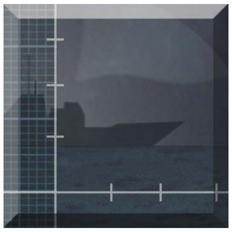

The Role of the Environmental Specialist Team in At-Sea Tests

Michael D. Mandelberg, Christian E. Buckingham, Michele E. D'Anna, and Christina J. Myles-Tochko

The natural environment is the medium in which the National Security Technology Department's technology field tests are conducted. The environmental scientist and environmental test team—who play a fundamental role in the success of these exercises—identify factors that may impact the feasibility and outcome of the field test as well as those factors of the environment that may be affected during an exercise. In addition, they are responsible for data collection during the test and data analyses after the test. This article discusses the pre-test environmental characterization, data collection, and post-test data analyses conducted by the department.

INTRODUCTION

The role of the environmental scientist and the environmental test team has been a crucial element in the success of the numerous field tests conducted by the National Security Technology Department (NSTD) over the past 20 years. Field tests support ongoing research and development related to specific projects within NSTD that ultimately contribute to the resolution of scientific issues of national importance. The real measure of success for a field test lies in the ability of staff members on all levels—from scientists and engineers, to technicians and administrative specialists—to work collectively, contributing individual expertise to form a comprehensive team.

The focus of this article is the role of the environmental scientist as part of the field test team. Beginning with the field test objectives, numerous factors must be considered, discussed, and documented—all of which may require 1 or more years of planning from initial concept to the actual test. The environmental scientist must coordinate with all team specialists in the planning process, during the field test, and after the test.

TEST PLANNING

Site Selection

The selection of a test site region that is conducive to project goals is a key factor in the success of a field test. From the initial planning stages, the environmental scientist is responsible for investigating geographic regions that support those project goals and for providing information about the environment. This requires a complete environmental characterization of candidate regions of interest. The environmental scientist provides the expertise needed to examine all aspects of the environment for a particular site and determines the potential level of environmental impact on the test.

All field tests are unique in terms of their requirements, which include a combination of specific scientific, engineering, and operational concerns. A scientific goal might be to investigate shallow-water acoustic propagation in environments where acoustic interaction with the ocean bottom is significant. Operational issues, such as the distance between available ports and site areas, transit time, and budget constraints, greatly affect the choice of test location. The availability of test assets (e.g., vessels) also has a major impact on site selection and is part of the operational requirements process. For example, the at-sea deployment of large, costly, and fragile equipment is not possible during adverse sea and wind conditions. Therefore, if the operation of such equipment is critical to the mission of a particular field test, areas must be avoided where extreme sea states occur.

Once the environmental requirements for a field test have been determined, an appropriate geographic region for the test must be found. The environmental scientist must consider all previously stated issues and provide the lead team members with a set of geographic region options, each of which would contribute to the success of the field test.

Environmental Characterization

The environmental scientist must characterize, as completely as possible, the range of environmental conditions that might be expected at a proposed test site for a proposed time of year, and must determine how environmental conditions in that region could affect specific test goals. For example, if the goal is to provide data on shallow-water acoustic fields, the particular features of the environment that may affect acoustic propagation are evaluated. This is done by analyzing data such as bathymetry (ocean bottom depths), bottom composition (e.g., sediment type and thickness), sea state, wind conditions, ocean currents, location of nearby shipping lanes and associated noise, and ocean water mass structure—all contributing to an understanding of a desired acoustic environment. The environmental scientist is responsible for consolidating these data and using his or her specific expertise to provide results that support the mission of the field test. In addition, as part of the environmental characterization, historical data are obtained from various sources such as the Naval Oceanographic Office, NOAA, the National Data Buoy Center, and others. These data are distributed to the test team in both graphical and digital formats.

Several relevant environmental data parameters such as the bathymetry (Fig. 1) and the composition of the ocean floor are static, that is, they do not vary

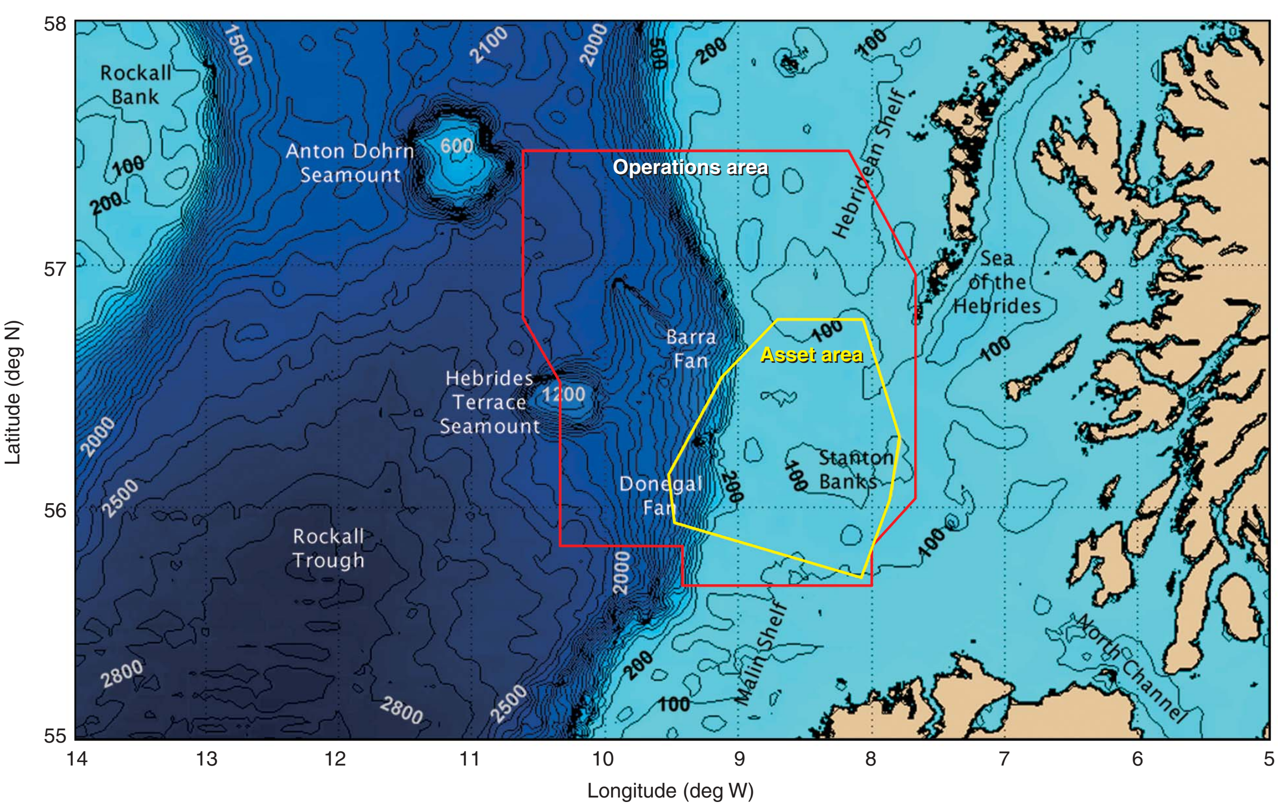

Figure 1. Bathymetry in the Northeast Atlantic, west of Scotland (depth contour interval = 100 m).

over time. Others are extremely dynamic and require a more in-depth analysis. Meteorological conditions, such as expected wind speeds, are often critical when considering a field test location for both operational and scientific reasons.

While extreme wind and wave conditions can cause major delays in test operations, their presence may be desired. Therefore, wind and wave conditions are carefully examined to determine their means (Fig. 2) and ranges. Often, detailed information on wind and wave variability is available from open ocean data buoys.

Other environmental parameters such as ocean currents can also vary considerably over time. Some of these quantities change seasonally, weekly, daily, or even diurnally.

Sea surface temperature (SST) often indicates ocean fronts and eddies, which may affect acoustic propagation and other ocean phenomena. Therefore, mean SSTs and statistical variability are also examined. Remotely sensed SST images are included to determine the range of expected conditions.

A detailed examination of specific water mass structures is always critical to an environmental assessment. For example, the speed of sound in the ocean is a direct function of the ocean temperature; as the temperature varies, so will the sound speed structure. Temperature is not the only contributing factor; so too is the salinity, or salt content, of the ocean. Ocean temperature and salinity vary considerably in different parts of the world and at different times of year. They also usually vary from year to year at the same location and time of year.

As part of the analysis process, both historical climatological and individually observed profiles are analyzed. Climatological profiles provide a look at average conditions observed at the test site, while the individual profiles provide insight into the variability in that same region. This analysis gives the environmental scientist critical knowledge about the environmental conditions that may be observed during the actual field test (Fig. 3).

Environmental Policy Compliance

In 1969, the National Environmental Policy Act (NEPA) was the first of its kind to be adopted by any national government. Its intent is to "declare a national policy which will encourage productive and enjoyable harmony between man and his environment."[1] The act is designed to promote efforts to prevent or eliminate damage to the environment. It requires federal agencies to objectively weigh environmental concerns in their decision-making process. The Navy publication for NEPA, the *Environmental and Natural Resources Program Manual*,[2] serves as a guide for requirements, responsibilities, and policy for management of all Navy ship and shore activities, tenants, and contractors within U.S. territorial waters. Any activities that take place outside U.S. territorial waters are governed by Executive Order 12114. NSTD is governed by these and any additional guidelines to comply with NEPA.

During the early planning phase of a sea test, as noted earlier, NSTD starts the process of determining whether the test has any potential for environmental impact. This phase can commence as much as 12 to 18 months before the planned date of the test. The department uses an elimination process to make this determination. The first step is to establish whether the test falls under a categorical exclusion (CATEX), i.e., an action that has been determined not to have, under normal circumstances, individually or cumulatively, a significant impact on the environment. A list of CATEXs can be accessed at any time. The at-sea tests conducted by NSTD that involve the use of an acoustic source do not fall into any existing CATEX, since certain acoustic sources may impact certain marine life.

The next step is to determine if the test will have a significant impact

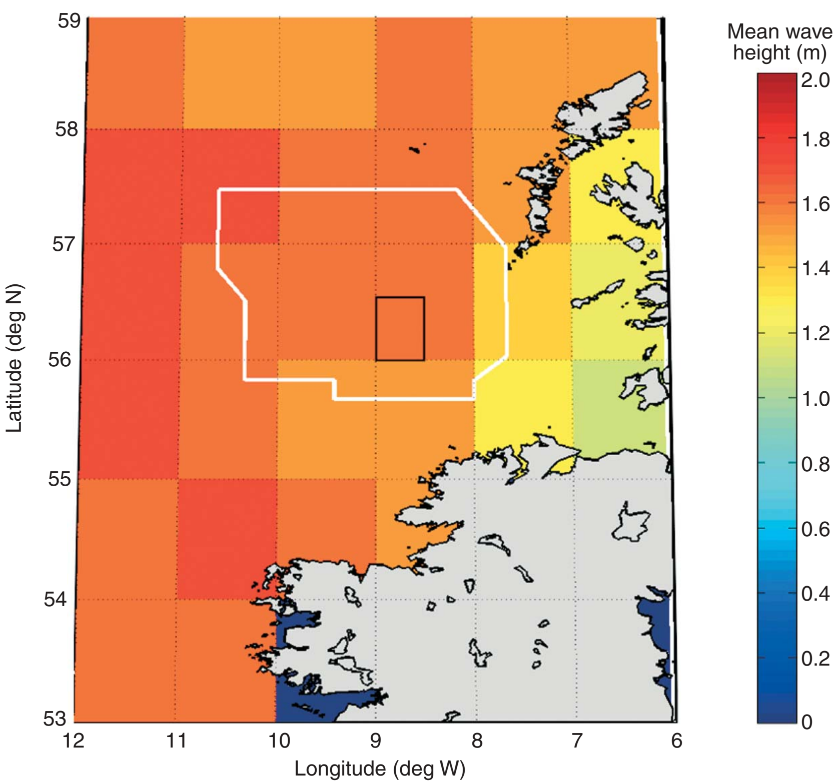

Figure 2. Mean wave heights in the Northeast Atlantic, west of Scotland, during July.

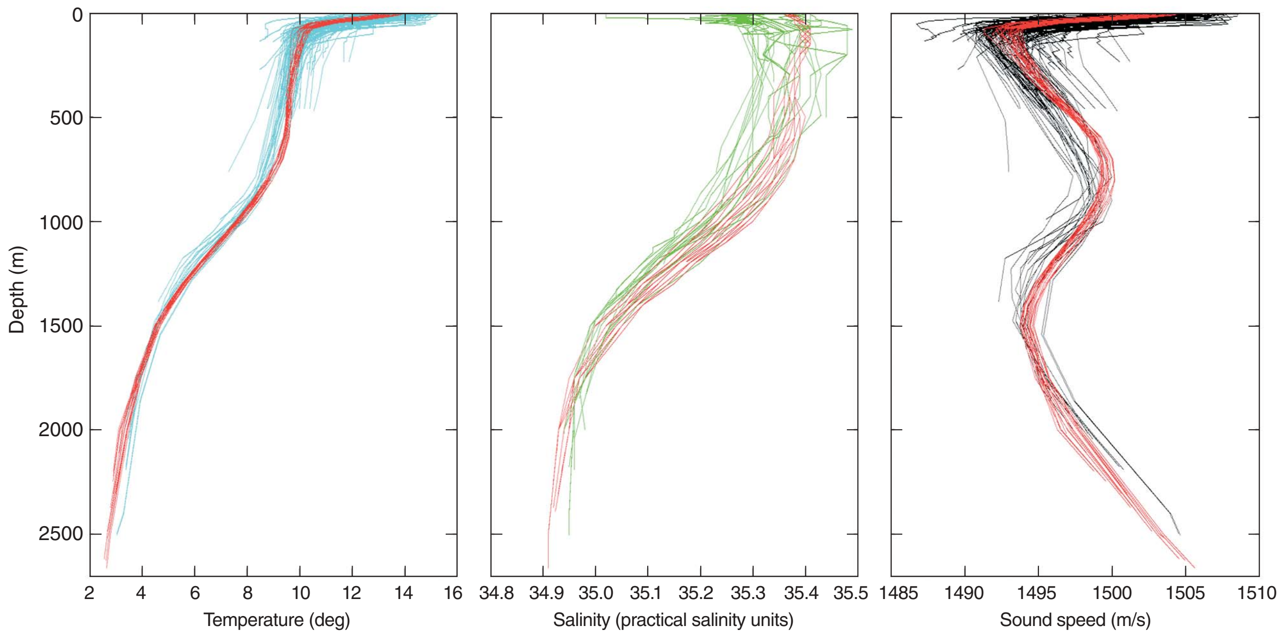

Figure 3. Climatological averaged (red) and individually observed ocean temperature, salinity, and sound speed profiles during July in the Northeast Atlantic, west of Scotland.

on the environment. NSTD uses extensive acoustic modeling transmission loss calculations to determine the range of influence of the source. Simultaneously, department staff members assemble detailed environmental information in a pre-assessment document about the test area and marine life. Information also is compiled concerning any sanctuaries or protected areas that might be affected. Great effort is made to ensure that the test in no way impacts any of these areas.

Based on the findings of the pre-assessment, a determination is made as to the potential impact of testing on the environment. If some impact is believed possible, NSTD staff meet with the Navy's Office of Environmental Readiness (CNO-N45), National Marine Fisheries Service personnel, other federal or state offices, or interested private organizations as necessary. When minimal impact is expected, an environmental assessment is prepared. This document, as defined by OPNAVINST 5090.1B,[2] provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement (EIS) or a finding of no significant impact (FONSI).

If the environmental assessment determines that the test may have a significant impact on the quality of the environment or is potentially controversial in environmental effects, then an EIS is prepared. To date, acoustic tests conducted by the department have been determined to have either minimal or no impact; no NSTD-conducted sea tests have required the preparation of an EIS.

A FONSI is a document in which the Navy briefly presents the reasons why a test will not have a significant impact on the environment. It includes a copy of the environmental assessment for reference as to the finding. If it is determined that there might be the potential for some, but not a significant, impact on the environment, the environmental assessment can propose mitigation measures, that is, actions that will reduce the severity or intensity of the impact.

Mitigation measures can vary. The primary potential impact that requires mitigation in NSTD-conducted sea tests is the effect of man-made noise on marine mammals. Acoustic sources used in field tests emit sound at different levels and frequencies, depending on the source. Marine mammals have hearing and sound-producing ability in a wide range of frequencies. They create and listen for sounds to communicate about food, danger, identity, positions, territoriality, etc. There are many sources of man-made noise in the ocean—helicopters, boats, marine dredging and construction, oil drilling, geophysical exploration—all with the potential to interfere with marine mammal sound reception.[3]

The Navy has accepted a standard set of mitigation procedures to ensure that the acoustic source used in at-sea testing does not interfere with any marine mammal communication. These measures include ramping up the source from low level to the operating level so that any marine mammals would hear the low noise first and be able to move away from the source. This ramping-up is done during daylight hours. Once the source is operating, a marine mammal observer is stationed on the ship that is towing the acoustic source. The observer informs the science staff if any of these mammals are sighted within the range of potential impact. The source is then shut down while the mammals are within range.

Other mitigation measures depend on the source level, frequency, and location of the exercise. For all tests, a log is kept for source operation and marine mammal observations as part of the test documentation. To date, NSTD has effectively used the mitigation measures and has observed no adverse effect of the acoustic source on any such mammal.

Some tests conducted by NSTD use a very low level acoustic source. Environmental pre-assessments for these tests have shown that the range of impact is as small as a 10-m radius around the source. For these tests, a record of negative decision, i.e., the test lacks the potential to significantly harm the environment, is prepared. Essentially, this record constitutes a decision not to prepare an environmental assessment or an EIS. The record of negative decision contains the pre-assessment material and presents the complete results. The original copy of this document is kept in the files of the sponsor, and a copy is retained in the NSTD Document Library.

The department will continue to conduct at-sea tests that comply with the requirements of NEPA and the Navy in support of research and development efforts directed by the Navy sponsors. In addition, NSTD will continue to interact with N45 and outside agencies as required to ensure that the latest information is used and all requirements are met.

DATA COLLECTION

At-Sea Measurements

Once a site is selected, the environmental scientist is responsible for determining the environmental measurement requirements and providing a written environmental measurements plan, which includes information on required instrumentation and materials as well as a measurements deployment schedule. Environmental data are usually collected from all participating test platforms (e.g., ships, aircraft), remote sensors, and models.

Both the scientific objectives of the test and the expected environmental conditions are examined to formulate an environmental measurements plan. The scientific objectives determine the actual type of environmental measurements; for example, acoustics tests require water column measurements of temperature and salinity to calculate sound speed. The test requirements, along with the environment, determine the frequency and spacing of environmental measurements. As noted earlier, some typical environmental parameters that are collected at sea include meteorological data such as wind speed, air temperature, and barometric pressure. Wave heights are often measured using wave buoys. Temperature and salinity data are collected using expendable bathythermographs and conductivity-temperature-depth profiling sensors.

Shore Support Measurements

The role of the shore support team is to provide brief summaries to the field test community and archive this information for post-test analysis. Providing succinct summaries requires an ability to interpret atmospheric and oceanographic data, which depends heavily on an understanding of satellite systems as well as atmospheric and oceanographic models. It is this understanding that allows the scientist to correctly forecast weather conditions to test members, helping to ensure the success of the test and the safety of those at sea.

Data from various Navy and civilian sources are also collected from a shore support team at APL. This team is responsible for collecting critical environmental data (forecasts, satellite images, etc.) for the scientists in the field and consolidating the data into comprehensive databases that are essential during the post-test analysis phase. For example, a staff member responsible for shore support often retrieves NOAA text forecasts and satellite imagery, reviews their content, sends the information in a compact form to staff at sea, and archives the data for post-test analysis. These responsibilities—forecasting weather and ocean environments and archiving data—require the environmental scientist to be familiar with many areas of Earth science.

Remote Sensors

The person responsible for shore support must have an understanding of space systems currently in operation, since so many of today's weather and ocean patterns are measured using satellites. Geostationary satellites over the United States facilitate our understanding of weather patterns. Other types of sensors aboard satellites include infrared imaging sensors which can help determine the probability of precipitation and measure ocean surface temperature, scatterometers which determine wind speed and direction, and other electromagnetic imaging sensors with which one can map both temperature and ocean chlorophyll levels.

Figure 4 is an example of scatterometer data. The plot illustrates wind speeds and direction over the Gulf of Alaska for 3 September 2002. Because wind speeds are derived from a pass of the QuikSCAT satellite, one must understand how the satellite collects the data in order to determine the data's reliability. The spacecraft sends out electromagnetic waves at wavelengths on the order of a few centimeters. The return at this wavelength from the surface waves is directly related to wind magnitude; thus, if the surface gives a strong return, the wind is thought to be high. The analyst must understand that an island or other physical mass in the water can distort these wind measurements. In the 3 September case, the swath of the satellite is not significantly affected by such disturbances.

SST maps are extremely useful in understanding the physical oceanography of a test site. Often, remote

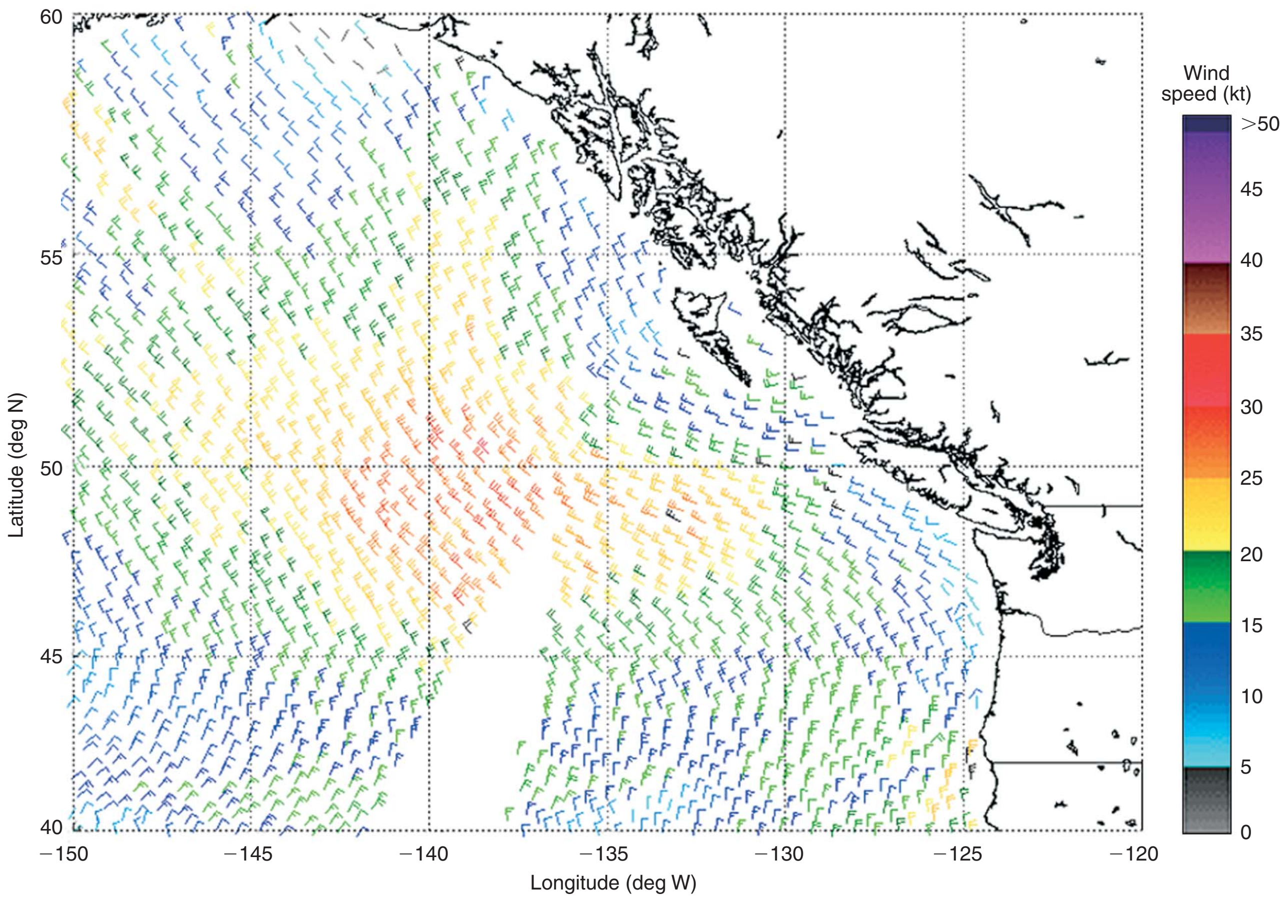

Figure 4. Wind speed and direction measurements from the NASA QuikSCAT satellite over the Gulf of Alaska on 3 September 2002. Black barbs indicate possible rain contamination. (Plot generated at NOAA/National Environmental Satellite, Data, and Information Service, Office of Research and Applications; http://orbit212.wwb.noaa.gov/quikscat.)

sensor SST maps are the best products available for real-time measurements, although *in situ* data from ships or aircraft using expendable bathythermographs are beneficial because of the additional depth component. Figure 5 is an example of an Advanced High Resolution Radiometer SST map measured from a spacecraft.

The Moderate Resolution Imaging Spectroradiometer (MODIS) satellite provides measurements of electromagnetic waves at several wavelengths, and together the data reflect SST and water clarity measurements. Examination of the MODIS data files aids the analyst in monitoring eddies in the test location.

Atmospheric and Oceanographic Modeling

The environmental specialist is also responsible for downloading and analyzing atmospheric and oceanographic models. Atmospheric modeling refers to the numerical representation of the atmosphere, where initial conditions are specified by the most recent environmental measurements. In general, an atmospheric model uses buoy, weather station, and voluntary observing ship records for model initialization. The

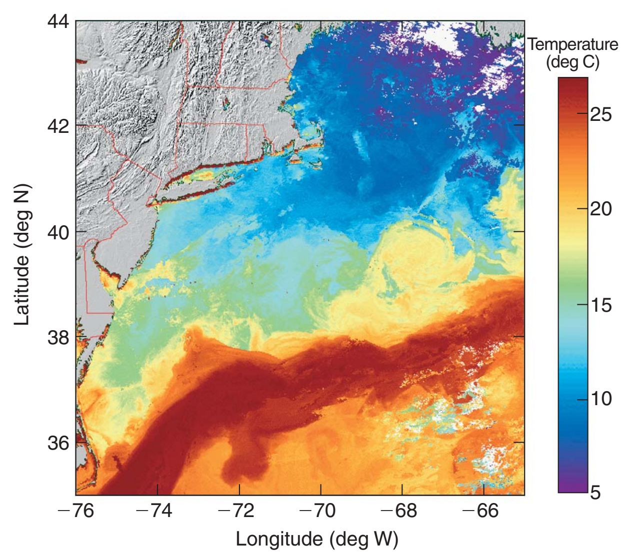

Figure 5. Average SST image for the U.S. Atlantic Coast from 16 to 18 April 2002. A field test during the month of July required the monitoring of the Gulf Stream prior to and during the test because eddies heavily influenced test location. This image, available at http://fermi.jhuapl.edu/, was generated by the Ocean Remote Sensing Group of APL.

accuracy of the forecast depends on the correctness of the model.

One model known for its accuracy in littoral areas is the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS), which consists of upper- and lower-atmosphere representations as well as ocean surface conditions such as wind and pressure. COAMPS is also used to drive regional wave models such as Wave Watch III (WW3), which is used by the Navy Fleet Numerical and Oceanography Center (FNMOC).

The environmental scientist relies heavily on these models to forecast wind speeds and wave heights in order to predict future weather conditions at the test site. Atmospheric and oceanographic models are maintained at FNMOC. FNMOC produces wind, wave, pressure, air, and ocean temperature fields for specific locations for DoD users. These products are specific to the location, data resolution, and length (hours) of forecast required. For example, a test conducted in the Gulf of Alaska in September 2002 required wind and wave forecasts to ensure the safety of those at sea. A request was made to FNMOC in the months prior to the test for COAMPS wind and WW3 wave forecasts. The atmospheric and ocean models were run in real time, and the data were retrieved via the Internet and manipulated to extract time-series forecasts for a specific latitude and longitude. Figure 6 is an example of data generated in this manner which are sent to test participants at sea in real time.

While the COAMPS and WW3 models describe ocean surface conditions that are necessary for the safety of those at sea, one must also have knowledge of conditions below the surface for the success of the test. One such model is the Modular Ocean Data Assimilation System (MODAS) developed by the Naval Research Laboratory Stennis Space Center. The MODAS model, which is maintained at the Naval Oceanographic Office, uses climatology data, and receives remotely sensed SST data, remotely sensed altimetry data, and recent *in situ* ocean temperature profile data to more accurately describe the speed of sound in the ocean at depth. MODAS files are three-dimensional fields of temperature, salinity, and/or sound speed, where the dimensions are latitude, longitude, and depth. MODAS has also been installed at APL and is often run with real-time measured data that are not available to the Naval Oceanographic Office.

POST-TEST DATA ANALYSIS

All environmental data are collected into a set of comprehensive databases, examined for quality, and reprocessed when necessary. Often, these data are analyzed after the field test to gain insight into the scientific objectives of the test. For example, the ocean sound speed profiles are analyzed to determine the geographical and temporal variability observed during the test and how that variability affected the scientific objectives of the exercise.

Once the comprehensive environmental databases have been prepared, the data are distributed to the test science team on CD-ROM for use in their analyses.

CONCLUSION

The responsibility of the environmental specialist team is to identify factors that may impact the feasibility and success of a field test as well as those components of the environment that may be affected during the conduct of the test. Pre-test environmental characterization, data collection during the test, and post-test data analyses are all vital to the success of the field tests conducted by NSTD. These successes result from the combined efforts of environmental test team personnel and their interactions with the test planning and science teams.

LAT/LON: 53/-143

FCST TIME	WIND (KT)	DIR (DEG)
03Sep2002.12Z	19.78	310
04Sep2002.00Z	21.33	317
04Sep2002.12Z	16.33	348
05Sep2002.00Z	11.56	347
05Sep2002.12Z	10.67	314

LAT/LON: 54/-144

FCST TIME	WIND (KT)	DIR (DEG)
03Sep2002.12Z	20	309
04Sep2002.00Z	19	323
04Sep2002.12Z	13	342
05Sep2002.00Z	9	328
05Sep2002.12Z	8	298

LAT/LON: 55/-145

FCST TIME	WIND (KT)	DIR (DEG)
03Sep2002.12Z	20.22	301
04Sep2002.00Z	17.67	328
04Sep2002.12Z	10.67	336
05Sep2002.00Z	7	304
05Sep2002.12Z	7.667	254

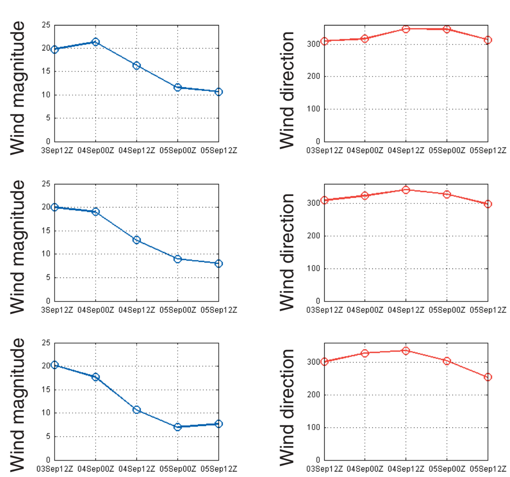

Figure 6. COAMPS wind speed (kt) and direction (deg) predictions for the Gulf of Alaska. The model was run on 3 September 2002 and forecasted 48 h in the future. The forecast plots were produced using custom code. Data were generated by FNMOC.

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