Monitoring Bloom Dynamics of a Common Coastal Bioluminescent Ctenophore

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LONG-TERM GOALS

The long-term objective is to develop predictive models of bioluminescence potential in the coastal zone environment.

OBJECTIVES

The ubiquitous nature of bioluminescent plankton in the world's ocean and its extreme sensitivity to mechanical excitation pose serious threats to clandestine operations. This is particularly true in the coastal zone where watershed run-off and discharge of submarine ground-water can profoundly impact growth conditions on very short space and time scales. Bioluminescent blooms include dinoflagellate red tides, which are occurring more frequently, lasting longer and extending further off shore due to excessive nutrient loading from land-based run-off and blooms of the carnivorous ctenophore *Mnemiopsis leidyi* that may be either seasonal or event driven, can develop on remarkably short time scales (Kremer, 1994) and also appear to be on the increase (Sullivan et al., 2001).

Mnemiopsis leidyi, a native-American comb jelly (Figure 1), was first introduced into the Black Sea in 1982, where it caused the total collapse of the local fisheries. It has recently broken out into the Mediterranean Sea. Also, there is evidence that blooms within its native range along the east coast of the United States are increasing and producing profound impacts on coastal ecosystems. Given its ubiquity and its exceptional hardiness there is concern that it may continue to spread.

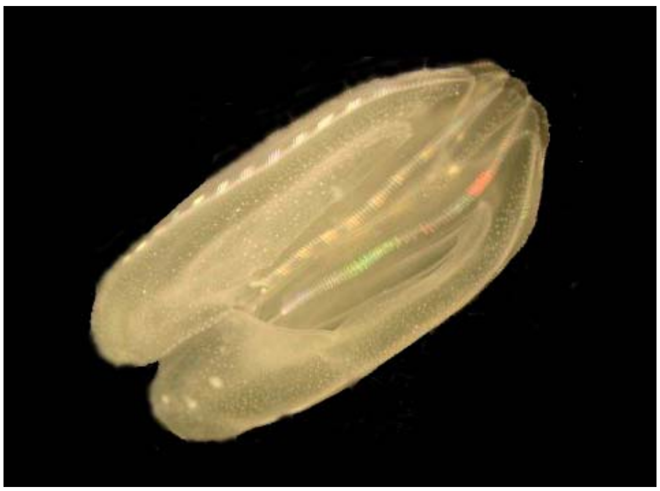

Figure 1: The ctenophore, Mnemiopsis leidyi

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The causes of jellyfish blooms are not well understood, but are generally assumed to be a combination of physical and biological factors, with temperature and salinity being the primary determinants of distribution and food availability, and predation being critical controlling factors of abundance (Graham et al., 2001, Kremer, 1994). Given the number of critical variables involved, any attempt at developing meaningful predictive models demands a large sample size, because sampling that is too broadly separated in space and time has little chance of correlating causes and effects. The most common practice for studying the abundance of *Mnemiopsis* is by net collection at established stations and with time gaps that severely limit the utility of the data. Our objective is to greatly reduce sampling intervals and greatly expand the spatial coverage of data collected by removing the requirement for hand sampling and automating all aspects of the data collection process.

APPROACH

Recently, with support from the Office of Naval Research, we have been developing a new kind of wireless, coastal monitoring system that is integrated at the component level in order to radically reduce costs and complexity. Each sensor string or Kilroy measures conductivity, pressure, speed-of-sound along several paths, optical backscatter, and two components of magnetic flux. From these basic measurements, salinity, flow speed and direction, package depth, tidal parameters, wave characteristics, and package orientation are calculated. Also, each Kilroy is fitted with a low-cost bathyphotometer, specifically designed for coastal monitoring. The geometry and sampling characteristics of the BP internal solid-state sensor array are based on recent findings with the HIDEX Bathyphotometer (Widder et al., 1993, 2003, 2005) and the data handling will incorporate recently developed classification and concentration measurement algorithms (Davis et al., 2005). Kilroy also integrates a GPS unit, communicates with up to 255 other systems via a multi-drop RS-485 connection, logs data in a PC-readable format to Secure Digital/MultiMediaCards, and is powered from either a single, internal, rechargeable Lithium Polymer battery or from an external unregulated supply – either solar or wave generator.

The installation of the Kilroy network will permit a novel approach to monitoring bloom dynamics, one that eschews the routine dependence on net collections, which are labor intensive, patchy and infrequent and, instead permits the collection of both biotic and abiotic data continuously. Our approach will be to correlate *M. leidyi* abundance with Kilroy-measured environmental variables, quantify the impact of *M. leidyi* blooms on the abundance of local primary and secondary producers, measure feeding, growth, and reproduction rates of *M. leidyi* in controlled laboratory studies to test hypotheses of control factors derived from multivariate correlation analyses and develop a likelihood of occurrence model based on a recently developed ecological forecasting system for the sea nettle, *Chrysaora quinquecirrha* (Decker et al., 2007). Specifically we will use multivariate regression techniques to develop habitat (i.e., environmental conditions) models for understanding and predicting variations in abundance of *M. leidyi*.

WORK COMPLETED

For the last year while development of the Kilroy network has progressed under separate funding, the food source for *Mnemiopsis* sp., mesozooplankton, has been monitored on a biweekly basis in the Indian River Lagoon. Monitoring *Mnemiopsis* sp., along with mesozooplankton, provides information on which changes in mesozooplankton may trigger *Mnemiopsis* sp. blooms, how the mesozooplankton community is altered after a *Mnemiopsis* sp. bloom, and seasonal cycles in mesozooplankton in the Indian River Lagoon. Mesozooplankton samples were collected on incoming and outgoing tides and filtered to analyze the mesozooplankton in the size range 100 to 850 µm. These samples were run through an imaging flow cytometer and images were classified into groups to genera. A full year of mesozooplankton samples has been collected to compare seasonal differences, and differences in the mesozooplankton assemblage on the incoming and outgoing tide.

For biological calibration of the Kilroy bathyphotometer and for laboratory feeding experiments, *Mnemiopsis* sp. need to be collected live. Over the last year, the methods and techniques for *Mnemiopsis* sp. collection have been modified to improve success rate. Multiple collection sites were tested for the presence of the jellies. Collections using a boat to access other locations began in February 2007. From February to May 2007, *Mnemiopsis* were collected on eight separate boat trips. From these efforts, a prime location was found for collections and better methods were implemented for ensuring survival of the jellies during transport back to the lab. *Mnemiopsis* and mesozooplankton prey maintenance in the lab were improved with development and modification of a planktonkreisel and methods for feeding experiments tested.

RESULTS

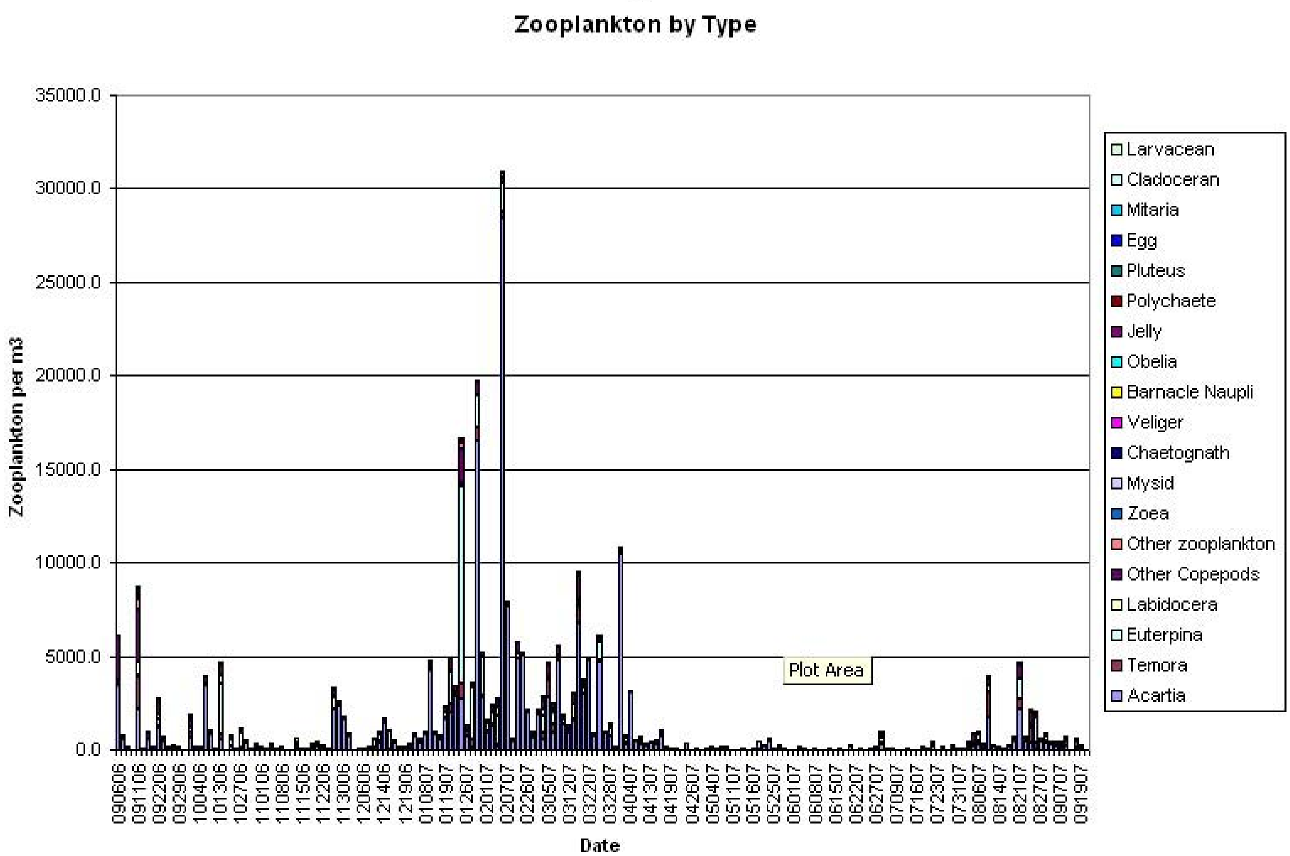

Figure 2: Mesozooplankton collected from the Indian River Lagoon and categorized by type over a one year period from September 6, 2006 to September 19, 2007. The bar graph plots zooplankton per cubic meter and shows a preponderance of the copepod, Acartia, throughout the year, with the greatest abundance between January and April 2007 and peak abundance exceeding 30,000 per cubic meter in February 2007.

Protocols and techniques for mesozooplankton monitoring with imaging flow cytometry were established. Large variations in abundance throughout the year were documented (Figure 2) with the greatest abundance of mesozooplankton occurring from January to April. The predominate zooplankter in the samples was the copepod, *Acartia* sp., a known prey item for *Mnemiopsis* sp. Attempts to correlate variations in mesozooplankton abundance with *Mnemiopsis* sp. abundance were unsuccessful, primarily due to the extreme patchiness of the ctenophore distribution, which supported our thesis that in order to conduct statistically significant correlation analyses, we need to be monitoring blooms on much shorter space and time scales than is possible with standard field sampling methods.

IMPACT/APPLICATIONS

Blooms of bioluminescent jellyfish, especially of *Mnemiopsis leidyi*, are a common occurrence that appear to be on the rise. Evidence indicates that these blooms can develop with remarkable rapidity. From a military standpoint such events can have a devastating impact on clandestine operations and from an ecological standpoint they can have a similarly devastating impact on fisheries. The ability to monitor and predict such blooms does not currently exist. The development of a bioluminescent jelly-bloom forecasting system would be of great value both to naval planners and to policy makers seeking proactive means to respond to the ecosystem imbalance that such blooms may represent.

RELATED PROJECTS

Development of a large scale wireless bioluminescence sensor array, which is the basis for the high-resolution data collection and proposed correlation analysis, is being funded under Office of Naval Research grant N00014-06-1-0153, entitled Bioluminescence Truth Data Measurement and Signature Detection.

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