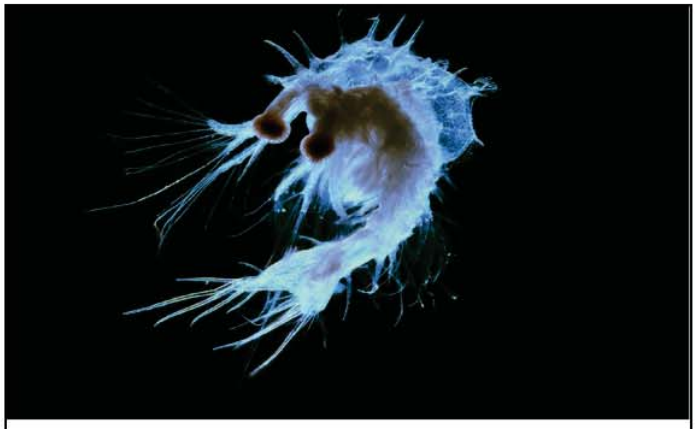

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Above :
Mud shrimp *Solenocera membranacea* larva, caught in the western Bay of Biscay. - Juan Bueno, Instituto Español de Oceanografía (IEO)

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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7.2 Helgoland Roads (Site 45)

Maarten Boersma and Jasmin Renz

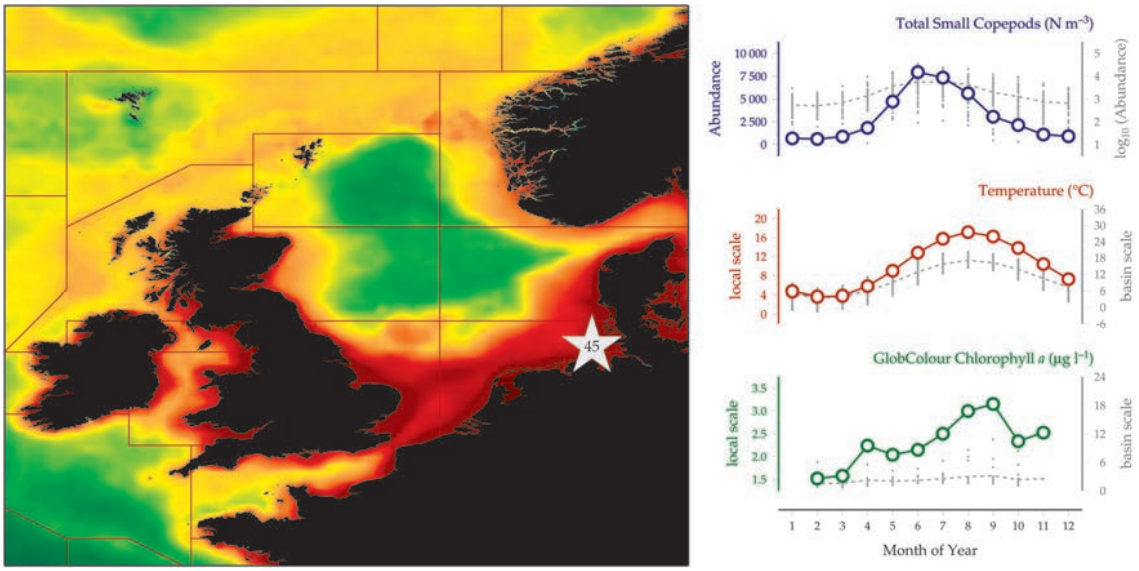

Figure 7.2.1
Location of the Helgoland Roads monitoring area (Site 45) plotted on a map of average chlorophyll concentration, and its corresponding seasonal summary plot (see Section 2.2.1).

The island of Helgoland is located in the German Bight, approximately 60 km off the German mainland (Figure 7.2.1). The Helgoland Roads time-series is one of the richest temporal marine datasets available. It includes daily surface water sampling from 1962 until the present, resulting in a pelagic dataset comprising phytoplankton species counts, salinity, transparency (Secchi-disc depth), and macronutrient concentrations. The phytoplankton time-series was merged with the Helgoland Roads zooplankton time-series, which was started in 1974. Sampling and analysis are now carried out by the Alfred Wegener Institute for Polar- and Marine Research and the German Centre for Marine Biodiversity. Every Monday, Wednesday, and Friday, two oblique plankton net samples (150 µm, 500 µm) are collected from the monitoring site (54°11′18″N 7°54′E). From each sample, almost 400 taxonomic entities of holoplankton and meroplankton (e.g. larvae from benthic organisms and fish larvae) are identified and counted, making the Helgoland Roads time-series one of the finest zooplankton series both in taxonomic resolution as well as in temporal sampling resolution.

The purpose of the Helgoland Roads programme was and is to document high-frequency plankton population dynamics in order to detect variability and regularities in distributions, with the ultimate aim being to differentiate between different signals (natural variability and anthropogenically induced climate change). A wealth of publications is available from the site, using several analytical techniques (e.g. Heyen *et al.*, 1998; Greve *et al.*, 2001, 2004; Bonnet *et al.*, 2005, 2007; Boersma *et al.*, 2007; Malzahn and Boersma, 2007; Wiltshire *et al.*, 2008; Schlüter *et al.*, 2010).

Seasonal and interannual trends (Figure 7.2.2)

At the Helgoland Roads sampling site, small calanoid copepods, mostly *Acartia clausi*, *Temora longicornis*, and *Para-/Pseudocalanus* spp. represent a significant fraction of the total zooplankton population. Seasonal and interannual variability in the small copepods is large both in timing as well as in magnitude. Maximum densities of the small copepods can be found in mid-summer in most years and the 37-year time-series shows clear decadal variability. Starting with a negative phase at the beginning of the times-series (1975), copepod abundance increased steadily and was consistently higher than average during much of the 1980s. After a period of transition (1990–1997), copepod density decreased and remains now in a negative phase where abundance is consistently getting lower. Looking at monthly mean copepod abundance by year and the corresponding monthly anomalies, years with strong positive annual anomalies (e.g. 1983–1990) were characterized by an extended period of high abundance in mid-summer, whereas years with strong negative annual anomalies (e.g. 2006–2010) had both a shorter period and lower maximum abundance during mid-summer. In general, years with a strong positive annual anomaly correspond to positive monthly anomalies for every month in that year, with the opposite also true for years with strong negative annual anomaly. The extent of the peak abundance of these species each year is, therefore, most likely influenced by the copepod population density present through the winter months and leading up to the summer peak.

The only copepod species showing a different pattern is *Oithona* spp. (see Figure 7.2.2). This smaller, cyclopoid species usually occurs later in the season, and its abundance increased more or less steadily over the time-period from the late 1980s until 2008.

Looking at causal agents for changes within the copepod community, the general trend of negative anomalies in copepod abundance over the last century was accompanied by positive anomalies in sea surface temperature in the Helgoland region and positive anomalies in diatom and dinoflagellate concentrations (Wiltshire *et al*., 2008; O'Brien *et al*., 2012). Furthermore, a general shift in the size structure within the diatom community towards larger diatoms (Kraberg *et al*., 2011) could be observed. It is, therefore, unclear whether the decreasing abundance of calanoids and concurrent increase in *Oithona* spp. is caused directly by internal physiological responses to the increasing temperature or indirectly by changes in predation and food, since e.g. *Oithona* spp., which has a different dietary preference and is considered to have a more omnivorous feeding mode, is the only copepod increasing in abundance. Further research is, therefore, needed to identify those factors responsible for changes within the different copepod populations.

The nearest CPR Standard Area to Helgoland Roads is "D1". The relationship between water temperature and CPR copepod abundance was variable, switching from positive to negative throughout periods in the time-series. Like the Helgoland Roads data, the CPR data have also clearly entered a phase of negative and decreasing annual anomalies since 1988. Comparing Helgoland Roads to the CPR data, there seems to be a time-lagged synchrony in copepod abundance, with the Helgoland Roads abundance anomalies leading the CPR anomalies by 3–5 years. Water temperature increases around the shallow Helgoland Roads site have been more dramatic than in the North Sea as a whole, possibly causing changes in the copepod population to occur faster than those sampled in the larger water body within the CPR standard area.

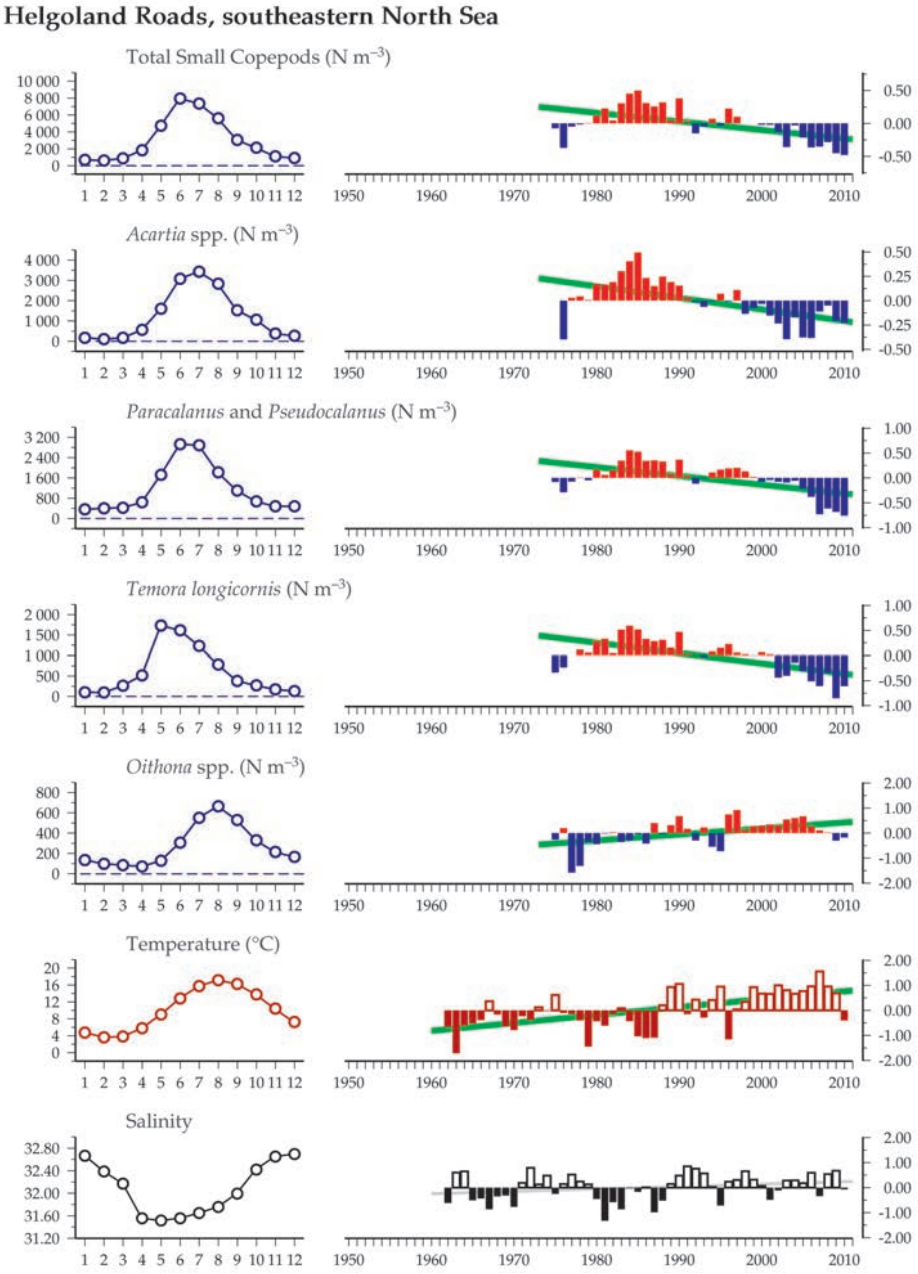

Figure 7.2.2
Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the Helgoland Roads monitoring area.

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

Figure 7.2.3
Regional overview plot (see Section 2.2.3) showing long-term sea surface temperatures and wind speeds in the general region surrounding the Helgoland Roads monitoring area, along with data from the adjacent CPR D01 Standard Area.