

# Environment in a (High-Tech) Box

## Navy Model Simulates Undersea Sound Fields & Marine Mammal Locations to Plan Training & Testing Activities

**IN COMPLIANCE WITH** environmental regulations, the Navy strives to protect the ocean environment as its personnel train and conduct testing in support of its national security mission. To accomplish this, Navy personnel work closely with the National Marine Fisheries Service (NMFS) and other government agencies responsible for wildlife and habitat conservation to conduct environmental planning. (For more insights, see our article entitled “Navy Moves Forward on Compliance Strategy for Training & Testing at Sea: The Latest on Phase I & II Environmental Planning Efforts” on page 44 of this issue of *Currents*.)

As part of the environmental planning process, the Navy and regulatory agencies require scientifically relevant information about the locations of marine mammals at sea and the likelihood of the animals being affected by manmade underwater sound sources. Because marine mammals are difficult to detect in real time and have varied behaviors based on species, geographic location and time of year, the Navy and NMFS depend on mathematical modeling to estimate the number of marine mammals that may be affected by specific training and testing activities.

The Navy has been modeling acoustic effects on marine mammals since 1997, using acoustic propagation models merged with other methods of estimating marine mammal locations within the water column. In simple terms, an effects analysis is the result of merging a three-dimensional (3-D) acoustic sound field with a 3-D profile of diving animals to estimate sound exposures on animals from individual sound sources. The model input shows energy accumulated by the marine mammals compared to a predefined threshold.

Over the years, the effects analysis process has evolved to more accurately represent animal placement. A NMFS Center for Independent Experts review of the various approaches to Navy effects analysis suggested refinements that led to the current effects analysis version, known as the Navy Acoustic Effects Model (NAEMO).

NAEMO is a single model now being used to analyze the effects of proposed Navy actions on marine mammals. The model has standardized input parameters (e.g., environments, animal density, source parameters) and more closely reflects marine mammal placement within the water column.

### NAEMO: A Technical Look

The NAEMO model is comprised of five basic components: 1) Scenario Builder, 2) Environment Builder, 3) Acoustic Builder, 4) Marine Mammal Distribution, and 5) Scenario Simulator.

#### 1. Scenario Builder module

A graphic user interface (GUI)-based tool that defines where an operation is taking place, the time of the action, what is occurring and what units are participating. Once a platform is chosen to be included in a scenario, all the sound sources typically associated with it are displayed. This provides standardization and repeatability in the process of entering data. Platforms can be moved through the operating area in either a defined track or random simulation.

#### 2. Environment Builder module

A user interface that extracts all of the oceanographic environmental data required for a scenario simulation. Based on the geographic area, information on bathymetry, average sound velocity profiles, wind speeds and bottom properties are extracted from an array of points across the region, using Oceanographic and Atmospheric Master Library (OAML) databases.



Members of NUWC Newport's MSMT gather data to run analyses for various training and testing scenarios.

### 3. Acoustic Builder module

A GUI for generating acoustic propagation analysis data. This module reads the scenario file, defines analysis points for propagation software, and exports the results. The propagation models utilized are Comprehensive Acoustic Simulation System/Gaussian Ray Bundle (CASS/GRAB), Range-dependent Acoustic Model (RAM), and Reflection and Refraction Multi-Layered Ocean/Ocean Bottoms with Shear Wave Effects (REFMS), depending on the specific application.

### 4. Marine Mammal Distribution module

Creates a GUI 3-D field of marine mammals, by species and by season (when available) for the specific geographic region.

### 5. Scenario Simulator module

Combines module numbers three and four above to execute a simulation to determine the maximum sound pressure level received by each marine mammal in the exposed area. This module incorporates the scenario, sound propagation data and marine mammal distribution data, ultimately providing raw data output for each simulation. The majority of Navy scenarios are four to 12 hour segments. Some scenarios are broken down by platform (e.g., ship, submarine, helicopter, other source), while others involve multiple platforms. Scenarios can be evaluated in multiple locations within a single range complex. Computation of estimated exposures is based upon the entire scenario, which may include several weeks of daily training operations. Once the simulation is completed, exposures of marine mammals are calculated by species. This allows users to introduce changes to the harassment criteria or sound sources within a scenario without having to re-run the entire simulation.

The Post Processor provides a means to look at the output from a simulation or series of simulations. Data are presented

in a series of tables and graphs. Raw output from NAEMO is written to a text file. Output from multiple simulations can be combined, and data from individual sound sources can be added or subtracted from the exposure calculations.

Naval Undersea Warfare Center (NUWC) Division Newport is overseeing development, upgrades and maintenance of the Navy's single model. NUWC has put together a Marine Species Modeling Team (MSMT) that consists of approximately 25 biologists, engineers and modelers who collaborate to develop the software codes, input data and produce the exposure estimates. There are twenty desktop workstations being utilized for the modeling. Sixteen of those systems have two quad core Central Processing Units (CPU) containing 24 gigabytes of memory. The other four have dual core CPUs with 12 gigabytes. Over 6,000 simulations will be run, requiring 50,000 CPU hours. So far, more than 55,000 propagation runs have been made for proposed Navy training and testing activities, generating four terabytes of data. The initial round of modeling covering Atlantic and Eastern Pacific operating areas will be completed in the spring of 2011, with additional geographic areas to be addressed afterwards.

By mid-2011, a version of the Navy's single model should be available for use by organizations doing Navy-specific work. Thereafter, NUWC, the Chief of Naval Operations Energy and Environmental Readiness Division and the Office of Naval Research plan to release an additional version for general unclassified use. 

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