CHAPTER 8

OCEANOGRAPHIC PRODUCTS AND TACTICAL DECISION AIDS

In the past 10 to 15 years an ever-increasing emphasis has been applied to the study of the oceans (both surface and subsurface). This increased emphasis on oceanography has provided on-scene commanders with tailored oceanographic computer products that help ensure successful evolutions at sea.

In this chapter, we will discuss various computer-generated oceanographic products that benefit the planning and execution of successful underway operations. Although this chapter only deals with TESS 3 products, benefit may also be realized with the products found in the *Navy Oceanographic Data Distribution System* (NODDS) *Products Manual*, the *Naval Integrated Tactical Environmental Sub-System* (NITES), the *National Oceanography Data Distribution exchange System* (NODDES), and the *Joint Maritime Combat Information System* (JMCIS). The applications, limitations, assumptions, and functional descriptions of various aids to the forecaster will be covered. For more detailed information, refer to the respective *Tactical Environmental Support System (TESS (3)) and Shipboard Meteorological and Oceanographic Observing System (SMOOS) Operator's Manuals,* NAVMETOCCOM instructions, and special publications. Now let's begin our discussion of the computer-generated aids.

TIDAL PREDICTION (TIDE)

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the tidal prediction product. Interpret the 24-hour tide station prediction and the tides geographic display.

The TIDE module uses location-specific tide data in combination with astronomical and bathymetric effects to yield quick reliable predictions. The tidal height may be forecast at any location for which observed tide data are available. These locations are provided in the tide data base. The tabular and graphic output of the module depict tidal height versus time at individual locations, as well as tidal heights at a given time for several locations.

APPLICATION

A knowledge of tides is important to safe navigation and naval warfare applications. The tides interact with surf conditions and storm surge. These near-shore phenomena in turn may heavily impact coastal and amphibious operations. Because the TIDE module provides a versatile method of rapidly forecasting tides, commensurate with the computer technology used for on-scene environmental prediction, it is a useful means of assessing tidal effects on pertinent operations.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the TIDE program areas follows:

- Spatial variations in tidal heights may be depicted for 4°, 2°, 1°, 0.5°, and 0.2° squares only.
- Tidal heights may only be forecast at locations for which observed tide data are available (that is, tide stations provided by the data base).
- Tidal currents are not predicted by this model.
- The impact of storm surge and surf conditions is not addressed by this model.
- The times of tidal extremes (high/low) are predicted to the nearest 6 minutes (min).
- Tidal stations previously saved to the "TIDAL STATION SELECTION" input screen will be erased when new tidal stations are saved at a later time.
- Only 15 tidal stations can be retrieved atone time in the area size selected. If more than 15 are retrieved, the user must choose a different area size or move the location slightly.

FUNCTIONAL DESCRIPTION

The TIDE module can generate tidal height forecasts at numerous locations on a worldwide basis.

Table 8-1 shows an example output of a 24-hour time/height graph. It is displayed if the prediction length is 1 day and a tabular output is selected Figure 8-1 shows an example output of a geographic display. An X placed in the column labeled “GEOGRAPHIC” on the “TIDAL STATION SELECTION” input screen sends the user directly to the Tides Geographic Display.

NAVAL SEARCH AND RESCUE (NAVSAR)

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the NAVSAR product. Interpret the three NAVSAR outputs.

The NAVSAR program provides search assistance with two main functions:

1. Search Object Probability of Location Map
2. Recommended Search Plan

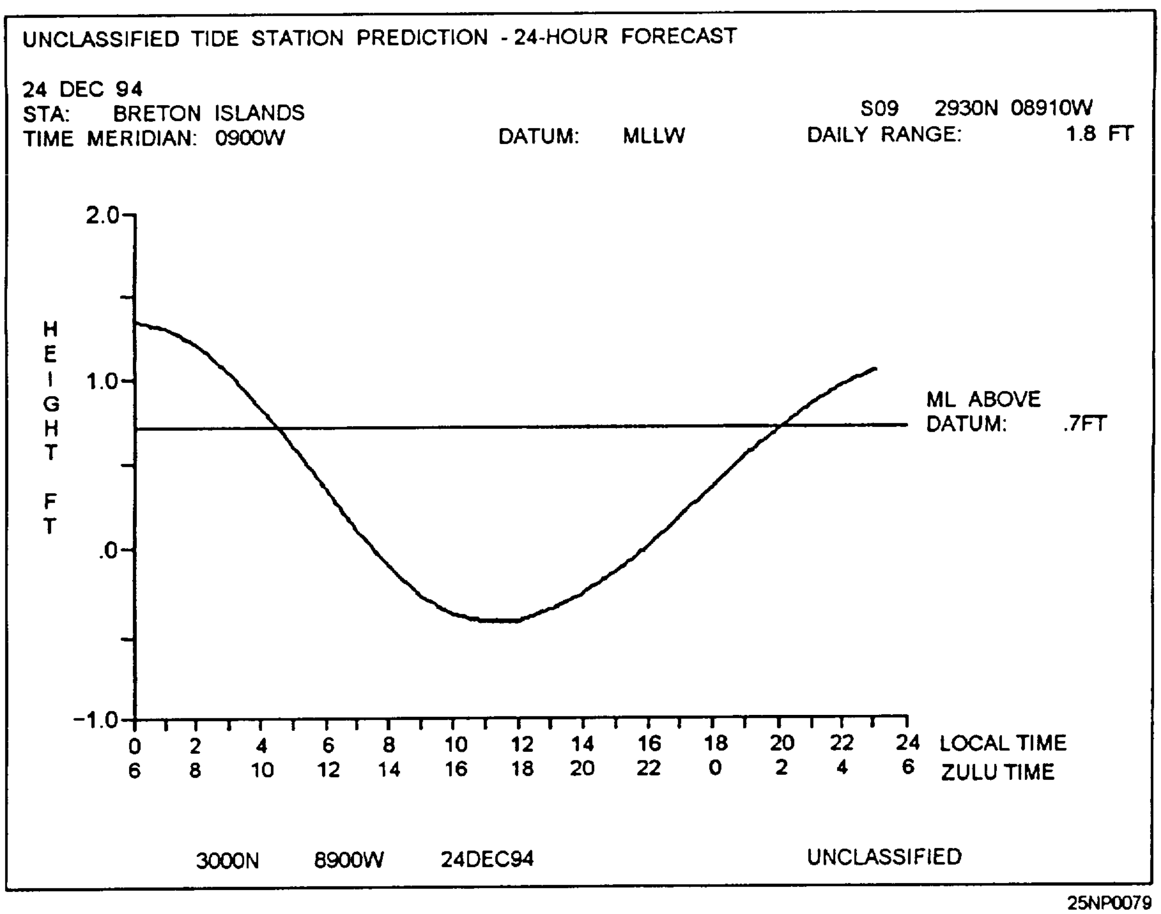
Both functions use environmental data to compute the search object's drift from distress time to determine the area of the search where the object maybe found. Function (1) divides the area into several cell areas of equal size, and ranks them according to probability y of search object containment. The second function provides a search plan by determining either the search asset on-station durations or the probability of search success or search effort for cell areas.

NAVSAR auxiliary functions include organizing and storing environmental and search object scenario data on a status board, and computing immersion survival time.

APPLICATION

NAVSAR provides information and planning assistance to the search mission coordinator (SMC) during search and rescue incidents at sea. NAVSAR is designed to assist the SMC in deciding where to search for a target, how many assets to commit to a search, and how to assign those assets to maximize their effectiveness.

Table 8-1.-Example Output of a 24-hour Tide Time/Height Graph



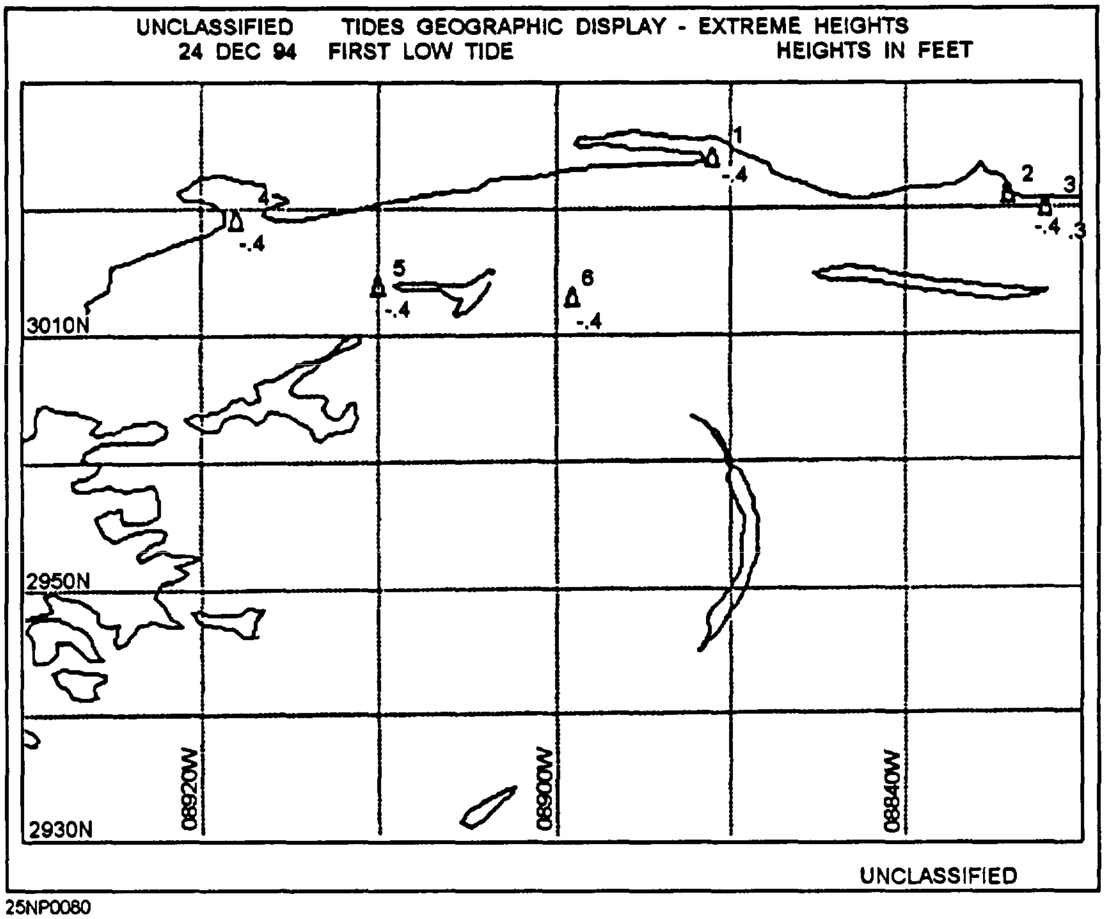


Figure 8-1.-Example output of the Tides Geographic Display.

NAVSAR uses the search object's description its last known location, and environmental data to estimate the search object location at the time of the search. Using search asset information provided by the SMC, the program will provide search recommendations in terms of rectangular areas in which to search.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the NAVSAR program areas follows:

- There are three search object location scenarios to define the search object's location prior to distress time. These are Last Known Position, Trackline, and Area of Uncertainty. The operator can select up to five plans of action to enter on the status board, but only one can be a Trackline scenario.

- There are two processing modes used by NAVSAR that result in different output formats for the recommended search plan. The first processing mode is referred to as level I. The level I mode occurs when the only object location scenario is the Last Known Position scenario. The recommended search is evenly distributed over the entire area, All other location scenarios and combinations of scenarios invoke the level II mode. The recommended search plan will contain a search effort density map. Search effort concentration is given as swept areas.

- A level I recommended search plan can be added to the status board. A level II recommended search plan cannot be added to the status board, but can be entered manually as a search plan via the search plan data.

- The operator selects the type of object to be searched from a predefine list.

- A search object trackline is described by up to four leg segments defined as either all great-circle or rhumb lines.

- Each search object location scenario must have a confidence value entered by the user. The total confidence values for all scenarios must add up to 100 percent. When revising the status board, the operator enters anew search object location scenario, and at least one of the previous location scenario confidence entries must be changed so that the total confidence for all scenarios is once again 100 percent.

- Up to eight weather and sea-current observations can be entered into NAVSAR. Sea-current observations that do not include the wind current need wind-speed and -direction observations prior to the time of the sea-current observation. Ideally, wind-speed and -direction observations representing conditions 48 hours before the sea-current observation should be entered. If there are no sea- or wind-current observations, sources of sea-current data consists of Fleet Numerical Meteorological and Oceanographic Center (FNMOC) monthly current charts and the Naval Oceanographic Office (NAVOCEANO) surface-current atlases.

- A maximum of five search assets can be entered on the status board for a particular search.

- Up to five search object probability maps can be requested for display in sequence.

- A maximum of five search plans can be added to the status board.

- NAVSAR computes the sweep widths for both visual and electronic search sensor types. For any other sensor types, the user must provide the sweep width.

- The searching altitude to enter for aircraft is the flight altitude; for ships, it is the bridge height or the height of the sensor.

- Search object location maps can only be produced after the earliest distress scenario date-time group (DTG).

FUNCTIONAL DESCRIPTION

NAVSAR can be subdivided into three main functions:

1. The status board maintenance function performs the data base management.

2. The map generation function purpose is to produce probability maps for the search object at user-entered times based on the data available in the current status board.

3. The search planning function is to provide search plan recommendations that allow the most effective use of the available search assets.

Table 8-2 shows an example output of the View Status Board. This is an organized table of the search object description, location scenario's ejection

Table 8-2.-Example Output of the NAVSAR View Status Board

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UNCLASSIFIED  NAVSAR  STATUS  BOARD

SEARCH  OBJECT  TYPE  IS:
BOAT 30-60 FT

SEARCH  OBJECT  LOCATION  DESCRIPTION:

        # 1 LAST KNOWN POSITION NAV AID:    NAVSAT
              DTG         CONF        CEN LAT       CEN LNG
           1807940800      90.%        6700N         0500W

SEA  CURRENT  INFORMATION
    DTG             CURRENT TO           CURRENT  SPEED          INCLUDES  WIND  CURRENT
1707940800           70. DEG                 3.0 KT                    Y
1907940800           70. DEG                 3.0 KT                    Y

WEATHER  INFORMATION
    DTG             WIND FROM        WIND SPEED       VIS        CLOUD        MIXED LAYER
1707940800           90. DEG            10 KT        7 NMI        50%            100 FT
1907940800           90. DEG            10 KT        7 NMI        50%            100 FT

SEARCH  ASSET  INFORMATION
NAME  SPEED  SENSOR  V  =VISUALE  =FF  BEACON  0####  =SWEEP  WIDTH
IN NMI

                SAR  EFFORT  0800Z  19  JUL  94                UNCLASSIFIED
```

information, sea-current data, weather observations, search asset data, and search plan information.

Figure 8-2 shows an example output of the search location density map. The output shows numbered cells that represent relative probabilities of the search object being located within the cell.

Table 8-3 shows an example output of a search recommendation, level I. This is a tabular display describing a recommended rectangular search area. The available assets are listed with their on-station duration and area of coverage. Also shown is the position of the search and the cumulative detection probability of previous searches.

RAYTRACE (RAY)

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the RAY program, Interpret the RAY program output.

The RAY program may be used to understand how sound propagates through a specific environment by tracing and displaying the paths of individual sound rays. The rays to be traced maybe specified by the user or selected by the module.

APPLICATION

The RAY program graphically displays the interaction between the environment and the sound energy propagating through it. Its function is to display regions of a water column for a given set of environmental parameters (that is, sound speed profile and bottom topography [insonify regions]). Likewise, it can be used to easily display those regions of the water column that are not insonified due to shadow zones and bathymetric blockage. The RAY program serves as a modifier of flat bottom omnidirectional propagation-loss output by depicting the ranges/bearings from the source location where bottom effects may impact the propagation-loss curve. For a skilled interpreter, a finely detailed ray diagram can also point out possible locations for convergence zones (CZs) and shadow zones.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the RAY program areas follows:

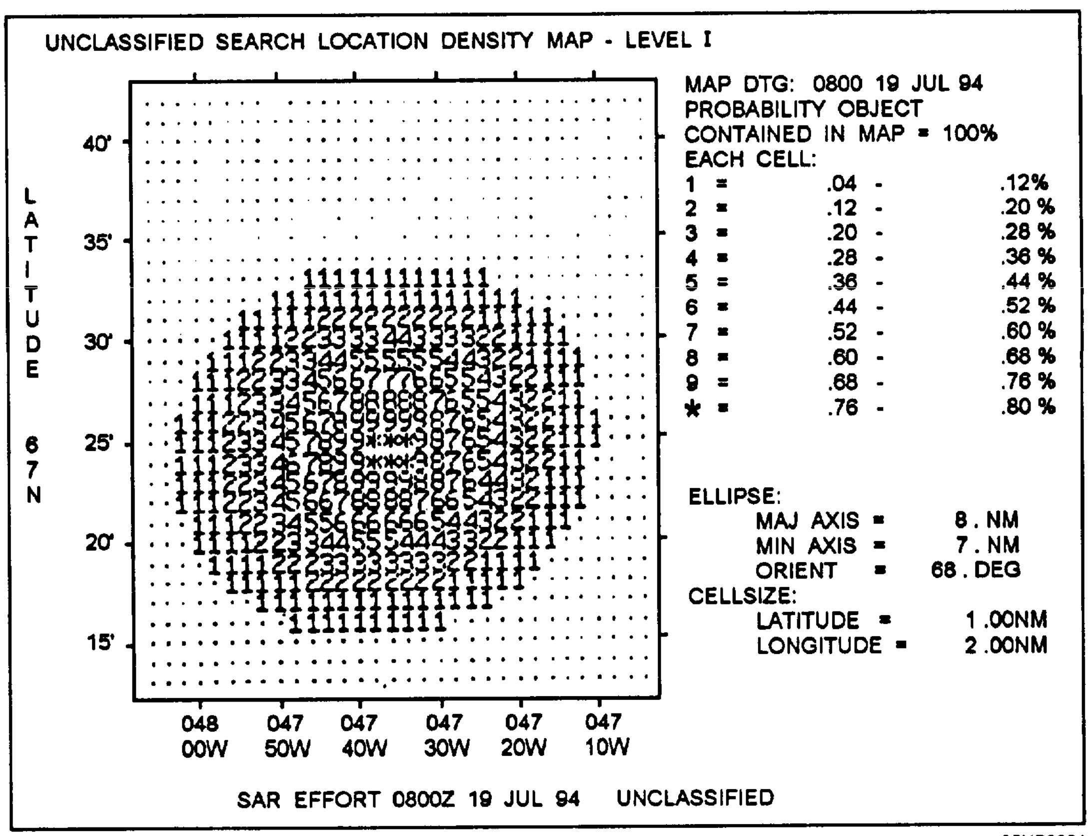

Figure 8-2.-Example output of a search location density map.

Table 8-3.-Example Output of a Search Recommendation - Level I

UNCLASSIFIED

SEARCH RECOMMENDATION - LEVEL I

SEARCH TIME: 1907940800

PROB OF SUCCESS: 100.%
CUM DETECTION PROB: 100.%
SEARCH AREA RECTANGLE:

CENTER LATITUDE:	6725N	CENTER LONGITUDE:	04736W
LENGTH:	42.NMI	WIDTH:	37.NMI
ORIENTATION:	68.DEG	TOTAL AREA:	1563.SQ-NMI

SEARCH ASSET INFORMATION AND RECOMMENDATION

ASSET NAME	SPEED (KT)	ALTITUDE (FEET)	SENSOR	ON STA (HHMM)	AREA (%)	COVERED (SQ-NMI)
P3	200.	1000.	v	0500	100.	1563.

SAR EFFORT 0800Z 19 JUL 94 UNCLASSIFIED

- The RAY program uses a single sound speed profile, generated by the Sound Speed Profile (SSP) program. Thus, sound speeds used-in this program are a function of depth, but not range.

- In output displays, horizontal and vertical plotting scales are often different, resulting in an apparent difference between the angle of incidence and the angle of reflection with respect to a locally sloping bottom.

- A positive ray is downgoing; a negative ray is upgoing.

- If the source is located at the surface (that is, source depth of zero), the operator should not select any negative (upgoing) rays.

- The module traces only outgoing rays. If the angle of reflection from a sloping bottom is <–89.9°, then the ray is terminated.

- Computed ray diagrams are very sensitive to the user's selection of launch angles and source depth, as well as bathymetry and sound speed,

- The RAY program uses the sound speed profile to calculate ray paths. If variable bottom depths, either automatically retrieved or manually supplied, exceed the deepest depth of that sound speed profile, the Raytrace module extrapolates the sound speed profile to the deepest variable bottom depth provided

- Because of computational limitations a 0° ray cannot be traced Whenever a 0° ray is requested or expected on the output diagram, a +0.01° ray and a -0.01° ray will be traced.

- Because temperature and salinity are relatively stable below 2500 m, sound speed profiles reaching 2500 m are accurately extrapolated. Extrapolations of sound speed profiles that do not extend to 2500 m, however, are suspect. Computed ray paths that descend to depths where extrapolated sound speeds are suspect should be used with caution.

FUNCTIONAL DESCRIPTION

The principle means of detection used in antisubmarine warfare (ASW) employs acoustic energy, Water, a poor medium for the transmission of electromagnetic (EM) energy, is an excellent conductor of acoustic energy or sound. Sound is a wave phenomenon, consisting of alternate compression and refraction of the medium. The speed of sound, or speed at which the acoustic waves advance through the medium, depend on certain characteristics of the medium. Properties of seawater that affect sound speed are salinity, temperature, and pressure. Output from this program is classified and should be labeled as required.

PASSIVE ACOUSTIC PROPAGATION LOSS (PPL)

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the PPL program. Interpret PPL outputs.

The PPL program calculates transmission loss as a function of range, frequency, source depth, and receiver depth. The calculations from this program will be used in the prediction of ASW sensor systems performance. The purpose of this program is to define the acoustic propagation conditions within the ocean area of interest. It is intended as an interface between environmental data read from the ocean environmental file (OEF) and operational data. The program will translate information about existing oceanographic conditions into an assessment of PPL versus range that is necessary for sensor system performance predictions.

APPLICATION

The PPL program computes the loss of sound intensity in traveling from the selected source (for example, submarine) to the receiver (for example, passive sonobuoy) for ranges (kyd) out to the maximum range specified. The operator-selectable input is the desired frequencies, source and receiver depths, and maximum range. The propagation-loss curve aids the operator in computing detection ranges and possible detection paths.

The range should be chosen to include the first CZ. A typical maximum range value varies from 60 to 100 kyd.

When the propagation-loss curve is displayed on the monitor, the operator can see the transmission loss associated with each range. In general, the propagation loss increases with range but may decrease rapidly (spike) when environmental conditions allow formation of CZs. If the operator knows the figure of merit (FOM), in decibels (dB), detection ranges can be determined instantly by looking at the display. At any range point where the FOM is greater than the propagation loss, the probability of detection (POD) is at least 50 percent.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the PPL program are as follows:

- The PPL program incorporates low-frequency bottom-loss (LFBL) data base processes, assumptions, and correction factors. Viability of output depends upon the degree of difference between the model and actual seabed conditions.
- System correction factors are preset to define an omnidirectional/vertical-line array DIFAR (VLAD) sonobuoy.
- Maximum range should include the first CZ.
- Horizontal homogeneity y is assumed. Therefore, the output should be used with caution in areas of high variability (for example, fronts and eddies).
- The SSP program must be used to create the environmental data set used by RAYMODE. The SSP program stores a sound speed profile, bottom depth, high- and low-frequency bottom-type information, wind speed, and so on, in the OEF.
- Propagation-loss curves may be generated for target frequencies in the range of 1 to 35,000 Hz. Due to the limitations of the LFBL data base, reliable output is constrained to frequencies >30 Hz.

FUNCTIONAL DESCRIPTION

The RAYMODE propagation-loss model was developed at the Naval Underwater Systems Center, New London, Corm. The original version of this model has been updated to incorporate factors for determining bottom-loss and system correction factors. This model considers the ocean bottom as a varying sound receptor and not simply a reflector. Computation of losses in the bottom sediment are a feature of PPL that treats the bottom of the ocean as a continuation of the water column, and computes the contribution of the bottom sediment to propagation loss, considering refracted paths through the sediment and reflections at the basement.

Locations beyond the coverage of the LFBL data base use the COLOSSUS data base model to estimate propagation loss. Output from this program is classified and should be labeled as required.

NEAR-SURFACE OCEAN THERMAL STRUCTURE (NOTS)

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the NOTS program. Interpret NOTS program outputs.

The NOTS program is used to forecast changes in the upper ocean thermal structure due to mixing by surface winds, heating and cooling by surface heat, precipitation, and evaporation. Program output consists of profiles of temperature with respect to depth at operator-specified forecast intervals; forecast profiles may be run through the SSP program and then routed to the OEF for use in various oceanographic and acoustic programs.

APPLICATION

The NOTS program uses initial temperature profiles and observed or forecasted surface meteorological data to predict changes in the upper ocean thermal structure with respect to time. The forecast NOTS temperature profiles can be input to SSP and then used by the RAY, PPL, and Sensor Performance Prediction (SPP) programs to predict acoustic propagation conditions and to predict environmental effects on fleet ASW sensors and operations.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the NOTS program areas follows:

- This program operates under the assumption that oceanic conditions are horizontally homogeneous. (Horizontal changes in the ocean thermal structure are not considered.) This program should not be used in the vicinity of strong currents, ocean fronts, or eddies.
- Since the quality of meteorological forecasts can degrade significantly with respect to time, NOTS forecasts more than 24 hours long should be used with caution.
- The operator should use caution when specifying cloud cover and precipitation rate information for a given forecast time. The program linearly interpolates these values for model forecast times between the meteorological forecast times.
- This program should not be used for locations over the continental shelf; neither should it be used near regions of significant river runoff.

FUNCTIONAL DESCRIPTION

The NOTS model is used to forecast changes in the upper ocean density structure due to mixing by surface winds, heating and cooling by surface heat fluxes, and evaporation and precipitation. Input to the model consists of date, time, and position information; initial temperature and salinity profiles; turbidity information; and forecasts (or observations) of surface meteorological conditions such as wind speed, wind direction, air temperature, humidity, atmospheric pressure, cloud cover, and precipitation rate. The date, time, and position information, as well as the initial temperature salinity profiles, are retrieved for the operator-selected data set in the OEF. The surface meteorological data are entered by the operator by way of the keyboard. Optical water-type (turbidity) information for location of interest is retrieved from the permanent data base (PDB) file.

Performing an upper ocean thermal structure forecast involves three processing steps:

1. Initializing the model
2. Calculating surface fluxes
3. Using the model to calculate the effects

Output from the NOTS program consists of forecast profiles of temperature with respect to depth for operator-selected forecast times. These profiles are routed to the NOTS forecast file. Operator-selected forecast profiles are displayed, both in tabular and graphical formats. Output from this program is classified and should be labeled as required.

SOUND SPEED PROFILE (SSP) GENERATOR MODULE

LEARNING OBJECTIVES: Identify applications, limitations, and assumptions of the SSP program. Interpret SSP module outputs.

The SSP generator module computes a sound speed profile by applying Wilson's equation for ocean sound speed to a merged depth/temperature/salinity profile. This creates a sound speed profile that represents local oceanic conditions. The output generated by the SSP generator module is a sound speed vs. depth profile from the sea surface to the ocean bottom, which is essential in making accurate sensor range predictions.

APPLICATION

The SSP module yields tactically useful information when a basic knowledge of underwater acoustics is applied to the products. This information can be used to make decisions regarding sensor depth settings, optimum frequency bands for search, and buoy pattern. By examining the sound speed profile and other module output, the experienced ASW technician can learn a great deal about available acoustic transmission paths and sensor performance.

The optimum frequency for detection in the sonic layer may be determined from the sonic layer cutoff frequency calculated by SSP. The presence, quality, and accessibility of a sound channel to available sensors can be identified from the generated sound speed profile.

CZs may exist where the sound speed at the bottom exceeds the sound speed at the source depth, providing there is an experienced analyst with a means to estimate CZ range and width from the shape of the sound speed profile.

LIMITATIONS AND ASSUMPTIONS

The restrictions as well as the principles taken for granted in using the SSP product areas follows:

- SSP allows the operator to review and correct manual input. This prevents aborting runs due to operator-input errors.

- In deep-water areas, on-scene bathythermograph (BT) data that do not extend below 200 m should be used with caution.

- Where no historical profile data are available, operator entry of surface-to-bottom depth/ temperature/salinity sound speed values is required.

FUNCTIONAL DESCRIPTION

The SSP module provides the operator with a sound speed profile that is representative of local oceanic conditions. This module also provides a link between environmental variability and sonar performance. An on-scene BT and a historical depth/temperature/salinity profile are used to compute the sound speed profile and related data.

The SSP merging routine combines BT data with a historical profile to form a surface-to-bottom temperature/salinity profile. The resulting merged profile consists of the BT data in the upper portion and the historical profile, modified by the merge, in the lower portion. The lower portion extends from the first depth value below the available BT data to the bottom depth. Output from this program is classified and should be labeled as required.

The first portion of this chapter was devoted to computer aids generated by the TESS 3 configuration. Now let's look at the BT collective product.

BATHYTHERMOGRAPH COLLECTIVE PRODUCT

LEARNING OBJECTIVES Identify applications, limitations, and assumptions of the bathythermograph collective product.

FLENUMMETOCCEN is capable of providing synoptic (real-time) and historical bathythermograph (BATHY) observation collectives for a specified area and timeframe. Pre-1985 BATHYs are stored in the Master Oceanographic Observation Data Set (MOODS) with over 4.6 million observations. More recent BATHYs, which have not yet been added to the MOODS data base are stored in a separate archive in a format called 4D. The last 12 hours of BATHYs are stored on the operational computers. Output from this program is classified and should be labeled as required.

APPLICATION

The BATHY collective product provides a convenient means for an activity or unit to retrieve historical data and/or receive synoptic data for a specific area/time period. The product can be used for onboard prediction systems or for exercise planning/ reconstruction.

LIMITATIONS AND ASSUMPTIONS

The synoptic BATHY collective is a simple and easily transmittable product that provides detailed temperature/depth data.

The synoptic or real-time BATHY collectives are transmitted in the raw JJXX format, not passing through quality control procedures as do those that are extracted from the historical data base.

Now let's look at the Mad Operational Effectiveness (MOE) charts, which are discussed in more detail in *Environmental Effects on Weapons Systems and Naval Warfare (U),* (S)RP1.

MAD OPERATIONAL EFFECTIVENESS (MOE) CHARTS

LEARNING OBJECTIVES: Explain the purpose of MOE charts. Describe the method used to obtain MOE charts.

MOE charts are prepared for selected areas throughout the world, and they display predicted environmental magnetic noise levels.

MOE charts are available through the *DMA Catalog of Maps, Charts, and Related Products, Part 2 - Hydrographic Products.* NAVOCEANO RP 28, *MAD Tactical Use of MOE Charts,* is also available from Defense Mapping Agency (DMA) distribution centers.

SUMMARY

In this chapter, we have discussed applications, limitations, assumptions, and functional descriptions of just a few of many computer and climatological products available to aid the Aerographer's Mate in the analysis and forecasting of oceanographic conditions, thus ensuring optimum support of operations at sea.