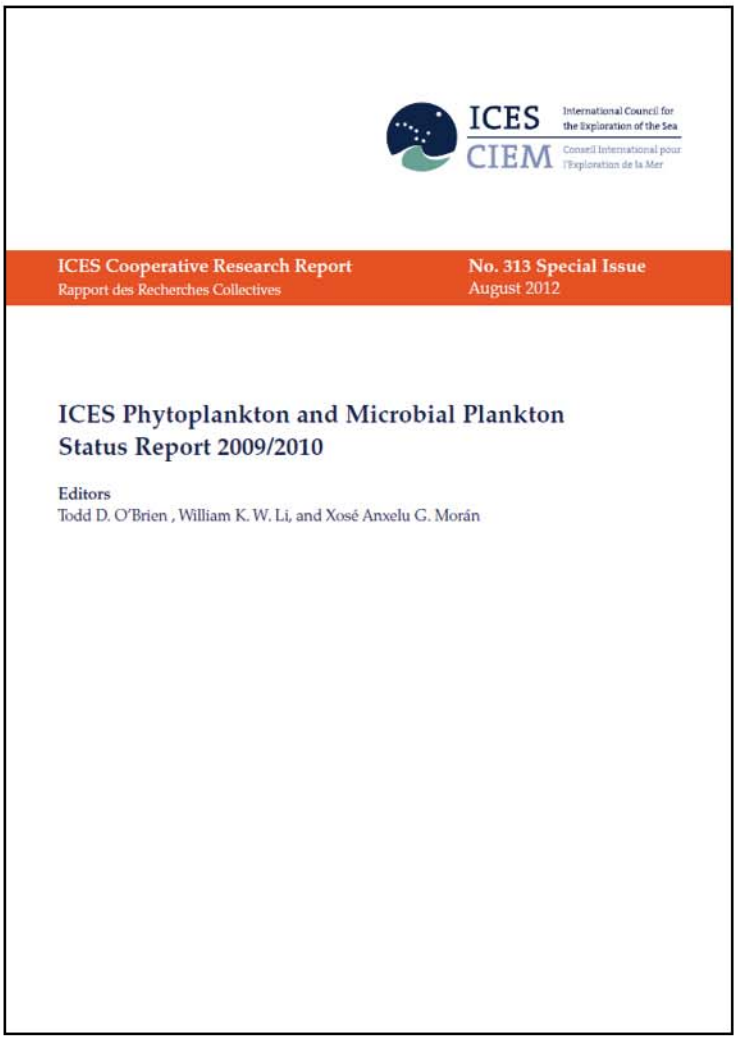

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O'Brien, T. D., Li, W. K. W., and Morán, X. A. G. (Eds). 2012.
ICES Phytoplankton and Microbial Plankton Status Report 2009/2010.
ICES Cooperative Research Report No. 313. 196 pp.

The time-series analyses and figures used in this report were created using COPEPODITE:
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6.6 Plymouth L4 (Site 36)

Claire Widdicombe, Glen Tarran, and Tim Smyth

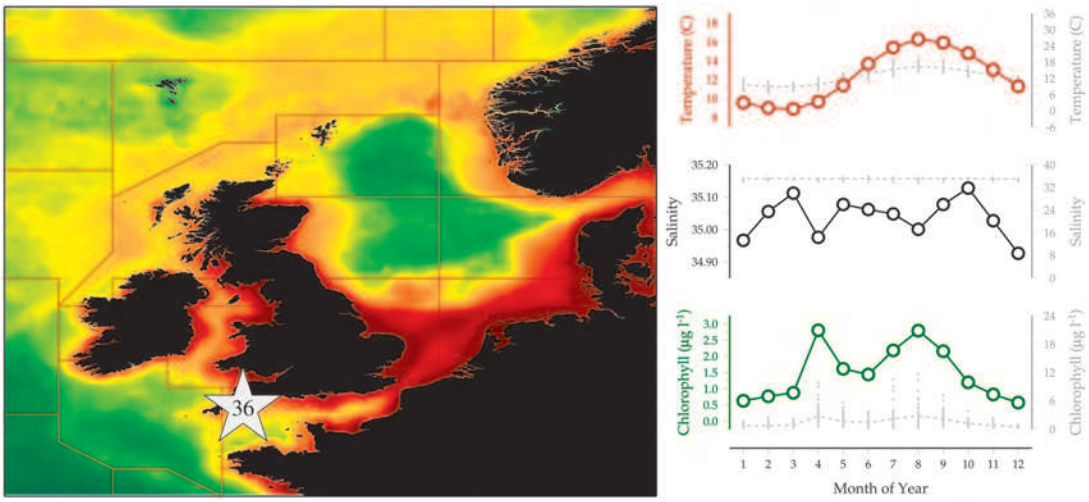

Figure 6.6.1
Location of the Plymouth L4 plankton monitoring area (Site 36), plotted on a map of average chlorophyll concentration, and its corresponding environmental summary plot (see Section 2.2.1).

The phytoplankton and microzooplankton time-series at Plymouth station L4 (Figure 6.6.1; 50°15'N 4°13'W) was established in 1992 to complement the ongoing zooplankton time-series (Harris, 2010), and continues to be sampled at weekly intervals (weather permitting). Station L4 is located in the western English Channel approximately 16 km southwest of Plymouth, where the water depth is ca. 50 m and conditions are typical of temperate coastal waters, with mixing during autumn and winter and weak stratification during spring and summer. Hydrodynamic variability, resulting from the interchange between wind-driven oceanic waters and rain-induced estuarine outflow, leads to a dynamic and variable plankton community.

Water samples for microscopy are collected using Niskin bottles from a depth of 10 m, and a 200 ml subsample is immediately preserved with acid Lugol's iodine solution for identifying and enumerating phyto- and microzooplankton species composition, and a second 200 ml subsample is preserved with buffered formaldehyde for the enumeration of coccolithophores (Widdicombe *et al.*, 2010). All analyses are conducted in the laboratory using light microscopy and the Utermöhl (1958) counting technique. Since April 2007, additional weekly samples are also collected from the surface, 10 m, 25 m, and 50 m for the live enumeration of small phytoplankton, bacteria, and heterotrophic flagellates by analytical flow cytometry. Sea surface temperature (SST) measurements have been made since 1988 using a mercury-in-glass thermometer submerged in an aluminium bucket containing surface water. Triplicate surface chlorophyll *a* samples are collected and analysed using a Turner fluorometer after filtration and extraction in 90% acetone. Surface-water nutrient concentrations (nitrate, nitrite, phosphate, and silicate) are available as far back as 2000, and water-column profiles of temperature, salinity, and fluorescence have been recorded using a conductivity-temperature-depth (CTD) instrument since 2002. All data are generated at the Plymouth Marine Laboratory and are available for download or via the links to Pangea and BODC at the Western Channel Observatory website www.westernchannelobservatory.org.uk.

Seasonal and interannual trends (Figure 6.6.2)

The phytoplankton community at station L4 exhibits strong seasonal and interannual patterns in abundance and composition. Surface chlorophyll *a* concentrations show a distinct seasonal cycle, with lowest values recorded during autumn and winter, two distinct peaks during spring and late summer, and variable values in between. Phytoplankton, enumerated by microscopy, are also less abundant during autumn and winter, when the community composition is relatively stable. An abrupt change between March and early May heralds the onset of the spring bloom, when phytoplankton are more abundant and species composition is more variable. This continues throughout summer until autumn, when the phytoplankton community becomes relatively stable again. Phytoflagellates numerically dominate the phytoplankton (ca. 87%) and exhibit

similar seasonal patterns in total abundance. Diatoms, however, follow a pattern of low abundance during winter, show a small increase during spring, but peak in abundance during summer, and this can continue through autumn. The floristic composition of the diatoms is also highly variable both seasonally and interannually (Widdicombe *et al.*, 2010). Coccolithophores, dominated almost entirely by *Emiliania huxleyi*, regularly bloom in the western English Channel, typically during late summer, but occasionally blooms have been monitored at station L4 during late spring.

Dinoflagellate abundance is generally low during winter and spring months, but as sea surface temperatures warm during summer, dinoflagellates steadily increase in abundance, often culminating in intensive, but brief, blooms dominated by either *Karenia mikimotoi* or *Prorocentrum minimum*. Colourless dinoflagellates form a comparatively minor component and are, on average, sevenfold lower in abundance than the main group of dinoflagellates. However, they too are relatively rare during winter and most abundant between late spring and early autumn when phytoplankton prey are most numerous. Unsurprisingly, the ciliates also peak in abundance between spring and autumn, with a gradual transition to and from low levels in winter. Enumeration of the small phytoplankton and microbial fraction by flow cytometry since 2007 demonstrates a different seasonal pattern. Concentrations of *Synechococcus* cyanobacteria, as well as picoeukaryotes, are, on average, lower during spring and summer and highest during autumn. However, their abundance is highly variable, particularly during spring and summer. The patterns observed in the phytoplankton, microzooplankton, and microbial groups are reflected in the measured nutrient concentrations. Generally, nitrate and nitrite, phosphate, and silicate are highest during winter, but the onset of the spring bloom and weak stratification, coupled with continued phytoplankton growth throughout summer, rapidly depletes nutrient concentrations, and levels generally do not recover again until winter.

Analysis of the L4 time-series demonstrates a generally consistent year-on-year seasonal pattern in the different phytoplankton, microzooplankton, and microbial groups. However, interannual variability of the species composition and magnitude of their abundance is considerable, thus making it difficult to observe clear long-term changes in the different components. However, the data do suggest that diatoms, in general, are decreasing, whereas coccolithophores and dinoflagellates are increasing at certain times of the year. A series of negative anomalies since 2006 implies that diatoms are decreasing, particularly between January and June, which suggests that the magnitude of the spring diatom bloom is weakening. At the same time, coccolithophores are becoming more common, as demonstrated by positive anomalies for most years since 2003, particularly for the period between April and June. The observed warming magnitude of ca. 0.5°C in the western English Channel over the past 50 years or so (Smyth *et al.*, 2010) is likely to favour dinoflagellates (Widdicome *et al.*, 2010). A change in the timing, magnitude, and floristic composition of phytoplankton communities may have an important impact upon zooplankton, meroplankton, and carbon export to the benthos, as well as the potential of harmful species to affect commercial fisheries and affect human health, and thus validates the importance of time-series studies such as at station L4.

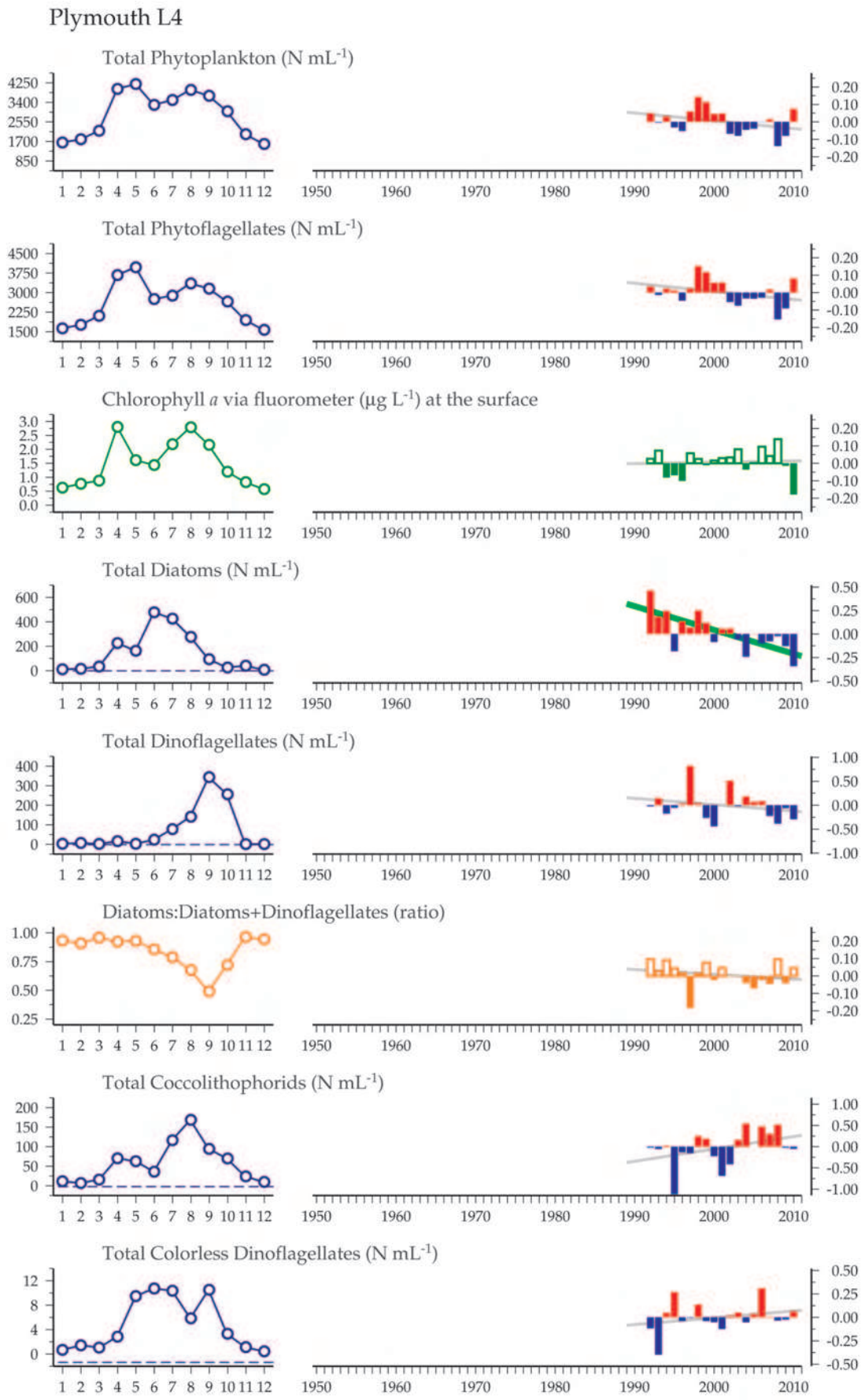

Figure 6.6.2 (continued overleaf)
Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the Plymouth L4 plankton monitoring site. Additional variables from this site are available online at http://wgpme.net/time-series.
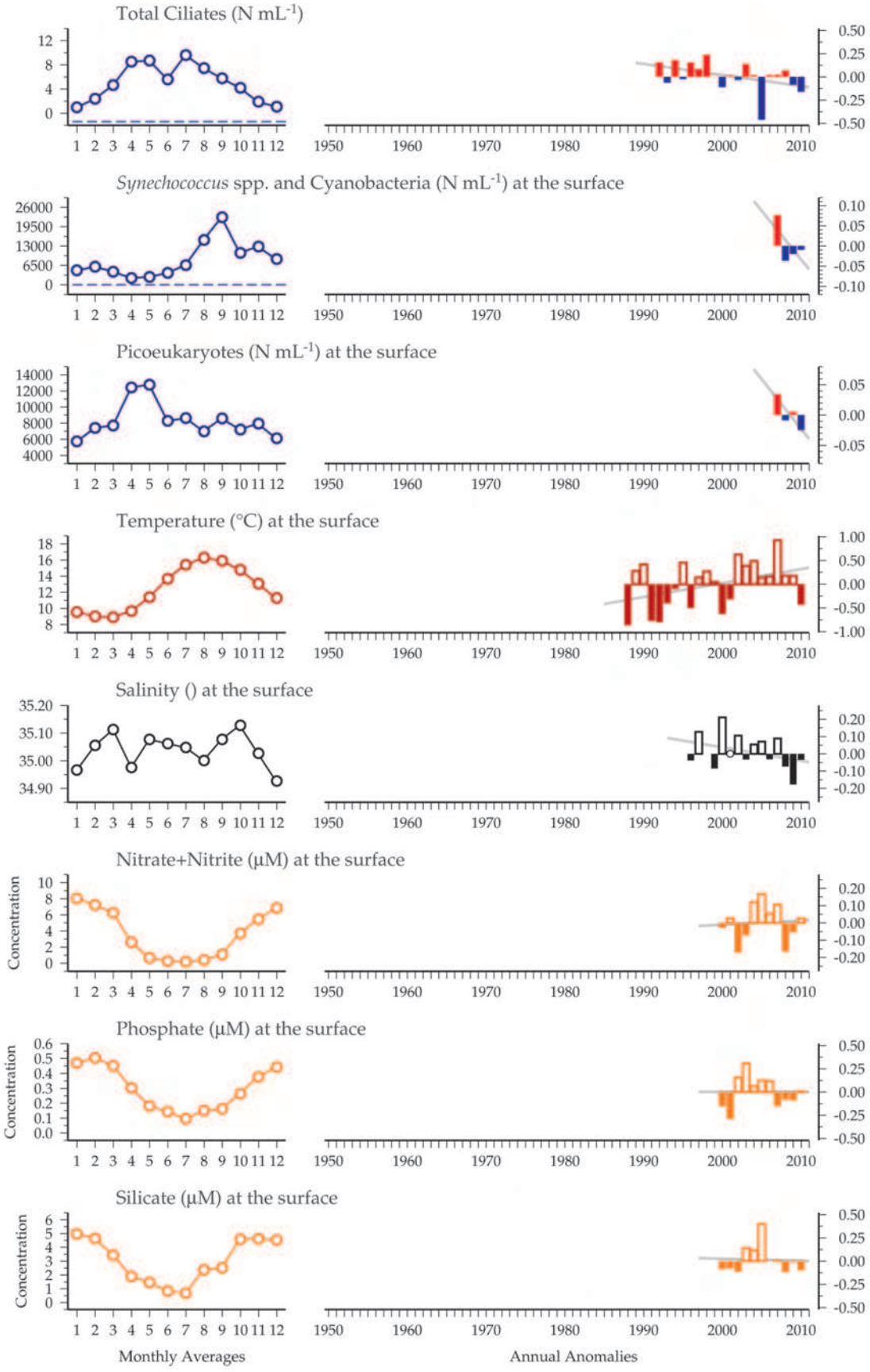
Figure 6.6.2 continued.