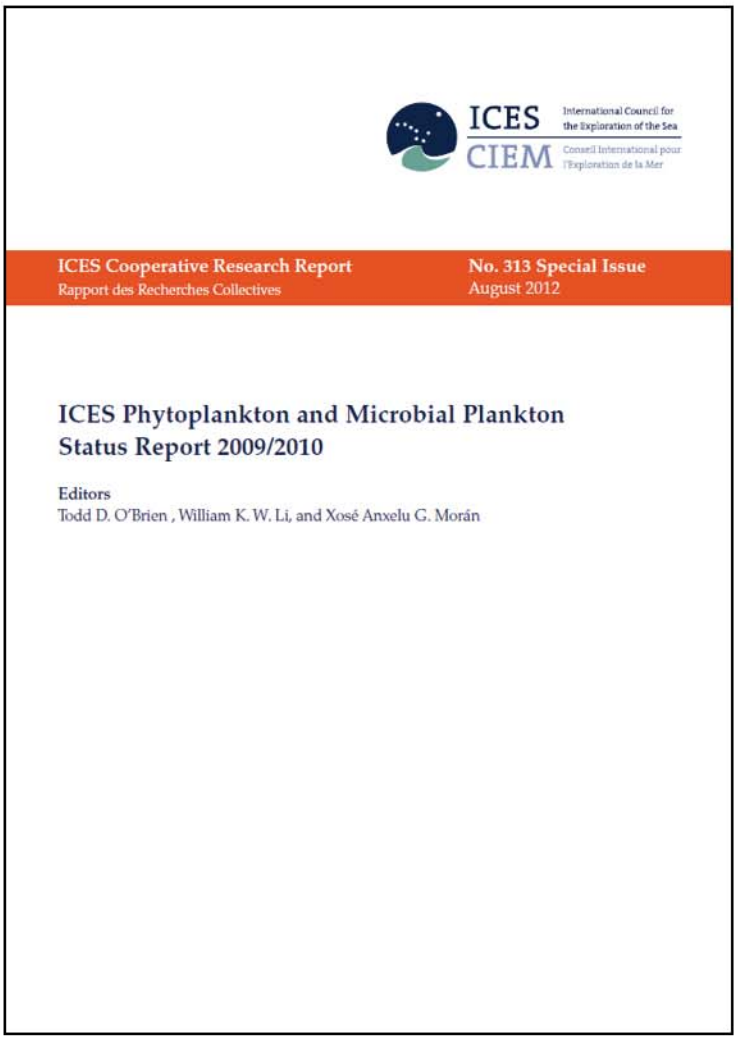

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O'Brien, T. D., Li, W. K. W., and Morán, X. A. G. (Eds). 2012.
ICES Phytoplankton and Microbial Plankton Status Report 2009/2010.
ICES Cooperative Research Report No. 313. 196 pp.

The time-series analyses and figures used in this report were created using COPEPODITE:
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8.2 AZTI Station D2 (Site 50)

Marta Revilla, Ángel Borja, Almudena Fontán, and Victoriano Valencia

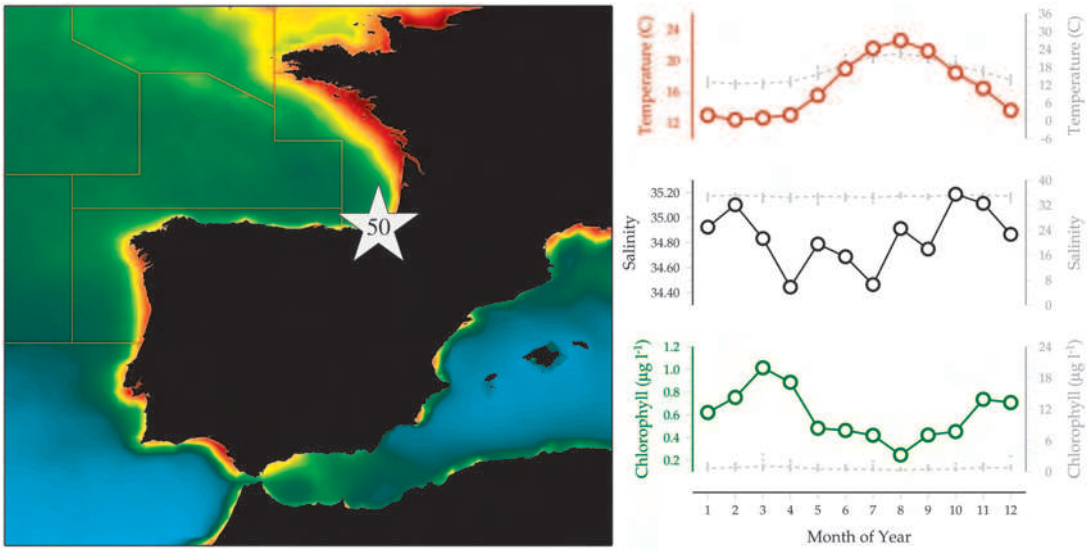

Figure 8.2.1
Location of the AZTI Station D2 plankton monitoring area (Site 50), plotted on a map of average chlorophyll concentration, and its corresponding environmental summary plot (see Section 2.2.1).

Along the Basque coast (southeastern Bay of Biscay), the longest series on phytoplankton biomass (chlorophyll *a* concentration) has been obtained at station D2 (Site 50, 43°27'N 01°55'W). This station is located 13.1 km offshore and at a water depth of 110 m. Data are collected since 1986 by AZTI-Tecnalia, within the project "Variaciones", funded by the Department of Environment, Territorial Planning, Agriculture and Fisheries of the Basque Government. Surveyed months and total number of surveys per year are variable (3–12). On average, eight surveys per year are conducted. Details on sampling and analytical methods are available in Revilla *et al.* (2010). Generally, CTD continuous vertical profiles have been obtained. Here, long-term series on chlorophyll, salinity, and temperature are presented.

Additionally, phytoplankton abundance and composition, together with general environmental conditions (e.g. oxygen, nutrients, and optical properties) are shown from 2002 to 2010. This is part of the Littoral Water Quality Monitoring and Control Network of the Basque Country, conducted by AZTI-Tecnalia for the Basque Water Agency (URA). For this purpose, the station D2 is sampled every three months from February to November. Water samples for phytoplankton analyses (Utermöhl, 1958) are collected at the surface with a clean bucket and immediately fixed with glutaraldehyde. Field and laboratory methods are described in detail by Garmendia *et al.* (2011).

The offshore station D2 is considered to be unaffected by anthropogenic influence, owing to its distance from the main pollution sources on land. The main fertilization factor for the surface waters of this area is the continental run-off coming from the rivers around the southeastern Bay of Biscay (Valencia and Franco, 2004; Díaz *et al.*, 2007; Ferrer *et al.*, 2009). Surface salinity is 34.8 ± 0.67 (average ± standard deviation) from 1986 to 2008 (n = 174), which indicates a low average freshwater content (2.3%).

Seasonal and interannual trends (Figure 8.2.2)

At station D2, sea surface temperature (SST) presents a distinct seasonal cycle, and chlorophyll in surface waters (0–1 m) is inversely correlated to SST. The cold season can be defined as November–April, with monthly averaged SST ranging from 12.5 to 16.5°C and surface chlorophyll ranging from 0.6 to 1.0 µg l^{-1}. The warm season can be defined as May–October (15.6–22.7°C, monthly averaged SST). During the warm months, the mean chlorophyll concentration is below 0.5 µg l^{-1} in surface waters.

The surface waters at D2 station have warmed up over the past 20–30 years ($1.4 \pm 1.1 \times 10^{-2}$ °C $year^{-1}$). The change could be faster for inshore waters, at around 2.4×10^{-2} °C $year^{-1}$ (González *et al.*, 2008; Revilla *et al.*, 2009). Warming patterns have also been described for other neighbouring areas (e.g. Goikoetxea *et al.*, 2009; Bode *et al.*, 2011b). In the

southern Bay of Biscay, Llope *et al.* (2007) linked the recent warming of the ocean surface with increasing stratification and weaker/shallower winter mixing, which could reduce nutrient inputs and cause stoichiometric changes. In this scenario, it has been hypothesized that primary production will be progressively lower and phytoplankton assemblages will change (Llope *et al.*, 2007).

At station D2, Revilla *et al.* (2010) found a slight decrease in the surface chlorophyll concentration between 1986 and 2008 ($-3.8 \pm 4.7 \times 10^{-3}$ µg l^{-1} $year^{-1}$). Further studies demonstrated that the photic-layer-averaged chlorophyll (0–50 m) had followed an opposite, increasing trend ($6.2 \pm 2.5 \times 10^{-3}$ µg l^{-1} $year^{-1}$). In addition, the location of the chlorophyll subsurface maximum could have moved progressively deeper in the water column, from 10 m at the beginning of the series to 30 m in the last decade. These trends could be related to climatic factors, such as the East Atlantic (EA) pattern (ICES, 2011).

The analysis of the annual anomalies at station D2 demonstrates a significant increase ($p < 0.05$) in the photic-layer-averaged chlorophyll over the 1986–2010 period. *In situ* surface temperatures taken immediately at the site had an increasing (but non-significant) trend, whereas HadISST date-matched data from the larger region did present a significant increasing trend ($p < 0.05$). These findings support previous results in the area that were obtained by other methods for trend analyses. Those were non-parametric methods based on seasonal variability removal and regression analysis, or KZA filter (Revilla *et al.*, 2010; ICES, 2011).

Decadal variations in climatic conditions have been described in this geographical area, with an increase in the positive phase of the EA occurring since 1997 (Borja *et al.*, 2008; Goikoetxea *et al.*, 2009). In the northern part of the Iberian Peninsula, the EA pattern is the most important variation pattern explaining temperature variability. In particular, in the southeastern Bay of Biscay, a positive EA involves warmer and drier winters, as well as stronger downwelling, caused by the southwesterly winds. At a larger scale, the positive phase of the EA is associated with above-average precipitation over northern Europe and Scandinavia, and with below-average precipitation across southern Europe (deCastro *et al.*, 2008).

At station D2, the oceano-meteorological variability coupled to the EA pattern could explain the decrease in phytoplankton biomass in surface waters and its increase in deeper waters in response to stronger downwelling and reduced cloudiness (ICES, 2011). Nevertheless, in other areas of the north Iberian Peninsula, the response of phytoplankton to climate variability could be different in relation to the relative influence of other hydrographic factors (e.g. upwelling activity and run-off) at the local scale (Bode *et al.*, 2011b).
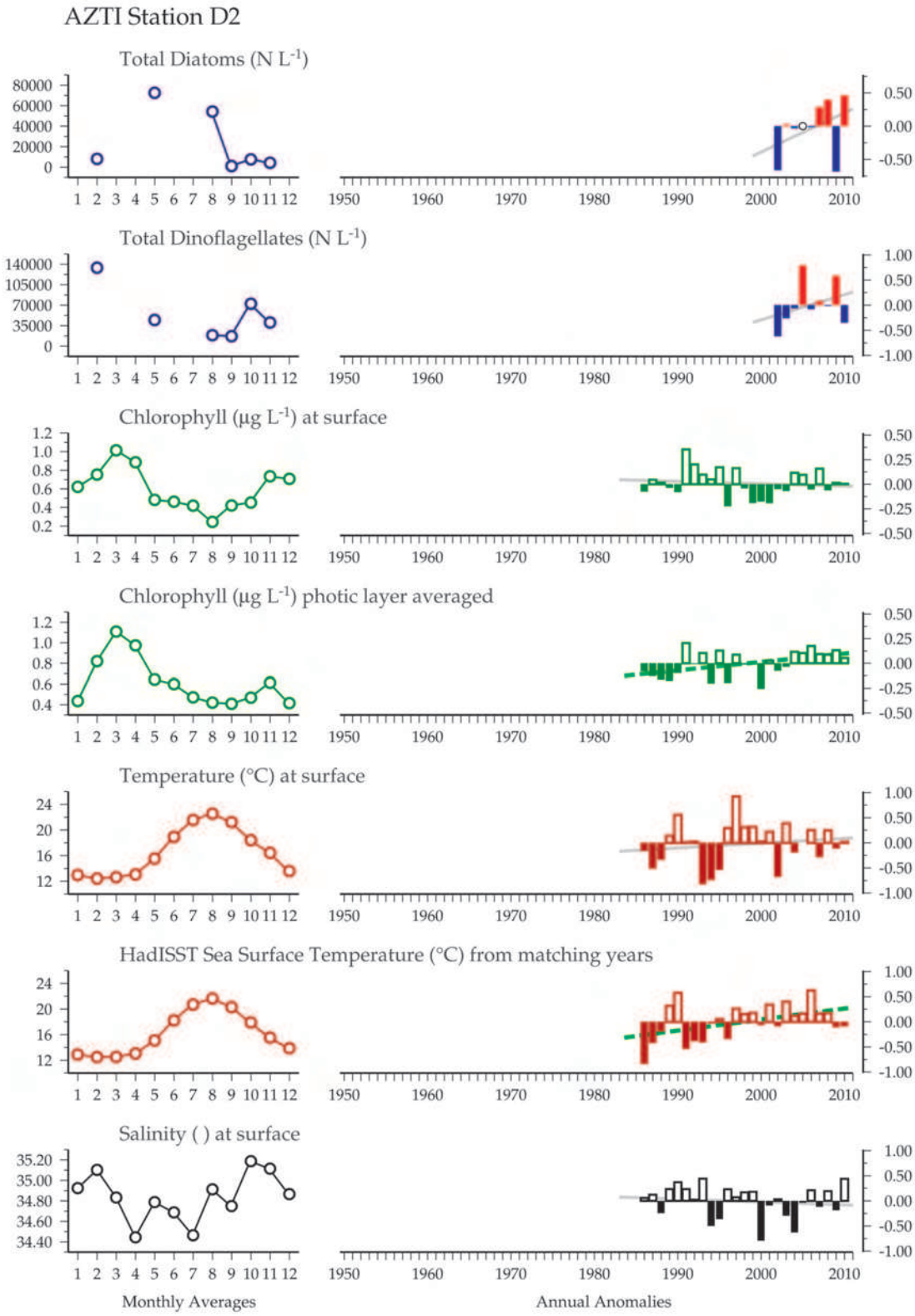
Figure 8.2.2
Multiple-variable comparison plot (see Section 2.2.2) showing the seasonal and interannual properties of select cosampled variables at the AZTI Station D2 plankton monitoring site. Additional variables from this site are available online at http://wgpme.net/time-series.