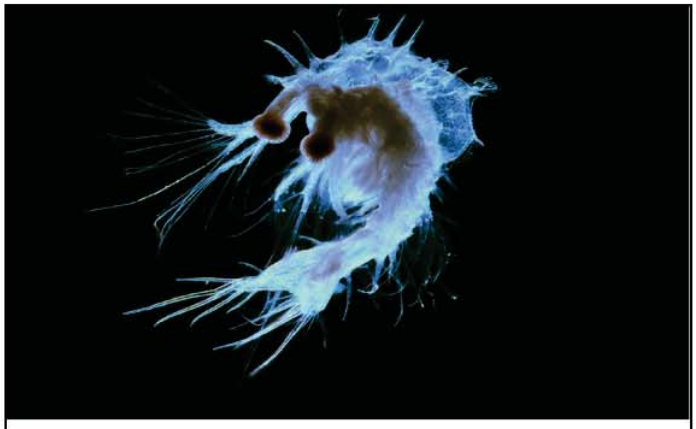

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Above :
Mud shrimp *Solenocera membranacea* larva, caught in the western Bay of Biscay. - Juan Bueno, Instituto Español de Oceanografía (IEO)

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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7.1 Arendal Station 2 (Site 44)

Tone Falkenhaug and Lena Omli

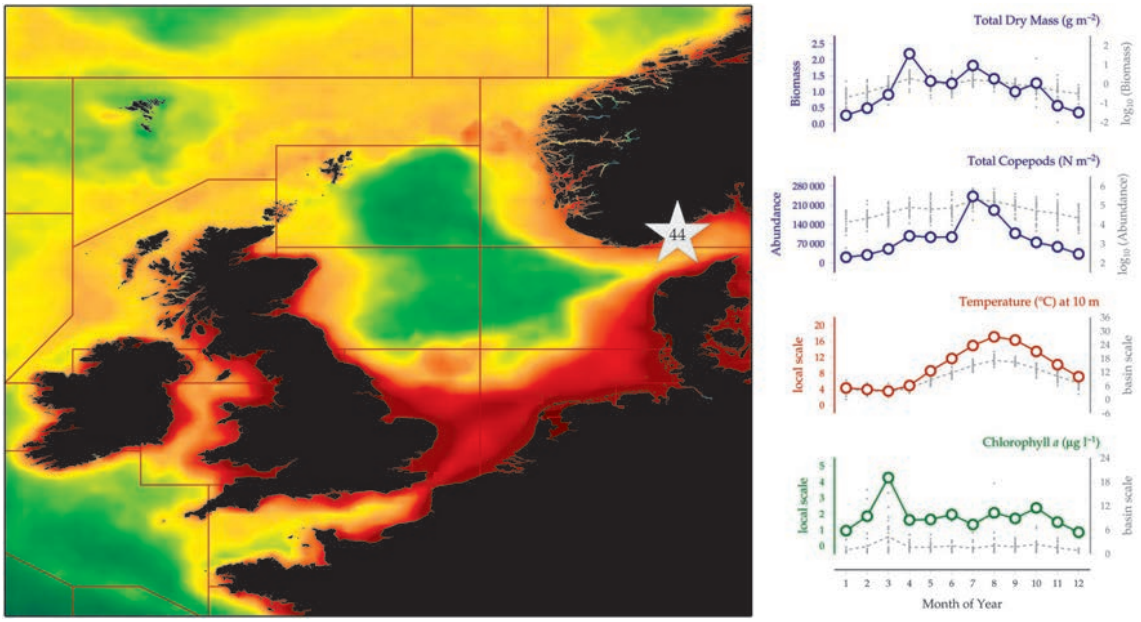


Figure 7.1.1
Location of the Arendal Station monitoring area (Site 44) plotted on a map of average chlorophyll concentration, and its corresponding seasonal summary plot (see Section 2.2.1).

The Arendal sampling site (northern Skagerrak) is located at 58°23′N 8°49′E, approximately 1 nautical mile offshore from the Flødevigen Research Station (Norwegian Institute of Marine Research, IMR) off southern Norway (Figure 7.1.1). The water depth at the site is 105 m. Sampling for hydrographic parameters and abundance of phytoplankton and zooplankton (biomass and species) has been carried out twice a month since January 1994. The sampling programme is part of the Norwegian Coastal Long-term Monitoring Programme of Environmental Quality. The objective of the programme is to monitor the environmental status in coastal waters and to document changes in the plankton communities.

Zooplankton is sampled fortnightly with a WP-2 net (56 cm diameter, 180 µm mesh) towed vertically from a depth of 50 m to the surface. Each sample is split in half, providing data on both species composition–abundance and biomass. During the first period of the time-series (1994–1999), copepods were identified into three main taxonomic groups (*Calanus* spp., other calanoid copepods, and cyclopoid copepods). From 2000 onwards, all copepods are identified to species or genus level.

Seasonal and interannual trends (Figure 7.1.2)

The Arendal sampling site is influenced by relatively fresh coastal waters (25–32 psu) in the upper 30 m and by saltier Skagerrak water (32–35 psu) in the greater depths. Water movement is generally westward and is caused by the coastal current bringing low-salinity water from the Baltic Sea and Kattegat. The site is also influenced by Atlantic water (>35 psu) advected from the Norwegian Sea into the Skagerrak Deep during winter. Together, these influxes create a relatively large seasonal cycle in salinity (Figure 7.1.2). The seasonal minimum temperature in the surface layer generally occurs in February (2°C) and the maximum in August (>20°C). At 75 m, the variation is less pronounced (minimum 4°C in February–March to maximum 14°C in August–September). Although the water column is mixed throughout winter, increased freshwater run-off causes a strong halocline to appear from February/March to June. A spring bloom usually occurs in April–March, dominated by diatoms. Chlorophyll values are generally low during summer (May–August), followed by an autumn bloom of dinoflagellates in August–September. In summer, the water remains stratified because of surface heating. During the past 20 years, a trend towards higher temperatures has been observed in the Skagerrak, both in surface and deeper layers. Since 2001, water temperatures in the region have been higher than those seen in the past 100 years (Figure 7.1.4). About 70% of the water entering the North Sea is assumed to pass through the Skagerrak before it leaves the North Sea, and thus many of the hydrographic events taking place in the North Sea will be reflected in this area.

At the Arendal site, the zooplankton biomass is dominated by copepods. The seasonal maximum in zooplankton biomass generally occurs in April–May (Figure 7.1.2), with a secondary, smaller peak occurring in July–August. The annual spring peak in zooplankton biomass is dominated by *Calanus finmarchicus*, whereas the secondary peak (July–August) is dominated by smaller copepods (*Para-* and *Pseudocalanus, Oithona, Acartia, Temora*). The important common copepod genus, *Calanus*, is represented by three species at the Arendal sampling site: *C. finmarchicus, C. helgolandicus,* and *C. hyperboreus.*

C. finmarchicus is the most abundant species during spring. This species overwinters in the Skagerrak Deep (Norwegian Trench, 20 nautical miles farther offshore from this station). Interannual variability in overwinter survival and advection is likely to affect the population dynamics. *C. helgolandicus* generally occurs in smaller numbers than *C. finmarchicus*, although the proportion of *C. helgolandicus* increases from spring (< 10%) to autumn (>80%). *C. hyperboreus* is rarely observed in spring (March–April) and is associated with the influx of Atlantic water from the Norwegian Sea.

Large interannual differences can be seen in the observed biomass of zooplankton, with maximum values in 2003 and minimum values in 1998. A general increase in biomass and copepod abundance was observed from 1998 to 2003, but a lesser abundance overall was observed in 2004–2010 (Figure 7.1.2). Values for the monthly mean copepod abundance by year reveal that years with negative annual anomaly (2004–2010) are characterized by low abundance of copepods in the late summer peak (July–August). This is mainly caused by the reduced abundance of the copepods *Oithona* spp. and the *Para-* and *Pseudocalanus* spp. in the period 2004–2010 (Figures 7.1.2 and 7.1.3).

The CPR standard area nearest to the Arendal site is B1. The CPR copepod data correspond well with the observed interannual trend in total copepods on Arendal, with positive anomalies in 1999–2003, and low or negative anomalies prior to and after this period. In 2010, however, the annual total copepod abundance in the CPR data was above average, which is in contrast with the observed copepod abundance at Arendal, which has been below average since 2006.

The invasive ctenophore species *Mnemiopsis leidyi* was observed in Skagerrak for the first time in 2006. During 2007–2009, the species occurred in high densities at Arendal Station 2 in late summer–autumn, but with lower abundance in 2010 and few observations in 2011–2012. The seasonal peak of *M. leidyi* coincides with maximum temperatures in the surface water (>20°C), which occur after the seasonal maximum in zooplankton abundance.

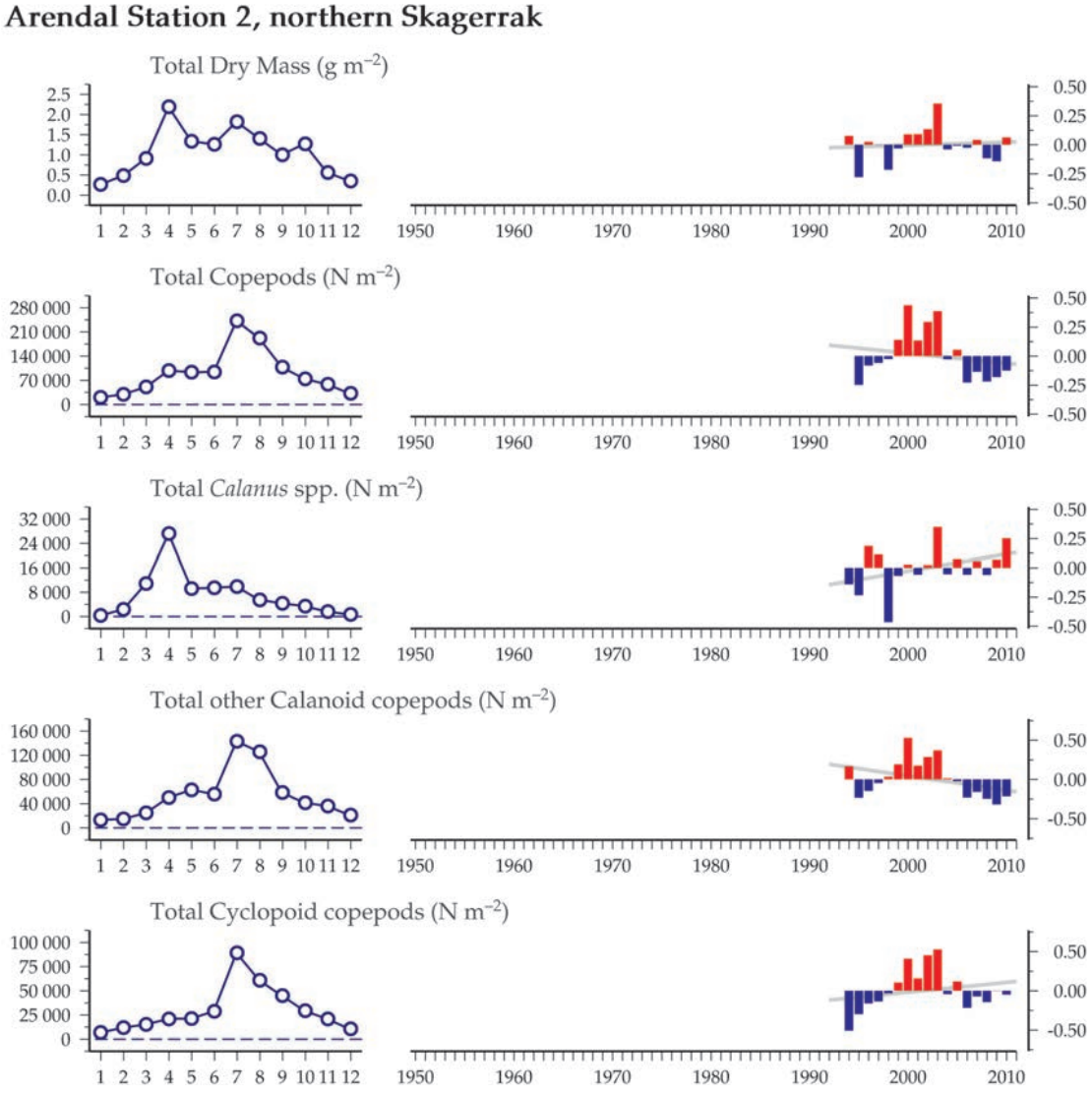
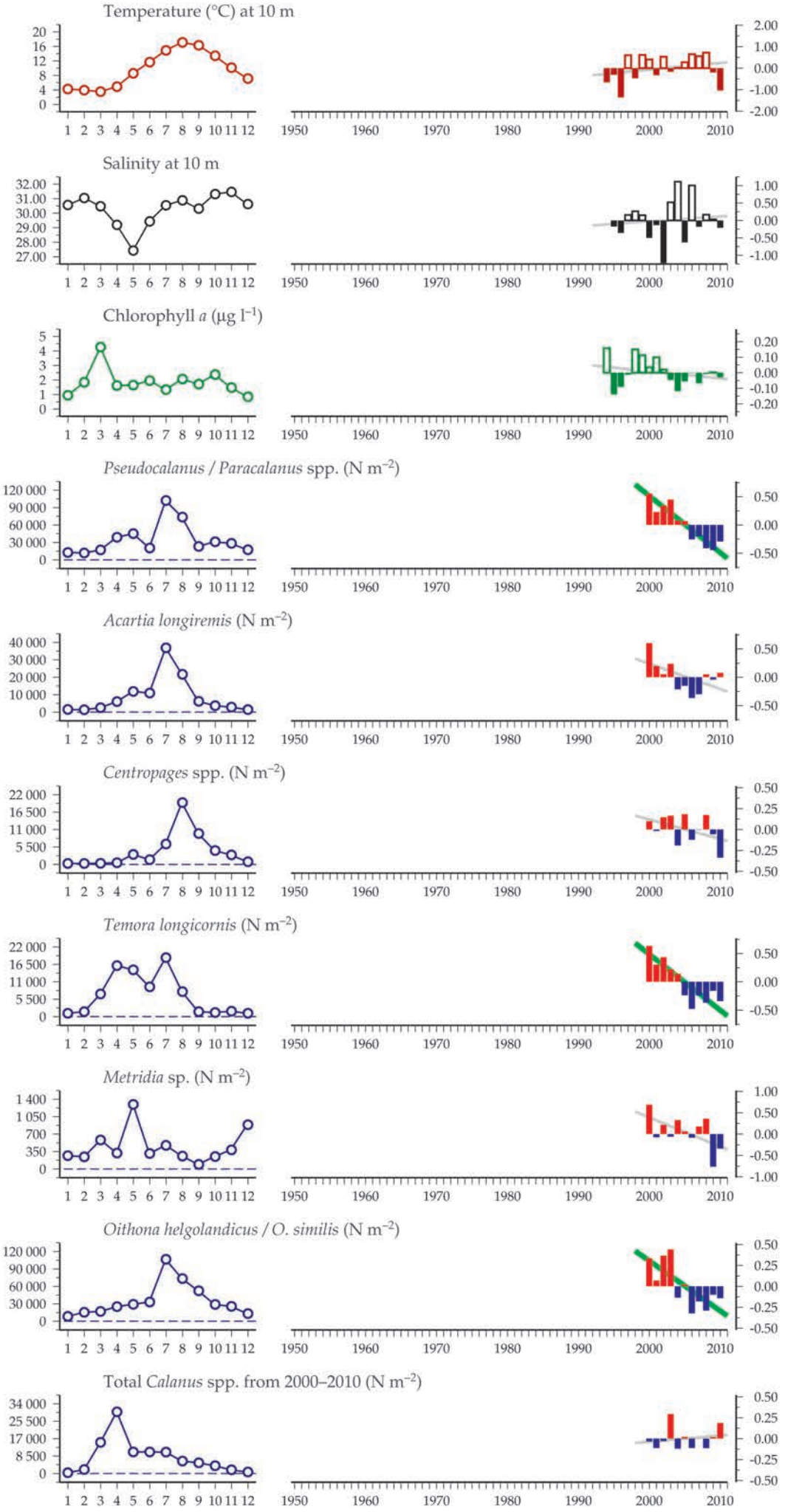


Figure 7.1.2
Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the Arendal Station 2 monitoring area.

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

Figure 7.1.2
continued



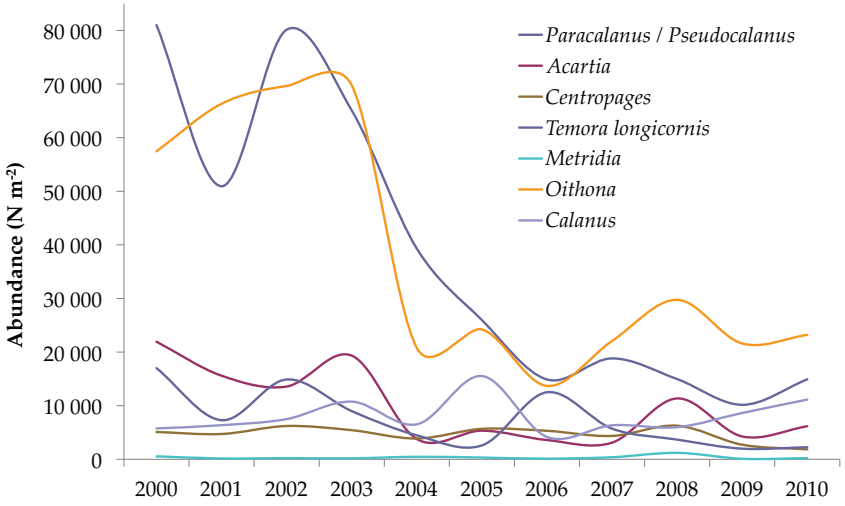


Figure 7.1.3
Annual average abundance of eight major copepod genera at Arendal Station 2.

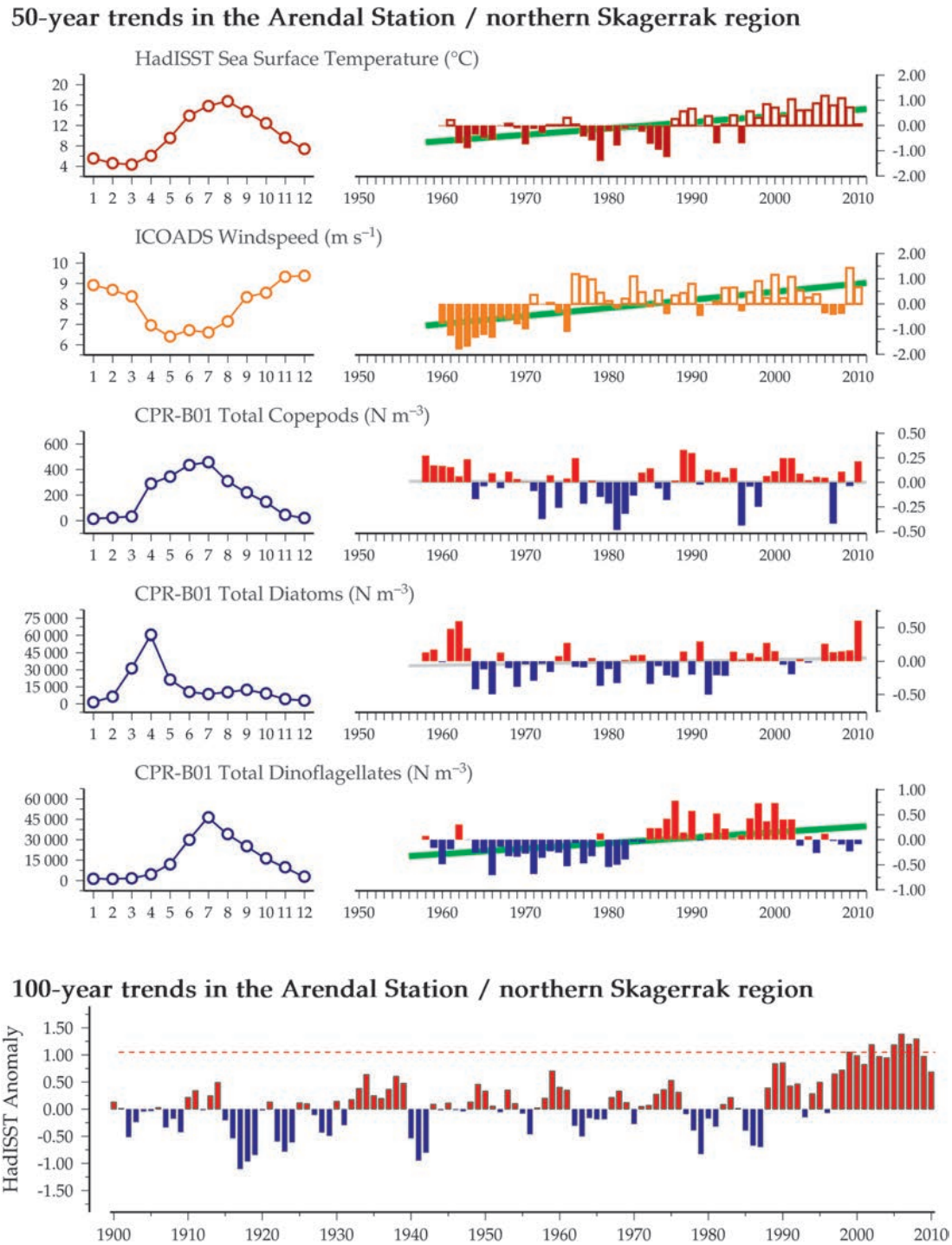


Figure 7.1.4
Regional overview plot (see Section 2.2.3) showing long-term sea surface temperatures and wind speeds in the general region surrounding the Arendal Station monitoring area, along with data from the adjacent CPR B01 Standard Area.