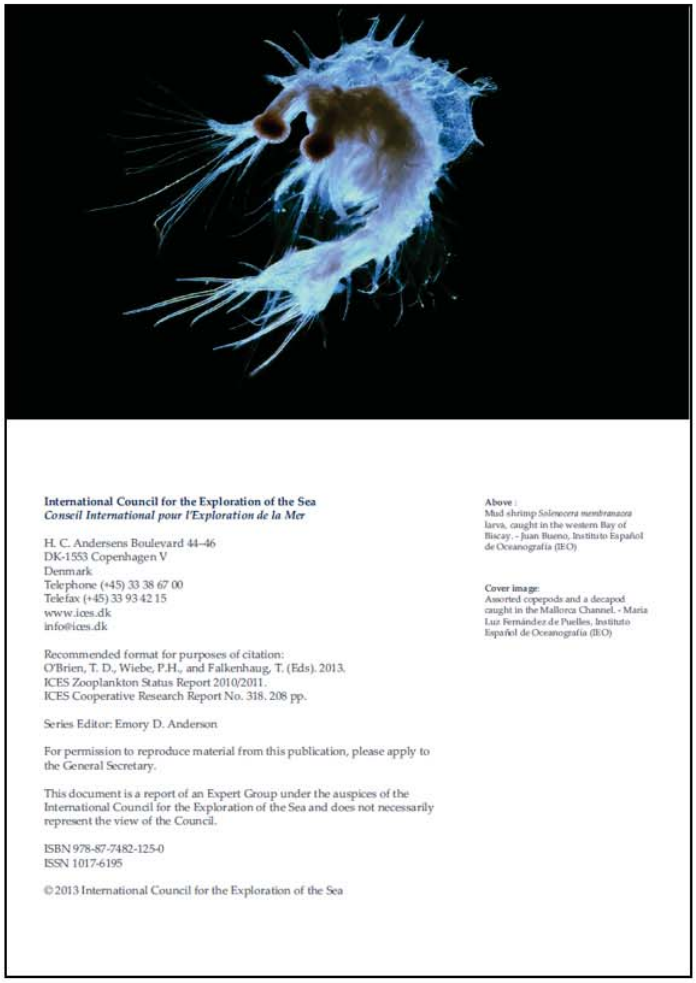

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Above :
Mud shrimp *Solenocera membranacea* larva, caught in the western Bay of Biscay. - Juan Bueno, Instituto Español de Oceanografía (IEO)

Cover image:
Assorted copepods and a decapod caught in the Mallorca Channel. - María Luz Fernández de Puelles, Instituto Español de Oceanografía (IEO)

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3.5 Bermuda Atlantic Time-series Study (Site 8)

Deborah Steinberg

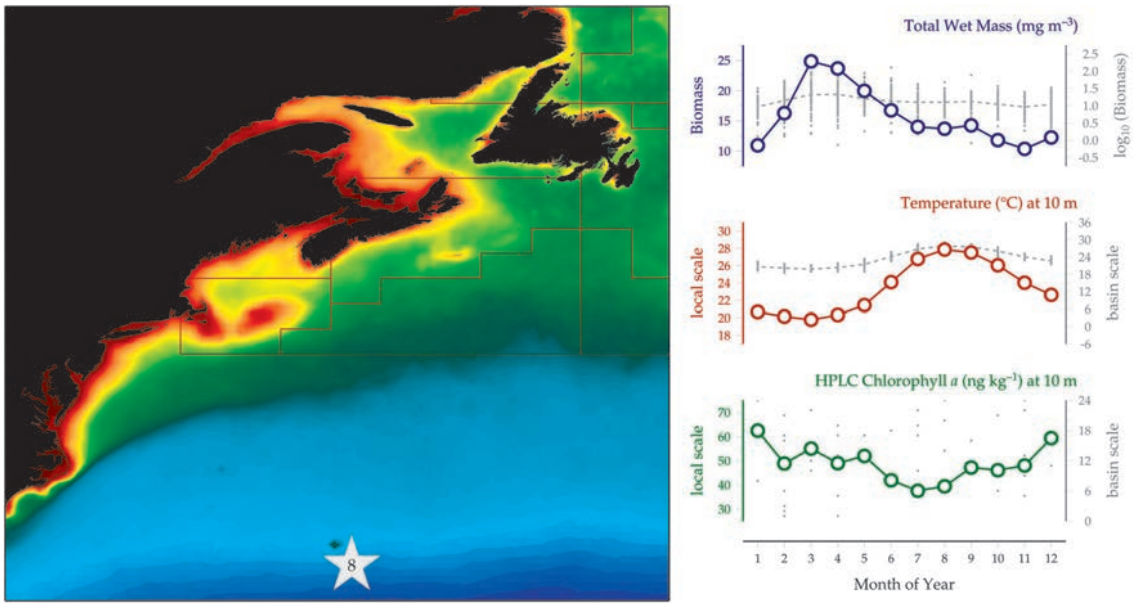

Figure 3.5.1
Location of the Bermuda Atlantic Time-series Study (BATS) monitoring site (Site 8), plotted on a map of average chlorophyll concentration, and its corresponding seasonal summary plot (see Section 2.2.1).

The Bermuda Atlantic Time-series Study (BATS) site is located in the Sargasso Sea at 31°50′N 64°10′W and is monitored by the Bermuda Institute of Ocean Sciences (BIOS). Zooplankton are collected at least once a month with a 0.8 × 1.2 m rectangular frame net with 202 µm mesh. Two replicate oblique tows are made during the day (between 09:00 and 15:00) and night (between 20:00 and 02:00) to a targeted maximum net depth between 150 and 200 m. Samples from the tows are split on board, with one half-split fractionated by wet sieving through nested sieves with mesh sizes of 5.0, 2.0, 1.0, 0.5, and 0.2 mm for subsequent wet and dry weight analyses, and the other half-split preserved in 4% buffered formaldehyde for taxonomic analysis (Madin *et al.*, 2001; Steinberg *et al.*, 2012).

Seasonal and interannual trends (Figure 3.5.2)

A recent analysis of the dataset (1994–2010) indicated that, during this 17-year period, total mesozooplankton biomass increased 61% overall, although a few short-term downturns occurred over the course of the time-series (Steinberg *et al.*, 2012). The overall increase was higher at night-time compared to daytime, resulting in an increase in calculated diel vertical migrator biomass (mean night minus mean day biomass in epipelagic zone). Night-time biomass values on average are 1.9-fold higher (range = 0.3–12.3) than daytime biomass for the whole time-series, and previous taxonomic analyses (Steinberg *et al.*, 2000) show that migrators such as *Pleuromamma* spp. copepods and euphausiids account for the majority of the night-only biomass. The largest seasonal increase in total biomass was in late-winter to spring (February–April). Associated with the larger increase in late-winter/spring biomass was a shift in the timing of annual peak biomass during the latter half of the time-series (from March/April to a distinct March peak for all size fractions combined, and April to March for the 2–5 mm size fractions).

Zooplankton biomass was positively correlated with sea surface temperature, water column stratification, and primary production, and negatively correlated with mean temperature between 300 and 600 m (Steinberg *et al.*, 2012). Significant correlations exist between multidecadal climate indices—the North Atlantic Oscillation plus three different Pacific Ocean climate indices—and BATS zooplankton biomass, indicating connections between patterns in climate forcing and ecosystem response. Resultant changes in biogeochemical cycling include an increase in the magnitude of both active carbon flux by diel vertical migration and passive carbon flux of fecal pellets as components of the export flux. The most likely mechanism driving the zooplankton biomass increase is bottom–up control by smaller phytoplankton, which has also increased in biomass and production at BATS, translating up the microbial foodweb into mesozooplankton. Decreases in top–down control or expansion of the range of tropical species northward as a result of warming may also play a role.

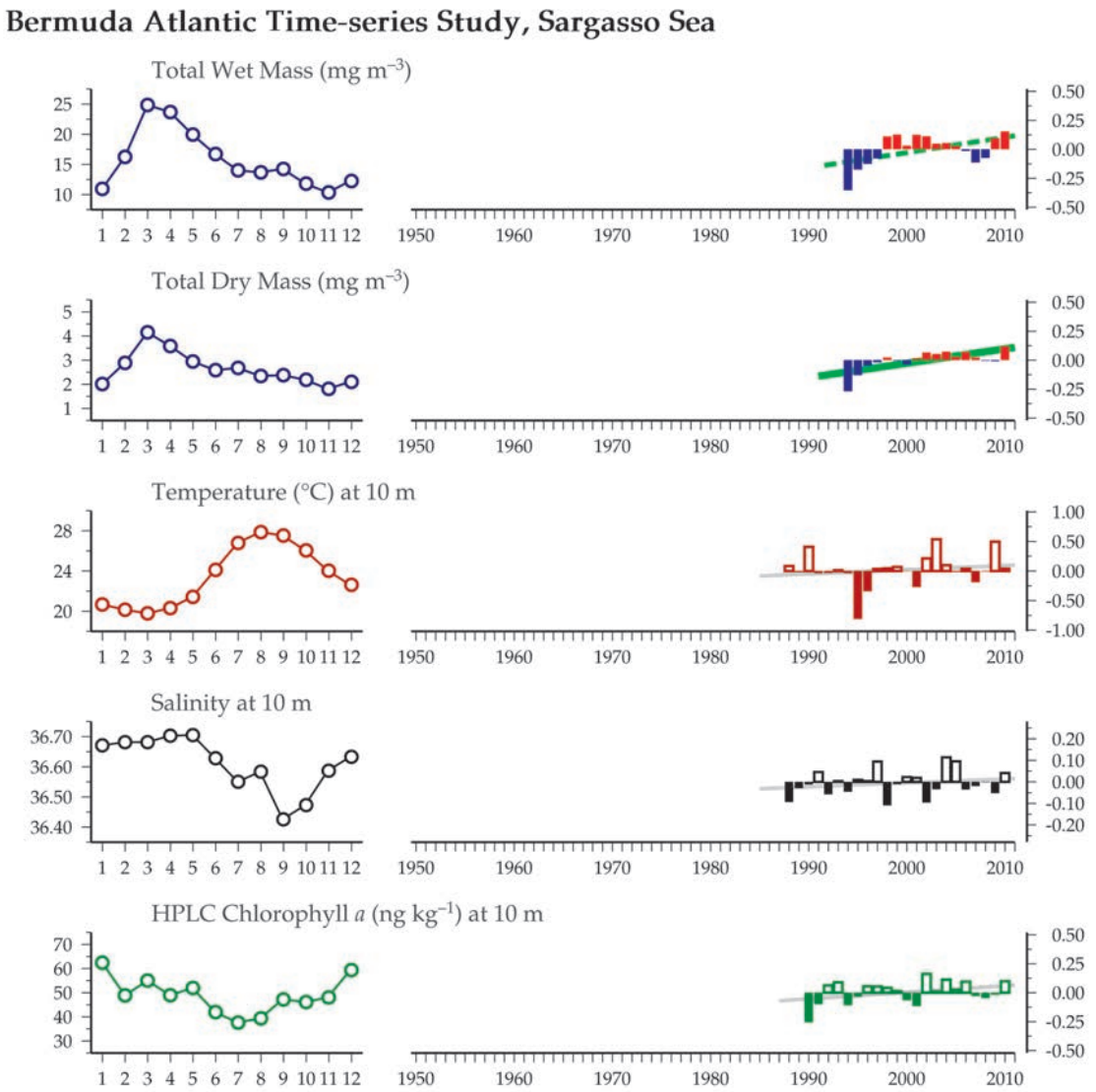

Figure 3.5.2
Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the BATS monitoring area.

Additional variables are available online at: http://WGZE.net/time-series.

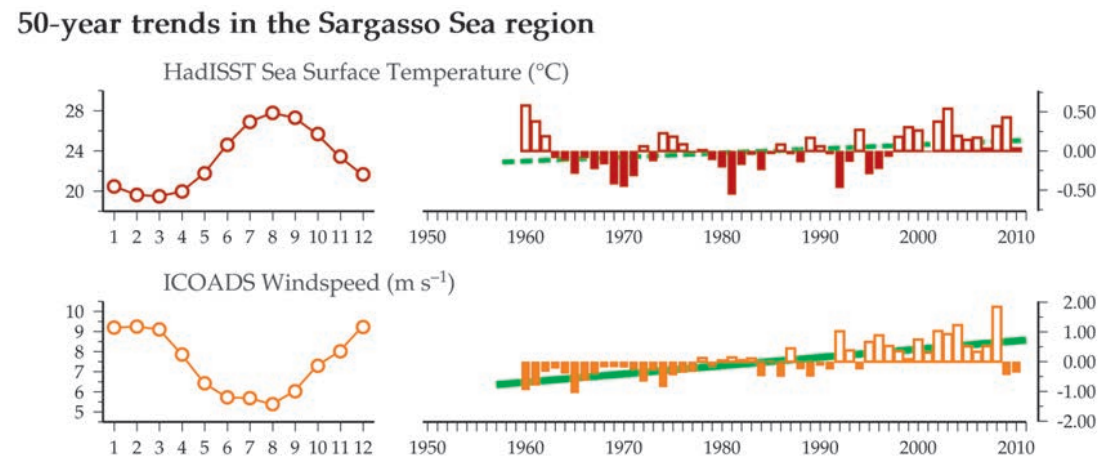
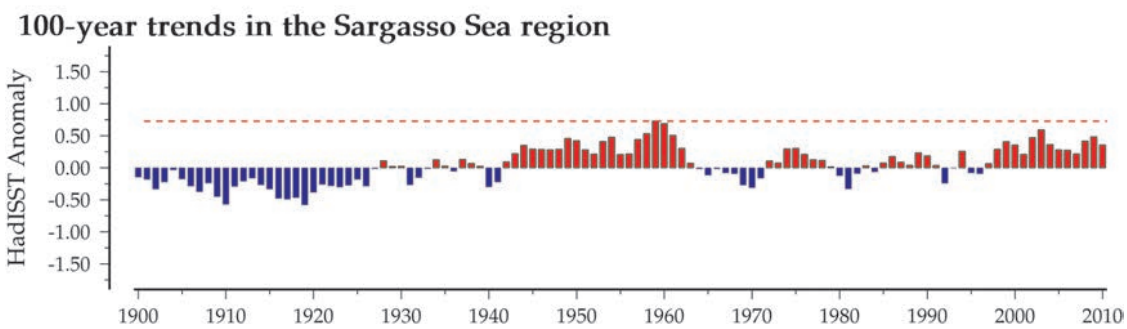
Figure 3.5.3
Regional overview plot (see Section 2.2.3) showing long-term sea surface temperatures and wind speeds in the general region surrounding the BATS monitoring area.