

Effect of Temporal and Spatial Environmental Variability on Littoral ASW Search Tactics

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LONG-TERM GOAL

My long-term goal is to better understand the temporal and spatial impact of oceanographic and meteorological dynamics on Navy sensors, systems, and operations. The current world political situation has resulted in increased emphasis on naval operations in littoral (usually shallow water) regions. However, current ASW sensor/system prediction systems and tactics are still heavily biased toward relatively homogeneous, deep-water areas where sea-bottom properties and temporal variability are not dominant factors. There is a requirement to improve shallow-water operations, including better search planning and tactics development in range and azimuth dependent environments, especially when weather variations and currents mitigate against a “frozen ocean” assumption.

OBJECTIVES

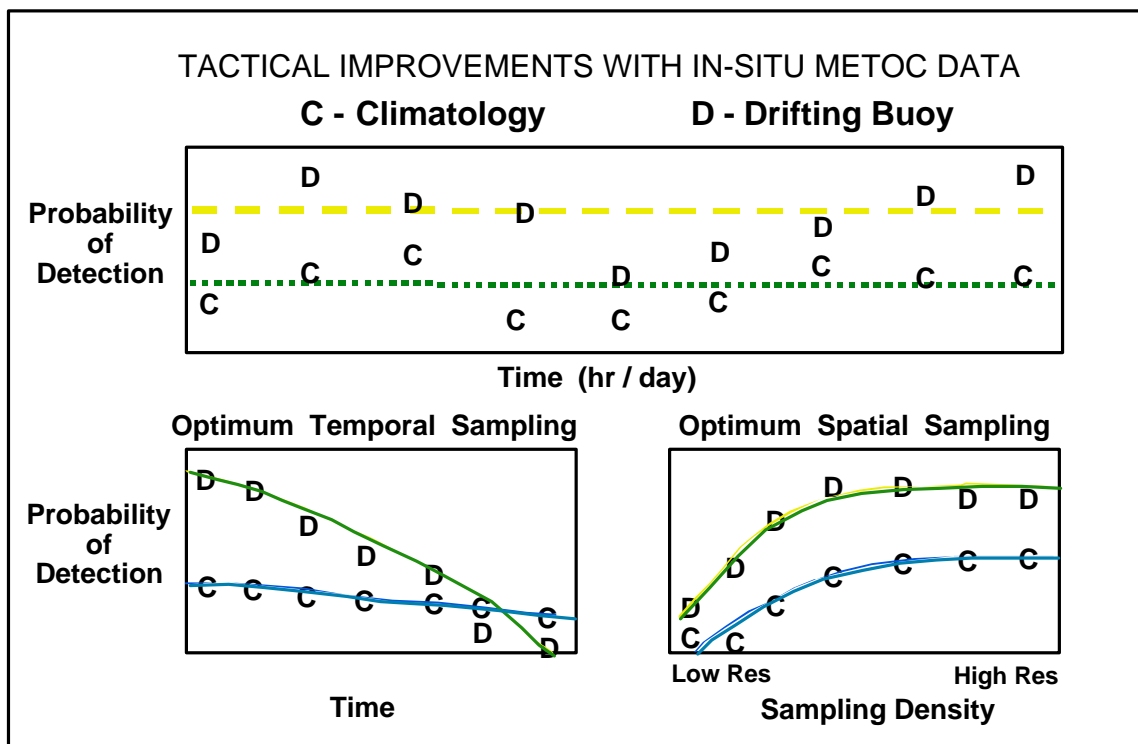
The objective of my FY98 effort was to examine the sensitivity of acoustic processes and sensor performance in the littoral zone to temporal environmental variations. A key question to be addressed is “How much better is a tactic based on nowcast sound speed profile (SSP) data using in-situ measurements (e.g., drifting buoy thermistor data) compared to archival GDEM data (climatology)?” Conceptually, this is illustrated below.

Report Documentation Page

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The top graph, for instance, suggests that although variability in detection capability is inevitable, one would expect better sensor and system performance predictions, and hence improved detection capabilities, if real in-situ data are used in place of historical climatology. In terms of optimal sampling rates, the lower left graph shows that the probability of detection is much greater for in-situ data at short temporal sampling rates, but falls off quickly as larger time scales are used. In contrast, the success of climatology-based estimates is consistently low for all time scales, exhibiting a nominal decrease with increasing sampling rate. With respect to spatial sampling, I expect in-situ based predictions to again provide better performance predictions compared to climatology estimates. Importantly, both curves plateau at some “measurable” spatial resolution.

APPROACH

My approach during FY 98 has been as follows. First, an appropriate environmental grid was constructed and populated with high-resolution environmental data, including Modular Ocean Data Assimilation System (MODAS) fields. Also collected was standard climatology for use as a baseline comparison, as well as all relevant bathymetric and geoacoustic data for the area. Second, an ASW scenario was defined and sensor/threat data were collected. Third, acoustic sensor performance was calculated for every grid point along several radial directions, which was then converted to signal excess. Fourth, “optimum” ASW search tactics were generated using genetic algorithms based on performance estimates from MODAS fields and from climatology. Last, the results were analyzed and evaluated in terms of cumulative probability of detection as the Measure of Effectiveness (MOE). A critical aspect of the present effort is to develop recommendations for further study, including a generalization of the results to other ocean areas.

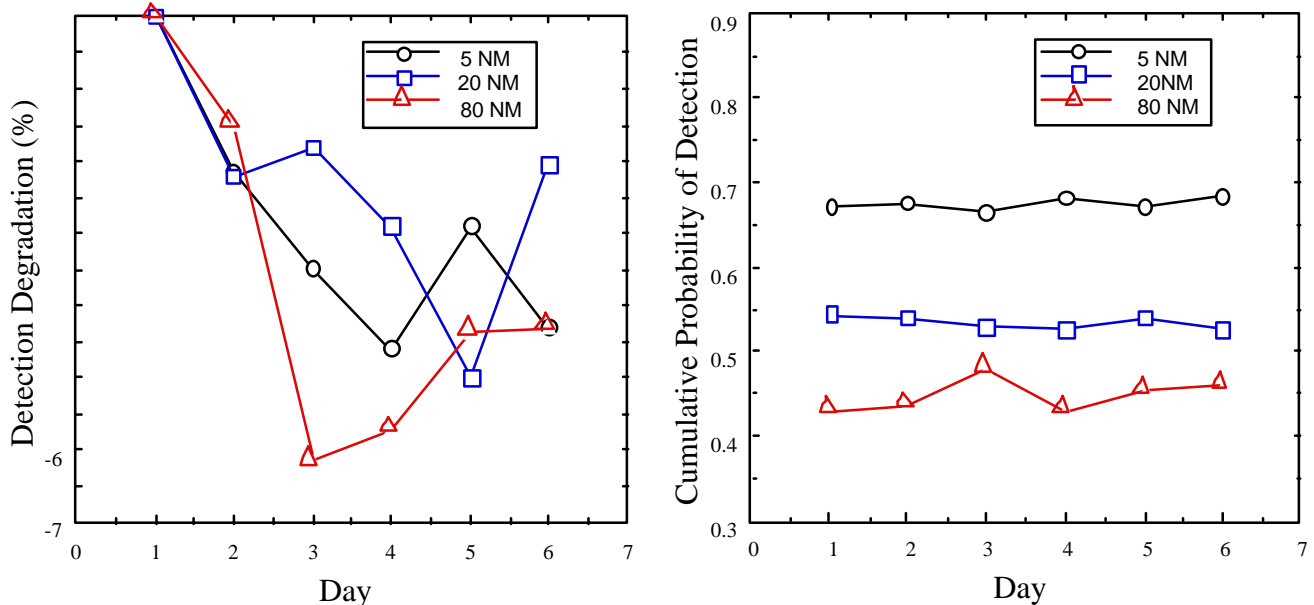
WORK COMPLETED

Although work is still in progress, results to date have been quite encouraging and provide considerable guidance with respect to the validity of the temporal and spatial assumptions used to develop the conceptual model. Furthermore, a firm foundation has been developed that is critical to answering the question of how often a tactic should be changed based on dynamic environmental conditions.

RESULTS

Major accomplishments for FY98 are as follows:

- I participated in the SHAREM 126 sea test to obtain field data for this study. During the sea test, MODAS data were collected to analyze the impact of daily environmental variations on sensor and systems performance predictions.
- Initial results are encouraging and validate assumptions of the conceptual model. The first six days of data collection at SHAREM 126 are used in the figures below.



The left figure shows detection degradation (% loss in the cumulative probability of detection) as a function of time, i.e., when an optimum tactic for Day 1 is used on successive days compared to daily optimizations. The figure on the right shows the cumulative probability of detection as a function of time and spatial sampling density. Environmental grid spacings of 5, 20, and 80 nautical miles were used for the study. The six days occur during a period with no major storm or frontal movement and represent a “best-case” scenario. I anticipate much greater degradation in tactical performance after a storm entered the area around Day 10.

IMPACT / APPLICATIONS

A more comprehensive understanding of the impact of METOC dynamics will provide valuable guidance in performance assessment and mission planning for Navy operations in the littoral zone. Importantly, I have discovered that the answer to temporal stability is a joint problem that cannot be effectively addressed without considering spatial resolution. This is critical if we are to answer questions such as (1) does inclusion of temporal variations in weather suggest a change in tactics? and (2) if tactics remain the same during weather cycles, will performance degrade significantly?

TRANSITIONS

I envision the product to be a component of a tactical decision aid for ASW mission planning, with particular value in dynamic, range-dependent environments. Potential transition sponsors are the Tactical Control Program (ASTO) and computer aided DRT (PMS-411)

RELATED PROJECTS

The Naval Research Laboratory has a comprehensive 6.2 Project (Warfare Effectiveness) with the following relevant components: (1) Corporate Laboratory Core efforts in environmental and sensor physics and system performance modeling in complicated, non-homogeneous environments, (2) Operations research and analysis efforts in the development of procedures to calculate the impact of fundamental environmental phenomena on mission success through high-level MOEs, and (3) development of search planning tools (based on genetic search algorithms) in complicated environments. The Naval Research Laboratory has also developed MODAS, which provides oceanographic data fields with sufficient accuracy and resolution to reflect meteorological variability.