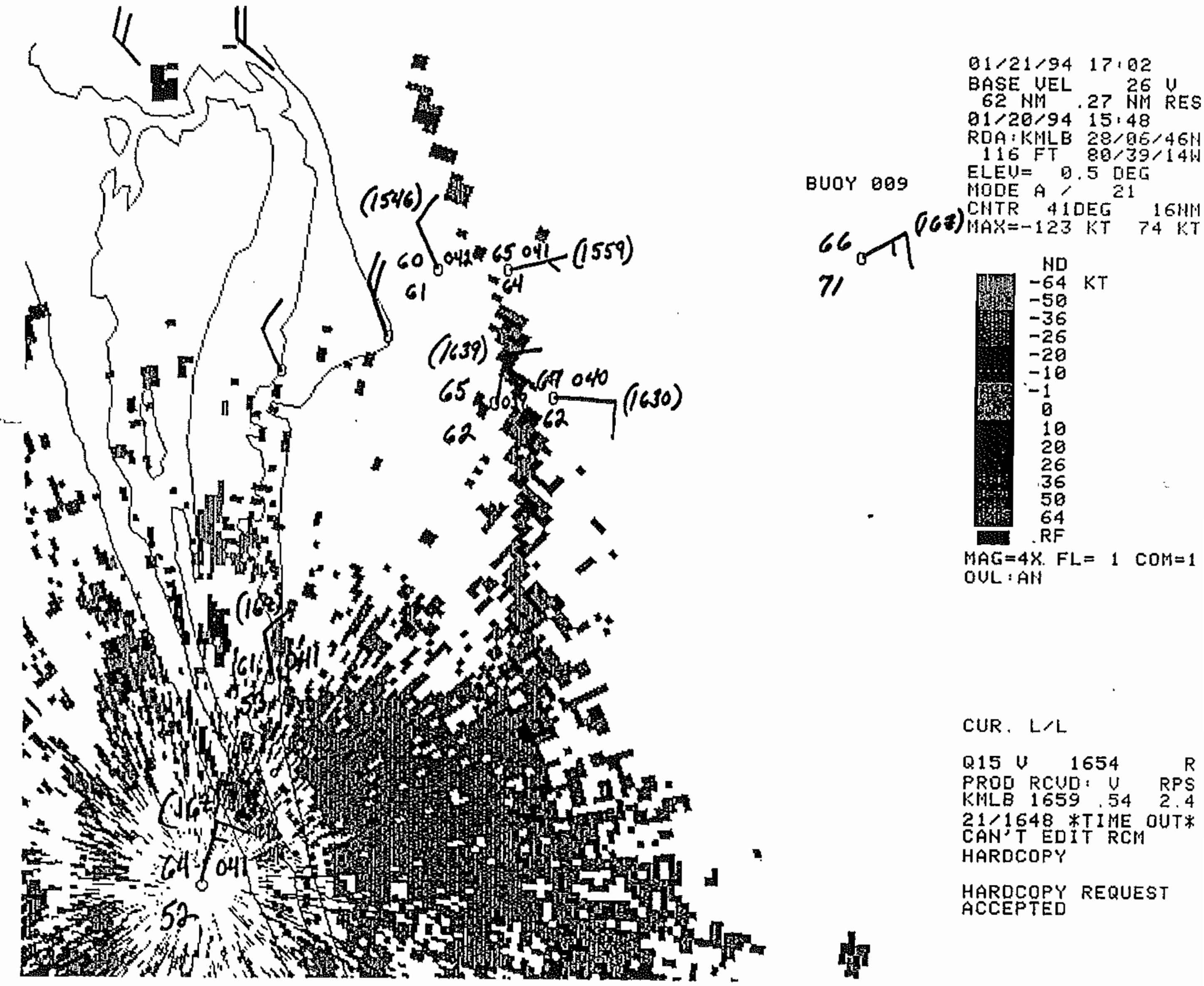
Appendix 3

WSR-88D Map Overlay of the Operations and Corresponding Station Plots



Appendix 4

Marine surface observations along a radar detected boundary off of Cape Canaveral. Corresponding tower wind observations at Kennedy Space Center and buoy observations are also plotted.



Appendix 5

Comments from SWIFT BOAT Participants

Although seemingly minor, I realized how big a difference 45° makes in a coastal wind forecast, especially near the coast. A northwesterly flow in this case would result in lower wave heights within a few miles of shore due to the much shorter fetch area.

From just my one day involvement with the SWIFT project, I realize the exciting potential it has, ranging from scientific investigation into the unknown conditions which frequently occur offshore, to gaining experience of the marine environment differently from how Weather Service forecasters commonly see it via buoy observations, radar displays, and satellite pictures.

Forecaster, NWSO Tampa Bay Area

This project also taught us land-lubbers how harsh the environment can be, especially with respect to instrumentation.

The project also allowed us to discover other interesting non-meteorological events such as ocean current boundaries. I was surprised on how marine life congregates on these boundaries, in addition to how a body of water which one would think would have no problem mixing would show such sharp discontinuities in temperature and water clarity. We also observed how current and winds affect navigation, especially with respect to inlets and the intracoastal waterways.

Being sea sick for hours is not my definition of having a good time.

Forecaster, NWSO Melbourne

Since I rarely go out onto the coastal waters, it helped me to learn what certain conditions are actually like in a small craft, not just numbers we put in a forecast. I now know that the difference between 3-ft seas and 5-ft seas can be very significant."

Forecaster, NWSO Melbourne

Participation in the SWIFT BOAT project allowed me to gain a much better understanding of how fast seas can react to shifting wind fields. The difficulty of traversing Atlantic/Intracoastal inlets during moderate easterly swell episodes was especially interesting. I believe that anyone who has taken part in a training exercise such as this will become a better marine forecaster.

Forecaster, NWSO Melbourne

As a hydrometeorological technician working the public service shift, I receive many calls requesting marine forecasts and information. The SWIFT BOAT project gave me insight into how much punishment a 6-ft sea state can inflict on a small craft and its crew.

HMT, NWSO Melbourne

Anybody participating in SWIFT BOAT learns. Even if it is how it feels to slam sea waves at 35-40 kts, or the frustration felt when you hear the NWR forecast of 3-5-ft waves while you are smothered by 10 ft...or hear 4 to 6 ft over a glassy ocean (perhaps your very own forecast). You learn, because this is what boaters see, feel, and live through every day. You learn because you *know* you have to do better.

Forecaster, NWSFO Miami