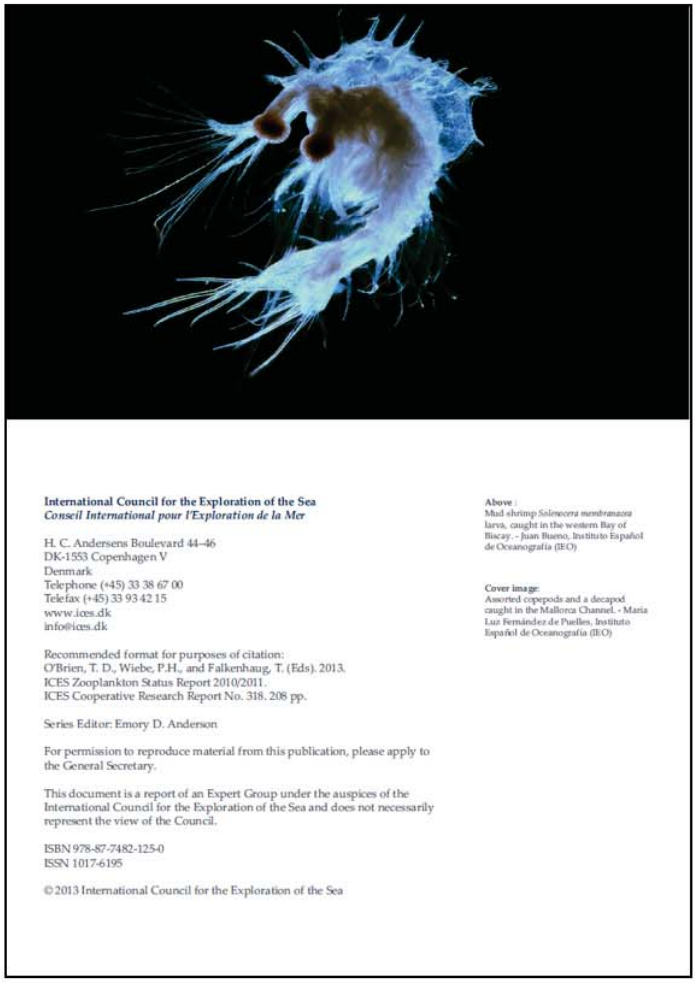

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Above :
Mud shrimp *Solenocera membranacea* larva, caught in the western Bay of Biscay. - Juan Bueno, Instituto Español de Oceanografía (IEO)

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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7.5 Plymouth L4 (Site 48)

Angus Atkinson, Elaine Fileman, Claire Widdicombe, Rachel Harmer, Andrea McEvoy, Roger Harris, and Tim Smyth

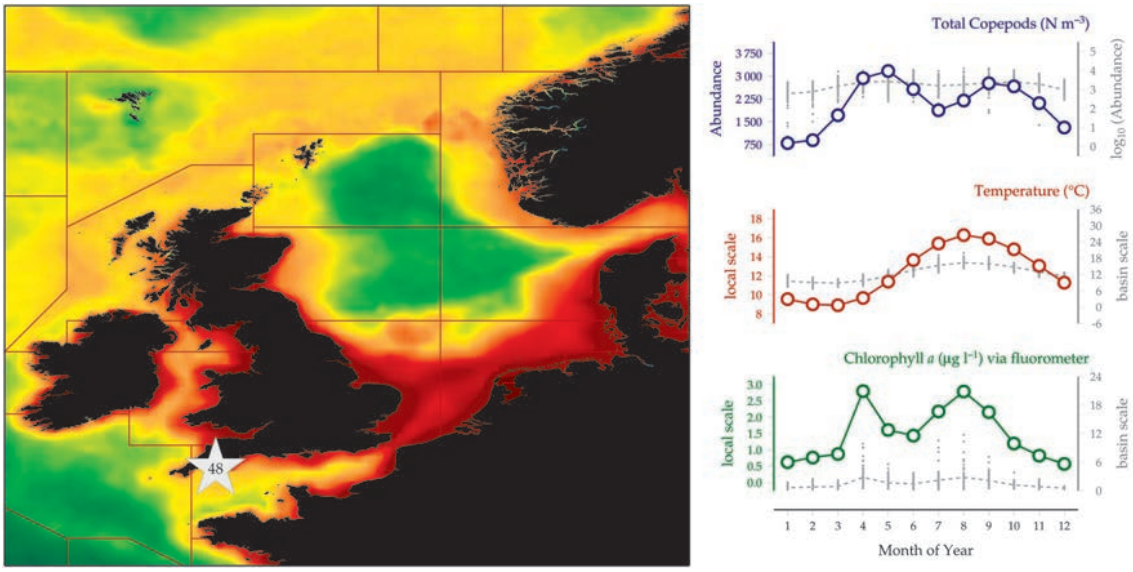

Figure 7.5.1
Location of the Plymouth L4 monitoring area (Site 48) plotted on a map of average chlorophyll concentration, and its corresponding seasonal summary plot (see Section 2.2.1).

The zooplankton time-series at Plymouth Station L4 (50°15′N 4°13′W) in the western English Channel is ongoing, with weekly sampling by Plymouth Marine Laboratory (PML) since 1988 (Harris, 2010; see http://www.westernchannelobservatory.org.uk/). Samples are usually taken every Monday morning at the site ~16 km southwest of Plymouth (Figure 7.5.1). Two replicate tows are made using a WP-2 net (56 cm diameter, 200 µm mesh) towed vertically from the seabed at ca. 50 m depth to the surface.

Mesozooplankton are identified and counted from catch fractions. For some taxa, particularly copepods such as *Calanus helgolandicus*, identification is to species level, with additional information on sex and life stages. Sea surface temperature (SST) has been measured since 1988 using a mercury-in-glass thermometer immersed in an aluminium bucket of water collected at the surface. Since 2002, water-column profiles have been recorded with a conductivity–temperature–depth (CTD) instrument, providing temperature, salinity, and fluorescence data. Water samples collected from a depth of 10 m with a Niskin bottle have been analysed since 1992 to determine abundance and to estimate carbon biomass of phytoplankton and microzooplankton. Organisms are counted and identified to genus or species level using inverted microscopy. At the same time, chlorophyll a triplicate measurements are made using a Turner fluorometer after filtering and extraction of sea surface water samples. Nutrient data (nitrate, nitrite, phosphate, and silicate) are also available from 2000 onwards. All L4 samples are analysed at PML, and the data are available through Pangaea, BODC, and the above Western Channel Observatory website.

Seasonal and interannual trends (Figure 7.5.2)

In line with observations around the UK shelf seas, the western English Channel has warmed by ~0.6°C per decade over the past 20 years. The greatest temperature rises followed a period of reduced wind speeds and enhanced surface solar irradiation in recent years (Smyth *et al*., 2010). Set in this context, Station L4 is continually affected by the tide, which is associated with an interplay of regular estuarine outflow from Plymouth Sound and oceanic waters coming in with the dominating southwesterly winds. The water column is weakly stratified from mid-April to September and mixed during winter (Pingree and Griffiths, 1978); the minimum and maximum surface temperatures occur in March (9.1°C) and August (16.4°C), respectively. The seasonal cycle of the phytoplankton community is characterized by spring diatom and autumn dinoflagellate blooms, but there is high interannual variability in abundance and floristic composition (Widdicombe *et al*., 2010).

Trends in total microzooplankton seasonal abundance show a transition from low abundance in winter months to a peak in summer, the timing of which has varied. Between 1992 and 2005, the peak in average monthly microzooplankton abundance varied from June to August, whereas since 2006, the peak in average abundance has occurred in May. Heterotrophic dinoflagellates are most abundant from May to September, and in the last decade, there have been a number of positive abundance anomalies for this group. The ciliate community is dominated by the genus *Strombidium* and *Myrionecta* rubra (Fileman *et al*., 2010; Widdicombe *et al*., 2010), and over the last decade, ciliates have shown a number of negative abundance anomalies.

The seasonal cycle of mesozooplankton abundance is characterized by high values from April right through to October (Figure 7.5.2). It then decreases, and the lowest values, in January–February, correspond to the lowest values in chlorophyll *a* and phytoplankton abundance. The mesozooplankton community at L4 is dominated by copepods, which typically form around 90% of the total during winter. In summer, this percentage drops to ~50% when meroplanktonic larvae and non-crustacean groups peak strongly (Eloire *et al*., 2010). Meroplankton larvae play an important role at L4 right through the productive season. Cirripedes are particularly abundant in March and April (see Figure 7.5.2; see also Highfield *et al*., 2010). By contrast, other groups, such as echinoderms, bivalves, and gastropods, reach maximum abundance in late summer or autumn. The non-crustacean holoplankton component is also significant and functionally diverse at L4, with appendicularians, chaetognaths, siphonophores, and medusae showing pronounced peaks, often during late summer.

Over the 23-year sampling period, trends in total mesozooplankton reflect those of the dominant component, the copepods. These typically show an irregular pattern often of 2–5-year periods of successive negative and positive anomalies (Figure 7.5.2, right subfigures). Interleaving periods of negative and positive anomalies are also seen in the CPR data for the corresponding area (Figure 7.5.3). However, these do not relate clearly to cycles seen at L4, suggesting either local conditions (L4 is a relatively inshore site) or effects of the different sampling method. More detailed investigations of relationships between phyto- and zooplankton phenological patterns are needed to understand predator–prey relationships and their impact on abundance variability (Mackas *et al*., 2012).

The last several years of data seem to reflect a period of positive abundance anomalies for most of the mesozooplankton taxa. As a group, the copepods have increased, as have the non-crustacean holoplankton (e.g. chaetognaths, siphonophores, medusae, appendicularians) and fish eggs and larvae. Most of the meroplanktonic taxa have shown a recent increasing trend (e.g. echinoderms, polychates, bivalves, gastropods, decapods), but this is not universal (e.g. cirrepede nauplii). Further, the timing of the progression from negative towards the recent positive anomalies varies. This occurs earlier for some taxa (e.g. fish eggs and larvae, echinoderms) than others (e.g. copepods, bivalves, gastropods). While the 23 years of data may be too short to reveal firm evidence of multidecadal or longer-term trends, the fine-resolution weekly sampling of zooplankton, phytoplankton, and nutrients at L4 captures well the complex variation in phenology as well as interannual and subdecadal periodicity.

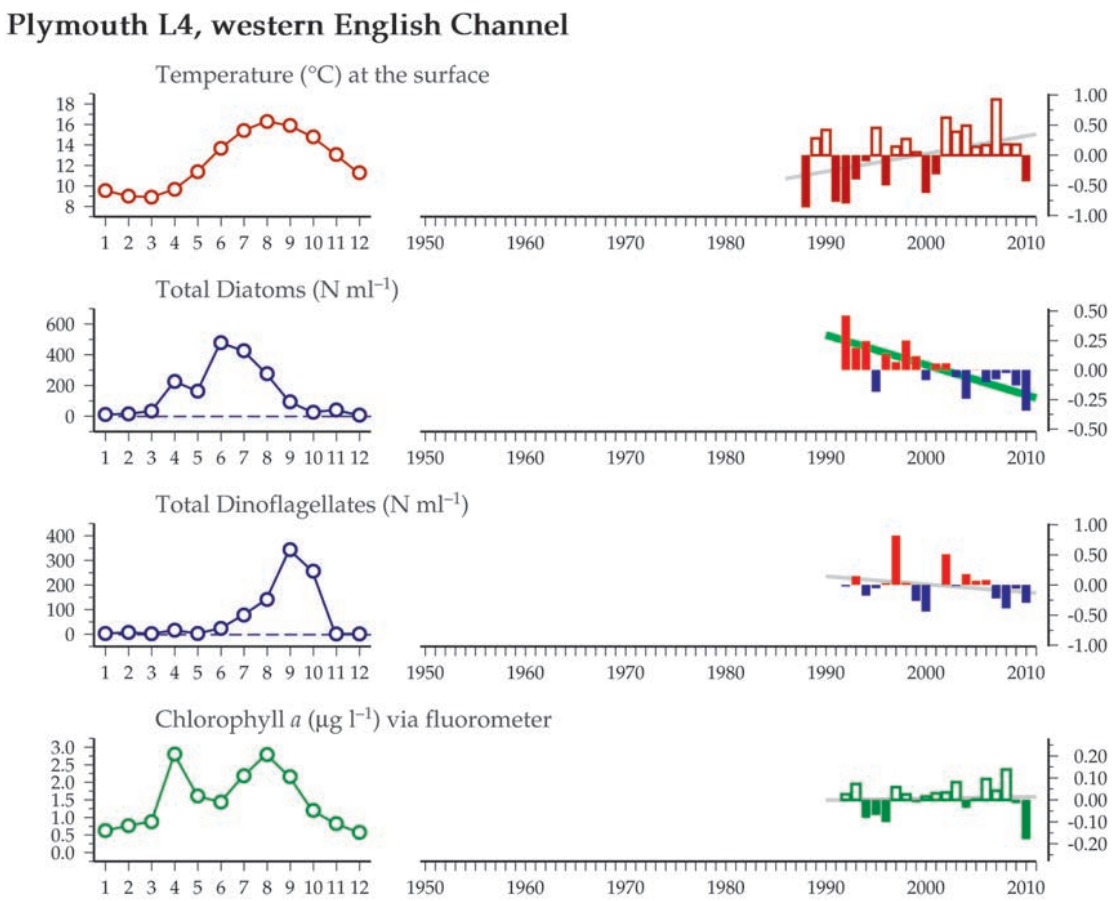

Figure 7.5.2 *Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the Plymouth L4 monitoring area.*

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

Figure 7.5.2
continued

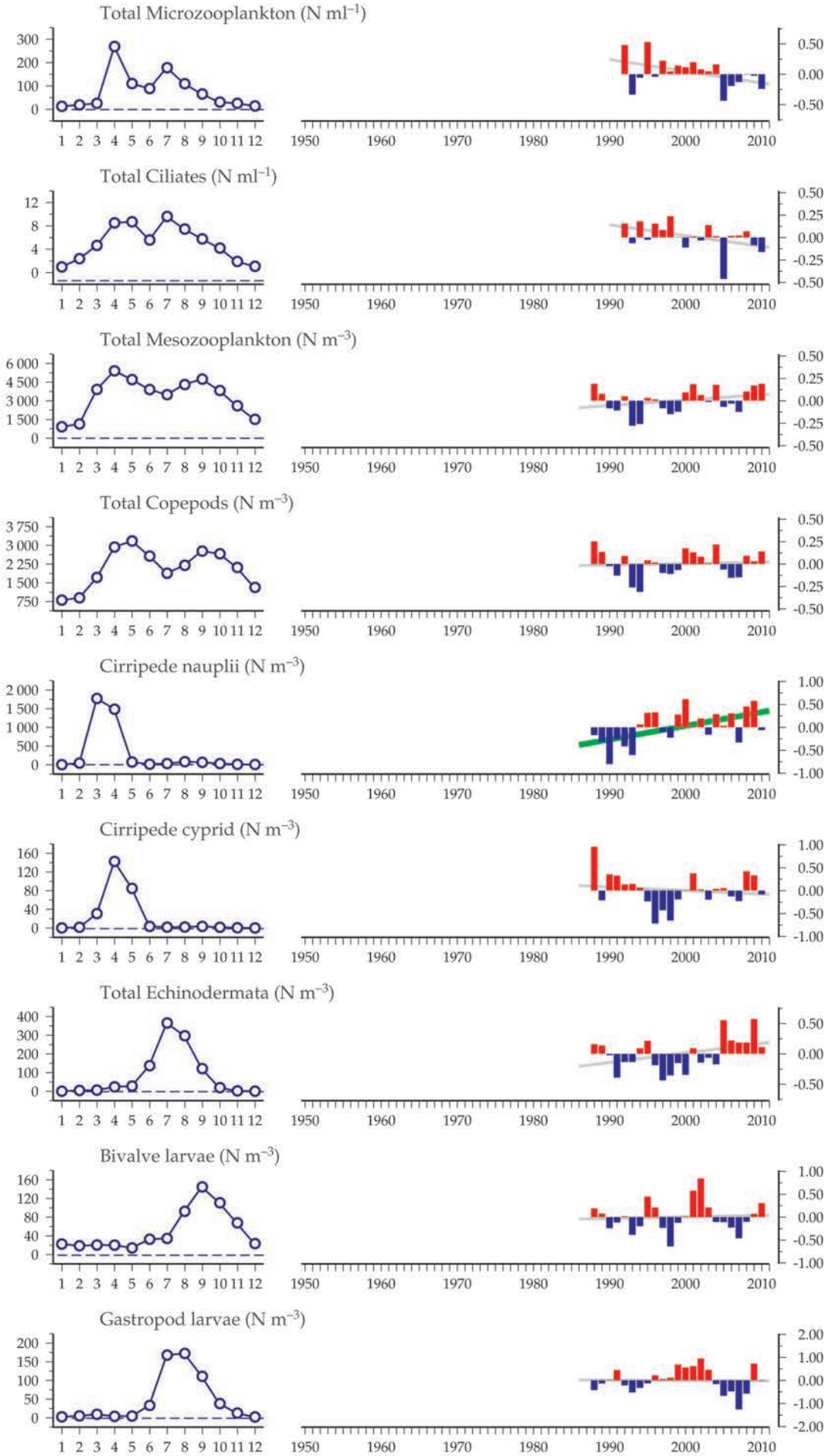

Figure 7.5.2
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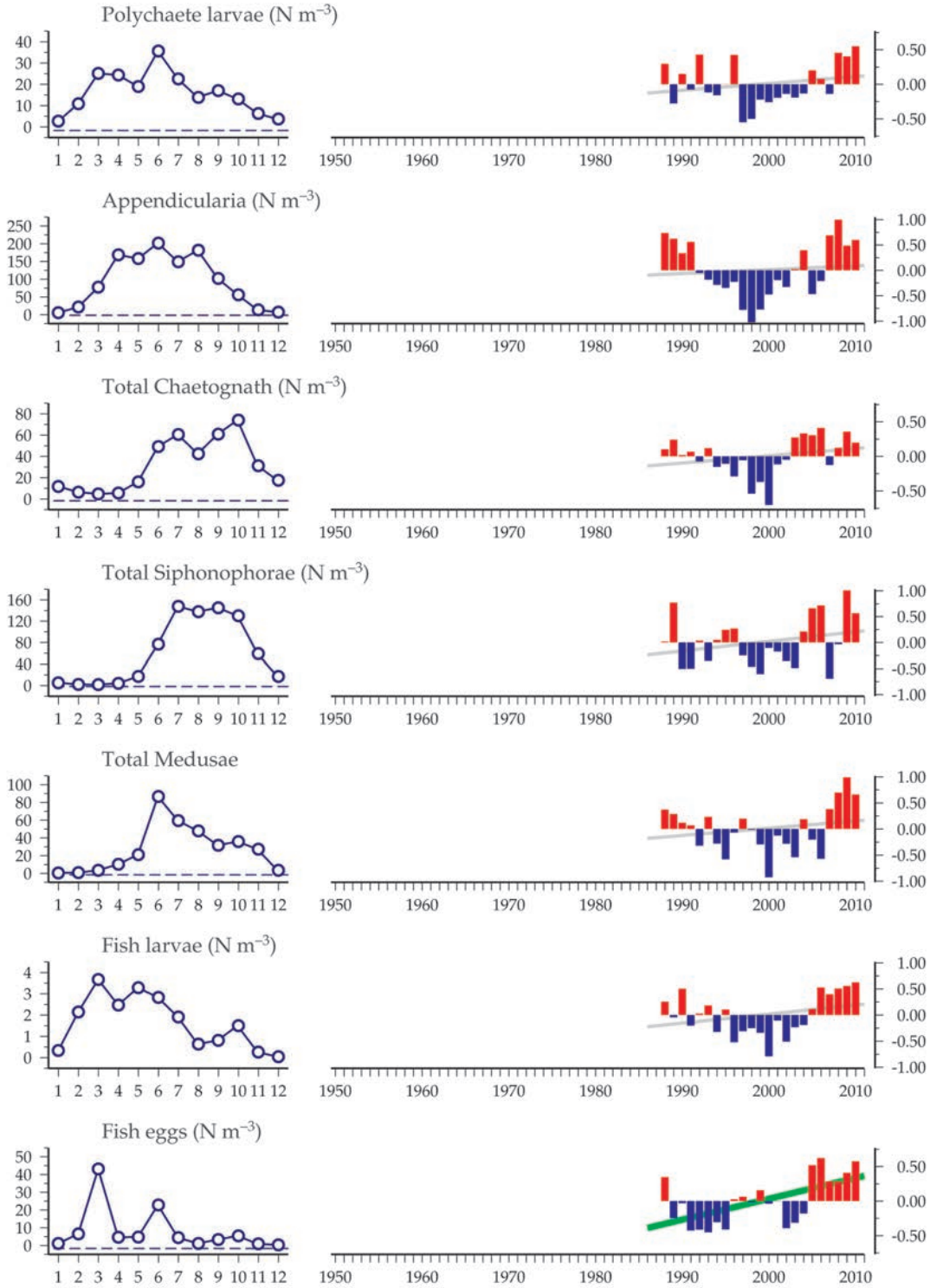

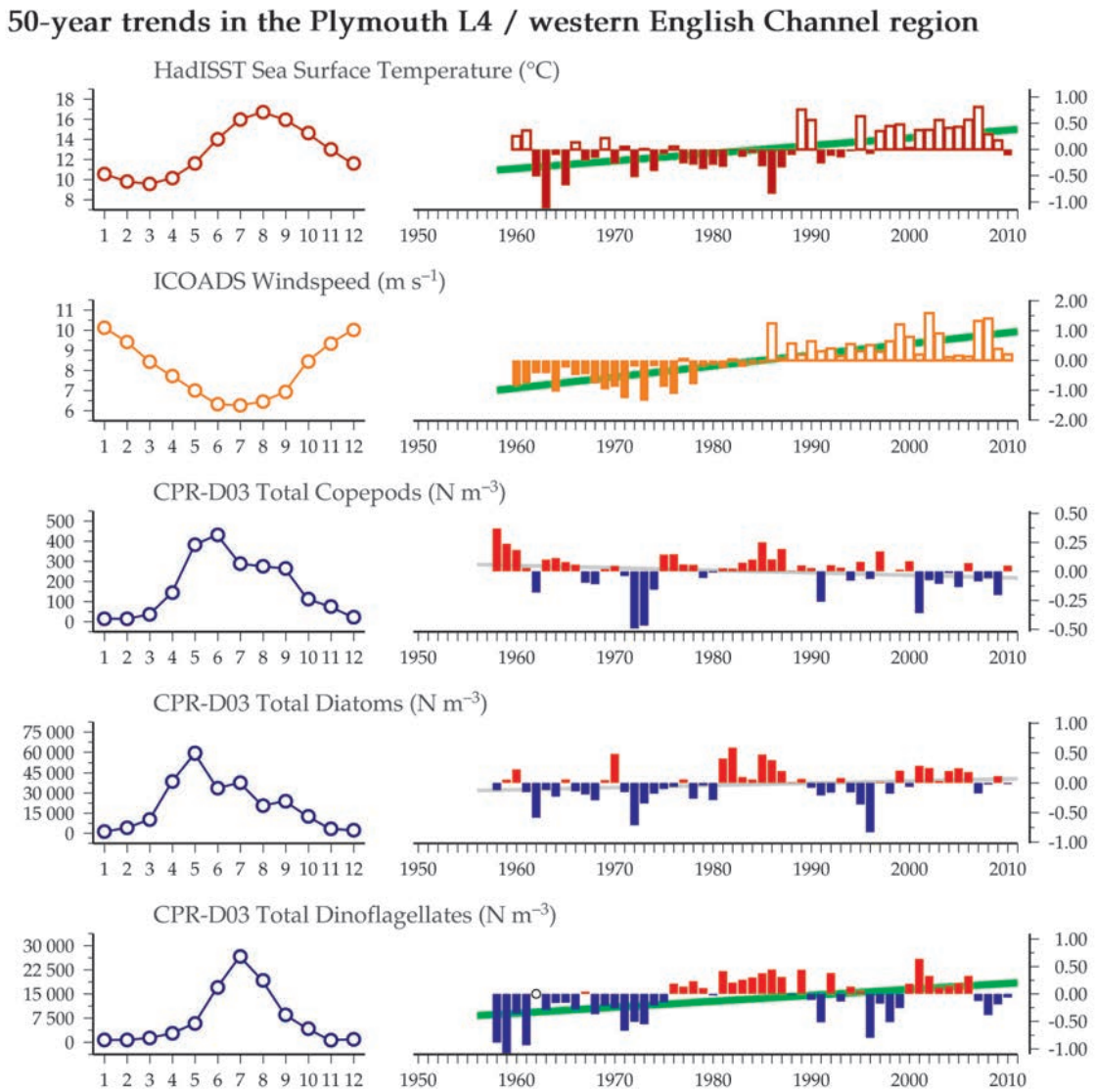
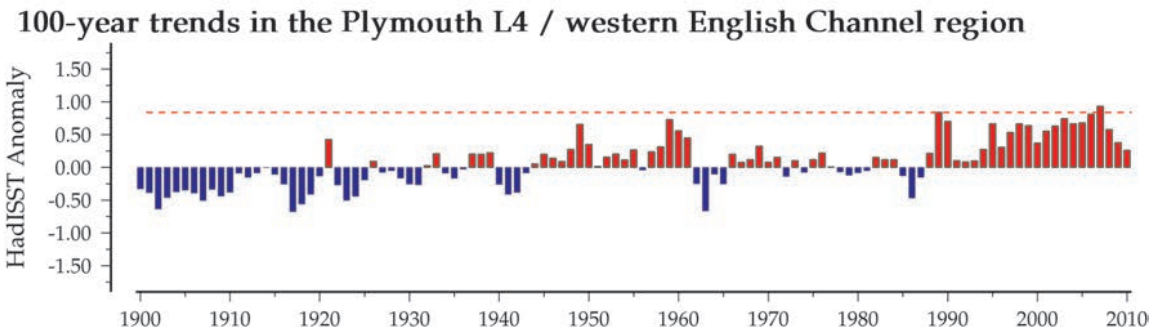
Figure 7.5.3
Regional overview plot (see Section 2.2.3) showing long-term sea surface temperatures and windspeeds in the general region surrounding the Plymouth L4 monitoring area, along with data from the adjacent CPR D03 Standard Area.