A National Oceanographic Partnership Program Award

Diel, seasonal, and interannual patterns in zooplankton and micronekton species composition in the subtropical Atlantic

Dr. Deborah Steinberg
Virginia Institute of Marine Science, P.O. Box 1346, Gloucester Pt., VA, 23062, USA
Phone: (804) 684-7838 FAX: (804) 684-7293 E-mail: debbies@vims.edu

Dr. Laurence Madin
Woods Hole Oceanographic Institution, Biology Dept., Woods Hole, MA, 02543, USA.
Phone: (508) 457-0809 FAX: (508) 457-2169 E-mail: lmadin@whoi.edu

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http://www.vims.edu/bio/zooplankton/BATS/index.html

Long-term goals

To provide a unique data set for use in the Ocean Biogeographical Information System (OBIS) – over a decade of monthly zooplankton and micronekton species composition data from the Bermuda Atlantic Time-series Study (BATS) site in the Sargasso Sea. Ultimately we wish to use this data to:

1) Enable us to dissect the difference between natural variability and real 'change' in the diversity of plankton communities

2) Provide data critical for: testing and validation of ecosystem models, understanding the effects of long term climate change on ecosystems

3) Understand the role of zooplankton community structure in biogeochemical cycling

Objectives

1) Complete a multi-species inventory of archived zooplankton and micronekton samples that have been collected at BATS

2) Provide high resolution data that covers diel, seasonal, interannual, and decadal time scales

3) Provide detailed accompanying data available from BATS cruises (e.g., water column temperature, oxygen, nutrients, plant pigment concentration)

4) Format both species and other BATS data for incorporation into the OBIS, using techniques already well developed and in use at BATS for organizing, archiving and serving data of this type.

Approach and work plan

Our technical approach began with a compilation of historical species data and literature from BATS, and assembly of archive type specimens from the Sargasso Sea. We then began work on three main BATS zooplankton and micronekton data and sample sets for our analyses: Monthly, day and night samples from plankton tows within the top 200 meters from all BATS cruises 1994-2000, monthly night zooplankton tows in the top 150 m from BATS cruises pre-1994, and

BATS deep-water trawl samples (0- 1000 m in 4 depth strata) from cruises at different times of the year during 1992- 1993.

Each lab is responsible for different major taxa from all samples, with Dr. Larry Madin and his technician Erich Horgan (Woods Hole Oceanographic Institution) concentrating on the gelatinous groups, amphipods, and mollusks; Dr. Lena Markhaseva (partner from Russian Academy of Sciences, Zoological Institute, St. Petersburg) and Dr. Frank Ferrari (partner from Smithsonian Institution's National Museum of Natural History) identifying copepods; Dr. Deborah Steinberg and her technicians Joseph Cope and Stephanie Wilson (Virginia Institute of Marine Science) focusing on krill, ostracods, and other crustaceans; and Dr. James Craddock (Woods Hole Oceanographic Institution) working on the larval fish. Data are entered directly into spreadsheet files, from which abundance, size distributions and species diversities can be calculated.

After some minor programming to match the characteristic time and space scale lengths of the zooplankton species and the BATS hydrographic data set, we will be able to make the zooplankton species data base synoptic with the existing BATS hydrographic data base. This means will be able to combine our species data with accompanying environmental data regularly collected on BATS cruises including: pressure, temperature, salinity, dissolved oxygen, nutrients (nitrate, nitrite, phosphate, and silicate), carbon dioxide, dissolved organic carbon, particulate organic carbon and nitrogen, bacterial abundance, and phytoplankton pigments. Rate measurements such as primary productivity, bacterial growth, and sediment trap flux are also available. This will be provided to the OBIS data base.

Our work plan for the upcoming year is to finish the sorting/identification of samples, and begin 'melding' the zooplankton species and hydrographic data sets together.

Work Completed

We have just completed the second year of our project, and have received a 1-yr. no-cost extension from NSF to continue the work. We have compiled all of our taxonomic resources and now have an extensive library of Sargasso Sea (and elsewhere) zooplankton references which are being placed on our website. Counting of samples continues in all laboratories. Dr. Markhaseva from the Russian Academy of Sciences visited Steinberg and Ferrari for one month again this year (she came in 2001 as well) to finish working on the copepod samples. She has now completed 6+ years of identification of the calanoid copepods (the most numerous and diverse group in our samples) and will finish working on the samples in Russia. We have also completed 6+ years of euphausiid, ostracod, and cladocera identifications. Madin's group has worked up the deep water trawl data, and is working on the gelatinous zooplankton identifications. Deborah Steinberg attended a meeting for all OBIS investigators at the Smithsonian Institution's National Museum of Natural History, and along with her technican visited Madin' laboratory in Woods Hole to consult on the project. Our existing data has been forwarded to the OBIS technical working group who have provided on-line access to the data at their pilot site (http://www.iobis.org/OBISPortal). We have continued to develop our own in-house Microsoft Access database to serve our own data from our website as well. We have also begun in earnest to analyze the species data for diel, seasonal, and interannual trends in species composition and diversity.

Results

Analysis of the species data to date has resulted in some significant preliminary findings. Diversity at this open ocean site is high, with 104 species of calanoid copepods alone identified. Many taxa (e.g., euphausiids, ostracods) exhibit peak abundances during the spring bloom (Feb. - Mar.) but there is considerable variation between species within a taxon, as well as interannual variation. Pronounced vertical migration occurs in many species. We have found 3 new species of calanoid copepods that are new to (i.e., never been recorded in) the Atlantic Ocean, and 7 that are new to the Sargasso Sea. We have also found 1 species of ostracod that is new to the Sargasso Sea. Species diversity within several of the major taxa is lowest in the winter and highest in spring and summer. Diversity is also significantly higher at night due to the presence of vertical migrators. Diel, seasonal, and interannual differences in species abundance are evident even at the genus level. For example, species of calanoid copepods within the same genus, which look almost identical, have very different patterns of seasonal abundance. These seasonal swings might be an example of "niche partitioning," wherein similar organisms evolve different life-style strategies to avoid competing for food or other resources.

Technical results achieved in this year include the completion of our Microsoft Access data base with 50 linked datasets (e.g., includes links for each taxa, hydrographic data, zooplankton biomass data, etc.). We began development of a cold fusion interface for dynamic access to the data over the web. We are also working on linking our interface with the OBIS portal.

Impact and Applications

Economic Development

This study addresses socioeconomic issues of importance such as improved prediction of variability and impact of fisheries.

Quality of Life

Information on seasonal and interannual variability in zooplankton biomass and species composition is crucial for testing and validation of ecosystem models, and for understanding the effects of long term climate change on ecosystems.

Science Education and Communication

Information from this data set will benefit both the research and educational communities by providing high quality, long term species composition data.

Transitions

Science Education and Communication

Species lists with accompanying images will become available for use of the broader scientific and education community for many different applications.

Related projects

The Bermuda Atlantic Time-series Study (BATS): An ongoing (1988-present) oceanographic time series in the Sargasso Sea and part of the U.S. Joint Global Ocean Flux Study (JGOFS). Researchers associated with BATS are conducting long time-series studies of biogeochemical cycles in the Sargasso Sea near Bermuda. This project involves making monthly measurements

of important hydrographic and biological parameters throughout the water column in the Sargasso Sea. The data set has been used extensively by the oceanographic community for everything from climate change modeling to food web analyses to nutrient dynamics studies. http://www.bbsr.edu/cintoo/bats/bats.html

Publications

Steinberg, D.K., Markhaseva, E , Cope, J.S., Wilson, S.E., Madin, L.P., (2003) Diel, seasonal, and interannual patterns in zooplankton species composition in the subtropical Atlantic: A census of marine life. American Society of Limnology and Oceanography Aquatic Sciences Meeting Program Abstracts.

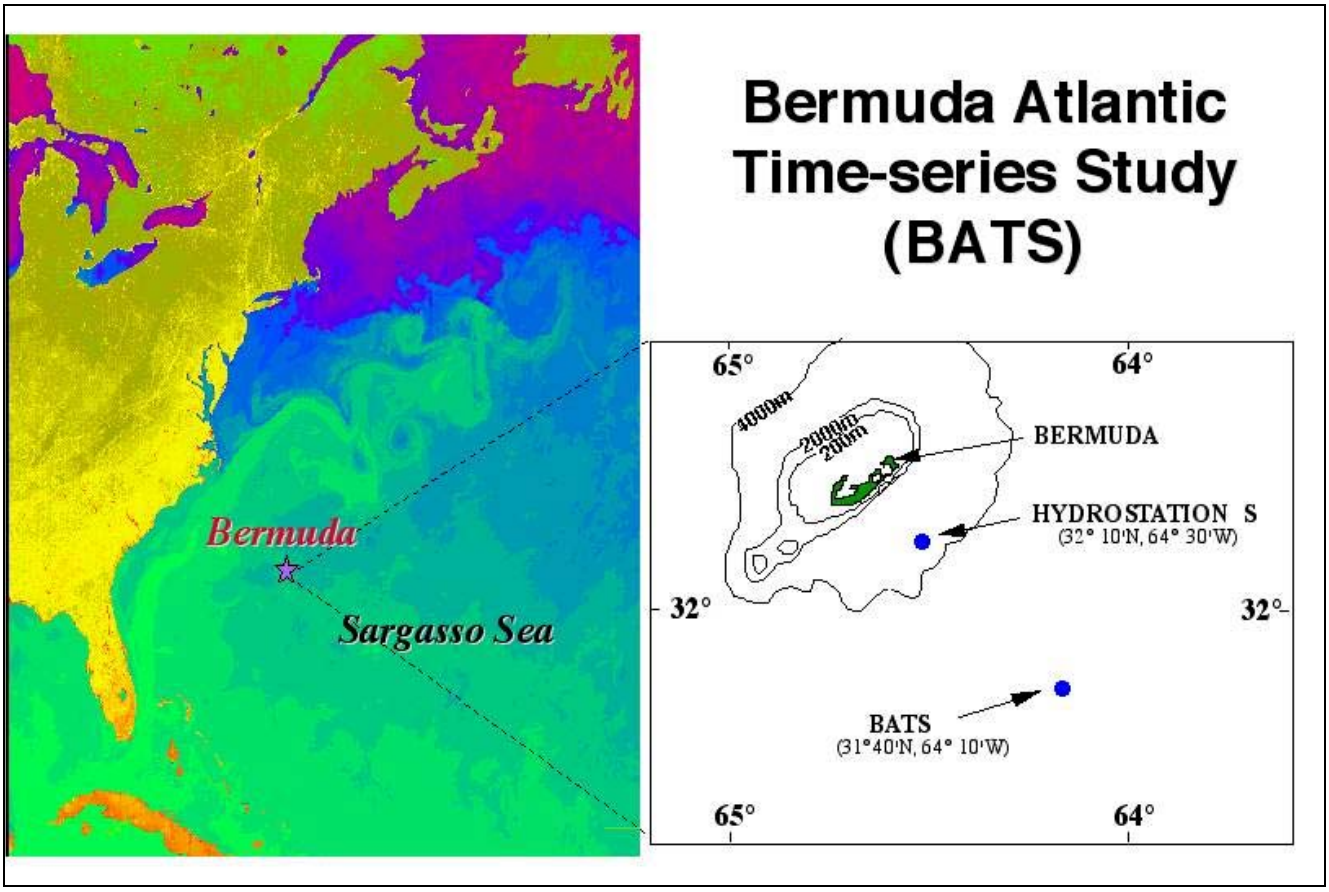

Figure 1. Sampling site for zooplankton census. Samples were collected at the Bermuda Atlantic Time-series Study (BATS) site. BATS is a 15-year, ongoing oceanographic time series situated in the western North Atlantic subtropical gyre or Sargasso Sea. The BATS station lies 82 km southeast of the island of Bermuda. This program, in combination with the continuous 49-year Hydrostation S hydrographic time-series, makes the site one of the most intensively studied parts of the world's oceans.

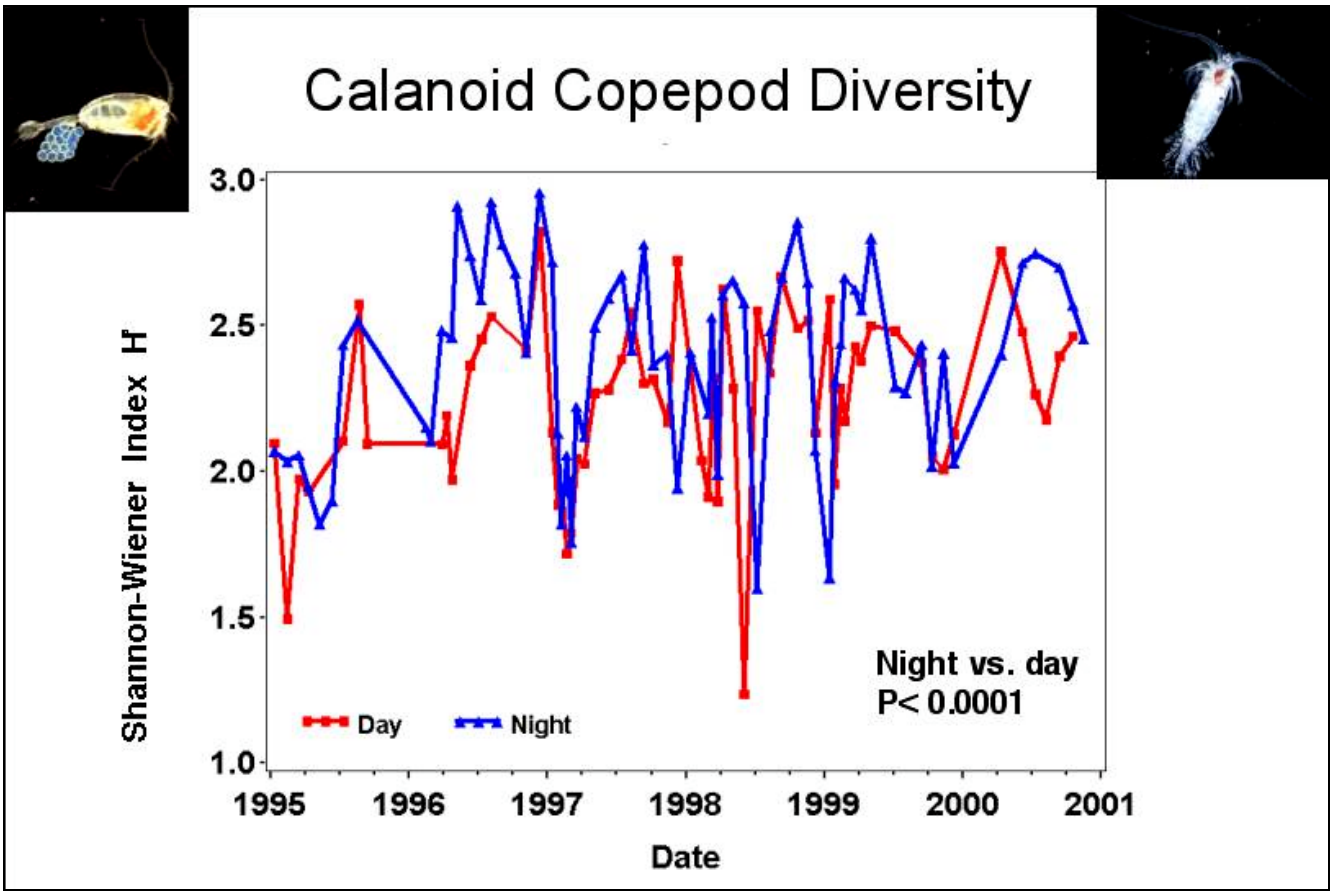

Figure 2. Calanoid copepod diversity. The Shannon-Wiener index of species diversity (based both on total number of species and species'eveness') was used to look at patterns of species diversity in one very diverse (104 species identified at BATS) group of zooplankton. Copepod diversity is significantly higher at night, due to vertical migration of deeper living species into the surface waters. Diversity is also lowest in the winter- likely due to deep mixing of the water column and decreased food resources, and highest in spring/summer- likely due to blooms of phytoplankton providing a food resource. The images are examples of different species of calanoid copepods (each about 3 mm in length).

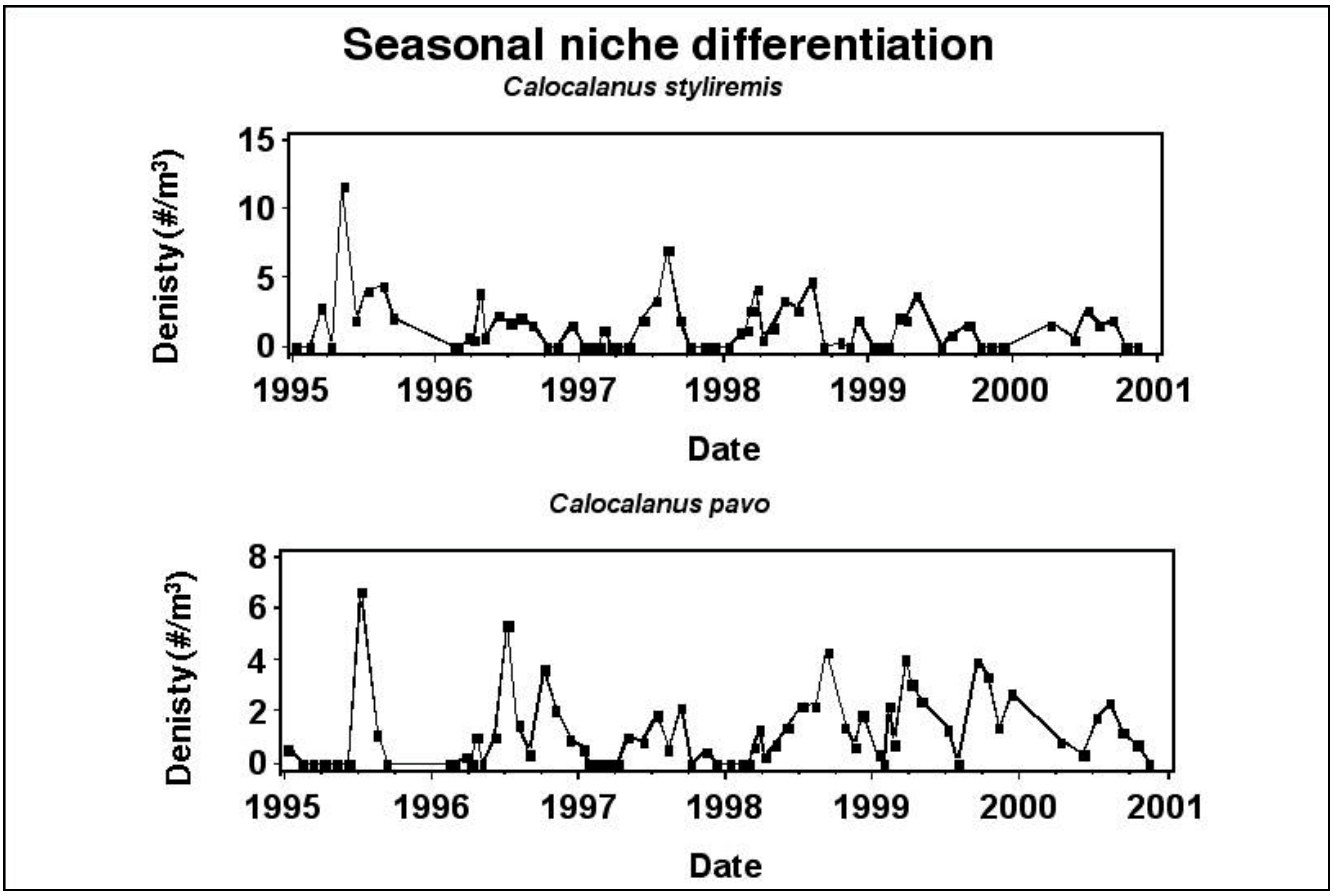

Figure 3. Seasonal niche differentiation of closely related copepod species. These two similar species have very different seasonal abundances. Calocalanus styliremis is generally most abundant in the spring, while Calocalanus pavo is most abundant in summer. This pattern might be an example of "niche partitioning," wherein similar organisms evolve different life-style strategies to avoid competing for food or other resources.